Naval Facilities Engineering Systems Command

Naval Facilities Engineering Systems Command Pacific
JBPHH HI

Monitoring Well Installation Work Plan Red Hill Bulk Fuel Storage Facility

JOINT BASE PEARL HARBOR-HICKAM, O‘AHU, HAWAI‘I

January 2025

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ACRONYMS AND ABBREVIATIONS

%	percent
AOC	Administrative Order on Consent
bgs	below ground surface
BMP	Best Management Practice
CGSP	Consolidated Groundwater Sampling Program
COLIWASA	composite liquid waste sampler
COPC	chemical of potential concern
COR	Contracting Officer’s Representative
CTO	contract task order
CWRM	Commission on Water Resource Management
DLA	Defense Logistics Agency
DLNR	Department of Land and Natural Resources, State of Hawai‘i
DO	dissolved oxygen
DOH	Department of Health, State of Hawai‘i
EAL	Environmental Action Level
EDMS	Environmental Data Management System
EPA	Environmental Protection Agency, United States
ft	foot/feet
gpm	gallons per minute
GPS	Global Positioning System
IDW	investigation-derived waste
JBPHH	Joint Base Pearl Harbor-Hickam
LNAPL	light nonaqueous-phase liquid
mL/min	milliliters per minute
msl	mean sea level
MWIWP	Monitoring Well Installation Work Plan
NAVFAC	Naval Facilities Engineering Systems Command
NPDES	National Pollutant Discharge Elimination System
ORP	oxidation-reduction potential
PFAS	per- or polyfluoroalkyl substances
PID	photoionization detector
ppmv	parts per million by volume
PVC	polyvinyl chloride
QAPP	quality assurance project plan
QC	quality control
SOP	standard operating procedure
TGM	Technical Guidance Manual
U.S.	United States
VOC	volatile organic compound

DEFINITIONS

Annulus	The opening between an inner and outer cylindrical body, often used to describe the space between the well screen or drill pipe and the borehole wall. Also called the annular space.
Aquifer	A geologic formation that is sufficiently permeable to conduct groundwater and to yield economically significant quantities of water to wells.
Bailer	A cylindrical piece of equipment used to collect groundwater samples.
Basal Groundwater	An aquifer in which a body of groundwater floats on a body of saltwater in accordance with the buoyant density difference of the two bodies of water. Oahu's southern basal aquifer is a drinking water source.
Borehole	The void created by the advancement of a drilling bit through the formation. Boreholes are sometimes enlarged in multiple passes with a reamer bit, to facilitate coring or testing in smaller-diameter holes, or to improve the alignment or cutting efficiency of the drill bits for larger-diameter boreholes.
Drill Bit	Cutting tools used in a drill to remove material to create holes, almost always of circular cross-section. Drill bits come in many sizes and shapes.
Casing [Conductor]	A cylindrical device (steel or plastic) that is installed in a well to maintain the well opening and to provide a seal. Conductor casing provides a seal for upper intervals while a deeper borehole is advanced.
Casing [Production]	The final well casing, including a screened interval, that is in communication with and will "produce" water from the aquifer.
Casing [Surface]	Near-surface casing used as an air diverter string during air drilling operations to provide a pipe connection between the borehole and the discharge line for drill cuttings and as a foundation for well control.
Confined Aquifer	An aquifer, separated from atmospheric pressure by an impermeable layer, in which the water is under pressure greater than that of the atmosphere.
Confining Layer	Geologic material with little or no permeability or hydraulic conductivity such as clay or dense rock. Water either does not pass through this layer or its rate of movement is extremely slow. In a confined groundwater system, the physical presence of water is constrained beneath a confining later, and the physical water occurs in the aquifer below the elevation that water would rise to in a well that penetrates the confining layer.
Consolidated Material	A tightly bound geologic formation composed of sandstone, limestone, granite, basalt, or other rock.
Core	A continuous cylinder of rock, usually from 5 to 10 centimeters in diameter, cut from the bottom of a borehole as a sample of an underground formation.
Corehole	Any borehole drilled for the purpose of obtaining rock core samples.
Cuttings	Small pieces of rock that break away due to the action of the bit. Cuttings are monitored for composition, size, shape, color, texture, hydrocarbon content, and other properties.
Depressed Head	A condition within a continuously saturated zone above a confined aquifer where the hydraulic head is hydraulically distinct from, but lower than, that within the confined aquifer.

Diverter	A device attached to a wellhead to divert the air, fluids, and drill cuttings traveling up the borehole annulus into a discharge hose for transfer into a container.
Drawdown	A lowering of the groundwater level caused by pumping.
Drilling Mud	A special mixture of clay, water, and chemical additives pumped downhole through the drill pipe and drill bit. The mud cools and lubricates the rapidly rotating bit, carries rock cuttings to the surface, and serves to limit fluid loss into the formation. Drilling mud also provides the weight or hydrostatic pressure needed to prevent formation fluids from entering the hole and prevent borehole collapse in unconsolidated formations.
Elevated Head	A condition within a continuously saturated zone above a confined aquifer where the hydraulic head is hydraulically distinct from, and higher than, that within the confined aquifer.
Formation	A general term for the rock or unconsolidated materials around the borehole.
Grout	A fluid-sealing mixture usually comprising bentonite and or cement that is used to seal well casing. Once emplaced, grout forms an impermeable seal.
Headspace Analysis	A technique for sampling and examining volatile compounds associated with a solid or liquid sample. The actual headspace itself is the volume of vapor or gas above the sample. The sample and its associated headspace are held within an enclosed container leaving one-third to one-half empty; the concentration of volatile compounds in the container's empty 'headspace' is measured, typically with a photoionization detector (PID).
Hydraulic Gradient	The rate of change in total head per unit of distance of in the direction perpendicular to the lines of equipotential for hydraulic head. Water will flow from higher hydraulic head to lower hydraulic head.
Hydraulic Head	In an aquifer, the altitude to which water will rise in a properly constructed well: the altitude of the water table in an unconfined aquifer or of the potentiometric surface in a confined aquifer.
Monitoring Well	A well constructed or used for collecting water level data, water quality data, or other data.
Over Drill	Drilling a larger borehole in the same footprint of a previous open borehole without a reamer and pilot bit, or redrilling a backfilled hole with a larger-diameter bit.
Perched Groundwater	Groundwater that occurs at a higher elevation than the regional unconfined aquifer and that is separated from the regional aquifer by an unsaturated zone.
Permeability	A measure of the resistance of rock or sediments to the movement of fluids.
Plug	A seal of cement (or other impervious material) deliberately placed in a wellbore to allow emplacement of materials above it that are separated from materials below it.
Potentiometric Surface	Under confined conditions, potentiometric surface is the elevation that represents the total hydraulic head of groundwater; i.e., the level to which the groundwater would rise in a well or if the confining layer were removed. Under unconfined or "water table" conditions, the potentiometric surface is the same as the elevation of the physical occurrence of the water.
PQ, HQ	Standard wire-line bit sizes for drilling rock cores. Outside hole/inside core diameters are 96/63.5 millimeters for an HQ bit and 122.6/85 millimeters for a PQ bit.

Reaming	Enlarging an existing open borehole by using a reamer and pilot bit assembly.
Rotary Drilling	A well drilling method achieved by the rotary cutting action of a drill bit. Typically refers to methods that use rotating or rolling cutting heads. Circulation can be normal, which is down through the drill pipe and up the annulus, reverse of which is down the annulus returning up the drill pipe, or dual-wall reverse circulation that requires drill pipe with concentric pipe.
Screen	A cylinder of steel or plastic material used to allow water to enter a well while preventing sediment or rock particles from entering the well. A screen operates similar to a sieve. Well screens can be wire-wrapped, louvered or perforated, saw-cut, or factory-slotted, and can be constructed from different materials and at different opening sizes. Selection of well screen design and opening size may depend on characteristics of the geologic formation, required yield, and thickness of the aquifer.
Test Hole [Test Boring]	A temporary uncased hole typically used for one-time collection of samples or evaluations in applications of engineering geology, whereas test wells are completed with well casing and used in groundwater investigations to obtain ongoing information about geologic or hydrologic conditions. Test holes are usually drilled at a small diameter, and require proper abandonment when testing is complete. Temporary test holes do not require a drilling permit.
Total Depth	The bottom of a particular hole section, hole, or wellbore.
Tremie Pipe	A pipe used to carry materials (usually grout) to a specific depth in a drilled hole to ensure proper depth of emplacement and to avoid bridging of materials.
Unconfined Aquifer	An aquifer in which the water table is at or near atmosphere pressure and is the upper boundary of the aquifer. Because the aquifer is not constrained by a confining unit, the water level in a well is the same as the water table outside the well.
Unconsolidated Material	Loosely bound geologic formation typically composed of clays, sands, or gravel.
Well	An excavation or opening into the ground, or an artificial enlargement of a natural opening, drilled, tunneled, dug, or otherwise constructed for the location, exploration, monitoring, development, injection, or recharge of groundwater and by which groundwater is drawn or is capable of being withdrawn or made to flow.
Well Development	The application of techniques following well construction designed to mitigate the impacts of drilling on the formation, remove fine particles from the filter pack, and confirm that the well will meet the conditions for water clarity, stability, and minimum yield required to meet the goals of the well.
Wellbore	A borehole intended for completion as a well by installing permanent casing.
Wellhead	The surface completion of a well.

1. Introduction

This *Monitoring Well Installation Work Plan* (MWIWP) documents the proposed approach for installing new groundwater monitoring wells within and in the vicinity of the Red Hill Bulk Fuel Storage Facility (the "Facility"). Existing monitoring wells are presented on Figure 1. The effort will expand the current groundwater monitoring network and increase understanding of groundwater heads and gradients (horizontal and vertical), stratigraphic formation hydraulic conductivities, subsurface geology, extent of chemicals of potential concern (COPCs), geochemical parameters, and potential lateral and vertical migration of COPCs in the project study area. The data gathered from these monitoring wells will be used to estimate risks to public water supply infrastructure and refine the conceptual site model, the groundwater flow model, and contaminant fate and transport model associated with the study area. This MWIWP describes the procedures and methodologies for drilling, well installation, well development. and sampling of these monitoring wells. The objectives and rationale for selection of well locations are described in Appendix B and maps showing proposed locations are presented in Figures B-1 and B-2.

This MWIWP supersedes the following project documents:

- MWIWP dated August 29, 2016 (DON 2016)
  - Addendum 01 dated January 4, 2017 (DON 2017a)
  - Addendum 02 dated August 25, 2017 (DON 2017e)
- Sentinel and Monitoring Well Installation Work Plan published on May 20, 2022 (DON 2022a)
  - Revision 01 dated September 2, 2022 (DON 2022b)
  - Revision 02 dated December 12, 2022 (DON 2022c)
  - Addendum 01 dated May 5, 2023 (DON 2023b)
  - Detailed Responses to EPA/DOH Feedback of June 26, 2023: Sentinel and Monitoring Well Installation Work Plan Addendum

The activities proposed under this MWIWP and the project Work Plan/Scope of Work (DON 2017f) are part of an investigation being performed by the United States (U.S.) Department of the Navy (DON; "Navy") and Defense Logistics Agency (DLA) to address the requirements and achieve the objectives of the Administrative Order on Consent (AOC) issued by the U.S. Environmental Protection Agency (EPA) Region 9 and the State of Hawaiʻi Department of Health (DOH) (EPA Region 9 and DOH 2015). The investigation specifically addresses the AOC Statement of Work Section 6, Investigation and Remediation of Releases, and Section 7, Groundwater Protection and Evaluation.

2. Field Project Implementation

2.1 Project Procedures

Drilling, sampling (during drilling), monitoring well installation, and other field activities will be conducted as applicable in accordance with the DOH *Technical Guidance Manual* [TGM] *for the Implementation of the Hawaii State Contingency Plan* (DOH 2021), the Hawaiʻi *Well Construction and Pump Installation Standards* (DLNR 2004), the relevant standard operating procedures from the *Project Procedures Manual, U.S. Navy Environmental Restoration Program, NAVFAC Pacific* (DON 2015), which are identified in Table 1, and the Red Hill *Sampling and Analysis Plan* and *Addendum 01* (DON 2017d; 2017c). An *Accident Prevention Plan* has been prepared under separate cover to address potential health and safety concerns that may arise during field work (current update is October 2023) (DON 2023a). Analytical data quality assurance project plan (QAPP) package requirements for groundwater sampling activities are presented in Appendix D.

Table 1: Field SOPs Reference Table

Reference Number	Title [a]	Originating Organization of Sampling SOP	Equipment Type
I-A-5	*Utility Clearance*	NAVFAC Pacific	Geophysical equipment (electromagnetic, magnetic, and ground-penetrating radar)
I-A-6	*Investigation Derived Waste Management*	NAVFAC Pacific	N/A
I-A-8	*Sample Naming*	NAVFAC Pacific	N/A
I-B-1	*Soil Sampling*	NAVFAC Pacific	Split-spoon sampler and liners with hollow-stem or solid-stem auger
I-B-2	*Geophysical Testing*	NAVFAC Pacific	Low frequency electromagnetic induction, magnetometers, and ground-penetrating radar
I-B-5	*Surface Water Sampling*	NAVFAC Pacific	N/A
I-C-1	*Monitoring Well Installation and Abandonment*	NAVFAC Pacific	Continuous coring drill rig
I-C-2	*Monitoring Well Development*	NAVFAC Pacific	Surge block or submersible pump
I-D-1	*Drum Sampling*	NAVFAC Pacific	COLIWASA or glass thieving tubes
I-E	*Soil and Rock Classification*	NAVFAC Pacific	N/A
I-F	*Equipment Decontamination*	NAVFAC Pacific	N/A
I-I	*Land Surveying*	NAVFAC Pacific	Theodolite - horizontal and vertical control; GPS
III-A	*Laboratory QC Samples (Water, Soil)*	NAVFAC Pacific	N/A
III-B	*Field QC Samples (Water, Soil)*	NAVFAC Pacific	N/A
III-D	*Logbooks*	NAVFAC Pacific	N/A
III-E	*Record Keeping, Sample Labeling, and Chain of Custody*	NAVFAC Pacific	N/A
III-F	*Sample Handling, Storage and Shipping*	NAVFAC Pacific	N/A

COLIWASA composite liquid waste sampler
GPS Global Positioning System
N/A not applicable
NAVFAC Naval Facilities Engineering Systems Command
QC quality control
SOP standard operating procedure
[a] Applicable procedures from the *Project Procedures Manual* (DON 2015).

Prior to drilling, all onsite activities will be coordinated with the Navy Contract Task Order (CTO) Contracting Officer's Representative (COR) and landowner's representative to ensure that all requirements such as obtaining site access, working hours, using or accessing water supply sources, or other requirements are understood and followed.

The Regulatory Agencies may conduct site visits for monitoring and split sampling. Advanced notice is appreciated for coordination. The Navy will provide weekly drilling and well installation notifications to the Hawaiʻi Department of Land and Natural Resources (DLNR) Commission on Water Resource Management (CWRM) as the well construction permitting authority, and to the Regulatory Agencies. These updates will typically include the forms in Appendix C.

- Well information
- Completed operations
- Upcoming, planned operations
- Water level data
- Field parameter data
- Photoionization detector (PID) readings

- Water lost during drilling
- Generalized geology
- Relative permeability
- Fractures zones
- No-recovery zones
- Well construction
- Borehole water levels
- Geophysical logs

If mud rotary drilling (not including rock coring) is proposed/employed, it will be noted in the weekly updates.

2.2 WELL CONSTRUCTION PERMITS AND REPORTING

A permit will be obtained from DLNR CWRM to construct each well. Well construction permit applications will be submitted by a drilling company licensed in the State of Hawai‘i. Well construction permits are not required for test borings. Coreholes are considered test borings and do not require well permits.

Following installation of each well, a Well Completion Report will be submitted by the drilling company to DLNR within 30 days following well installation. A Well Completion Report is a standard DLNR CWRM form signed by the driller that includes the State well number, well completion details, and a general driller's lithologic log.

Within 90 days of well installation, the following documentation associated with that well will be uploaded to the Navy's Joint Base Pearl Harbor-Hickam (JBPHH) Red Hill Bulk Fuel Storage Facility Environmental Data Management System (EDMS): lithologic log, well construction diagram, geophysical logs, and data collected during drilling (monitored water levels, PID readings, and drilling water usage).

2.3 SITE SURVEYS

Prior to ground disturbance, available utility drawings will be reviewed, and utility clearance surveys will be performed by a qualified subcontractor to locate and delineate subsurface utilities in all areas where the ground will be disturbed in the vicinity of the drilling locations. The survey will employ geophysical techniques that may include magnetic, electromagnetic, or ground-penetrating radar. All utility clearance activities will be conducted in accordance with Procedure I-A-5, *Utility Clearance* (DON 2015).

An application for site clearance will be submitted to 811 One-Call to obtain information from local utilities on potential underground conflicts at least 5 working days before intrusive activities begin. Prior to coring or drilling, each drilling location will be cleared using air knife, hand auger, or other manual method to a minimum depth of 5 feet (ft) below ground surface (bgs) or refusal on bedrock. The proposed well locations may be adjusted, if necessary, based on information gathered during the shallow subsurface clearance.

Surveying will be conducted in two phases. Prior to drilling, a licensed surveyor will establish the land surface elevation of the drilling location. After the well has been installed, the well will be surveyed to establish the horizontal and vertical coordinates and measurement point elevation for the final well completion using Second Order, Class I procedures consistent with those described in the *Technical Memorandum, Topographic Survey* (DON 2017e). Land survey activities will be conducted as applicable in accordance with Procedure I-I, *Land Surveying* (DON 2015).

2.4 Site Preparation

To facilitate drilling and well completion, site preparation may include vegetation clearance, tree trimming, access pathway construction, drill site grading, cutting, or concrete coring. Each borehole location will be marked once the area is cleared of utilities (Section 2.3) and the staging area is established. The construction site will be maintained in accordance with National Pollutant Discharge Elimination System (NPDES) permit requirements, including implementation of site-specific BMPs to control run-on and run-off. Noise and dust monitoring will be implemented at all proposed well installation locations and will be maintained throughout drilling activities. A drilling pad will be established at unpaved locations, if necessary, by grading and filling to level the area, as much as practicable, to provide an even working surface for the drill rig and support equipment. The drill pad will be finished with coarse gravel. Any unstable surface conditions encountered (e.g., ponding, soft ground after heavy rainfall, presence of voids) may require the use of gravel or rock (e.g., base course or surge rock) to stabilize the ground surface during pad construction, drilling, and well installation.

Secondary containment will be installed around roll-off bins and off-rig storage tanks. Rainwater within secondary containment will be inspected for evidence of contamination (sheen, olfactory, PID). If no evidence of contamination is found, the water can be discharged to the ground surface. If evidence of contamination is observed, the water will be containerized and disposed of appropriately.

Drip pans and absorbents will be used under or around items with the potential to leak fluids. Recycled oil and oily wastes will be recycled/disposed of in accordance with Federal, State, and local requirements. Impacted surfaces or areas will be cleaned up immediately, using dry cleanup measures where practicable, to eliminate the source of the spill and prevent a discharge or furtherance of an ongoing discharge. Adequate supplies will be kept available at all times to handle spills, leaks, and disposal of used liquids, such as absorbent pads or similar. Surfaces are not to be cleaned by hosing down the affected area.

Refueling or vehicle maintenance conducted on site will be limited to vehicles or equipment engaged in active drilling activities. Vehicles that leave the project site daily should not be refueled on location. Best Management Practices (BMPs) to protect the environment during refueling activities will include inspection of equipment and vehicles for leaks daily, performed in a contained area with impervious surface and berms around the refueling areas, and the use of drip pans and absorbents. Additionally, supervision is required of any and all refueling or fuel transfer operations, and these activities will implement the use of nozzles with automatic shutoff devices. All onsite fuels will be stored in approved, flammable-rated containers within appropriately sized secondary containment.

After well completion, drilling locations will be restored to their roughly original pre-construction condition.

3. Protection of the Site

3.1 Drilling Additives

No additives other than potable water and acceptable well materials will be added to the borehole without prior notification to the Navy's COR. All chemicals, lubricants, and drilling fluid additives used during any part of the drilling or well construction process that have the potential to impact water quality will be reviewed prior to use. Drillers will use products selected from the list of acceptable materials (the current list of acceptable materials as of the date of this report is included in Appendix A, but items are subject to change based on drillers' requests and Navy COR approval). Additional materials can be considered with sufficient advance notice. Drillers propose materials for use and submit relevant product information (e.g., Safety Data Sheets) to the Navy. The Navy then reviews and concurs when materials are appropriate. The drilling subcontractor will provide a food-grade, non-petroleum-containing oil or grease for use on all downhole tools and water pump lubricants. No products documented to contain Teflon or other compounds containing per- or polyfluoroalkyl substances (PFAS) will be used. Coated bentonite pellets (which are known to contain PFAS) will not be used. Uncoated bentonite pellets, bentonite chips, powdered bentonite, or bentonite granules may be used where appropriate.

Compressed air systems will be equipped with an oil-coalescing air filter(s) to capture oil that could otherwise be discharged downhole in the compressed air stream. Oil used for air compressors and downhole lubrication of drill bits will be selected from the list of acceptable materials and described on the inventory of well materials. The quantities and rate of application of oil for downhole bit lubrication and other drilling additives will be listed on the drilling log forms for drilling. All drilling equipment will also be placed within or on secondary containment.

3.2 Drilling Water

Drilling water will be required for circulation fluid during drilling to remove drill cuttings and to cool and lubricate the bit. Water used for drilling activities will be obtained from a potable water source.

3.3 Equipment Materials and Decontamination

Downhole equipment and tools will not contain or be treated with any materials that have the potential to impact groundwater quality in the well. No substances, materials, or equipment will be introduced to the borehole or well without prior approval from the Navy. All downhole drilling tools and equipment will be decontaminated prior to use in accordance with Procedure I-F, *Equipment Decontamination* (DON 2015). Drilling equipment rinse water will be collected and treated as investigation-derived waste (IDW) (Section 5).

3.4 Spill Containment for In-Tunnel Wells

A spill kit will be located on the drill rig. Plastic sheeting will be place on the tunnel floor beneath and surrounding the drill rig. All drilling fluids will be contained within the borehole, drill rig pump and hoses (recirculation), the mud pan, or appropriate waste containers. A hydrated bentonite seal will be used to seal the mud pan at the tunnel floor. Additionally, sorbent socks will be placed beneath the mud pan (within the concave curve of the tunnel floor between the tracks), and biosocks will be placed around the base of the mud pan. A high-capacity wet-dry vacuum will be on standby for immediate solid or liquid spill recovery. Drums and totes should be placed on spill containment pallets within secondary containment and, when feasible, water alert systems should be used for early spill detection.

4. Monitoring Well Drilling and Installation Procedures

Basalt bedrock is anticipated to be encountered at shallow depths underneath and in the vicinity of ridges, and at deeper depths in valleys or lower topographic areas. Lithology will be characterized at each site by core drilling. Water table, perched, depressed, or elevated head conditions may also be evaluated during coring by pumping, bailing, or air lifting, or monitoring water levels and water quality. Observations of perched, depressed, or elevated head will be confirmed during drilling of the corehole or well borehole with air methods. Evaluation of perched groundwater, depressed heads, elevated heads, and contamination during corehole drilling and well borehole drilling is described in Section 4.4.3 and Section 6. Bailer jar headspace PID tests will be conducted during coring at the beginning of each day. Jar headspace PID tests will be collected off the cyclone at the start of air drilling and tricone / mud rotary each day. The corehole and well borehole will be spaced approximately 15 ft apart at the land surface. The corehole will be drilled first, if practicable. The well borehole may be reamed or overdrilled on top of the corehole or drilled in a separate borehole.

1. Procedures for monitoring well drilling and installation are described below, including: Drilling for Lithological Investigation
2. Drilling for Well Installation

3. Geophysical and Video Logging
4. Evaluation of Groundwater Conditions
5. Conductor Casing, if required
6. Well Design and Completion
7. Well Development
8. Initial Sampling
9. Borehole, Corehole, and Well Abandonment

4.1 DRILLING FOR LITHOLOGICAL INVESTIGATION

At each location, initial drilling at the site may be advanced through unconsolidated materials using hollow-stem auger, bucket auger, or other method that allows for soil sampling and inspection. Soil will be collected for logging using split-spoons or from drill cuttings. Logged soil cuttings will be screened for volatile organic compounds (VOCs) using a PID in accordance with Procedure I-B-1, *Soil Sampling* (DON 2015). Logging and screening will take place at intervals of no greater than 5 ft. Unconsolidated material that has observable signs of contamination (visual or olfactory) will be sampled and submitted for laboratory analysis (see Section 6). The auger may be left in place during coring as a temporary surface casing to stabilize the unconsolidated interval. These procedures apply to the first drilled borehole or corehole at each site. Similar procedures apply to in-tunnel wells.

Below the top of bedrock, lithologic characterization will be accomplished by diamond core drilling methods to total depth in general accordance with ASTM D2113 (ASTM 2014). Subsurface material will be continuously collected using rotary wireline coring to record the lithologic characteristics and description of the subsurface material, and screening for contaminants by PID, visual, and olfactory inspection to the extent practicable in accordance with Procedure I-B-1, *Soil Sampling* (DON 2015). Coreholes may intersect intensely fractured or faulted zones, where poor rock strength or difficult drilling conditions may be encountered. Reasonable measures will be taken to maximize core recovery, including timely replacement of worn equipment such as drill bits or core sleeves, changes in type of drill bit, rate of feed, down-pressure on the drill bit, volume of water added, length of coring interval, or type of coring equipment.

The cores will be inspected and logged to characterize the lithology and evaluate potential pathways for migration of light nonaqueous-phase liquid (LNAPL) and associated constituents. The entire corehole will be logged by the field geologist (according to the procedures described below). A summary rock core chart will be used in the field to log the information. In general, each log will note rock-quality designation; rock color; texture; strength; degree and angle of fracturing; shape, size, and volume of voids; weathering; and secondary staining and mineralization. Additionally, details of basalt flow and intraflow structures (e.g., aʻā clinker flow-top breccias [clinker sub-types], inflated pāhoehoe lobes, massive aʻā dense core interiors) will be included in logging of the core.

Fracture types (cooling joints versus drilling-induced fractures) and any mineralization within the fractures will also be noted. High-resolution photographs will be taken to document the cores, and detailed photo logs will be prepared. The Geological Society of America rock color chart (Munsell 2009) with Munsell color chips will be used for color characterization. Lithologic descriptions, PID screening results and other observations will be recorded on the geologic logs in conformance with Procedure I-E, *Soil and Rock Classification* (DON 2015). Cores will be stored in a secure on-island location and available for inspection if approved by the Navy.

Evaluation of perched groundwater, elevated head, and contamination during corehole drilling is described in Section 4.4.3 and Section 6. If the corehole is drilled before the well borehole, coring will pause at a depth elevation of 30 ft mean sea level (msl), and the presence of inflow to the borehole will be evaluated by bailing, air injection, or pumping down the water level and measuring water level recovery and conducting bailed water jar headspace PID tests to evaluate contamination. If groundwater inflow is detected from intervals above the basal aquifer, a video borehole inspection may be conducted (Section 4.2). Procedures for evaluating the bailer jar headspace test results and required actions and notifications are described in Section 6. If the well bore was drilled first and did not encounter significant amounts of groundwater inflow greater than 5 gallons per minute (gpm), or contamination above 30 ft msl as described in Section 6, core drilling will proceed without interruption to the target depth elevation. Deep wells (i.e., to be screened deeper than across the basal aquifer head elevation) will be investigated to identify zones of higher flow or good hydraulic connection to the basal aquifer by means of periodically pausing drilling to perform water level and water quality testing (e.g., associated with or following bailing, air injection, slug testing, or pumping; with or without use of packer(s) to isolate testing zones), and video or geophysical logging. Packers may not be appropriate in certain conditions, such as in unstable boreholes or coreholes.

Geophysical logging and video surveys may be conducted in the corehole (see Section 4.3) if conditions are acceptable. If conditions are unfavorable geophysical logging may be conducted in the well borehole.

4.1.1 Outside-Tunnel Coreholes

Outside of the tunnel coreholes will be advanced to approximately 20 ft greater depth than the target depth of the well borehole. For water-table wells, the coreholes will be advanced to -25 ft msl. After the corehole is drilled to total depth, and geophysical logging, if conducted, is complete, the corehole will be backfilled to above the proposed screened interval in the adjacent monitoring well with sand and/or uncoated bentonite pellets using a tremie pipe. The purpose of this sand backfill is to minimize impacts to water quality or hydraulic conductivity of the adjacent monitoring well. Above approximately 30 ft msl, the corehole will be backfilled with neat cement, cement-bentonite grout, uncoated bentonite granules, chips, or uncoated pellets, or sand-cement slurry in accordance with DLNR (2004) standards for hole abandonment. If the required grout volume is more than 150% of the calculated borehole volume due to voids in the formation, then gravel, bentonite chips, sand, or uncoated bentonite pellets can be used to fill intervals of the corehole. In some cases, the corehole may be reamed to a larger diameter to install a well in the same borehole.

4.1.2 Inside-Tunnel Coreholes

Drilling will be conducted using an electrically powered hydraulic drill rig with rock coring and wet rotary drilling capabilities. A thin layer (0.25–2 ft thick) of manmade fill (fines, gravel or cobble) is anticipated to be encountered directly below the tunnel floor overlying basalt bedrock. Bedrock may range from massive aʻā to pāhoehoe basalt to incompetent clinker.

Inside the tunnel coreholes will be advanced to the target depth of the well borehole. Coring will be conducted from ground surface at the tunnel floor. If unconsolidated material or fill material is encountered, it will be evaluated and sampled as described in Section 4.1 for soil. Evaluation of perched groundwater, elevated head, and contamination during corehole drilling is described in Section 4.4.3 and Section 6. After evaluating for the presence of groundwater at 30 ft msl, coreholes will be advanced to the target depth of the well borehole, if conditions are favorable.

After the corehole is drilled, it will be reamed to a diameter large enough to install a well. Multiple reaming passes may be required. Geophysical and video logging may be conducted if conditions are stable.

4.2 DRILLING FOR WELL INSTALLATION

Drilling of the well borehole will follow core drilling (when practicable) and will incorporate information from the lithologic characterization data obtained in the corehole to direct drilling and well design. Logged soil cuttings will be screened for volatile organic compounds (VOCs) using a PID in accordance with Procedure I-B-1, *Soil Sampling* (DON 2015). Evaluation of perched groundwater, elevated head, and contamination during well borehole drilling is described in Section 4.4.3 and Section 6.

4.2.1 Outside-Tunnel Well Boreholes

The well borehole will be advanced through unconsolidated materials (which could include soil such as valley fill, saprolite, tuff, or other materials) using hollow-stem auger, bucket auger, or other methods that allow inspection and sampling until competent bedrock is encountered. A surface casing may be required to install a diverter for the discharge during air drilling and may be temporary or permanent. A conductor casing may be installed to mitigate groundwater conditions in accordance with Section 4.5 or to maintain the integrity of the borehole through unconsolidated material.

Below the top of bedrock, well boreholes will typically be advanced using air-rotary or percussion air-hammer drilling methods. Drill cuttings and fluids will be collected periodically from the discharge for lithologic description and screening for contamination. Note that the cores from the nearby corehole will be screened with a PID.

In cases where air drilling methods are not effective, alternative methods such as mud rotary may be used. Notice will be provided to the Regulatory Agencies, via weekly drilling update emails, when mud rotary (not including coring) is planned.

For intervals where the borehole is unstable or shows evidence of perched, depressed, or elevated head groundwater conditions, the affected interval may be grouted and redrilled, and conductor casing may be installed, in accordance with Section 6.

Deep wells (i.e., to be screened deeper than across the basal head elevation) will be investigated to identify zones of higher flow or good hydraulic connection to the basal aquifer by means of periodically pausing drilling to perform water level and water quality testing (e.g., associated with or following bailing, air injection, slug testing, or pumping; with or without use of packer(s) to isolate testing zones), and video or geophysical logging. Packers may not be appropriate in certain conditions, such as in unstable boreholes or coreholes. Boreholes for wells with submerged screens will be extended at least 60 ft below the base of the confining unit until hydraulic communication with the basal aquifer is established to provide sufficient borehole length for this testing.

4.2.2 Inside-Tunnel Well Boreholes

After rock coring is complete, the corehole will be reamed, over drilled, or a new borehole may be advanced within approximately 15 ft to install a monitoring well. For intervals where the borehole is unstable or shows evidence of perched or elevated head groundwater conditions, the affected interval may be grouted and redrilled, and conductor casing may be installed, in accordance with Section 6.

4.3 GEOPHYSICAL AND VIDEO LOGGING

In addition to lithologic logging completed by the field geologists, portions of the open borehole or corehole will be logged using downhole geophysical techniques. Logging will be conducted in accordance with Procedure I-B-2 *Geophysical Testing* (DON 2015). Borehole geophysical or video logging may be conducted in the vadose zone if hole stability and impacts to drilling logistics are judged acceptable. Geophysical or video logging may not be performed if there are concerns with hole stability. Logging tools may include optical televiewer, caliper, natural gamma ray, induction resistivity, colloidal borescope, downhole camera, or others. Below the basal aquifer water level, logging may include acoustic televiewer, optical televiewer, caliper, natural gamma ray, induction resistivity, fluid temperature and conductivity, electromagnetic flowmeter, colloidal borescope, downhole camera, or others. The data will be used to inform well construction and obtain additional information on the hydrogeology and geochemistry.

After the monitoring well is installed, a well alignment survey will be conducted, and the results will be used to conduct a quantitative true-vertical-depth analysis to apply to depth to water measurements for the purpose of more accurately determining hydraulic gradient.

4.4 EVALUATION OF GROUNDWATER CONDITIONS

Groundwater conditions will be evaluated in coreholes and in well boreholes using different methods. Either hole may be cleared of water for recovery water level testing by bailing, pumping, or air injection. Small-diameter coreholes are best suited for packer testing but may be unsafe for other tools. Well boreholes provide a larger-diameter and safer hole for pumping tests, and video and geophysical logging. Information from either type of hole will be used for determining the well screened interval

4.4.1 Unconfined Groundwater

Outside the tunnel, after drilling to target depth approximately -25 ft msl, the static water level will be evaluated by removing groundwater from the well borehole by air injection, pumping, or bailing the corehole and measuring recovery of the water level using a pressure transducer, water level meter, or oil/water interface probe. If the estimated water level stabilizes within the range of the regional unconfined groundwater elevation expected in the basaltic basal aquifer (roughly 16–20 ft msl), then the borehole has been drilled in unconfined conditions and the well can be installed with well screen from 10 ft above to 20 ft below the water level (Section 4.6.2). If groundwater elevations do not fall within this range, indicating non-water table conditions, then the borehole will be extended and tested until good communication with the basal basalt aquifer is observed (see Section 4.4.2).

4.4.2 Confined Groundwater

Outside the tunnel, if confined conditions are suspected in the basal aquifer, drilling will advance to approximately -25 ft msl. The water level (i.e., potentiometric head) will be evaluated by air injection, pumping, or bailing the borehole clear and measuring recovery of the water level. If groundwater elevations do not fall within the regional unconfined groundwater elevation of approximately 16–20 ft msl, the borehole will be extended and tested until communication with the basaltic basal aquifer is observed. If the water level is confirmed to be outside this range, a confined or elevated head condition may be present, and the proposed well screen interval may need to be adjusted to ensure that the well is in hydraulic communication with the basalt basal aquifer.

If confined conditions are confirmed, drilling will advance until the water level in the isolated borehole interval stabilizes at approximately 16–20 ft msl, and the initial rate of water recovery in the borehole is greater than 0.5 gpm after the hole is cleared by air injection, pumping, bailer, or other acceptable method. Water level recovery data will be evaluated further to recommend a revised well screen depth. Construction of temporary wells in the borehole or temporary conductor casing with seals may be required to evaluate true groundwater elevation for a depth interval without the borehole water level being affected by upper intervals.

4.4.3 Perched or Elevated Head Conditions

During coring, the drill rod and open bit stabilize the hole and allow direct measurement of water levels. Water levels will be measured in the corehole at the beginning and end of each day, and a transducer will be deployed overnight, where practicable. A bailer jar headspace test will be conducted each morning. The drilling log will record totalizer readings and an average gallons per foot of drilling water added to the borehole. Perched or elevated head water encountered during drilling will not be sampled or analyzed, except for under Scenarios 3, 4, and 5, as described in Sections 6.3, 6.4, and 6.5, respectively.

During well borehole drilling, downhole tools prevent direct measurement of water levels; however, the discharge will be monitored for signs of groundwater infiltration into the borehole. If inflow of groundwater to the borehole is suspected above the basal aquifer, the hole will be cleared by air injection, pumping, bailer, or other acceptable method, and a jar headspace sample will be collected from the discharged water to evaluate the presence of contamination. During air drilling, groundwater in the borehole will be cleared and observations will be conducted at the start of each day and at approximately 40-ft intervals while drilling. The drilling log will record water loss totalizer readings and an average gallons per foot for each core run or drilling rod.

In well boreholes and coreholes, testing and evaluation will be conducted at a depth equal to approximately 30 ft msl to evaluate the potential for water from the vadose zone to impact the basal aquifer. Testing will include removal of water by air injection, pumping, or bailing and recovery. Discharged water quality parameters will be evaluated, and PID jar headspace tests and visual inspection will be conducted. If groundwater inflow is detected from perched groundwater interval(s), a video borehole inspection may be conducted (Section 4.3). Procedures for evaluating the bailer jar headspace tests and required actions and notifications are described in Section 6.

4.4.4 In-Tunnel Groundwater Conditions

Bailer jar headspace tests are used to evaluate whether there are indications of potential perched water contamination. Drilling will then proceed as follows:

No Signs of Perched Water or Contamination:

- If perched water or evidence of contamination is not observed at 30 ft msl, coring will be conducted until the target depth is reached.
- After coring is complete, the borehole will be reamed to total depth using a reaming tool with a pilot bit to increase the borehole diameter.

Perched Water and No Signs of Contamination:

- If perched water is indicated in the vadose zone and there are no signs of contamination, the interval of suspected perched water will be sealed off by grouting with neat cement, cement-bentonite grout, or sand-cement slurry, or casing cemented to surface, if applicable. The interval will be re-drilled with the original bit. If grouting the suspected interval is successful in stopping the inflow of perched water, drilling of the borehole may proceed.
- At a borehole depth equal to an elevation of 30 ft msl, drilling will pause, and the core and any fluids in the borehole will be evaluated for contamination as indicated by PID readings of core and bailed jar headspace tests.
- If there are no indications of contamination, the borehole will be cleaned out and advanced into the basal aquifer without installing conductor casing and reamed, and a well will be constructed.

Continued Perched Water or Suspected Perched Water Contamination:

- If grouting of the hole is unsuccessful in stopping the inflow of perched water, the borehole may be reamed to 3 ft below the base of the suspected perched water, and the suspected interval of perched water will be grouted to just beneath the floor surface using a tremie pipe. The interval will be re-drilled with the original bit.
- If grouting the suspected interval is successful in stopping the inflow of perched water, drilling with the original dill bit will proceed.
- At a borehole elevation of 30 ft msl, drilling will pause, the core and any fluids in the borehole will be evaluated for contamination as indicated by PID readings of core and bailer jar headspace tests.
- If there are no indications of contamination, the borehole will be reamed.

- When the borehole depth reaches an elevation of approximately 30 ft msl drilling will pause, any fluids in the borehole will be evaluated for contamination.
- If results indicate contamination of the basal aquifer is not likely to occur, the borehole will be advanced, reamed, and the 2-inch-diameter polyvinyl chloride (PVC) well will be constructed as described in Section 4.6.2 in accordance with well DLNR construction standards (DLNR 2004).

Additional Intervals of Contamination or Perched Water

- If additional contaminated intervals (i.e., visual, olfactory, sustained PID readings above ambient background conditions, or staining on drill cuttings and recovered rock cores) of unconsolidated material or perched groundwater are subsequently observed, the boring will be abandoned by grouting as described in Section 4.9.
- If practicable, a new boring will then be advanced with permanent conductor casing set below the depth of the deepest contamination encountered and in a low-permeability zone (e.g., clay, silt, or low-porosity basalt layer).

4.5 SURFACE AND CONDUCTOR CASINGS

Surface or conductor casing may be required at some locations to provide a pipe connection (diverter) between the borehole and the discharge line for drill cuttings, to stabilize unconsolidated materials or to seal intervals where contaminated perched groundwater, confined conditions, depressed or elevated heads are encountered. A surface or diverter casing is required for air drilling methods but in some cases a temporary casing can be used and removed before well surface completion. Temporary casings installed without a grouted annular space will be removed in a manner that will permit complete grouting of the annular space between the permanent casing and drilled hole to the ground surface.

If conductor casing is required due to contaminated soil or contaminated perched groundwater (as described in Section 6) in the well borehole, the well borehole may be reamed or plugged back and over drilled, and conductor casing installed to seal the intervals of contaminated perched groundwater. Alternatively, the well bore may be abandoned in accordance with DLNR (2004) standards and re-drilled near the same location to a larger diameter to accommodate the surface casing.

If conductor casing is required, the rationale for determining the depth to set conductor casing in the vadose zone would be the deepest of the following conditions:

- Should extend to a minimum depth of 20 ft bgs or top of bedrock if <20 ft bgs.
- Should extend through any contaminated perched groundwater with PID readings greater than 10 parts per million by volume (ppmv) detected above 30 ft msl or where significant inflow to the borehole (e.g., >5 gpm) cannot be prevented by grouting the perched water interval.
- Should extend through any observed vadose zone contamination above 30 ft msl.

If used, conductor casing will be installed in accordance with DLNR (2004) standards with a minimum 1.5-inch-thick annular seal composed of neat cement, cement-bentonite grout, or sand-cement slurry. If the annular space is less than 2 inches thick, grout must be emplaced using positive displacement methods, such as injecting grout from the bottom up using a tremie pipe in the annulus. The conductor casing will be installed under tension with centralizers at 40-ft maximum spacing. An initial interval of 3–5 ft of cement plug will be installed at the base of the casing and allowed to cure to prevent cement from entering the inside of the casing.

If the required grout volume is more than 150% of the calculated borehole volume due to voids in the formation, then gravel, bentonite chips, sand, or uncoated bentonite pellets can be used to fill up to a 10-ft vertical interval of the borehole.

4.6 WELL DESIGN AND COMPLETION

4.6.1 Well Design

Proposed wells will be installed as single-screen monitoring wells screened across or below the approximate elevation of the regional basal aquifer (water table conditions), or other depths (e.g., confined conditions or deeper intervals farther below the potentiometric elevation). In some cases, wells may also be completed in perched, depressed-head, or elevated-head groundwater conditions. Co-located wells in separate boreholes will be considered. Wells screened at deeper intervals may be used to monitor for evidence of plume diving, evaluate vertical gradients, evaluate groundwater chemistry deeper in the aquifer, and gather lithologic data at greater depths within the basal aquifer to further refine the conceptual site model.

Typical monitoring well designs are shown on the following figures:

- Figure 2 for unconfined conditions, with 10 ft of slotted screen above and 20 ft of slotted screen below the basal aquifer water level
- Figure 3 for unconfined conditions with 20 ft of screen installed considerably below the basal aquifer water level
- Figure 4 for confined conditions, with 20 ft of slotted screen below the confining layer in an interval with hydraulic communication with the basal aquifer
- Figure 5 for perched, depressed- or elevated-head groundwater conditions with screen across the perched water level (perched groundwater condition), or submerged screen at depths below the basal aquifer potentiometric surface (confined conditions, depressed- or elevated-head conditions)
- Figure 6 for typical in-tunnel wells
- Figure 7 for in-tunnel wells with reamed and grouted interval for perched groundwater or unstable conditions

4.6.2 Well Construction

The field manager or field geologist will oversee all monitoring well construction activities. Following video and geophysical logging, the driller will install monitoring wells in conformance with DLNR (2004) standards and Procedure I-C-1, *Monitoring Well Installation and Abandonment* (DON 2015). Monitoring well completion will include the following:

- *Casing and screen:* The typical well designs use PVC or stainless steel well casing and slotted or wire-wrapped screens. All well designs will be in accordance with the DLNR (2004) well construction standards with a minimum of 1.5-inch-thick annular well seals. To ensure the casing is centered in the borehole, centralizers will be installed at the top and bottom of the screened sections and placed at 30-ft to 40-ft intervals on the blank casing. Manufacturer-supplied O-rings will be installed on all threaded joints.
- *Annular materials:* During installation of annular materials, the casing and screen will be suspended under tension above the bottom of the borehole. Annular materials will be installed via tremie pipe. Any excess drilled footage more than 8 ft below the target depth (i.e., 5 ft below the bottom of the screen) will be backfilled with uncoated bentonite pellets or sand.
- *Sand filter pack:* Sand will be installed from the bottom of the borehole to above the monitoring well screen. The filter pack will be surged midway and at the top of the interval during placement.

The depth to top of the filter pack will be monitored during surging. Additional material will be added if settling occurs.

- *Bentonite seals:* If the top of sand is below water, a 5-ft to 10-ft thick seal (depending on depth) of uncoated bentonite pellets will be emplaced via tremie pipe and allowed to hydrate. If top of sand is above water level, a 5-ft to 10-ft thick seal (depending on depth) of bentonite granules or chips will be emplaced via tremie pipe in two lifts and allowed to hydrate following each lift.
- *Cement seals:* Neat cement, cement-bentonite grout, or sand cement slurry will be installed in stages or lifts to limit potential for casing damage from heat of hydration and excessive hydrostatic pressure. Gravel, bentonite chips, sand, or uncoated bentonite pellets can be used over short intervals to raise the top of the annular materials if the presence of voids or other features would otherwise consume excessive grout.
- *Design variances:* Other designs, well casing and borehole diameters, materials, and screen type and slot sizes may be considered where conditions require modification of the typical design. Stainless steel well casing and screen may be used in place of PVC.

Cement Grout. Grout used for annular seals, filling coreholes, or borehole abandonment will be in accordance with DLNR (2004) standards and Procedure I-C-1, *Monitoring Well Installation and Abandonment* (DON 2015). Specifically, one of the three mixes below will be followed:

- *Neat cement grout:* Neat cement for grouting will be mixed at a ratio of one 94-pound sack of Portland Type I or IL cement to not more than 6 gallons of potable water.
- *Cement-bentonite grout:* A slurry of Type I or Type IL Portland cement, bentonite and water. The amount of bentonite added will not exceed 8% bentonite per dry weight of cement (7.5 pounds of bentonite per 94-pound sack of cement). The volume of additional water used in preparing these slurries is limited to three quarters (0.75) of a gallon per 94-pound sack of cement for each 1% of bentonite added.
- *Sand-cement slurry:* Sand-cement for grouting will be mixed at a ratio of not more than one part sand to one part Type I or Type IL Portland cement, by weight, and not more than 6 gallons of potable water per sack of cement.

Excess grout and rinse fluids will be minimized and re-used to the extent practicable. Handling of excess grout and grout rinse fluids is discussed in Section 5.

4.6.3 Surface Completion

Each monitoring well will be completed in accordance with Procedures I-C-1, *Monitoring Well Installation and Abandonment* and I-C-2, *Monitoring Well Development* (DON 2015).

4.6.3.1 Aboveground Completions

Selected monitoring wells will be completed aboveground with a monument-style steel protective casing fitted with a locking, tamper-proof lid that covers the steel protective casing and well head, as shown on Figure 8. The lock will be recessed and covered for added protection, and permanent labels will be applied both inside and outside the casing via painting, marking, or engraving on the protective casing or surface completion. The steel casing will be set in concrete at the well head for strength and security and to provide a continuous cement surface seal. The steel protective casing will be filled with cement grout extending to a level 6 inches below the top of the PVC or stainless steel well casing.

4.6.3.2 Flush-Mount Vaults

Depending on the specific conditions surrounding a well, some wells may require a flush-mount traffic-rated steel cover, as shown on Figure 9.

- *Outside-tunnel wells.* The covers will be corrosion resistant, leak resistant, and lockable. The concrete pad surrounding traffic-rated covers will be 0.25 inch above the road surface in paved areas, and 1.5 inches above ground surface in unpaved areas. Cement or grout will then be brought to surface or ground level. The vaults will have an H-20 load rating and bolt-down, gasketed covers with recessed padlocks.
- *In-tunnel wells.* The surface completion will be a H-20 load-rated vault installed flush with the tunnel floor to limit obstruction to the train with a minimum of 2 inches of cement annulus around the manhole. The vault will have a gasket and bolt-down cover and will be installed such that there is 6 inches of clearance between the cover and the top of the well casing. The top of the 2-inch casing will be approximately 6.5 inches below the existing grade (tunnel floor). The top of the cement grout in the annulus of the well will be approximately 3 inches below the top of the casing or 9.5 inches below the tunnel floor.

4.7 WELL DEVELOPMENT

Monitoring well development will be performed in accordance with Procedure I-C-2, *Monitoring Well Development* (DON 2015), including surging and bailing, pumping, and monitoring water quality parameters until stabilization is achieved. Well development will not occur until 24 hours after the completion of the annular seal to allow the cement to cure. Well development will consist of a combination of surging and bailing techniques, and pumping groundwater with a submersible pump until fine sediment particles have been removed and the water turbidity is minimized. Development will continue until at least three borehole volumes have been removed, turbidity stabilizes at or below 5 nephelometric turbidity units, and three successive readings taken 5 minutes apart indicate the water quality parameters have stabilized. This ensures that formation water enters the well and that the water affected by drilling is removed. The parameters of dissolved oxygen (DO), oxidation-reduction potential (ORP), pH, temperature, specific conductance, and turbidity will be monitored during the development cycle. Because DO and ORP are affected by the agitation of surging and pumping, the values obtained for these parameters during development may vary and may not be representative of the aquifer water. The alternative criteria provided in Procedure I-C-2 Section 5.7.1 (DON 2015) may be employed for low-yield wells.

The well development activities will be documented in the field book and on well development forms.

4.8 INITIAL SAMPLING

After a minimum of 24 hours following successful development of a monitoring well, the electrical submersible development pump will be removed and a sampling bladder pump will be installed and a groundwater sample will be collected in accordance with the Red Hill Consolidated Groundwater Sampling Program (CGSP) (DOH 2024). An offsite laboratory will perform the analyses specified in the CGSP. Groundwater sampling will include measuring depth to groundwater and depth to well bottom from the top of casing and assessing the presence or absence of an immiscible phase. A PID will be used to record whether VOC levels just inside the wellhead casing are above ambient conditions prior to deploying an oil/water interface probe. Bailer sampling will also be conducted to evaluate the presence or absence of fuel product using processes and procedures identified in the CGSP (DOH 2024).

Purging of the water column prior to sample collection will be conducted in accordance with Procedure I-C-3, *Monitoring Well Sampling* (DON 2015) at a rate of between 100 and 300 milliliters per minute (mL/min) designed to minimize drawdown. Purging will be considered complete once groundwater parameters have “stabilized” (minimum of five readings with three consecutive sets of readings within ±0.2 degree Celsius for temperature, ±0.1 standard units for pH, ±3 percent for specific conductance, ±10 percent for DO, and ±10 millivolts for redox potential). All purge water will be handled as IDW (Section 5).

Once purging has been completed, the flow rate will be reduced to 100 ml/min and samples will be collected directly from the bladder pump. All samples will be immediately labelled according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody* (DON 2015) and wrapped with bubble wrap or other appropriate padding to prevent breakage. Samples will then be maintained as close to 4 degrees Celsius as possible from the time of collection through transport to the analytical laboratory. All samples will be handled, stored, and shipped in accordance with Procedure III-F, *Sample Handling, Storage, and Shipping.*

All observations (i.e., water turbidity and evidence of free product), water level and total depth measurements, groundwater sampling parameters, and instrument calibration results will be documented and preserved in field logbooks and sampling/calibration logs.

4.9 Borehole, Corehole, and Well Abandonment

Borehole, corehole, or well abandonment may be required for test borings or any borehole or well that cannot be completed. Abandonment will be performed in accordance with DLNR (2004) well construction standards and Procedure I-C-1, *Monitoring Well Installation and Abandonment* (DON 2015). Wells and boreholes will be sealed with neat cement, cement-bentonite grout, concrete, or sand-cement slurry. The grout will be emplaced with a tremie pipe from the bottom of the boring to within a minimum of 2 ft bgs. Additional grout may need to be placed if significant settlement occurs. If the required grout volume is more than 150% of the calculated borehole volume due to voids in the formation, then gravel, bentonite chips, sand, or uncoated bentonite pellets can be used to fill intervals of borehole to bring the annular materials above the top of voids.

5. IDW Management and Disposal

Solid, liquid, and mud IDW generated during monitoring well installation and development activities will be collected as it is generated. The IDW will be handled, stored, and labeled in accordance with Procedure I-A-6, *Investigation-Derived Waste Management* (DON 2015). Bulk containers and drums will be segregated according to matrix, and at least one composite IDW sample will be collected annually from each grouping for waste characterization in accordance with Procedure I-D-1, *Drum Sampling* (DON 2015) and the *Investigation-Derived Waste Consolidation Plan Revision 03, 2024* (DON 2024b). IDW characterization samples will be submitted for analysis to a laboratory certified by the Department of Defense Environmental Laboratory Accreditation Program. Waste profile forms will be prepared and submitted to potential disposal facilities for approval. The IDW will be kept at a staging area until the IDW analytical data are received and/or associated waste profile forms are approved by the disposal facilities and the Navy. The IDW will then be removed from the staging area, transported to, and disposed of at the approved disposal facilities. IDW will be disposed of within 90 calendar days of the generation date. Disposable personal protective equipment, clean disposable well construction materials, and disposable sampling equipment will be collected in plastic trash bags and disposed of as municipal solid waste.

Excess grout and grout-rinse fluids will be minimized and re-used to the extent practicable. Grout fluids and rinse water will be labeled as process water for subsequent mixing of grout. When grout-impacted fluids are no longer needed as process water for mixing grout, residual fluids will be solidified, and excess grout-impacted fluids will be labeled as waste and neutralized, if necessary, in accordance with the *Draft Standard Operating Procedure for Waste Management of Residual Grout and Grout Rinse Water, revised September 13, 2024* (DON 2024a).

For in-tunnel wells, drill cuttings and fluids removed from the borehole and sediments and pumped water generated during development will be containerized for transport to the IDW staging area.

6. Contamination Scenarios, Notifications, and Response Actions

Five scenarios are identified to address anticipated conditions encountered during drilling and notifications and response actions associated with each are listed below. PID readings can be collected from bailer jar headspace tests, borehole headspace, mud pan, roll-off bins, rock cores, or drill cuttings. The five scenarios are:

- Scenario 1: PID Reading <10 ppmv, No Contamination Observed
- Scenario 2: PID Reading >10 ppmv but <50 ppmv, No Contamination Observed
- Scenario 3: Moderate Contamination Observed and PID <50 ppmv
- Scenario 4: Moderate Contamination Observed and PID >50 ppmv
- Scenario 5: Gross Contamination

Details are summarized below regarding notification requirements and response actions for each scenario where groundwater inflow or soil contamination are observed.

6.1 Scenario 1: PID Reading <10 ppmv, No Contamination Observed

In this scenario:

- Navy will notify the Regulatory Agencies weekly via email regarding progress and observations and provide tabulated data.
- Drilling will continue.
- If inflow is >5 gpm, attempts will be made to seal the hole by grouting, and conductor casing may be required.
- If inflow is <5 gpm, drilling and screening will continue without conductor casing. The corehole or well will be completed as quickly as practicable and the final well seal will seal off the interval of groundwater inflow.

6.2 Scenario 2: PID Reading >10 ppmv but <50 ppmv, No Contamination Observed

In this scenario:

- Navy will notify the Regulatory Agencies weekly via email regarding progress and observations and provide tabulated data.
- Drilling will continue.
- If inflow is >5 gpm after grouting attempts, conductor casing will be used to isolate groundwater inflow. Note that conductor casing may not be possible inside tunnels.
- If inflow is <5 gpm, drilling and screening will continue without conductor casing. The corehole or well will be completed as quickly as practicable and the final well seal will seal off the interval of groundwater inflow.

6.3 Scenario 3: Moderate Contamination Observed and PID <50 ppmv

Moderate levels of contamination observed (e.g., with evidence of olfactory or visual oily staining or sheen on rock core or drill cuttings and PID readings less than 50 ppmv). In this scenario:

- Navy will notify the Regulatory Agencies via email within 1 week after contamination is encountered.

- Drilling will continue.
- If applicable, soil or groundwater (or other liquid if groundwater is not present) sampling will occur in accordance with the Red Hill *Sampling and Analysis Plan* and *Addendum 01* (DON 2017d; 2017c). The Navy will provide sampling results (validated or not) 45 days after shipping or 7 days after receipt, whichever comes first. The Navy agrees to provide unvalidated data if validated results are not received in the requested timeframes, with the understanding that unvalidated data presents opportunity for misuse, if publicly reported, or generates responses on non-validated results. The Navy will notify Regulatory Agencies within 24 hours of receipt of unvalidated results that exceed current EALs at the time of construction. Validated results will include explanations if the respective unvalidated result is changed. The Navy will also continue to submit validated results within 30 days of receipt via EDMS.
- Conductor casing or grouting will be used to isolate contaminated soil and contaminated perched water with inflow >5 gpm outside tunnels. Note that conductor casing may not be possible inside tunnels.
- If inflow is <5 gpm, drilling and screening will continue without conductor casing. The corehole or well will be completed as quickly as practicable and the final well seal will seal off the interval of groundwater inflow.

6.4 SCENARIO 4: MODERATE CONTAMINATION OBSERVED AND PID >50 PPMV

Moderate levels of contamination observed (e.g., with evidence of olfactory or visual oily staining or sheen on rock core or drill cuttings) and PID readings greater than50 ppmv. In this scenario:

- Navy will notify the Regulatory Agencies via email within 24 hours after contamination is encountered.
- Drilling will continue.
- If applicable, soil or groundwater (or other liquid if groundwater is not present) sampling will occur in accordance with the Red Hill *Sampling and Analysis Plan* and *Addendum 01* (DON 2017d; 2017c). The Navy will provide sampling results (validated or not) 45 days after shipping or 7 days after receipt, whichever comes first. The Navy agrees to provide unvalidated data if validated results are not received in the requested timeframes, with the understanding that unvalidated data presents opportunity for misuse, if publicly reported, or generates responses on non-validated results. The Navy will notify Regulatory Agencies within 24 hours of receipt of unvalidated results that exceed current EALs at the time of construction. Validated results will include explanations if the respective unvalidated result is changed. The Navy will also continue to submit validated results within 30 days of receipt via EDMS.
- Conductor casing or grouting will be used to isolate contaminated soil and contaminated perched water with inflow >5 gpm outside tunnels. Note that conductor casing may not be possible inside tunnels.
- If inflow is <5 gpm, drilling and screening will continue without conductor casing. The corehole or well will be completed as quickly as practicable and the final well seal will seal off the interval of groundwater inflow.

6.5 SCENARIO 5: GROSS CONTAMINATION

Gross contamination is defined as visual observation of mobile fuel product. In this scenario:

- Drilling will be discontinued, borehole will be stabilized, and the Navy COR will be immediately contacted for collaboration.

- Upon discovery of oily staining or sheen/observation of mobile fuel product the Navy will verbally notify Navy Leadership and the Regulatory Agencies within 24 hours of discovery and before advancing the boring further for collaboration to determine next steps.
- If applicable, soil or groundwater (or other liquid if groundwater is not present) sampling will occur in accordance with the Red Hill *Sampling and Analysis Plan* and *Addendum 01* (DON 2017d; 2017c). The Navy will provide sampling results (validated or not) 45 days after shipping or 7 days after receipt, whichever comes first. The Navy agrees to provide unvalidated data if validated results are not received in the requested timeframes, with the understanding that unvalidated data presents opportunity for misuse, if publicly reported, or generates responses on non-validated results. The Navy will notify Regulatory Agencies within 24 hours of receipt of unvalidated results that exceed current EALs at the time of construction. Validated results will include explanations if the respective unvalidated result is changed. The Navy will also continue to submit validated results within 30 days of receipt via EDMS.
- Navy will provide the Regulatory Agencies with written confirmation of the results and a description of how drilling will proceed (e.g., with borehole abandonment or completion of the well with conductor casing) within 30 days of the discovery of the impacted soil, sent with proof of delivery.

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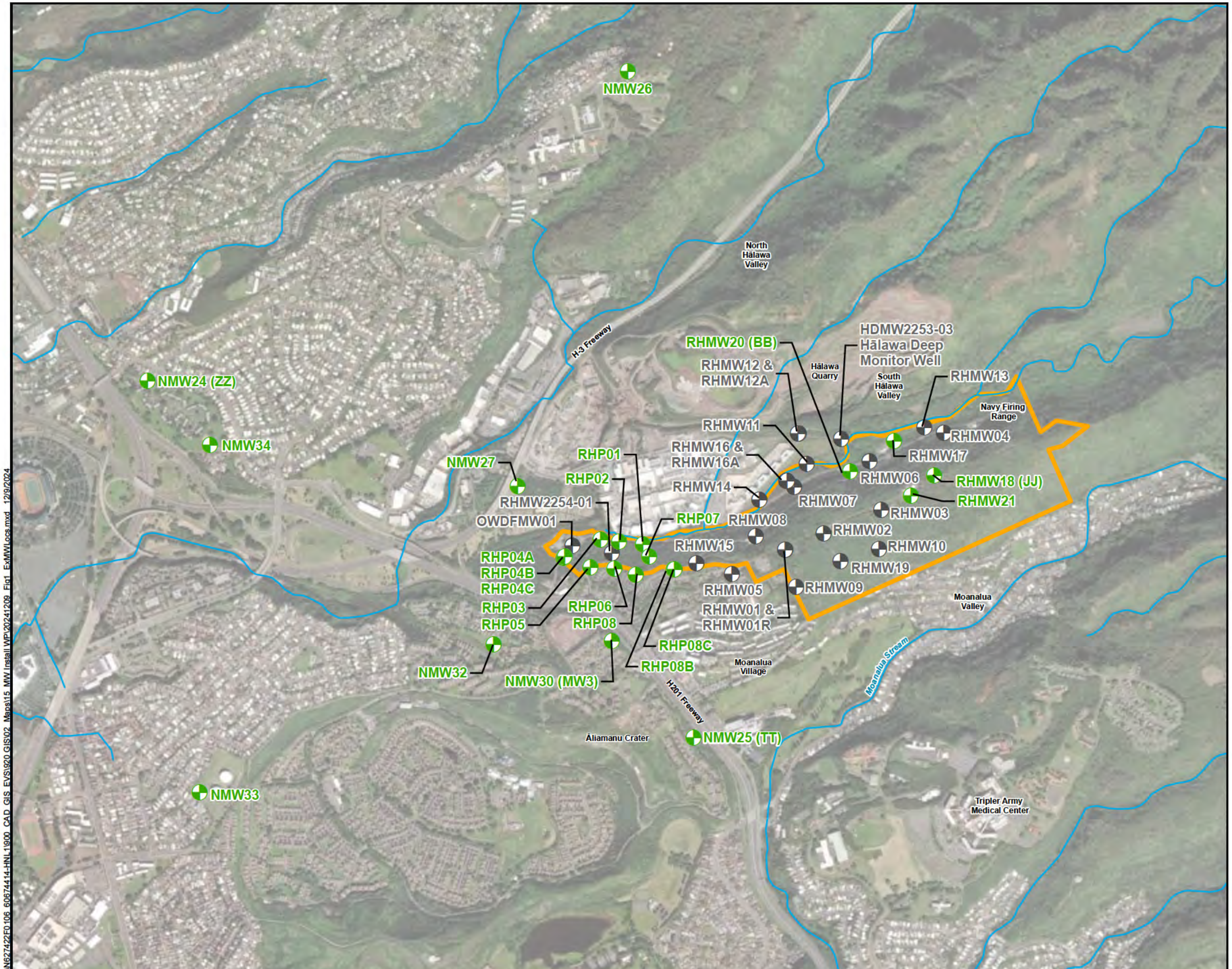


B:\N62742\2F0106 60674414-HNL1\900 CAD GIS EVS\920 GIS\02 Maps\15 MW Install WP\20241209 Fig1 ExMWLocs.mxd 12/9/2024

Location Map

Legend

- Recently Completed
- Existing Monitoring Well
- Stream
- Red Hill Facility Boundary

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Base Map: Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
3. Coordinates: NAD 1983 Hawaii State Plane Z3 ft

N

0 700 1,400 2,800 Feet

Figure 1
Existing Monitoring Well Locations
Monitoring Well Installation Work Plan
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

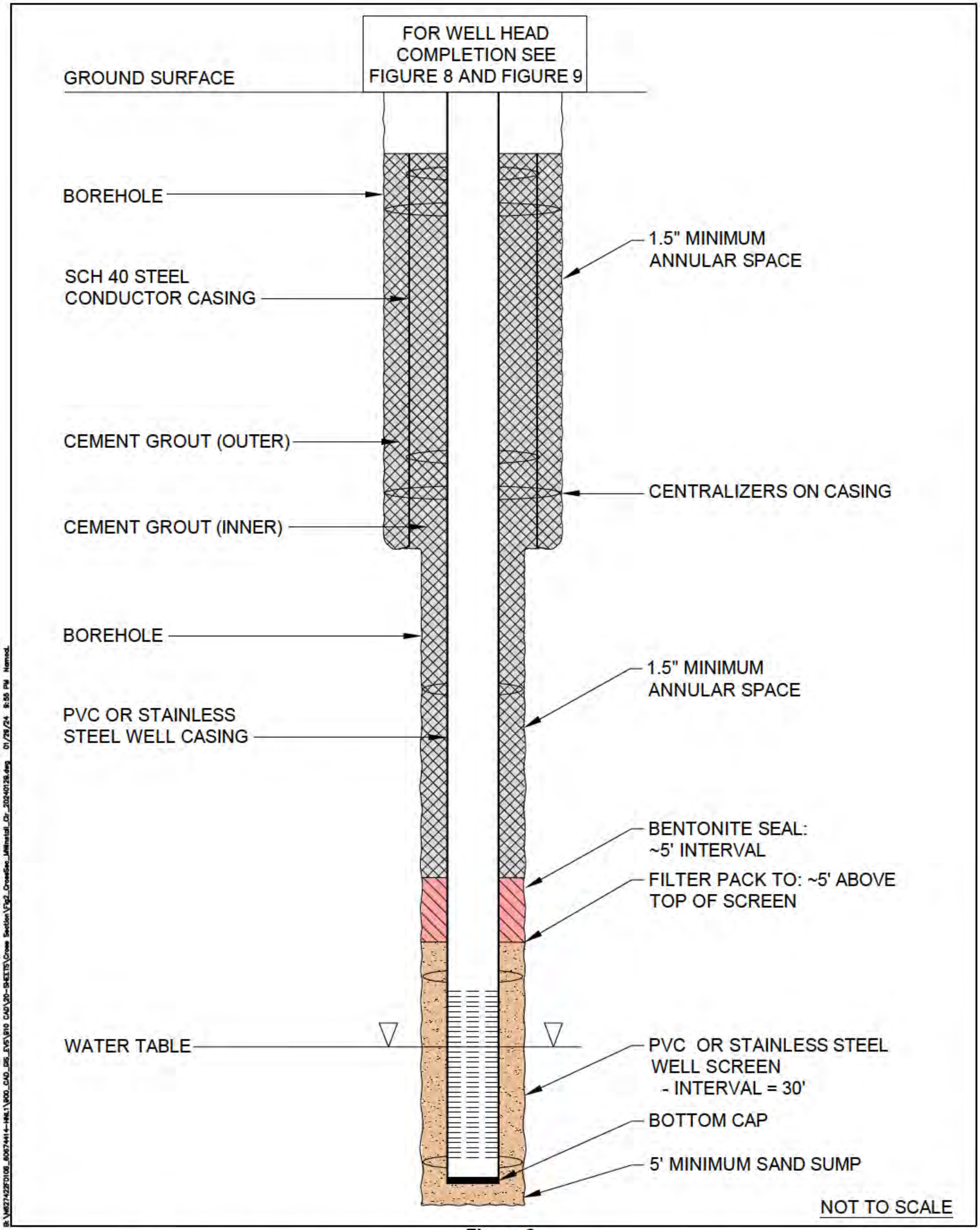


Figure 2
Typical Well Construction Diagram for Monitoring Well (Unconfined Conditions)
Monitoring Well Installation Work Plan
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

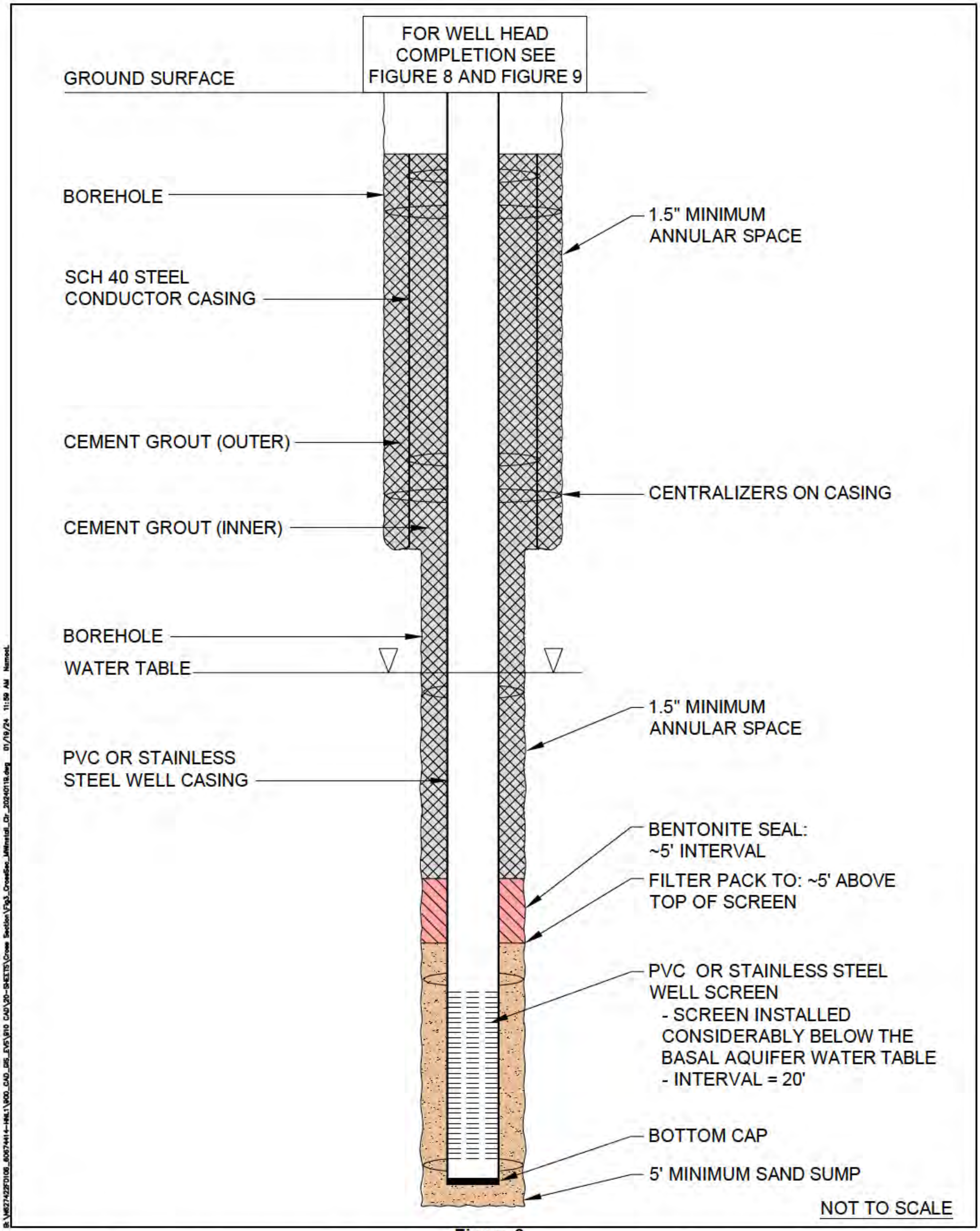


Figure 3
Typical Well Construction Diagram for Monitoring Well (Unconfined Conditions - Deep Well)
Monitoring Well Installation Work Plan
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

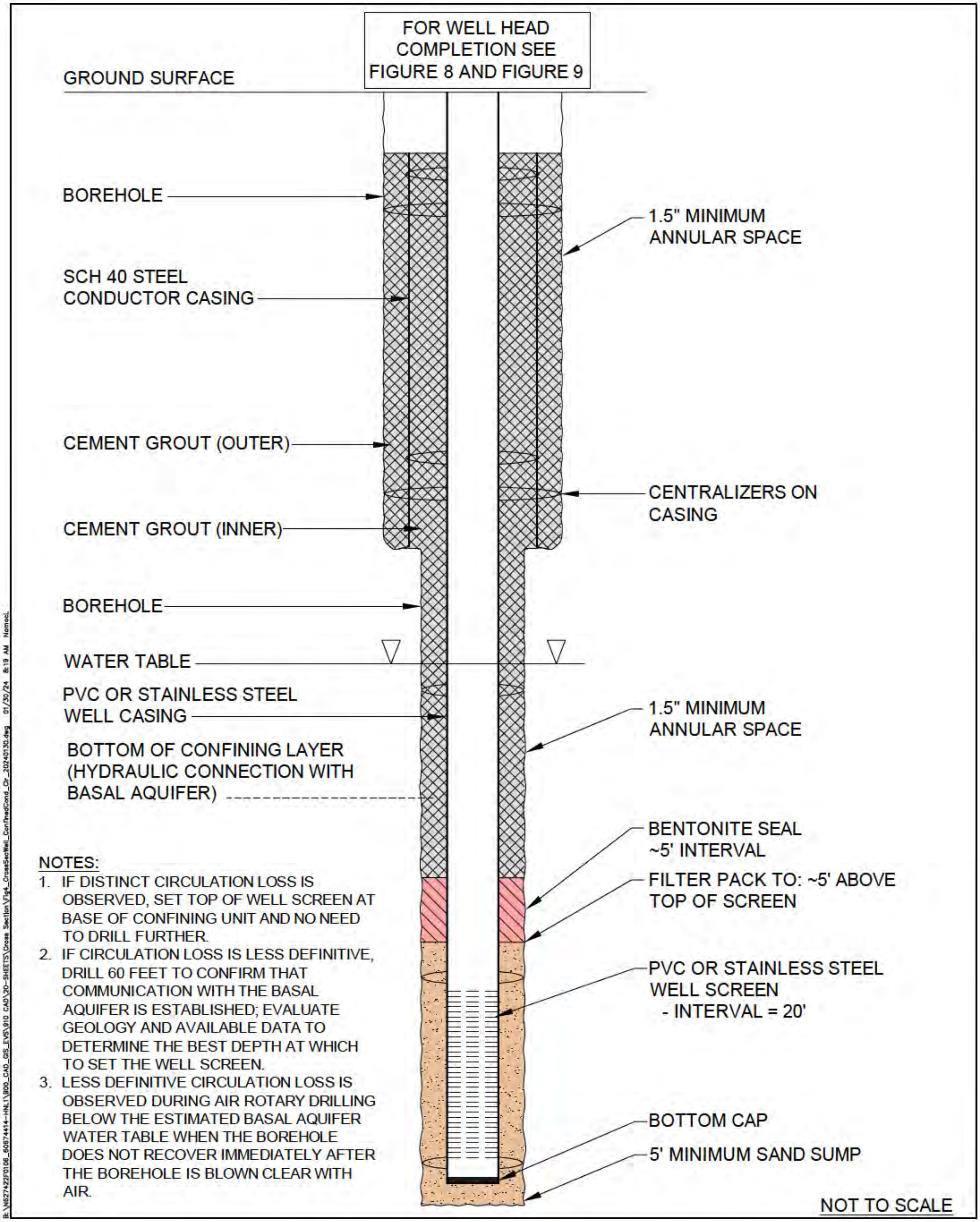


Figure 4
Typical Well Construction Diagram for Monitoring Well (Confined Conditions)
Monitoring Well Installation Work Plan
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

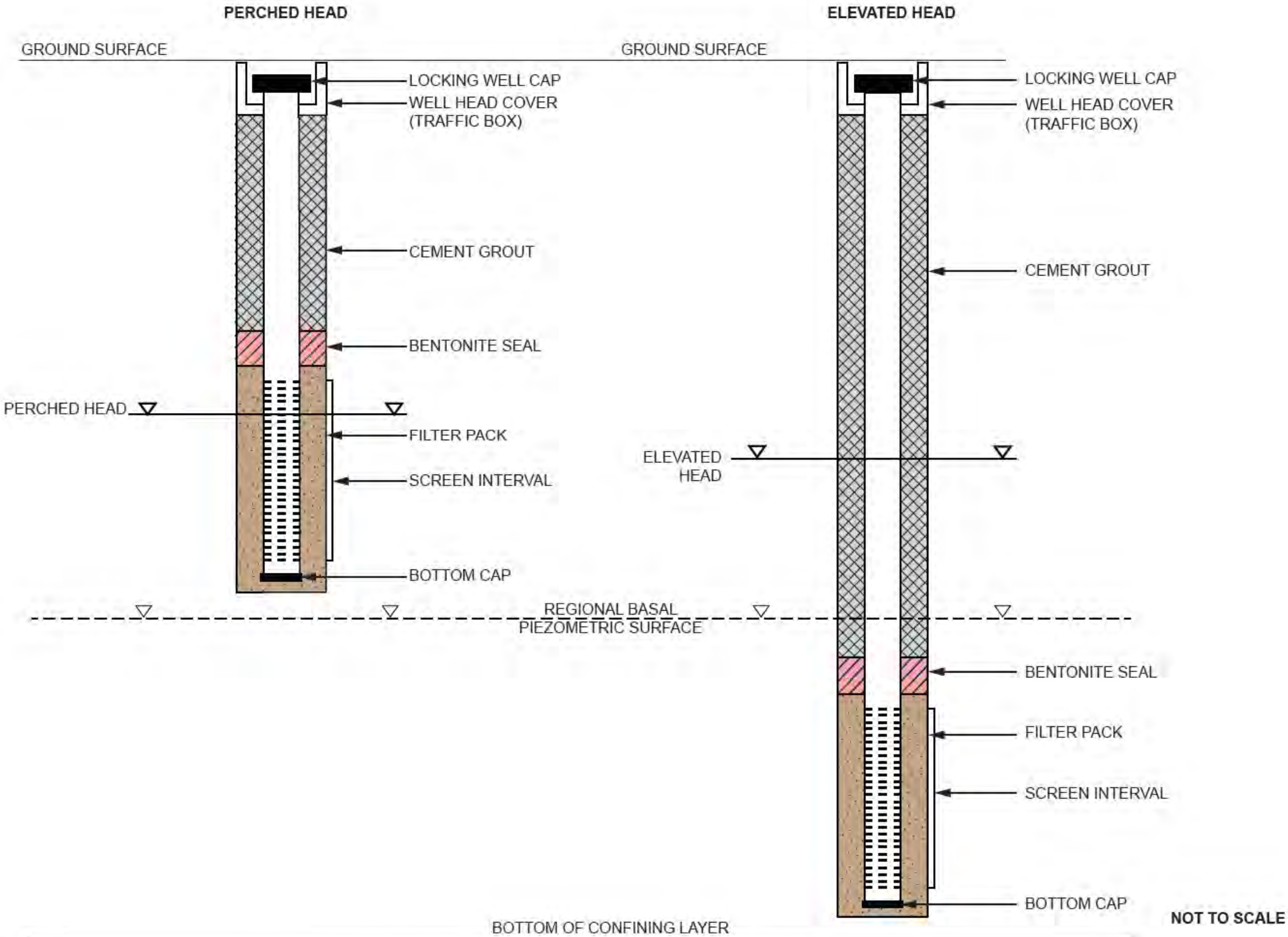


Figure 5
Typical Well Construction Diagram for Perched and Elevated Head Aquifers
Monitoring Well Installation Work Plan
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

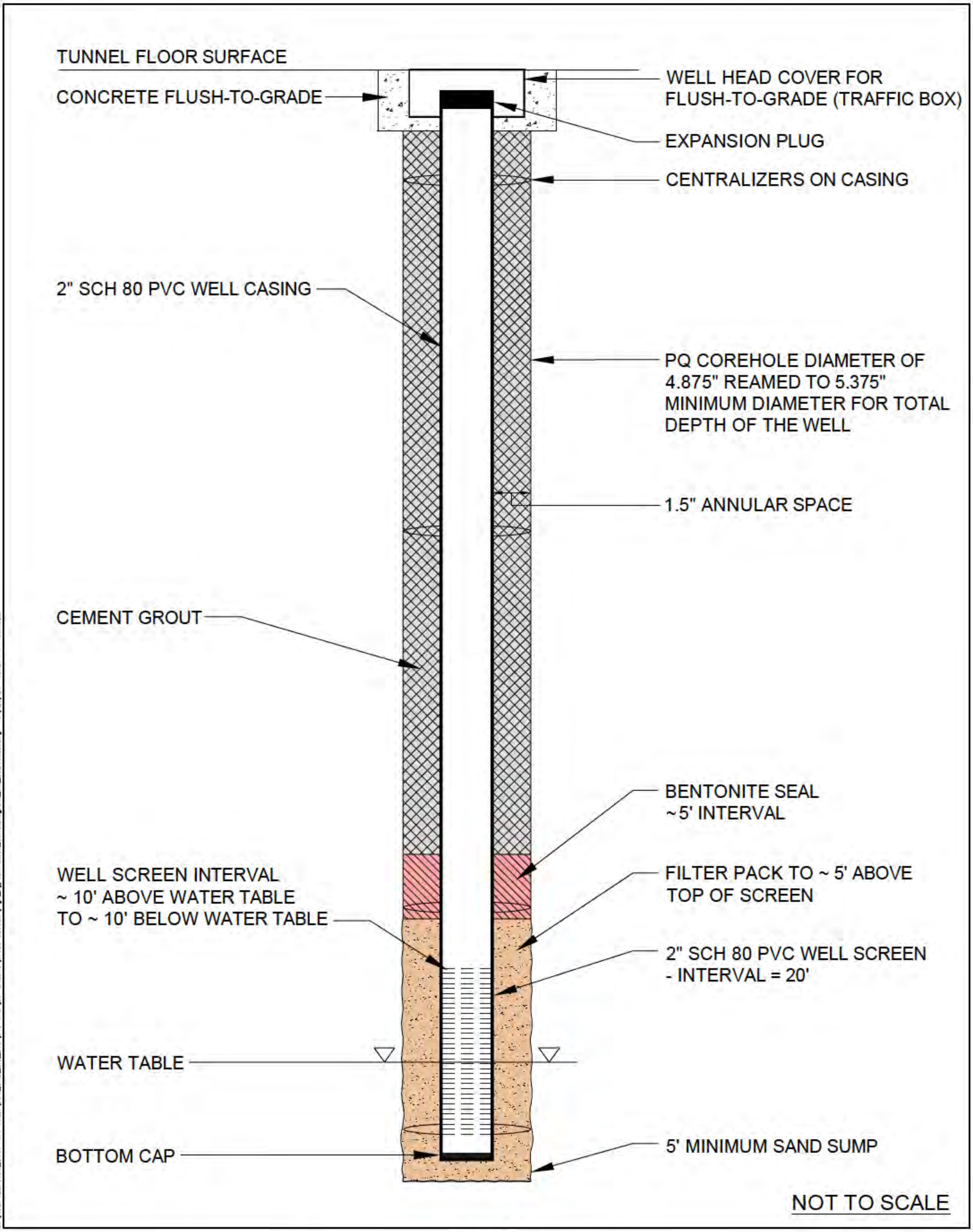


Figure 6
Typical Tunnel Well Construction Diagram
Monitoring Well Installation Work Plan
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

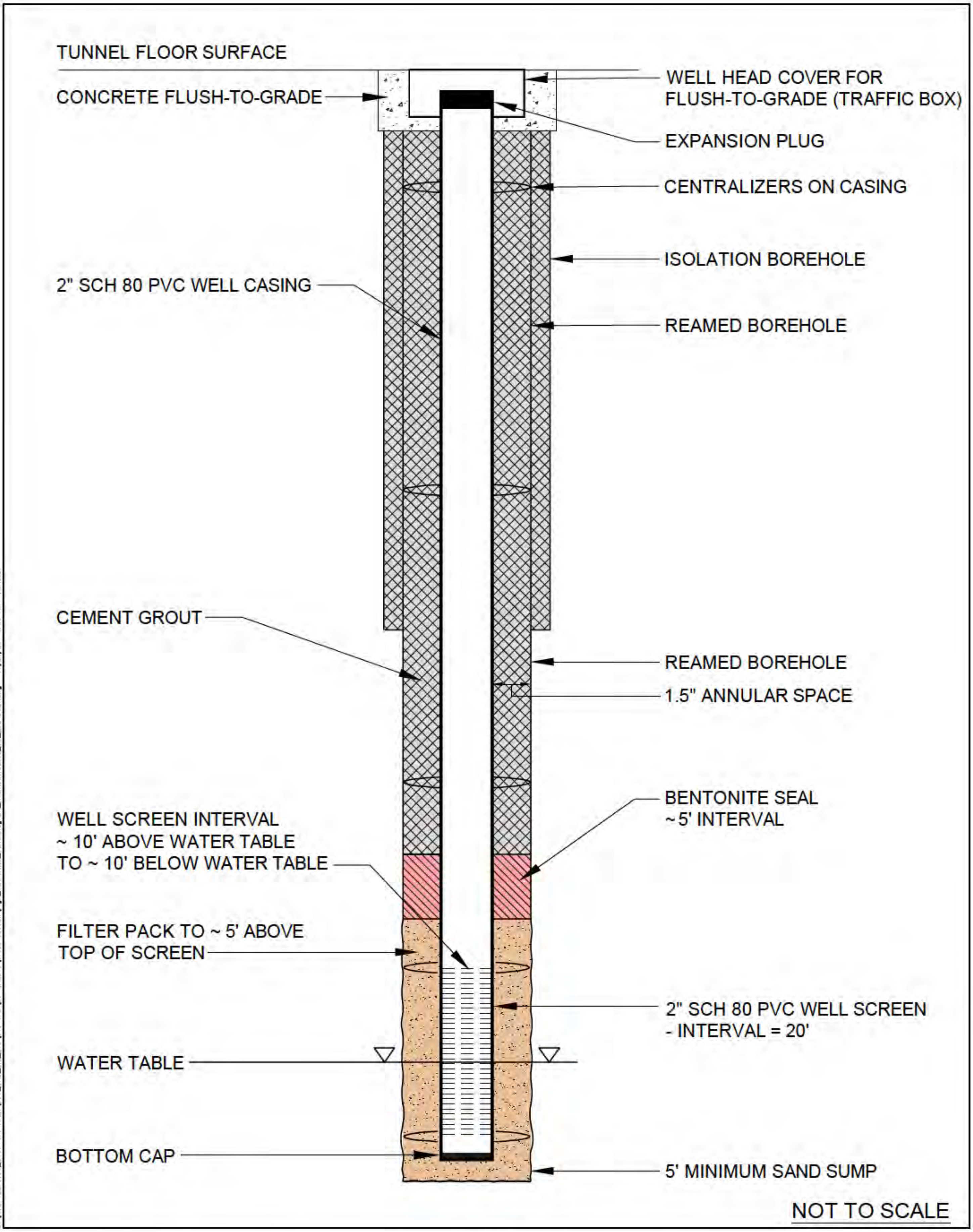


Figure 7
Tunnel Well Construction Diagram with Reamed and Grouted Interval
Monitoring Well Installation Work Plan
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

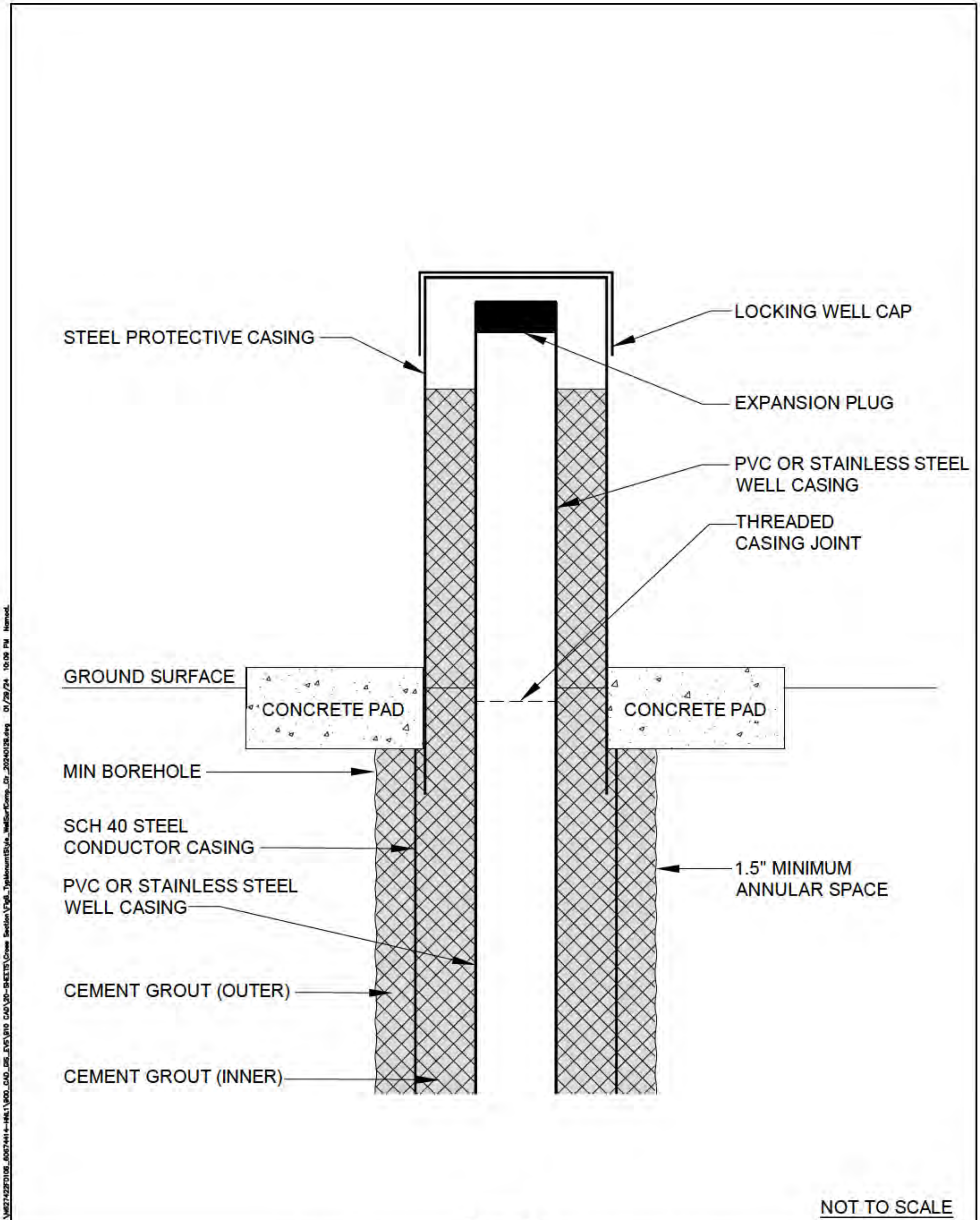
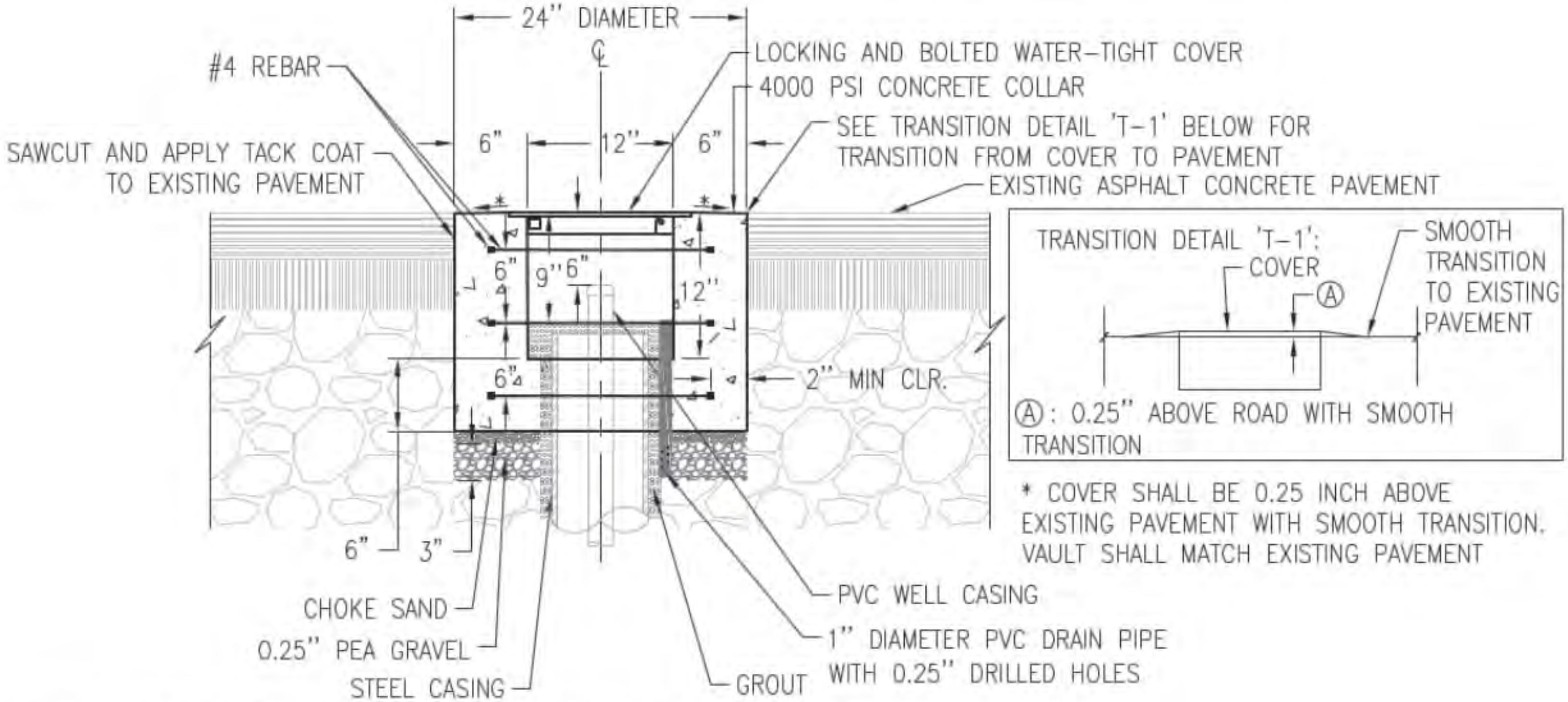


Figure 8
Typical Monument Style Well Surface Completion
Monitoring Well Installation Work Plan
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i



VAULT SPECIFICATIONS: H-20 TRAFFIC-RATED STEEL VAULT LOCKING AND BOLTED COVER WATER TIGHT WITH GASKET FOR COVER.

ASPHALT PATCH: USE 4" CITY MIX #4 ACP

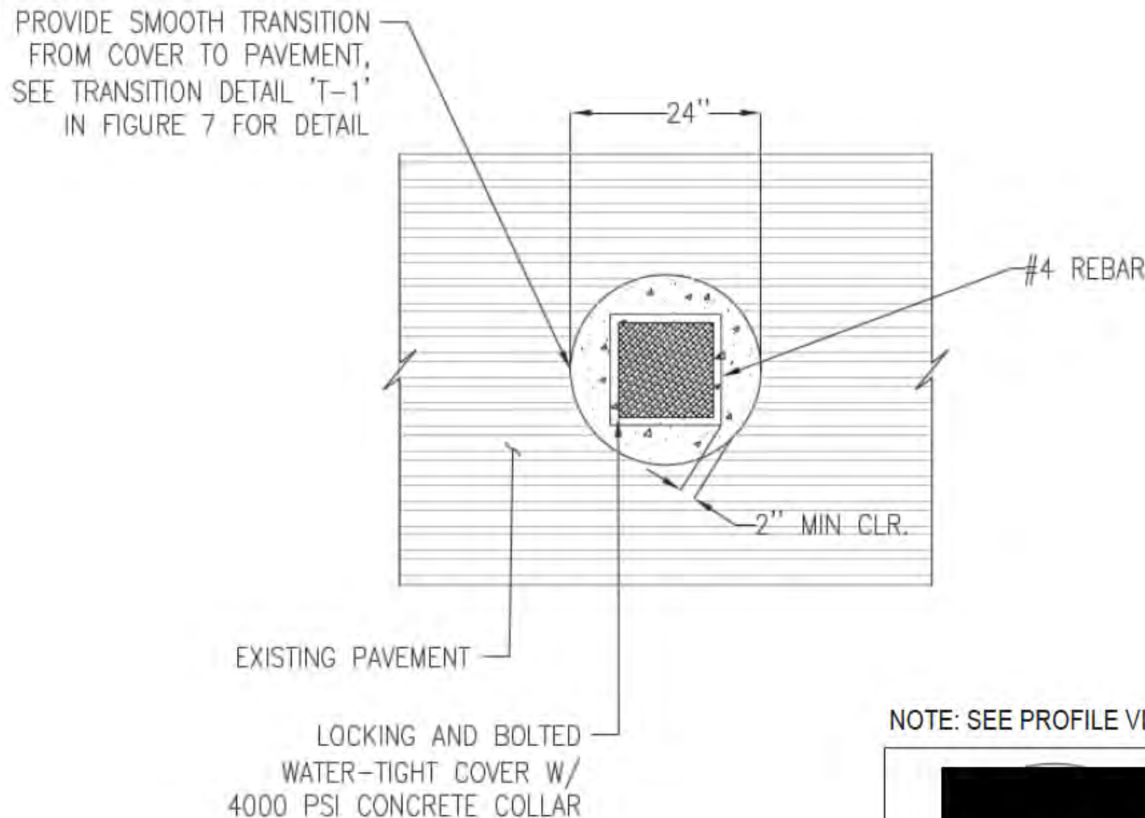
PROFILE VIEW

[redacted]
LICENSED PROFESSIONAL ENGINEER
[redacted]
HAWAII, U.S.A.

[redacted] 4/30/24
SIGNATURE

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION AND CONSTRUCTION OF THIS PROJECT WILL BE UNDER MY OBSERVATION.

Figure 9
Flush-Mount Vault Well Surface Completion
Monitoring Well Installation Work Plan
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i



NOTE: SEE PROFILE VIEW

[redacted]
LICENSED PROFESSIONAL ENGINEER
[redacted]
HAWAII, U.S.A.

[redacted] 4/30/24
SIGNATURE

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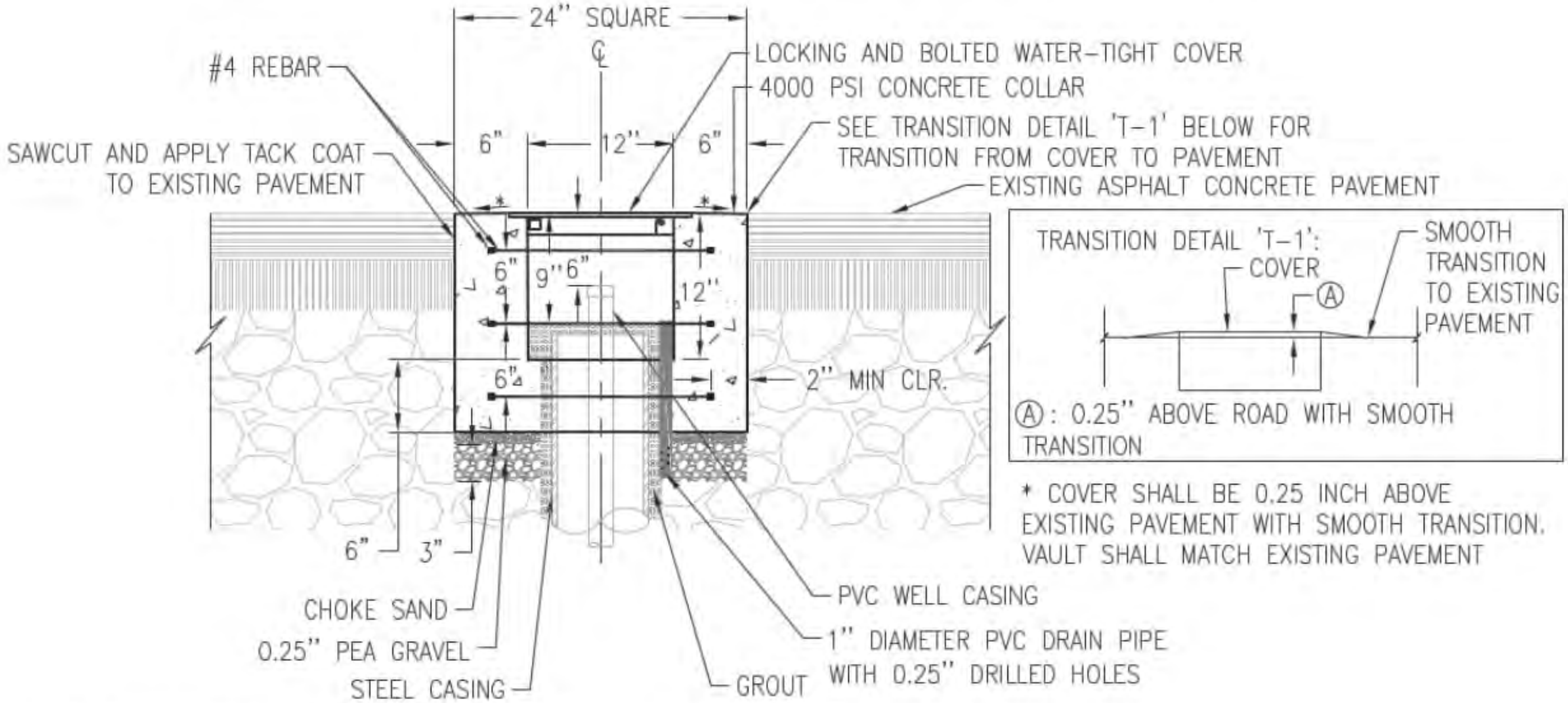
PLAN VIEW

Figure 9 (cont.)
Flush-Mount Vault Well Surface Completion
Monitoring Well Installation Work Plan
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i



VAULT SPECIFICATIONS: H-20 TRAFFIC-RATED STEEL VAULT LOCKING AND BOLTED COVER WATER TIGHT WITH GASKET FOR COVER.

ASPHALT PATCH: USE 4" CITY MIX #4 ACP

[redacted]
LICENSED PROFESSIONAL ENGINEER
[redacted]
HAWAII, U.S.A.

[redacted] 4/30/24
SIGNATURE

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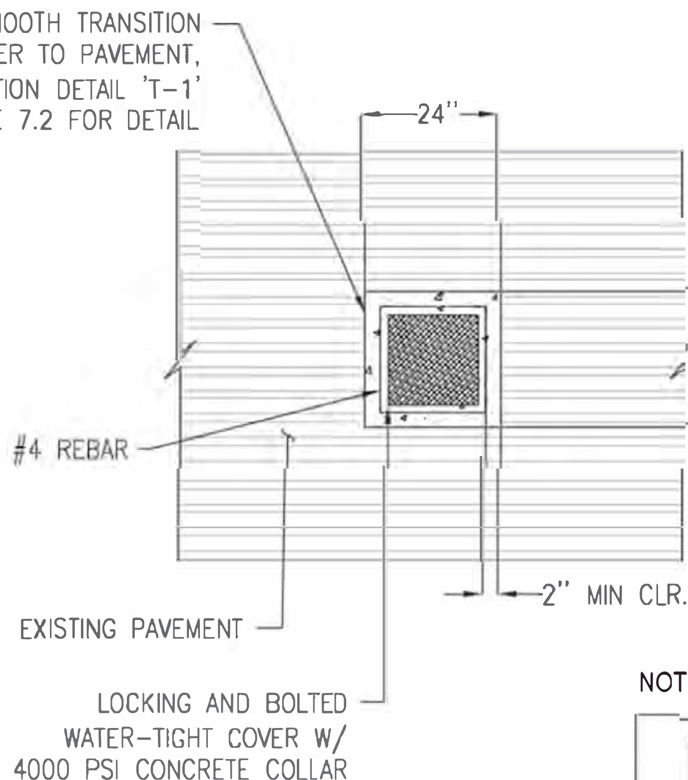
PROFILE VIEW (SQUARE)

Figure 9 (cont.)
Flush-Mount Vault Well Surface Completion
Monitoring Well Installation Work Plan
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i



NOTE: SEE PROFILE VIEW (SQUARE)

PLAN VIEW (SQUARE)

[redacted]
LICENSED
PROFESSIONAL
ENGINEER
[redacted]
HAWAII, U.S.A.

[redacted] 4/30/24
SIGNATURE

THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION AND CONSTRUCTION OF THIS PROJECT WILL BE UNDER MY OBSERVATION.

Figure 9 (cont.)
Flush-Mount Vault Well Surface Completion
Monitoring Well Installation Work Plan
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

Appendix A:
Acceptable Drilling Materials and Additives
(as of: January 23, 2025)

Product Type	**Product Name**	**Product Manufacturer**
Thread Joint Compound	Biolube TJC	BioBlend Renewable Resources
Lost Circulation Material (LCM)	N-Seal	Halliburton
Hydraulic Oil	ISO46 & ISO68 Hydraulic Oil	Plews/Edelmann
	ENVIRONM MV 32, 46	Petro-Canada
	MOBILFLUID 424	ExxonMobil
Hammer Oil/ Rock Drill Oil	RDO 302 ES	Control Chemical/MATEX
Hammer Oil	BioLube RDP	BioBlend Renewable Resources
Biodegradable Penetrating Oil Aerosol	BioBlend PO Aerosol	BioBlend Renewable Resources
Food Grade Grease	Food grade Gear Oil SAE 90	CRC Industries
	SoyGrease Food Machinery/ UltraLube	Environmental Lubricants Manufacturing, Inc.
	Clarion Food Machinery Grease No. 2	CITGO Petroleum
Drill Foam	Foamer ES	Control Chemical/MATEX
Defoamer	Xiameter® AFE-150 Antifoam Emulsion	Xiameter (Dow Corning)

Appendix B:
Objectives and Rationale for New Well Installations

Table B-1: Objectives and Rationale for New Well Installations

The objectives and rationale for selection of potential new monitoring well locations are presented in the following table. Figure B-1 depicts the potential new monitoring well locations.

Well	Area	Monitoring Well	Caprock / Saprolite	Data Objectives and Rationale	Well Installation Parameters			
					Surface Elevation (ft msl)	Depth to Groundwater (ft bgs)	Monitoring Well Screen Interval (ft bgs) [b]	Total Depth (ft bgs)
NMW28 (PP)	North Hālawa Valley	✓	✓	NMW28 will provide groundwater elevation data west of the Halawa Quarry pit to further evaluate groundwater elevations directly between Red Hill Shaft and BWS Hālawa Shaft. The data will be used to obtain groundwater elevation data in the upper portion of North Hālawa Valley near BWS Hālawa Shaft. Lithologic data from this location will be used to further define the geometry of the valley fill sediments and saprolite layers in North Hālawa Valley. Groundwater quality data will be used to evaluate the groundwater quality in the vicinity of BWS Hālawa Shaft. This well is co-located with NMW28A and is anticipated to be a confined basal well. The submerged well screen will be 20 ft long.	150	130	Screen interval to be determined during drilling. [a]	Total drilled depth to be determined during drilling. [a]
NMW28A	North Hālawa Valley	✓	✓	NMW28A will provide groundwater elevation data west of the Halawa Quarry pit to further evaluate groundwater elevations directly between Red Hill Shaft and BWS Hālawa Shaft. The data will be used to obtain groundwater elevation data in the upper portion of North Hālawa Valley near BWS Hālawa Shaft. Lithologic data from this location will be used to further define the geometry of the valley fill sediments and saprolite layers in North Hālawa Valley. Groundwater quality data will be used to evaluate the groundwater quality in the vicinity of BWS Hālawa Shaft. This well is co-located with NMW28 and is anticipated to be a deeper confined basal well. The submerged well screen will be 20 ft long.	150	130	Screen interval to be determined during drilling. [a]	Total drilled depth to be determined during drilling. [a]
NMW29 (MW1)	North Hālawa Valley	✓		NMW29 will provide groundwater elevation data west of the Hālawa Industrial Park to further evaluate groundwater patterns northwest of Red Hill Shaft. The data from this well will be used to further evaluate groundwater flow patterns in North Hālawa Valley, toward Navy ‘Aiea Hālawa Shaft. Lithologic data from this location will be used to further define the properties of the basalt in the southern portion of North Hālawa Valley. Groundwater quality will be used to evaluate groundwater quality south of BWS Hālawa Shaft and prior to Navy ‘Aiea Hālawa Shaft. This well is co-located with NMW29A and is planned to be installed across the basal water table.	147	127	117–147	152

Well	Area	Monitoring Well	Caprock / Saprolite	Data Objectives and Rationale	Well Installation Parameters			
					Surface Elevation (ft msl)	Depth to Groundwater (ft bgs)	Monitoring Well Screen Interval (ft bgs) [b]	Total Depth (ft bgs)
NMW29A	North Hālawa Valley	✓		NMW29A will provide groundwater elevation data west of the Hālawa Industrial Park to further evaluate groundwater patterns northwest of Red Hill Shaft. The data from this well will be used to further evaluate groundwater flow patterns in North Hālawa Valley, toward Navy ʻAiea Hālawa Shaft. Lithologic data from this location will be used to further define the properties of the basalt in the southern portion of North Hālawa Valley. Groundwater quality will be used to evaluate groundwater quality south of BWS Hālawa Shaft and prior to Navy ʻAiea Hālawa Shaft. This well is co-located with NMW29 and is planned to be an unconfined basal well with the well screen set approximately 300 ft below the water table. The submerged well screen will be 20 ft long.	147	127	407–427	452
SS	Moanalua Valley	✓	✓	SS will provide groundwater elevation data to further evaluate groundwater flow patterns south of Red Hill Shaft. The data from this well will be used to further evaluate groundwater flow patterns south of the Facility and determine whether there was fuel in this down-dip direction from the Facility. Lithologic data from this location will be used to further define the geometry and extent of the Āliamanu Crater volcanic tuffs, valley fill sediments, and saprolite layers along the northern edge of Moanalua Valley. Groundwater quality data will be used to evaluate the groundwater quality to the south of the Facility where no nearby monitoring wells currently exist. Former proposed location was considered not viable based on site reconnaissance. The re-located SS location was selected to be a short distance to the southeast (approximately downgradient) of RHS to help determine the downgradient stagnation area for RHS capture and monitor for potential migration toward Moanalua. NMW30 and to a lesser extent NMW25 will partially meet the objectives of the original SS location, even though different stratigraphy may be encountered. This well is anticipated to be an unconfined basal well with the well screen set approximately 150 ft below the water table. The submerged well screen will be 20 ft long.	337	317	Screen interval to be determined during drilling. [a]	Total drilled depth to be determined during drilling. [a]
NMW22 (MM)	South Hālawa Valley	✓	✓	NMW22 will provide groundwater elevation data between Red Hill and BWS Hālawa Shaft to further evaluate groundwater flow patterns southeast of the Halawa Quarry pit. The data from this well will be used to further evaluate groundwater flow patterns in and adjacent to South Hālawa Valley and the potential for groundwater flow toward the northwest. Lithologic data from this location will be used to further define the geometry (size/shape) of the valley fill sediments and saprolite in South Hālawa Valley. Groundwater quality data will be used to evaluate the groundwater quality to the northwest approximately halfway between Red Hill tanks and BWS Hālawa Shaft. This location has been slightly revised from previous depictions based on site access issues. This well is anticipated to be a confined basal well. The submerged well screen will be 20 ft long.	237	217	Screen interval to be determined during drilling. [a]	Total drilled depth to be determined during drilling. [a]

Well	Area	Monitoring Well	Caprock / Saprolite	Data Objectives and Rationale	Well Installation Parameters			
					Surface Elevation (ft msl)	Depth to Groundwater (ft bgs)	Monitoring Well Screen Interval (ft bgs) [b]	Total Depth (ft bgs)
NMW23 (XA)	South Hālawa Valley	✓	✓	NMW23 will provide groundwater elevation data between Red Hill and BWS Hālawa Shaft to further evaluate groundwater flow patterns southwest of the Halawa Quarry pit. The data from this well will be used to further evaluate groundwater flow patterns in and adjacent to South Hālawa Valley and the potential for groundwater flow toward the northwest. Lithologic data from this location will be used to further define the geometry and extent of the valley fill sediments and saprolite layers in South Hālawa Valley. Groundwater quality data will be used to evaluate the groundwater quality to the northwest approximately halfway between Red Hill Shaft/lower Red Hill tanks and BWS Hālawa Shaft. This location has been slightly revised from previous depictions based on site access issues. This well is anticipated to be a confined basal well. The submerged well screen will be 20 ft long.	209	189	Screen interval to be determined during drilling. [a]	Total drilled depth to be determined during drilling. [a]
XE	South Hālawa Valley	✓	✓	XE will provide groundwater elevation data between Red Hill and BWS Hālawa Shaft to further evaluate groundwater flow patterns to the northwest of Red Hill. The data from this well will be used to further evaluate the potential for groundwater flow across South Hālawa Valley and North Hālawa Valley. Lithologic data from this location will be used to further define the geometry of the valley fill sediments and saprolite layers in South Hālawa Valley. Groundwater quality data will be used to evaluate the groundwater quality to the northwest approximately halfway between upper Red Hill tanks and BWS Hālawa Shaft. The XE location was selected to provide (a) hydraulic data in response to pumping of BWS Hālawa Shaft, and (b) monitoring of potential migration from the Facility toward BWS Hālawa Shaft with sufficient remaining travel time as to enable response actions; however, due to access issues, XE is not feasible for the foreseeable future. MW-2 and PP partially meet the first objective, but do not meet the second objective. The well screen is planned to be installed across the basal water table.	374	354	344–374	379

Well	Area	Monitoring Well	Caprock / Saprolite	Data Objectives and Rationale	Well Installation Parameters			
					Surface Elevation (ft msl)	Depth to Groundwater (ft bgs)	Monitoring Well Screen Interval (ft bgs) [b]	Total Depth (ft bgs)
NMW42 (LL)	South Hālawa Valley	✓	✓	NMW42 will provide groundwater elevation data between Red Hill and BWS Hālawa Shaft to further evaluate groundwater flow patterns southeast of the Halawa Quarry pit. Groundwater elevation data from this well will help to further evaluate groundwater flow patterns in and adjacent to South Hālawa Valley. Lithologic data from this location will be used to further define the geometry and extent of the valley fill sediments and saprolite layers in South Hālawa Valley. Groundwater quality data will be used to evaluate the groundwater quality to the northwest of the upper end of the tank farm. The original proposed location was relocated due (a) steep topography (b) due to property accessibility issues. The new LL location was selected to provide (a) hydraulic data in response to pumping of BWS Hālawa Shaft, and (b) monitoring of potential migration from the Facility toward BWS Hālawa Shaft with ample remaining travel time as to enable response actions. This well is co-located with NMW42A and is anticipated to be an elevated head well. The well screen will be 30 ft long.	261	TBD	Screen interval to be determined during drilling. [a]	Total drilled depth to be determined during drilling. [a]
NMW42A	South Hālawa Valley	✓	✓	NMW42A will provide groundwater elevation data between Red Hill and BWS Hālawa Shaft to further evaluate groundwater flow patterns southeast of the Halawa Quarry pit. Groundwater elevation data from this well will help to further evaluate groundwater flow patterns in and adjacent to South Hālawa Valley. Lithologic data from this location will be used to further define the geometry and extent of the valley fill sediments and saprolite layers in South Hālawa Valley. Groundwater quality data will be used to evaluate the groundwater quality to the northwest of the upper end of the tank farm. Former proposed location removed due to property accessibility issues The NMW42A location was selected to provide (a) hydraulic data in response to pumping of BWS Hālawa Shaft, and (b) monitoring of potential migration from the Facility toward BWS Hālawa Shaft with ample remaining travel time as to enable response actions. This well is co-located with NMW42 and is anticipated to be a confined basal well. The submerged well screen will be 20 ft long.	261	241	Screen interval to be determined during drilling. [a]	Total drilled depth to be determined during drilling. [a]
XC	South Hālawa Valley	✓	✓	XC will provide groundwater elevation data between Red Hill and BWS Hālawa Shaft to further evaluate groundwater flow patterns southwest of the Halawa Quarry pit. The data from this well will be used to further evaluate groundwater flow patterns in and adjacent to South Hālawa Valley and the potential for groundwater flow toward the northwest. Lithologic data from this location will be used to further define the geometry and extent of the valley fill sediments and saprolite layers in South Hālawa Valley. Due to property accessibility issues, the Navy contends that NMW23 will meet the original objectives. NMW23 meets most of the original objectives of the XC location (when considered together with NMW22). NMW35 and NMW36 will partially meet the objectives of the original XC as well. This well is anticipated to be a confined basal well. The submerged well screen will be 20 ft long.	242	222	Screen interval to be determined during drilling. [a]	Total drilled depth to be determined during drilling. [a]

Well	Area	Monitoring Well	Caprock / Saprolite	Data Objectives and Rationale	Well Installation Parameters			
					Surface Elevation (ft msl)	Depth to Groundwater (ft bgs)	Monitoring Well Screen Interval (ft bgs) [b]	Total Depth (ft bgs)
NMW40 (OO)	North Hālawa Valley	✓	✓	NMW40 is located near BWS Hālawa Shaft. Currently, all monitoring wells are clustered around the Facility tank farm and Red Hill Shaft, with only mild gradients between wells. Evaluation of regional gradients will be enhanced with this additional well. This would be one of two monitoring wells in North Hālawa Valley. Groundwater elevation data from this well will improve understanding of hydraulic characteristics in this area due to BWS Hālawa Shaft pumping. It will provide groundwater elevation data northwest of the Halawa Quarry pit to further evaluate groundwater elevations directly between Red Hill Shaft and BWS Hālawa Shaft. Lithologic data from this location will be used to further define the geometry of the valley fill sediments and saprolite layers in North Hālawa Valley and evaluate the existence of confining conditions in North Hālawa Valley similar to those that existing in South Hālawa Valley. Groundwater quality data will be used to evaluate the groundwater quality in the vicinity of BWS Hālawa Shaft. Original location OO has been re-located to the current location due to site access at Halawa Quarry. This well is co-located with NMW40A and is anticipated to be a confined basal well. The submerged well screen will be 20 ft long.	154	134	Screen interval to be determined during drilling. [a]	Total drilled depth to be determined during drilling. [a]
NMW40A	North Hālawa Valley			NMW40A will provide groundwater elevation data west of the Halawa Quarry pit to further evaluate groundwater elevations directly between Red Hill Shaft and BWS Hālawa Shaft. The data will be used to evaluate groundwater flow patterns across South Hālawa Valley and North Hālawa Valley. Lithologic data from this location will be used to further define the geometry of the valley fill sediments and saprolite layers adjacent to North Hālawa Valley. Groundwater quality data will be used to evaluate the groundwater quality to the north between Red Hill Shaft and BWS Hālawa Shaft. This well is co-located with NMW40 and is anticipated to be a confined basal well. The submerged well screen will be 20 ft long.	169	149	Screen interval to be determined during drilling. [a]	Total drilled depth to be determined during drilling. [a]
NMW35	South Hālawa Valley	✓	✓	NMW35 will provide groundwater elevation data between Red Hill and BWS Hālawa Shaft to further evaluate groundwater flow patterns southwest of the Halawa Quarry pit. The data from this well will be used to further evaluate groundwater flow patterns in and adjacent to South Hālawa Valley and the potential for groundwater flow toward the northwest. Lithologic data from this location will be used to further define the geometry and extent of the valley fill sediments and saprolite layers in South Hālawa Valley. Locations NMW23 and NMW35 will meet many of the objectives of the original XC. This well is anticipated to be a confined basal well. The submerged well screen will be 20 ft long.	195	175	Screen interval to be determined during drilling. [a]	Total drilled depth to be determined during drilling. [a]

Well	Area	Monitoring Well	Caprock / Saprolite	Data Objectives and Rationale	Well Installation Parameters			
					Surface Elevation (ft msl)	Depth to Groundwater (ft bgs)	Monitoring Well Screen Interval (ft bgs) [b]	Total Depth (ft bgs)
NMW36	South Hālawa Valley	✓	✓	NMW36 will provide groundwater elevation data between Red Hill and BWS Hālawa Shaft to further evaluate groundwater flow patterns southwest of the Halawa Quarry pit. The data from this well will be used to further evaluate groundwater flow patterns in and adjacent to South Hālawa Valley and the potential for groundwater flow toward the northwest. Lithologic data from this location will be used to further define the geometry and extent of the valley fill sediments and saprolite layers in South Hālawa Valley. Groundwater quality data will be used to evaluate the groundwater quality to the northwest approximately halfway between Red Hill Shaft/lower Red Hill tanks and BWS Hālawa Shaft. Location NMW36 will meet many of the objectives of the original XC. This well is anticipated to be a confined basal well. The submerged well screen will be 20 ft long.	173	153	Screen interval to be determined during drilling. [a]	Total drilled depth to be determined during drilling. [a]
NMW31	North Hālawa Valley	✓	✓	NMW31 is located near BWS Hālawa Shaft. Currently, all monitoring wells are clustered around the Facility tank farm and Red Hill Shaft, with only mild gradients between wells. Evaluation of regional gradients will be enhanced with this additional well. This would be one of two monitoring wells in North Hālawa Valley. Groundwater elevation data from this well will improve understanding of hydraulic characteristics in this area due to BWS Hālawa Shaft pumping. It will provide groundwater elevation data northwest of the Halawa Quarry pit to further evaluate groundwater elevations directly between Red Hill Shaft and BWS Hālawa Shaft. Lithologic data from this location will be used to further define the geometry of the valley fill sediments and saprolite layers in North Hālawa Valley and evaluate the existence of confining conditions in North Hālawa Valley similar to those that existing in South Hālawa Valley. Groundwater quality data will be used to evaluate the groundwater quality in the vicinity of BWS Hālawa Shaft. This well is anticipated to be a confined basal well. The submerged well screen will be 20 ft long.	200	180	Screen interval to be determined during drilling. [a]	Total drilled depth to be determined during drilling. [a]
NMW37	Āliamanu Crater		✓	NMW37 will provide groundwater elevation data SSW of Red Hill Shaft, southwest of the Red Hill tanks and adjacent to Moanalua Valley. The data from this well will be used to further evaluate groundwater flow patterns south of the Facility. Lithologic data from this location will be used to further define the geometry and extent of the Āliamanu Crater volcanic tuffs, valley fill sediments and saprolite layers along the northern edge of Moanalua Valley. Groundwater quality data will be used to evaluate the groundwater quality to the south of the facility where no nearby monitoring wells currently exist. This well is anticipated to be a confined basal well. The submerged well screen will be 20 ft long.	64	44	Screen interval to be determined during drilling. [a]	Total drilled depth to be determined during drilling. [a]

Well	Area	Monitoring Well	Caprock / Saprolite	Data Objectives and Rationale	Well Installation Parameters			
					Surface Elevation (ft msl)	Depth to Groundwater (ft bgs)	Monitoring Well Screen Interval (ft bgs) [b]	Total Depth (ft bgs)
NMW39	Āliamanu Crater		✓	NMW39 will provide groundwater elevation data southwest of Red Hill Shaft, southwest of the Red Hill tanks and south of Hālawa Valley. The data from this well will be used to further evaluate groundwater flow patterns southwest of the Facility. Lithologic data from this location will be used to further define the geometry and extent of the Āliamanu Crater volcanic tuffs, valley fill sediments and saprolite layers along the southern edge of Hālawa Valley. Groundwater quality data will be used to evaluate the groundwater quality to the southwest of the Facility where no nearby monitoring wells currently exist. This well is anticipated to be a confined basal well. The submerged well screen will be 20 ft long.	167	147	Screen interval to be determined during drilling. [a]	Total drilled depth to be determined during drilling. [a]
NMW38	South Hālawa Valley		✓	RHMW38 will provide groundwater elevation data west of Red Hill Shaft to further evaluate groundwater flow patterns. The data from this well will be used to further evaluate groundwater flow patterns in and adjacent to the H-3 Freeway Corridor near the confluence of South and North Hālawa Valleys and the potential for groundwater flow toward the northwest. Lithologic data from this location will be used to further define the geometry and extent of the valley fill sediments and saprolite layers in the area. Groundwater quality data will be used to evaluate the potential for COPCs to flow to the northwest toward North Hālawa Valley. This well is co-located with NMW38A and is anticipated to be an elevated head well. The well screen will be 30 ft long.	93	TBD	Screen interval to be determined during drilling. [a]	Total drilled depth to be determined during drilling. [a]
NMW38A	South Hālawa Valley		✓	RHMW38A will provide groundwater elevation data west of Red Hill Shaft to further evaluate groundwater flow patterns. The data from this well will be used to further evaluate groundwater flow patterns in and adjacent to the H-3 Freeway Corridor near the confluence of South and North Hālawa Valleys and the potential for groundwater flow toward the northwest. Lithologic data from this location will be used to further define the geometry and extent of the valley fill sediments and saprolite layers in the area. Groundwater quality data will be used to evaluate the potential for COPCs to flow to the northwest toward North Hālawa Valley. This well is co-located with NMW38 and is anticipated to be a confined basal well. The submerged well screen will be 20 ft long.	93	73	Screen interval to be determined during drilling. [a]	Total drilled depth to be determined during drilling. [a]
NMW41	North Hālawa Valley		✓	NMW41 will provide groundwater elevation data west of Red Hill Shaft to further evaluate groundwater flow patterns. The data from this well will be used to further evaluate groundwater flow patterns at the H-201 and H-3 Freeway interchange near the confluence of South and North Hālawa Valleys and the potential for groundwater flow toward the northwest. Lithologic data from this location will be used to further define the geometry and extent of the valley fill sediments and saprolite layers in the area. Groundwater quality data will be used to evaluate the potential for COPCs to flow to the northwest toward Navy ‘Aiea Hālawa Shaft. This well is anticipated to be a confined basal well. The submerged well screen will be 20 ft long.	86	66	Screen interval to be determined during drilling. [a]	Total drilled depth to be determined during drilling. [a]

Well	Area	Monitoring Well	Caprock / Saprolite	Data Objectives and Rationale	Well Installation Parameters			
					Surface Elevation (ft msl)	Depth to Groundwater (ft bgs)	Monitoring Well Screen Interval (ft bgs) [b]	Total Depth (ft bgs)
NMW33A	Āliamanu Crater		✓	NMW33A will provide groundwater elevation data southwest of Red Hill Shaft, southwest of the Red Hill tanks, and south of Hālawa Valley. The data from this well will be used to further evaluate groundwater flow patterns southwest of the Facility. Lithologic data from this location will be used to further define the geometry and extent of the Āliamanu Crater volcanic tuffs, valley fill sediments, saprolite layers and underlying basalt along the southern edge of Hālawa Valley. Groundwater quality data will be used to evaluate the groundwater quality to the southwest of the Facility. This well is co-located with existing well NMW33, which was installed with the well screen set in volcanic tuff. NMW33A will have the well screen set in basalt at a depth in hydraulic connection with the basal aquifer. This well is anticipated to be a confined basal well. The submerged well screen will be 20 ft long.	132	122	Screen interval to be determined during drilling. [a]	Total drilled depth to be determined during drilling. [a]
NMW43 (MW4)	Moanalua Valley			NMW43 (MW4) will be located in Moanalua Valley and will provide groundwater elevation data in Moanalua Valley, southwest of the tank farm. Lithologic data from this location will be used to indicate the geometry of valley fill sediments, saprolite, and differentiate the basalt in Moanalua Valley. Groundwater quality will be provided for Moanalua Valley. There are currently no other wells located this far up in Moanalua Valley. The original location is being relocated to the current location due to deconfliction with another project. This well is co-located with NMW43A and is anticipated to be an elevated head well. The well screen will be 30 ft long.	120	TBD	Screen interval to be determined during drilling. [a]	Total drilled depth to be determined during drilling. [a]
NMW43A	Moanalua Valley			NMW43A will be located in Moanalua Valley and will provide groundwater elevation data in Moanalua Valley, southwest of the tank farm. Lithologic data from this location will be used to indicate the geometry of valley fill sediments, saprolite, and differentiate the basalt in Moanalua Valley. Groundwater quality will be provided for Moanalua Valley. There are currently no other wells located this far up in Moanalua Valley. This well is co-located with NMW43 and is anticipated to be a confined basal well. The submerged well screen will be 20 ft long.	120	100	Screen interval to be determined during drilling. a	Total drilled depth to be determined during drilling. a
RHMW44	Red Hill Ridge	✓		RHMW44 will be located north of Tank 5 and will be installed to assess groundwater quality and further evaluate groundwater flow directions adjacent to South Hālawa Valley. The well will provide geologic and hydrogeologic information at higher elevations relative to the site. The well screen is planned to be installed across the basal water table.	500	480	470–500	505

Well	Area	Monitoring Well	Caprock / Saprolite	Data Objectives and Rationale	Well Installation Parameters			
					Surface Elevation (ft msl)	Depth to Groundwater (ft bgs)	Monitoring Well Screen Interval (ft bgs) [b]	Total Depth (ft bgs)
RHMW44A	Red Hill Ridge	✓		RHMW44A will be located north of Tank 5 and will be installed to assess groundwater quality and further evaluate groundwater flow directions adjacent to South Hālawa Valley. The well will provide geologic and hydrogeologic information at higher elevations relative to the site. This well is proposed to be an unconfined basal well with the well screen set approximately 150 ft below the water table. The submerged well screen will be 20 ft long.	500	480	610–635	635
RHMW45	Red Hill Ridge	✓		RHMW45 will be located south of the tank farm, between existing wells RHMW02 and RHMW19, and will be installed to assess groundwater quality and further evaluate groundwater flow directions adjacent to Moanalua Valley. The well will provide geologic and hydrogeologic information at higher elevations relative to the site. The well screen is planned to be installed across the basal water table.	475	455	445–475	480
RHMW45A	Red Hill Ridge	✓		RHMW45A will be located south of the tank farm, between existing wells RHMW02 and RHMW19, and will be installed to assess groundwater quality and further evaluate groundwater flow directions adjacent to Moanalua Valley. The well will provide geologic and hydrogeologic information at higher elevations relative to the site. This well is proposed to be an unconfined basal well with the well screen set approximately 150 ft below the water table. The submerged well screen will be 20 ft long.	475	455	585–605	610
RHMW46	Red Hill Ridge	✓		RHMW46 will be located south of the tank farm, at a midpoint between existing wells RHMW02 and RHMW03, and will be installed to assess groundwater quality and further evaluate groundwater flow directions adjacent to Moanalua Valley. The well will provide geologic and hydrogeologic information at higher elevations relative to the site. The well screen is planned to be installed across the basal water table.	530	510	500–530	535
RHMW46A	Red Hill Ridge	✓		RHMW46A will be located south of the tank farm, at a midpoint between existing wells RHMW02 and RHMW03, and will be installed to assess groundwater quality and further evaluate groundwater flow directions adjacent to Moanalua Valley. The well will provide geologic and hydrogeologic information at higher elevations relative to the site. This well is proposed to be an unconfined basal well with the well screen set approximately 150 ft below the water table. The submerged well screen will be 20 ft long.	530	510	640–660	665

Well	Area	Monitoring Well	Caprock / Saprolite	Data Objectives and Rationale	Well Installation Parameters			
					Surface Elevation (ft msl)	Depth to Groundwater (ft bgs)	Monitoring Well Screen Interval (ft bgs) [b]	Total Depth (ft bgs)
RHMW47	Red Hill Ridge	✓		RHMW47 will be located south of the upper end of the tank farm, at a midpoint between existing wells RHMW03 and RHMW21, and will be installed to assess groundwater quality and further evaluate groundwater flow directions adjacent to the upper portion of Moanalua Valley. The well will provide geologic and hydrogeologic information at higher elevations relative to the site. The well screen is planned to be installed across the basal water table.	530	510	500–530	535
RHMW47A	Red Hill Ridge	✓		RHMW47A will be located south of the upper end of the tank farm, at a midpoint between existing wells RHMW03 and RHMW21, and will be installed to assess groundwater quality and further evaluate groundwater flow directions adjacent to the upper portion of Moanalua Valley. The well will provide geologic and hydrogeologic information at higher elevations relative to the site. This well is proposed to be an unconfined basal well with the well screen set approximately 150 ft below the water table. The submerged well screen will be 20 ft long.	530	510	640–660	665
RHMW48	Red Hill Ridge	✓		RHMW48 will be located southeast of the upper end of the tank farm, between existing wells RHMW21 and BWS DH43, and will be installed to assess groundwater quality and further evaluate groundwater flow directions adjacent to the upper portion of Moanalua Valley. The well will provide geologic and hydrogeologic information at higher elevations relative to the site. The well screen is planned to be installed across the basal water table.	570	550	540–570	575
RHMW48A	Red Hill Ridge	✓		RHMW48A will be located southeast of the upper end of the tank farm, between existing wells RHMW21 and BWS DH43, and will be installed to assess groundwater quality and further evaluate groundwater flow directions adjacent to the upper portion of Moanalua Valley. The well will provide geologic and hydrogeologic information at higher elevations relative to the site. This well is proposed to be an unconfined basal well with the well screen set approximately 150 ft below the water table. The submerged well screen will be 20 ft long.	570	550	680–700	705
RHMW49	Red Hill Ridge	✓		RHMW49 will be located northeast of the tank farm and will be installed to assess groundwater quality and further evaluate groundwater flow directions on Red Hill ridge between the upper portions of South Hālawa Valley and Moanalua Valley. The well will provide geologic and hydrogeologic information at higher elevations relative to the site. The well screen is planned to be installed across the basal water table.	690	670	660–690	695

Well	Area	Monitoring Well	Caprock / Saprolite	Data Objectives and Rationale	Well Installation Parameters			
					Surface Elevation (ft msl)	Depth to Groundwater (ft bgs)	Monitoring Well Screen Interval (ft bgs) [b]	Total Depth (ft bgs)
RHMW49A	Red Hill Ridge	✓		RHMW49A will be located northeast of the tank farm and will be installed to assess groundwater quality and further evaluate groundwater flow directions on Red Hill Ridge between the upper portions of South Hālawa Valley and Moanalua Valley. The well will provide geologic and hydrogeologic information at higher elevations relative to the site. This well is proposed to be an unconfined basal well with the well screen set approximately 150 ft below the water table. The submerged well screen will be 20 ft long.	690	670	800–820	825
NMW50	North Hālawa Valley	✓		NMW50 will provide groundwater elevation data to further evaluate groundwater patterns northwest of Red Hill Shaft. The data from this well will be used to further evaluate groundwater flow patterns in North Hālawa Valley. Lithologic data from this location will be used to further define the properties of the basalt in the mid portion of North Hālawa Valley. Groundwater quality will be used to evaluate groundwater quality west of BWS Hālawa Shaft. This well is co-located with NMW50A and is planned to be installed across the basal water table.	525	505	495–525	530
NMW50A	North Hālawa Valley	✓		NMW50 will provide groundwater elevation data to further evaluate groundwater patterns northwest of Red Hill Shaft. The data from this well will be used to further evaluate groundwater flow patterns in North Hālawa Valley. Lithologic data from this location will be used to further define the properties of the basalt in the mid portion of North Hālawa Valley. Groundwater quality will be used to evaluate groundwater quality west of BWS Hālawa Shaft. This well is co-located with NMW50 and is planned to be an unconfined basal well with the well screen set approximately 150 ft below the water table. The submerged well screen will be 20 ft long.	525	505	635–655	660
NMW51	Moanalua	✓	✓	NMW51 will provide groundwater elevation data southeast of Red Hill Shaft, south of the Red Hill tanks and adjacent to Moanalua Valley. The data from this well will be used to further evaluate groundwater flow patterns south of the Facility. Lithologic data from this location will be used to further define the geometry and extent of the Āliamanu Crater volcanic tuffs, valley fill sediments and saprolite layers along the northern edge of Moanalua Valley. Water quality data will be used to evaluate the groundwater quality to the south of the facility. This well is co-located with NMW51A and is planned to be installed across the basal water table.	285	265	255–285	290

Well	Area	Monitoring Well	Caprock / Saprolite	Data Objectives and Rationale	Well Installation Parameters			
					Surface Elevation (ft msl)	Depth to Groundwater (ft bgs)	Monitoring Well Screen Interval (ft bgs) [b]	Total Depth (ft bgs)
NMW51A	Moanalua	✓	✓	NMW51A will provide groundwater elevation data southeast of Red Hill Shaft, south of the Red Hill tanks and adjacent to Moanalua Valley. The data from this well will be used to further evaluate groundwater flow patterns south of the Facility. Lithologic data from this location will be used to further define the geometry and extent of the Āliamanu Crater volcanic tuffs, valley fill sediments and saprolite layers along the northern edge of Moanalua Valley. Water quality data will be used to evaluate the groundwater quality to the south of the facility. This well is co-located with NMW51 and is planned to be an unconfined basal well with the well screen set approximately 150 ft below the water table. The submerged well screen will be 20 ft long.	285	265	395–415	420
KK	South Hālawa Valley			KK will be located northeast of the tank farm and will be installed to assess groundwater quality and further evaluate groundwater flow directions and groundwater quality adjacent to the upper portion of South Hālawa Valley. The well will provide geologic and hydrogeologic information at higher elevations relative to the site. The USGS initially suggested KK be located up-ridge of the Red Hill Facility at an elevation of roughly 1,000 ft msl. Because of difficulties in gaining access, three alternative locations are being evaluated. KK-1 in South Hālawa Valley and KK-3 in Moanalua Valley are potential locations for slant/directional drilling. KK-2 is a potential location on Red Hill ridge for conventional drilling. Note, existing monitoring well RHMW18 partially meets the original objectives of KK. A monitoring well will be placed in only one of the three alternative locations. All three potential locations have conditions that indicate the well would be screened across the basal water table.	KK-1: 400 KK-2: 750 KK-3: 250	KK-1: 380 KK-2: 730 KK-3: 230	KK-1: 370–400 KK-2: 720–750 KK-3: 220–250	KK-1: 405 KK-2: 755 KK-3: 255

(green)	Well currently under construction.

Notes:
BWS Board of Water Supply, City and County of Honolulu
USGS United States Geological Survey
[a] Deep wells (i.e., to be screened deeper than the basal head elevation in water table conditions or below the confining unit in confined conditions) will be investigated to identify zones of higher flow and/or good hydraulic connection to the basal aquifer by means of periodically pausing drilling to perform water level and water quality testing (e.g., associated with or following bailing, slug testing, and/or pumping; with or without use of packer(s) to isolate testing zones), video logging, and/or geophysical logging. Boreholes in confined conditions will be extended at least 60 ft below the base of the confining unit and good hydraulic communication with the basal aquifer in order to provide sufficient borehole length for this testing.
[b] Monitoring well screen intervals specified in this table are target depths developed from discussions with the Regulatory Agencies. These intervals may be adjusted in the field based on conditions encountered during drilling. Any adjustments will be completed so that the data objectives and rationale for this location are achieved.

Table B-2: Objectives and Rationale for Installed Monitoring Wells

The objectives and rationale for installed monitoring well locations are presented in the following table. Figure B-2 depicts existing and recently completed monitoring well locations.

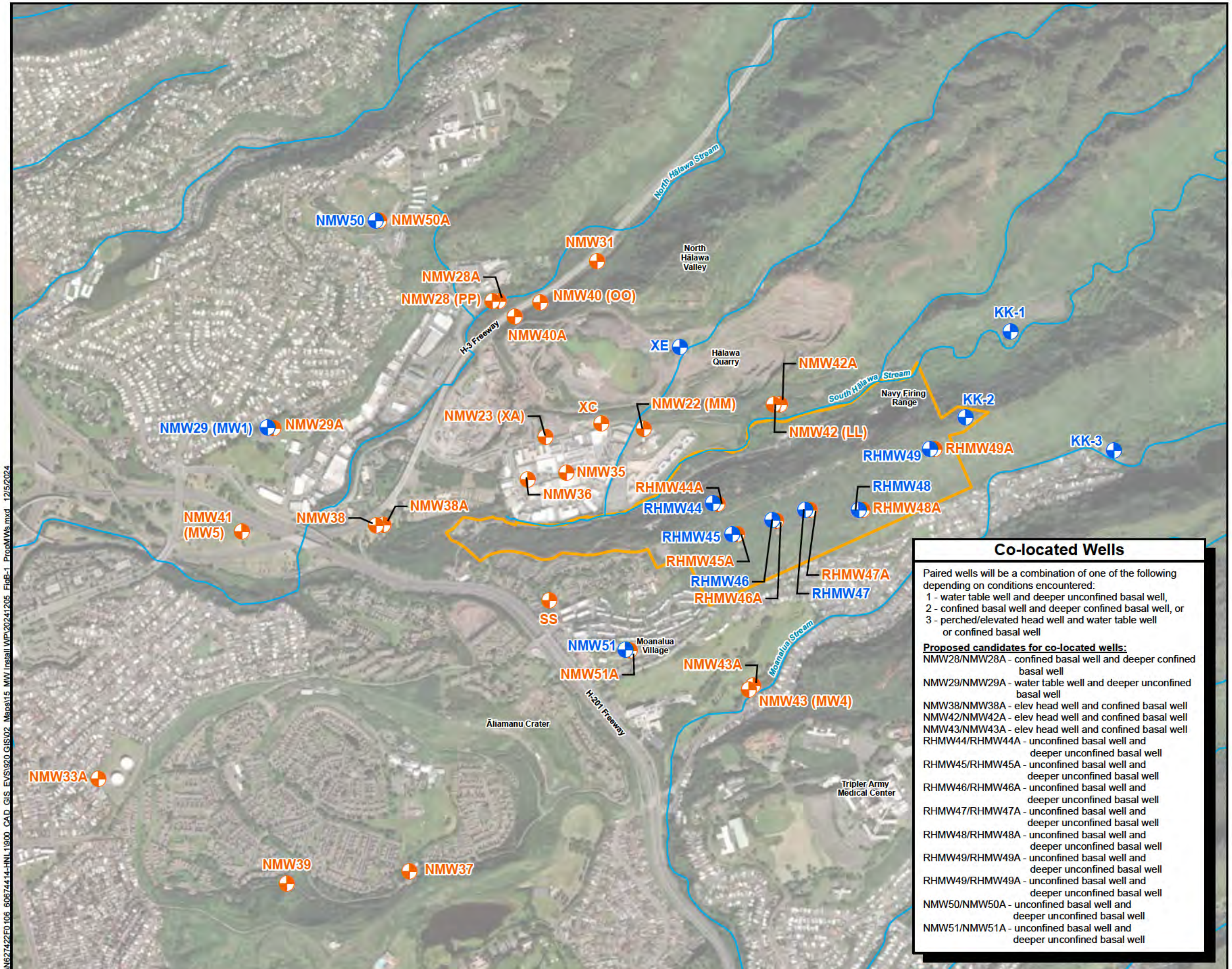
Well	Area	Monitoring Well	Caprock / Saprolite	Data Objectives and Rationale	Well Installation Parameters			
					Surface Elevation (ft msl)	Depth to Groundwater (ft bgs)	Monitoring Well Screen Interval (ft bgs)	Total Depth (ft bgs)
RHMW21 (II)	Tank Farm	✓		RHMW21, currently under construction, is located inside the Facility lower access tunnel between Tanks 18 and 20. RHMW21 will provide a well at the northeastern/upper end of the tank farm that is screened across the approximate elevation of the regional basal aquifer. Lithologic data from this location will provide information on the nature of basalt in the basal aquifer in the tank farm area. Groundwater quality data from this well will be used to further evaluate impacts to groundwater near the source of the May 2021 release. The well screen is installed across the basal water table.	132	114	104–124	130
RHP08B	Lower Red Hill Ridge	✓		RHP08B will provide groundwater elevation data to further evaluate groundwater flow patterns near Red Hill Shaft and evaluate groundwater properties in a spatial gap along the facility boundary. This well is proposed to monitor salinity of groundwater for evaluation of the potential for vertical flow. This well is co-located with RHP08 and RHP08C. This well is installed as an unconfined basal well with the well screen set approximately 150 ft below the water table. The submerged well is 20 ft long.	309	290	416–436	452
RHP08C	Lower Red Hill Ridge	✓		RHP08C will provide groundwater elevation data to further evaluate groundwater flow patterns near Red Hill Shaft and evaluate groundwater properties in a spatial gap along the Facility boundary. This well is proposed to monitor salinity of groundwater for evaluation of the potential for vertical flow and saltwater intrusion. This well is co-located with RHP08 and RHP08B. This well is an unconfined basal well with the well screen set approximately 300 ft below the water table. The submerged well screen is 20 ft long.	309	291	575–595	602

Well	Area	Monitoring Well	Caprock / Saprolite	Data Objectives and Rationale	Well Installation Parameters			
					Surface Elevation (ft msl)	Depth to Groundwater (ft bgs)	Monitoring Well Screen Interval (ft bgs)	Total Depth (ft bgs)
NMW27 (QQ)	Near Confluence of North and South Hālawa Valleys	✓	✓	NMW27 will provide groundwater elevation data between Red Hill and BWS Hālawa Shaft to further evaluate groundwater flow patterns northwest of Red Hill Shaft. The data from this well will be used to further evaluate groundwater flow patterns in and adjacent to the H-3 Freeway corridor in the southern portion of North Hālawa Valley and the potential for groundwater flow toward the northwest. Lithologic data from this location will be used to further define the geometry and extent of the valley fill sediments and saprolite layers in the southern portion of North Hālawa Valley. Groundwater quality data will be used to evaluate the potential for COPCs to flow to the northwest toward North Hālawa Valley and BWS Hālawa Shaft. This well is a deep confined basal well with the well screen set below the confining layer at approximately 490 ft below the water table. The submerged well screen is 20 ft long.	127	108	585–605	620
NMW24	Navy ‘Aiea Hālawa Shaft	✓	✓	NMW24 provides groundwater elevation data to further evaluate groundwater flow patterns west of North Hālawa Valley in the vicinity of Navy ‘Aiea Hālawa Shaft. Data from this well will be used to further evaluate groundwater flow patterns in and adjacent to the confluence of North and South Hālawa Valleys, and the potential for groundwater flow toward the west-northwest. Lithologic data from this location will be used to further define the geometry and extent of the volcanic tuff, valley fill sediments, caprock and saprolite layers along the western edge of Hālawa Valley. Groundwater quality data are used to evaluate the groundwater quality proximal Navy ‘Aiea Hālawa Shaft. This location was added to the plan with the goal of restoring production at Navy ‘Aiea Hālawa Shaft. The well screen is installed across the basal water table.	106	91.18	80–110	117.7
RHMW20	South Hālawa Valley	✓	✓	RHMW20 is located northwest of the tank farm and was installed to assess groundwater quality and further evaluate groundwater flow directions along the southern edge of South Hālawa Valley adjacent to the tank farm. Lithologic data from this location will be used to further define the geometry and extent of the volcanic tuff, valley fill sediments, caprock and saprolite layers along the South Hālawa Valley. Groundwater quality data will be used to evaluate the potential for COPCs to flow to the northwest toward North Hālawa Valley and Hālawa Shaft. The well screen is installed across the basal water table.	252.2	234.5	223–253	261.4

Well	Area	Monitoring Well	Caprock / Saprolite	Data Objectives and Rationale	Well Installation Parameters			
					Surface Elevation (ft msl)	Depth to Groundwater (ft bgs)	Monitoring Well Screen Interval (ft bgs)	Total Depth (ft bgs)
NMW25	Moanalua/ Āliamanu	✓	✓	NMW25 provides groundwater elevation data southeast of Red Hill Shaft, south of the Red Hill tanks and adjacent to Moanalua Valley. The data from this well are used to further evaluate groundwater flow patterns south of the Facility. Lithologic data from this location are used to further define the geometry and extent of the Āliamanu Crater volcanic tuffs, valley fill sediments and saprolite layers along the northern edge of Moanalua Valley. Groundwater quality data are used to evaluate the groundwater quality to the south of the facility. This location was moved south of the original location across the freeway due to property access issues. It partially meets the original objectives of the well. The well screen is installed across the basal water table.	208.5	190.7	81–211	216
NMW32	Āliamanu Crater	✓	✓	NMW32 provides groundwater elevation data southwest of Red Hill Shaft, southwest of the Red Hill tanks and between Moanalua and Hālawa Valleys. The data from this well will be used to further evaluate groundwater flow patterns southwest of the Facility. Lithologic data from this location will be used to further define the geometry and extent of the Āliamanu Crater volcanic tuffs, valley fill sediments and saprolite layers along the northern edge of Moanalua Valley. Groundwater quality data will be used to evaluate the groundwater quality to the southwest of the facility where no nearby monitoring wells currently exist. The well screen is installed across the basal water table.	188.5	171.13	161–191	211
NMW33	Āliamanu Crater	✓	✓	NMW33 provides groundwater elevation data southwest of Red Hill Shaft and the Red Hill tanks and south of Hālawa Valley. Lithologic data from this location will be used to further define the geometry and extent of the Āliamanu Crater volcanic tuffs, valley fill sediments and saprolite layers along the southern edge of Hālawa Valley. Groundwater quality data will be used to evaluate the groundwater quality to the southwest of the facility. This well is co-located with proposed well NMW33A. The well screen is installed across a perched water table in volcanic tuff.	131	117.53	108–138	143.7

Well	Area	Monitoring Well	Caprock / Saprolite	Data Objectives and Rationale	Well Installation Parameters			
					Surface Elevation (ft msl)	Depth to Groundwater (ft bgs)	Monitoring Well Screen Interval (ft bgs)	Total Depth (ft bgs)
NMW30	Āliamanu Crater	✓	✓	NMW30 provides groundwater elevation data south of Red Hill Shaft, south southwest of the Red Hill tanks and adjacent to Moanalua Valley. The data from this well will be used to further evaluate groundwater flow patterns south of the Facility and determine whether there was fuel in this down-dip direction from the Facility. Lithologic data from this location will be used to further define the geometry and extent of the Āliamanu Crater volcanic tuffs, valley fill sediments and saprolite layers along the northern edge of Moanalua Valley. Groundwater quality data will be used to evaluate the groundwater quality to the south of the Facility where no nearby monitoring wells currently exist. Former proposed location was considered not viable based on site reconnaissance. The SS location was selected to be a short distance to the southeast (approximately downgradient) of Red Hill Shaft to help determine the downgradient stagnation area for RHS capture and monitor for potential migration toward Moanalua. NMW30 and to a lesser extent NMW25 will partially meet the original objectives of the SS location, even though different stratigraphy may be encountered. The well screen is installed across the basal water table.	310	292.63	282–312	325
RHMW18	Tank Farm	✓		RHMW18 is located northeast of the tank farm to assess groundwater quality and further evaluate groundwater elevations and flow directions on Red Hill ridge upslope from the tank farm. Its location was selected to be up-ridge of the tunnel wells. Lithologic data from this location will be used to further define the properties of basalt farther up the ridge Groundwater quality data will be used to evaluate the potential for COPCs to travel to the north. The well screen is installed across the basal water table.	621.8	601.83	592–622	633.5
NMW26	North Hālawa Valley	✓		NMW26 is located northwest of North Hālawa Valley and north of the tank farm. It was installed to assess groundwater quality and further evaluate groundwater elevation and flow directions adjacent to North Hālawa Valley. The well will provide geologic and hydrogeologic information at higher elevations relative to the site. The well screen is installed across the basal water table.	767	750.36	741–771	790.5
NMW34	North Hālawa Valley	✓	✓	NMW34 provides groundwater elevation data to further evaluate groundwater flow patterns west of North Hālawa Valley in the vicinity of Navy ʻAiea Hālawa Shaft, as well as groundwater flow patterns in and adjacent to the confluence of North and South Hālawa Valleys, and the potential for groundwater flow toward the west-northwest. Lithologic data from this location will be used to further define the geometry and extent of the volcanic tuff, valley fill sediments, caprock and saprolite layers along the western edge of Hālawa Valley. Groundwater quality data will be used to evaluate the groundwater quality proximal Navy ʻAiea Hālawa Shaft. The well screen is installed across the basal water table.	82.3	65.7	56–86	95

Notes:
[a] Deep wells (i.e., to be screened deeper than the basal head elevation in water table conditions or below the confining unit in confined conditions) will be investigated to identify zones of higher flow and/or good hydraulic connection to the basal aquifer by means of periodically pausing drilling to perform water level and water quality testing (e.g., associated with or following bailing, slug testing, and/or pumping; with or without use of packer(s) to isolate testing zones), video logging, and/or geophysical logging. Boreholes in confined conditions will be extended at least 60 ft below the base of the confining unit and good hydraulic communication with the basal aquifer in order to provide sufficient borehole length for this testing.



Co-located Wells

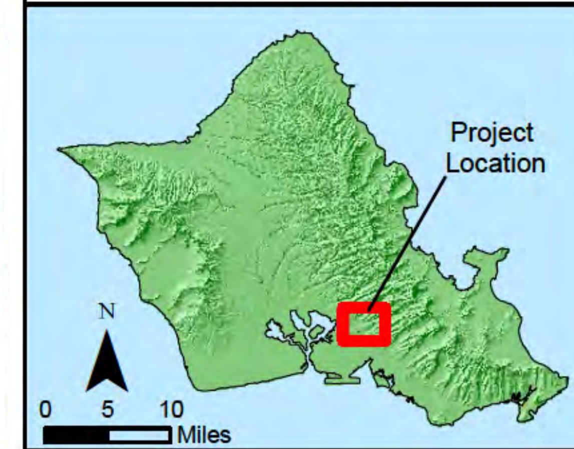
Paired wells will be a combination of one of the following depending on conditions encountered:

1 - water table well and deeper unconfined basal well,
2 - confined basal well and deeper confined basal well, or
3 - perched/elevated head well and water table well or confined basal well

Proposed candidates for co-located wells:

NMW28/NMW28A - confined basal well and deeper confined basal well
NMW29/NMW29A - water table well and deeper unconfined basal well
NMW38/NMW38A - elev head well and confined basal well
NMW42/NMW42A - elev head well and confined basal well
NMW43/NMW43A - elev head well and confined basal well
RHMW44/RHMW44A - unconfined basal well and deeper unconfined basal well
RHMW45/RHMW45A - unconfined basal well and deeper unconfined basal well
RHMW46/RHMW46A - unconfined basal well and deeper unconfined basal well
RHMW47/RHMW47A - unconfined basal well and deeper unconfined basal well
RHMW48/RHMW48A - unconfined basal well and deeper unconfined basal well
RHMW49/RHMW49A - unconfined basal well and deeper unconfined basal well
RHMW49/RHMW49A - unconfined basal well and deeper unconfined basal well
NMW50/NMW50A - unconfined basal well and deeper unconfined basal well
NMW51/NMW51A - unconfined basal well and deeper unconfined basal well

Location Map



Legend

- Potential New Monitoring Well Expected to be Completed as a Water Table Well
- Potential New Monitoring Well Expected to be Completed as a Deeper Screened Well in the Basaltic Basal Aquifer beneath Tuff or other Surficial Units (the well may be installed in the confined or unconfined aquifer as a confined or unconfined basal well)
- Red Hill Facility Boundary
- Stream

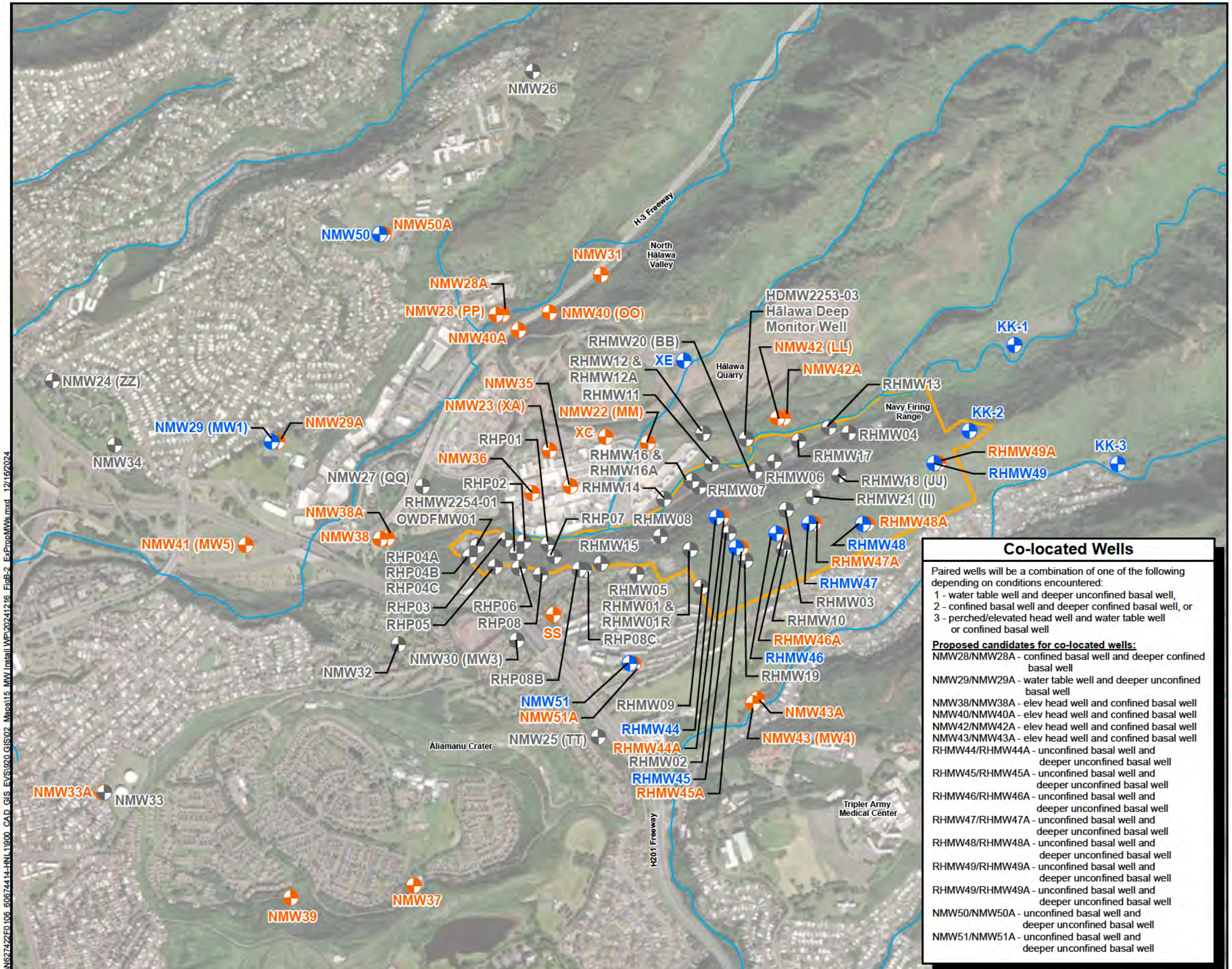
Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Base Map Service Layer Credits: Esri, Maxar, Earthstar Geographics and the GIS User Community

N
0 700 1,400 2,800 Feet

Figure B-1
Potential New Monitoring Well Locations
Monitoring Well Installation Work Plan
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

B:\N627422F0106_60674414-HNL1\900_CAD_GIS_EVS\920_GIS\02_Maps\15_MW Install WP\20241205_FigB-1_PropMWs.mxd 12/5/2024



Co-located Wells

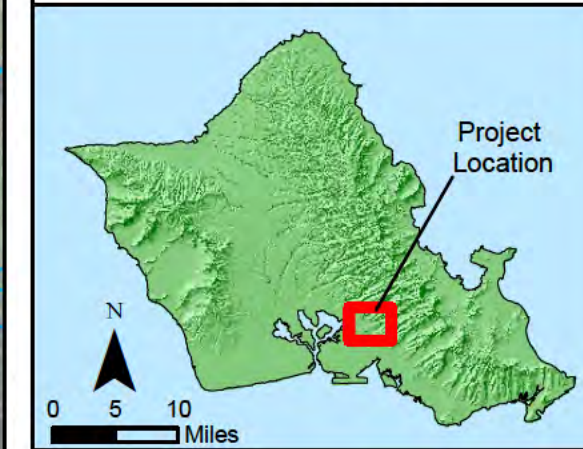
Paired wells will be a combination of one of the following depending on conditions encountered:

1 - water table well and deeper unconfined basal well,
2 - confined basal well and deeper confined basal well, or
3 - perched/elevated head well and water table well or confined basal well

Proposed candidates for co-located wells:

NMW28/NMW28A - confined basal well and deeper confined basal well
NMW29/NMW29A - water table well and deeper unconfined basal well
NMW38/NMW38A - elev head well and confined basal well
NMW40/NMW40A - elev head well and confined basal well
NMW42/NMW42A - elev head well and confined basal well
NMW43/NMW43A - elev head well and confined basal well
RHMW44/RHMW44A - unconfined basal well and deeper unconfined basal well
RHMW45/RHMW45A - unconfined basal well and deeper unconfined basal well
RHMW46/RHMW46A - unconfined basal well and deeper unconfined basal well
RHMW47/RHMW47A - unconfined basal well and deeper unconfined basal well
RHMW48/RHMW48A - unconfined basal well and deeper unconfined basal well
RHMW49/RHMW49A - unconfined basal well and deeper unconfined basal well
RHMW49/RHMW49A - unconfined basal well and deeper unconfined basal well
NMW50/NMW50A - unconfined basal well and deeper unconfined basal well
NMW51/NMW51A - unconfined basal well and deeper unconfined basal well

Location Map



Legend

- Existing Monitoring Well
- Potential New Monitoring Well Expected to be Completed as a Water Table Well
- Potential New Monitoring Well Expected to be Completed as a Deeper Screened Well in the Basaltic Basal Aquifer beneath Tuff or other Surficial Units (the well may be installed in the confined or unconfined aquifer as a confined or unconfined basal well)
- Red Hill Facility Boundary
- Stream

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Base Map Service Layer Credits: Esri, Maxar, Earthstar Geographics and the GIS User Community

N

0 700 1,400 2,800 Feet

Figure B-2
Existing and Potential New Monitoring Well Locations
Monitoring Well Installation Work Plan
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

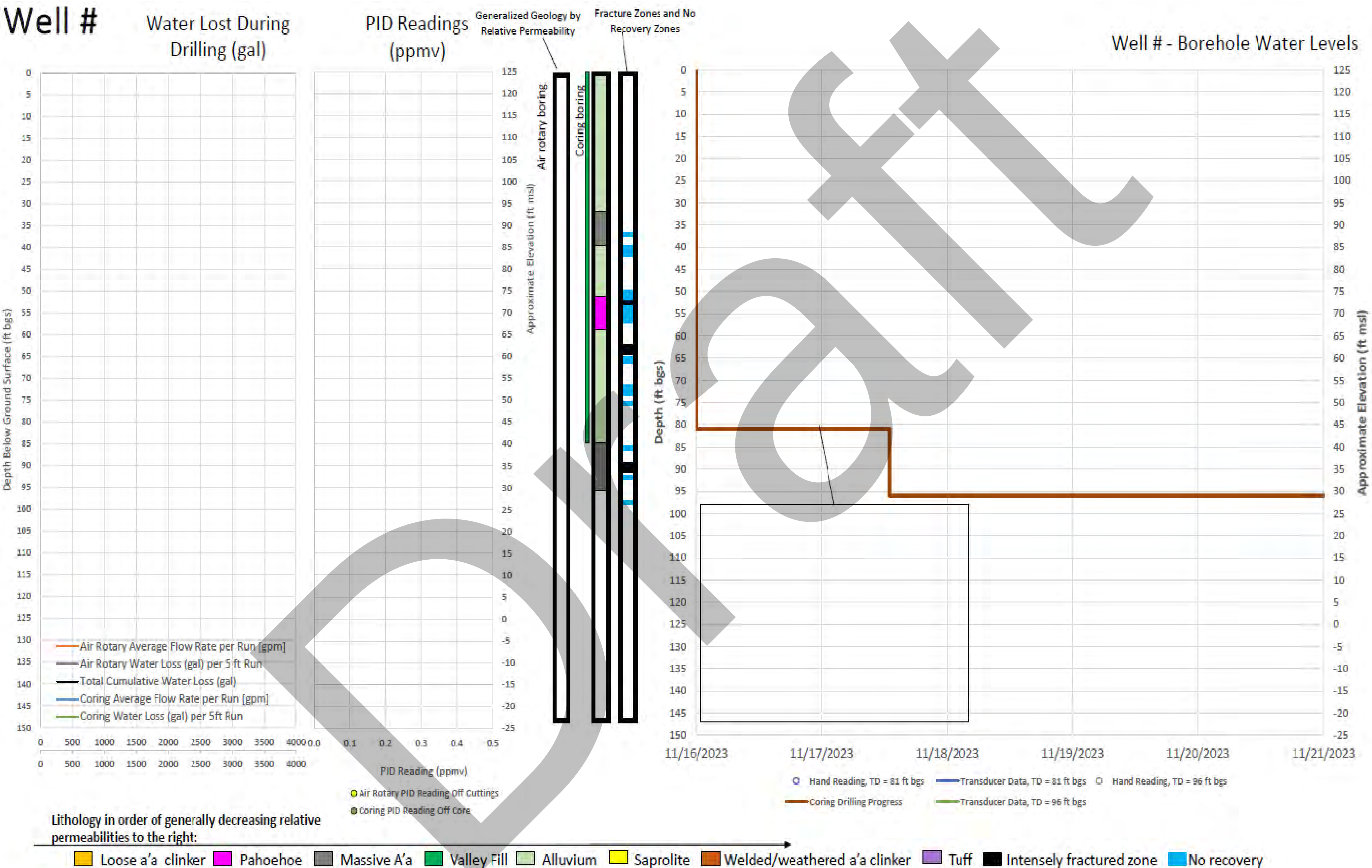
Appendix C:
Weekly Drilling and Well Installation Notifications

Field Parameter Data

Date	Depth (ft bgs) / Elevation (ft msl)	Approximate Gallons Removed	TDS (ppt)	pH	Specific Conductivity (µS/cm)	DO (mg/L)	Turbidity (NTU)	Temperature (°C)	ORP (mV)	Sal (psu)
	Drill Water									
	Drill Water									

PID Readings (Ground Surface XXX ft msl)

PID Reading Off Cuttings (Air Rortary)					
Depth (ft bgs)	PID (ppmv)	Depth (ft bgs)	PID (ppmv)	Depth (ft bgs)	PID (ppmv)


Well #
Water Lost During Drilling (gal)
PID Readings (ppmv)
Generalized Geology by Relative Permeability
Fracture Zones and No Recovery Zones
Well # - Borehole Water Levels
Depth Below Ground Surface (ft bgs)
Approximate Elevation (ft msl)
Air rotary boring
Coring boring
Depth (ft bgs)
Approximate Elevation (ft msl)
Air Rotary Average Flow Rate per Run [gpm]
Air Rotary Water Loss (gal) per 5 ft Run
Total Cumulative Water Loss (gal)
Coring Average Flow Rate per Run [gpm]
Coring Water Loss (gal) per 5ft Run
PID Reading (ppmv)
Air Rotary PID Reading Off Cuttings
Coring PID Reading Off Core
11/16/2023
11/17/2023
11/18/2023
11/19/2023
11/20/2023
11/21/2023
Hand Reading, TD = 81 ft bgs
Transducer Data, TD = 81 ft bgs
Hand Reading, TD = 96 ft bgs
Coring Drilling Progress
Transducer Data, TD = 96 ft bgs
Lithology in order of generally decreasing relative permeabilities to the right:
Loose a'a clinker
Pahoehoe
Massive A'a
Valley Fill
Alluvium
Saprolite
Welded/weathered a'a clinker
Tuff
Intensely fractured zone
No recovery

Appendix D:
Quality Assurance Project Plan (QAPP)
Data Package Requirements for Chemical Analyses

Table D-1: GC-FID Stage 4 Deliverables

Item No.	Deliverable
1*	Chain of Custody
2*	Sample results with analysis and extraction/preparation dates
3*	Summary of MS/MSD/Duplicate recoveries and control limits (listing or link with associated samples)
4*	Summary of LCS/LCSD recoveries and control limits (listing or link with associated samples)
5*	Method blanks (listing or link with associated samples)
6*	Summary of surrogate recoveries
7*	Summary of initial calibration data (RF and %RSD, or r if applicable)
8*	Summary of continuing cal bration (%D)
9*	Injection logs
10*	Extraction/preparation logs
11*	Case narrative to discuss anomalies
12	Raw data associated with the summary forms listed above
13	Raw data for item #2 which includes chromatograms, logbooks, quantitation reports, and spectra

Note: The data deliverable package must have a table of contents and be paginated.

%D percent difference
%RSD percent relative standard deviation
MS matrix spike
MSD matrix spike duplicate
LCS laboratory control sample
LCSD laboratory control sample duplicate
RF response factor

* Included in Level 2B report.

Table D-2: GC-MS Stage 4 Deliverables

Item No.	Deliverable
1*	Chain of Custody
2*	Sample results with analysis and extraction/preparation dates
3*	Summary of MS/MSD/Duplicate recoveries and control limits (listing or link with associated samples)
4*	Summary of LCS/LCSD recoveries and control limits (listing or link with associated samples)
5*	Method blanks (listing or link with associated samples)
6*	Summary of surrogate recoveries
7*	Summary of initial calibration data (RRF and %RSD, or r if applicable)
8*	Summary of continuing cal bration (%D and RRF)
9*	Summary of internal standards (area response and retention time)
10*	Summary of instrument tuning (listing or link with associated samples, must show 12-hour clock)
11*	Injection logs
12*	Extraction/preparation logs
13*	Case narrative to discuss anomalies
14	Raw data associated with the summary forms listed above
15	Raw data for item #2 which includes chromatograms, logbooks, quantitation reports, and spectra

Note: The data deliverable package must have a table of contents and be paginated.

%D percent difference
%RSD percent relative standard deviation
MS matrix spike
MSD matrix spike duplicate
LCS laboratory control sample
LCSD laboratory control sample duplicate
RF response factor
RRF relative response factor

* Included in Level 2B report.

Table D-3: General Chemistry Stage 2B Deliverables

Item No.	Deliverable
1*	Chain of custody
2*	Sample results with analysis and extraction/preparation dates
3*	Summary of MS/MSD/Duplicate recoveries and control limits (listing or link with associated samples)
4*	Summary of LCS/LCSD recoveries and control limits (listing or link with associated samples)
5*	Method blanks (listing or link with associated samples)
6*	Summary of initial calibration data (correlation coefficient, r)
7*	Summary of continuing cal bration (%D or % recovery), if applicable
8*	Injection logs
9*	Extraction/preparation logs, if applicable
10*	Case narrative to discuss anomalies
11	Raw data associated with the summary forms listed above
12	Raw data for item #2, which includes logbooks, quantitation reports, and spectra

Note: The data deliverable package must contain a table of contents and be paginated.
%D percent difference
MS matrix spike
MSD matrix spike duplicate
LCS laboratory control sample
LCSD laboratory control sample duplicate
* Included in Level 2B report.

DATA DELIVERABLES REQUIREMENTS

The final report package will include amended and additional pages requested during data review and validation. To support the data review and validation by AECOM Technical Services, Inc. or third-party, the laboratory shall be required to submit a final report electronically with the following directly into the EDMS online database:

- The images shall be clear and legible.
- The images shall be right side up.
- The images shall be straight.
- The report shall be submitted in Portable Document Format (PDF) and each file shall be bookmarked. The PDF shall be identified by the sample delivery group (SDG, also known as batch or work order) number.
- If the images are not clear, legible, right side up, straight or in order, then the laboratory shall resubmit the PDF.
- The report cover page or narrative shall contain the following information:
  - Navy contract number
  - Contract task order name and number
  - Sample delivery group number
  - Matrices and methods
  - Date of submittal
- The EDD for each report shall be submitted to the EDMS database in the format below:

Laboratory Electronic Data Specification

Data from the laboratory.

FieldName	Data Type	VVL?	Required?	Column Width	Start Position	End Position	Description
AFIID	varchar	True	Yes	5	1	5	Facility identification is the unique code used to represent an installation, plant, or base.
LOCID	varchar	False	Conditional	15	7	21	Location Identification is the unique identifier assigned to a location within a project where measurements or samples are taken.
LOGDATE	varchar	False	Conditional	11	23	33	The date that the groundwater was collected.The format for this field is [DD-MMM-YYYY] where YYYY is the calendar year, MMM is the abbreviated month and DD is the numeric date.
LOGTIME	varchar	False	Conditional	4	35	38	The time of the day (24 hour clock) that a sample is collected, a field measurement is made, or a quality control sample is created. This value is expressed in the HHMM format of the Local Time.
MATRIX	varchar	True	Yes	2	40	41	Sampling Matrix is a coded value identifying the specific sample medium actually being analyzed. I.e., soil, water, drill cuttings, waste water, etc.
SBD	numeric	False	No	8	43	50	Sample Beginning Depth is the upper depth in feet from the ground surface or the water surface at which a sample is collected or recovered.
SED	numeric	False	No	8	52	59	Sample Ending Depth is the lower depth in feet from the ground surface or the water surface at which a
SACODE	varchar	True	Yes	2	61	62	Sample Code is a coded value identifying whether the sample is a QC or normal.
SAMPNO	int	False	Yes	2	64	65	Sample Number is the numerical identifier for the sample taken.
LOGCODE	varchar	True	No	4	67	70	Logging Company Code is the coded value identifying the company performing the field tests.
SMCODE	varchar	True	No	2	72	73	Sample Method Code is a coded value identifying the sampling method used to collect a sample.
FLDSAMPID	varchar	False	Yes	30	75	104	Field Sample Identification is a unique number assigned to the sample in the field. This number will be a reference to the specific sample regardless of the sample date or location.
COCID	varchar	False	No	12	106	117	Chain of Custody Identification is a unique identification reference to the chain of custody describing the transport of the sample to the laboratory.
COOLER	varchar	False	No	2	119	120	Cooler Number is the unique number assigned to the cooler transporting the sample.
ABLOT	varchar	False	No	8	122	129	Ambient Blank Field Lot Identifier is used to link the lot of normal samples (collected in the field) to the corresponding ambient blank. There will only be an entry for normal samples that are associated to an ambient blank. This field in the sample record for the ambient blank itself will be left blank. The format for the Ambient Blank Field Lot Identifier is [DDMMYYNN] where DD is the numeric date, MM is the number for the month, YY is the last two digits of the calendar year, and NN is the sequentially assigned number for the lot.

Laboratory Electronic Data Specification

Data from the laboratory.

FieldName	Data Type	VVL?	Required?	Column Width	Start Position	End Position	Description
EBLOT	varchar	False	No	8	131	138	Equipment Blank Field Lot Identifier is used to link the lot of normal samples (collected in the field) to the corresponding equipment blank. There will only be an entry for normal samples that are associated to an equipment blank. This field in the sample record for the equipment blank itself will be left blank. The format for the Equipment Blank Field Lot Identifier is [DDMMYYNN] where DD is the numeric date, MM is the number for the month, YY is the last two digits of the calendar year, and NN is the sequentially assigned number for the lot.
TBLOT	varchar	False	No	8	140	147	Trip Blank Field Lot Identifier is used to link the lot of normal samples (collected in the field) to the corresponding trip blank. There will only be an entry for normal samples that are associated to a trip blank. This field in the sample record for the trip blank itself will be left blank. The format for the Trip Blank Field Lot Identifier is [DDMMYYNN] where DD is the numeric date, MM is the number for the month, YY is the last two digits of the calendar year, and NN is the sequentially assigned number for the lot.
REMARKS	varchar	False	No	240	149	388	Contains comments about the sample.
SDG	varchar	False	No	20	390	409	A lab created code used to identify a group or selection of samples. The SDG is used for processing and reporting accuracy by labs. This value is included in a prime project file for integrity references.
LABCODE	varchar	True	Yes	4	411	414	Analytical Laboratory Code is a coded value identifying the laboratory which performed the analysis of the samples.
ANMCODE	varchar	True	Yes	7	416	422	Analytical method code is a coded value representing the method of analyses of a given parameter.
EXMCODE	varchar	True	Yes	7	424	430	Extraction Method Code is a coded value representing the method used to extract or prepare a sample.
LCHMETH	varchar	True	Yes	7	432	438	Leachate Method is a coded value identifying the leachate method used in the test.
RUN_NUMBER	int	False	Yes	2	440	441	This information is stored in the test procedure class and is replaced by the use of test sequence.
LABSAMPID	varchar	False	Yes	20	443	462	Lab Sample Identification is a unique number assigned to a sample by a laboratory and included in the reporting of the results. This number is the prime number that the Lab will use to reference a specific sample for tests and results.
EXTDATE	varchar	False	Conditional	11	464	474	Extraction Date is the data that represents the start of an extraction test or other preparation methods. The format is [DD-MMM-YYYY] where YYYY is the calendar year, MM is the numeric month and DD is the numeric date.
EXTTIME	varchar	False	Conditional	4	476	479	Extraction Time is the time of day (24 hour clock) that represents the start of an extraction test or other preparation methods. This value is expressed in HHMM of the local time.
LCHDATE	varchar	False	Conditional	11	481	491	Leachate Date is the date on which a sample was leached. The format is [DD-MMMYYYY] where YYYY is the calendar year, MM is the numeric month and DD is the numeric date.

Laboratory Electronic Data Specification

Data from the laboratory.

FieldName	Data Type	VVL?	Required?	Column Width	Start Position	End Position	Description
LCHTIME	varchar	False	Conditional	4	493	496	Leachate Time is the time of day (24 hour clock) that represents the time a sample was leached. This value is expressed in HHMM of the local time.
LCHLOT	varchar	False	Conditional	10	498	507	Leachate Lot is the batch designator of an autonomous group of environmental samples and associated quality control samples leached together.
ANADATE	varchar	False	Yes	11	509	519	Analysis Date is a date that represents the start of a test or procedure. The Date represents the date the sample or extraction is analyzed in the laboratory.The format is [DD-MMM-YYYY] where YYYY is the calendar year, MMM is the abbreviated month and DD is the numeric date.
ANATIME	varchar	False	Yes	4	521	524	Analysis Time is the time of day (24 hour clock) that represents the datart of a test or procedure. This value is expressed in HHMM of the local time.
ANALOT	varchar	False	Yes	10	526	535	Analysis Lot is the batch designator of an autonomous group of environmental samples and associated quality control samples analyzed together.
LABLOTCTL	varchar	False	Yes	10	537	546	Lab Lot Control is a more general identifier to indicate extractions or other preparation methods during the testing process.
CALREFID	varchar	False	No	10	548	557	Calibration Reference Identification is a coded value which establishes a reference link between environmental and quality control samples and their corresponding calibration records.
RTTYPE	varchar	True	No	5	559	563	Remediation Technology Type is a coded value describing the type of remediation technology being used. This value is the coded value for remediation technology like slurry wall, in situ vitrification, bio-reactor, etc.
BASIS	varchar	True	Yes	1	565	565	Basis is a coded value detailing whether tissue or solid sample results are reported on a wet (W) or dry (D) basis.
PARLABEL	varchar	True	Yes	12	567	578	Parameter Label Code is an abbreviated, common acronym representing a parameter/analyte.
PRCCODE	varchar	True	Yes	3	580	582	Parameter Class Code is a coded value identifying a class or group that a parameter is associated with. I. e., ORG, MET, STD, etc.
PARVQ	varchar	True	Yes	2	584	585	Parameter Value Qualifier is a coded value qualifying the analytical results field (Parameter Value). Note that in general, this field does not indicate QC failures or deficiencies such as accuracy, precision, blank contamination, or holding time violations.
PARVAL	numeric	False	Yes	17	587	603	Parameter value is the value of a calculated parameter reported in units consistent with the Units field.
PARUN	numeric	False	Conditional	13	605	617	Parameter Uncertainty is a value which measures the uncertainty of the measurement. This value is expressed as positive (+) or negative (-) some value.
PRECISION_	int	False	Yes	1	619	619	Precision is number indicating the number of digits after the decimal point of the results.
EXPECTED	float	False	Conditional	17	621	637	Expected Result is a number indicating the target result for a quality control sample or surrogate spike.

Data from the laboratory.

FieldName	Data Type	VVL?	Required?	Column Width	Start Position	End Position	Description
EVPREC	int	False	Conditional	1	639	639	Expected Value Precision is a number indicating the number of digits after the decimal point in the results of a test.
MDL	numeric	False	Yes	17	641	657	Method detection limit is the smallest quantity of an analyte that can be detected from a prepared sample.
RL	numeric	False	Yes	17	659	675	Reporting Limit is a number which is the smallest quantity of an analyte that should be reported in accordance with the QAPP.
UNITS	varchar	True	Yes	10	677	686	The Units field refers to the units of measure used for the parameter value.
VQ_1C	varchar	True	Conditional	2	688	689	1C Value Qualifier is a coded value qualifying the analytical results field.
VAL_1C	numeric	False	Conditional	17	691	707	First Column Parameter Value is a number field which represents the primary or initial value for a analyte generated from a Gas Chromatography or Gas Chromatography/Mass Spectroscopy results.
FCVALPREC	int	False	Conditional	1	709	709	First Column Value Precision is a number indicating the number of digits after the decimal point of the results of a test.
VQ_CONFIRM	varchar	True	Conditional	2	711	712	Value Qualifying Confirmation is a coded value qualifying the confirming analytical result.
VAL_CONFIRM	numeric	False	Conditional	17	714	730	Confirming Value is a number value of a chromatographic analytical result that requires second column confirmation.
CNFVALPREC	int	False	Conditional	1	732	732	Confirmation Value Precision is a number indicating the number of digits after the decimal point of the results of a test.
DILUTION	numeric	False	Yes	17	734	750	Dilution Required is a numeric expression of the amount of dilution required to bring the analyte concentration in the sample into analysis range.
PRIME_DQT	varchar	True	No	5	752	756	Prime Data Qualifier Type is a coded value identifying the type of data qualifier that the prime used
PRIME_FLAG	varchar	True	No	6	758	763	Prime Flags are codes that are assigned during chemistry data validation.
LAB_DQT	varchar	True	No	5	765	769	Laboratory Data Qualifier Type is a coded value indicating the specific QAPP or DQO document from which the entered performance criteria data originates.
LAB_QC_FLAG	varchar	True	Conditional	6	771	776	Laboratory Quality Control Flag is coded values entered by the laboratory to indicate the existence of a specific quality control exception or condition.
BEST_RESULT	varchar	False	Yes	1	778	778	Best Result is a single value that has been determined to be the best result. I.e., the value reported in the prime contractor's final report for the sampling event in focus. Appropriate Values are Y (Yes) or N (No)
REASON_CODE	varchar	False	No	30	780	809	Reason Code is a coded value that indicates why a laboratory or contractor flag was issued to a data point.
PERCENT_RECOVERY	numeric	False	Conditional	15	811	825	Percent Recovery is the calculated recovery value for the spiked or surrogate analyte. This value is expressed in percent plus 2 decimals.
RPD	numeric	False	Conditional	15	827	841	Relative Percent Difference is a measure of variability that adjust for the magnitude of observations. This value is used to assess total and analytical precision of duplicate measurements.

Laboratory Electronic Data Specification

Data from the laboratory.

FieldName	Data Type	VVL?	Required?	Column Width	Start Position	End Position	Description
UPPER_RPD	numeric	False	Conditional	15	843	857	Upper Relative Percent Difference is a number representing the upper performance limit for relative percent difference.
UPPER_ACCURACY	numeric	False	Conditional	15	859	873	Accuracy Upper Limit is a number representing the upper control limit of percent recovery as measured for a known target analyte spiked into a quality control sample.
LOWER_ACCURACY	numeric	False	Conditional	15	875	889	Accuracy Lower Limit is a number representing the lower control limit of percent recovery as measured for a known target analyte spiked into a quality control sample.
SPIKE_ADDED	numeric	False	Conditional	17	891	907	Spike Amount Added is a number value of a final concentration of an analyte spiked into a sample.
SPIKE_ADDED_PREC	smallint	False	Optional	1	909	909	Spike Amount Added Precision is number indicating the number of digits after the decimal point of the spike added.
VALCODE	varchar	True	No	4	911	914	Coded value identifying the company validating analytical results.
TIC_NAME	varchar	False	No	54	916	969	Name of the Tentatively Identified Compound being reported.
RETENTION_TIME	varchar	False	No	6	971	976	Retention time of a Tentatively Identified Compound.
LOD	numeric	False	No	17	978	994	Limit of Detection

Valid values can be found on the project portal; navigate to Reports, ADR and Submission Reports, Valid Value Lists and select the field of interest from the dropdown menu.

Data Type Descriptions

float	A number in scientific notation containing a variable number of decimal places
int	An integer from -2,147,483,648 to 2,147,483,647
numeric	A number containing a fixed number of decimal places
smallint	An integer from -32,768 to 32,767
varchar	Text of variable length

Appendix D.1: Field Sampling, Analytical, and Quality Management Reference Tables

ACRONYMS AND ABBREVIATIONS

%D	percent difference
BFB	4-bromofluorobenzene
CA	corrective action
CAS	Chemical Abstracts Service
CCV	continued calibration verification
D	difference
DFTPP	decafluorotriphenylphosphine
DoD	Department of Defense
DQI	data quality indicator
EICP	extracted ion current profile
EPA	Environmental Protection Agency, United States
g	gram
GC	gas chromatography
GC-FID	gas chromatography-flame ionization detector
GC-MS	gas chromatography-mass spectrometry
HCl	hydrogen chloride
ICAL	initial calibration
ICV	initial calibration verification
IS	internal standard
L	liter
LCS	laboratory control sample
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
mg/kg	milligram per kilogram
mL	milliliter
MPC	measurement performance criteria
MS	matrix spike
MSD	matrix spike duplicate
N/A	not applicable
NIST	National Institute of Standards and Technology
oz	ounce
PFTBA	perfluorotributylamine
QA	quality assurance
QC	quality control
QSM	Quality Systems Manual
RPD	relative percent difference
RRT	relative retention time
RSD	relative standard deviation
RT	retention time
SOP	standard operating procedure

Table D.1-1: Location-Specific Sampling Methods/SOP Requirements

A descriptive ID number will identify the sampling location, type, sequence, matrix, and depth. The descriptive ID number for all samples is assigned as follows:

For Soil & Product: AAAAA-BBCC##-ff.f-yymmwk#

Where:

AAAAA = Well Location area

For soil:

BB = Matrix (Table D.1-1.1)

CC = SACODE (normal or quality control [QC]) (Table D.1-1.2)

= Sample Number (e.g. 02 is the second sample taken at the same location within the same week)

ff.f = End depth of sample interval in ft bgs (measured to the tenth of a ft) for soil (e.g. 95.5 for 95 1/10 ft bgs)

yymmwk# **=** Sample collection date- yy is the 2-digit year, mm is the 2-digit month, and wk# is the week of the month (e.g. 2412WK3 for the 3rd Week of December2024)

As a soil example, the sample number NMW34-SON01-95.5-2412WK03 would indicate that the sample is collected from:

- Well Location Area NMW34 (Monitoring Well NMW34 at a depth of 95.5 ft)
- Matrix is “SO” (subsurface soil)
- SACODE is “N” (normal environmental sample, not a QC sample)
- Sample taken the 3rd Week of January 2025

As a QC sample example, the sample number NMW34-SQTB01-95.5-2412WK03 would indicate that the Equipment Blank (EB) sample is associated with:

- Associated QC sample is for Well Location Area NMW34 (Monitoring Well NMW34 at a depth of 95.5 ft)
- Associated QC matrix is “SQ” (soil/solid QC)

- SACODE is “TB01” (Trip blank QC sample, not a normal environmental sample)
- Sample taken the 3rd Week of January 2025

These characters will establish a unique descriptive identifier that will be used during data evaluation.

Table D.1-1.1: Sample Type and Matrix Identifiers

Identifier	Sample Type	Matrix
SS	Surface Unconsolidated Material	Unconsolidated Material
SO	Subsurface Unconsolidated Material	Unconsolidated Material
LA	Light Non-Aqueous Phase Liquids	LNAPL
SQ	QC Soil	QC

Table D1-1.1: Field QC (SACODE) Type Identifiers

Identifier	Field or QC Sample Type	Description
N	Primary Sample	All field samples except QC samples
FD	Field Duplicate	Co-located for unconsolidated material
TB	Trip Blank	Water

Sampling ID Number	Matrix	Analytical Group	Number of Samples	Sampling SOP Reference
AAAAA-SOCC##-ff.f-yymmwk#	Unconsolidated Material	Chemical Analyses: VOCs, PAHs, TPH	1 primary per location [a, b] 1 duplicate per location [b] 1 MS/MSD pair per event [b] 1 trip blank per event [c]	Procedure I-B-1 *Soil Sampling*
AAAAA-SOCC##-ff.f-yymmwk#	Unconsolidated Material	Chemical Analyses: TPH with Silica Gel Cleanup	Contingent on non-Silica Gel Cleaned TPH-d and TPH-o detections [d]	Procedure I-B-1 *Soil Sampling*
AAAAA-SOCC##-ff.f-yymmwk#	Unconsolidated Material	Geotechnical Analyses: Atterberg Limits, Effective Porosity, Permeability, Moisture Content and Density, Grain Size Distribution, Cation Exchange Capacity, pH, Total Organic Carbon	1 primary per location [a, b]	Procedure I-B-1 *Soil Sampling*
AAAAA-LACC##-ff.f-yymmwk#	Product [e]	Dynamic viscosity, density, interfacial tension, Saturated Hydrocarbon, Alkylated PAHs, PIANO	1 primary	Procedure I-B-1 *Soil Sampling*

Note: Procedures are from the *Project Procedures Manual* (DON 2015).

[a] Actual number of unconsolidated material samples will be dependent on field observations during coring. Refer to Section 6 of MWIWP
[b] Volumes for geotechnical, field duplicate, and MS/MSD samples will only be collected if sufficient unconsolidated material is present at each sampling interval. If limited volume is present, collecting volume for VOCs, PAHs, and TPH will take priority.
[c] One trip blank will be collected during each unconsolidated material sampling event.
[d] TPH with silica gel cleanup will only be analyzed for sample with detections of TPH-d and TPH-o from the non-silica gel cleaned extract.
[e] Testing will commence upon confirmation with Navy.

Table D.1-2: Analyte List and Reference Limits

Matrix–Unconsolidated Material

Analyte	CAS No.	DOH EAL (mg/kg)[a,b]	PSL (mg/kg)	Laboratory-Specific Limits		
				LOQ (mg/kg)	LOD (mg/kg)	DL (mg/kg)
VOCs						
Benzene	71-43-2	0.3	0.3	0.25	0.1	0.025
Ethylbenzene	100-41-4	3.7	3.7	0.25	0.05	0.02
m,p-Xylenes	1330-20-7	2.1	2.1	0.25	0.1	0.05
o-Xylenes	95-47-6	2.1	2.1	0.25	0.05	0.03
Toluene	108-88-3	3.2	3.2	0.25	0.1	0.03
TPH						
TPH-G (C5–C12)	STL00349	100	100	6.5	6.4	3.18
TPH-DRO (C12-C24)	STL00096	180	180	50	30	12.4
TPH-ORO (C24-C40)	STL00631	500	500	50	30	20
PAH						
1-Methylnaphthalene	90-12-0	4.2	4.2	0.0055	0.005	0.00238
2-Methylnaphthalene	91-57-6	4.1	4.1	0.006	0.005	0.00295
Naphthalene	91-20-3	4.4	4.4	0.005	0.004	0.00162

— Not Available
CAS Chemical Abstracts Service
DL detection limit
DOH department of health
EAL environmental action level
EPA environmental protection agency
LOD limit of detection
LOQ limit of quantitation
RSL regional screening levels
SL screening level
[a] references total Xylene values
[b] EALs (DOH 2024): Action Levels Surfer Table A-1, Soil Action Levels (groundwater is a current or potential drinking water resource; surface water body is not located within 150m of release site)

Matrix: LNAPL

Analytical Group: Alkylated PAHs (8270-SIM)

Analyte	CAS No.	PSL[a]	Laboratory-Specific Limits		
			LOQ	LOD	DL
1-Methylnaphthalene	90-12-0	—	TBD	TBD	TBD
2,3,5-Trimethylnaphthalene	2245-38-7	—	TBD	TBD	TBD
2,6-Dimethylnaphthalene	581-42-0	—	TBD	TBD	TBD
2-Methylnaphthalene	91-57-6	—	TBD	TBD	TBD
2-Methylnaphthalene	91-57-6	—	TBD	TBD	TBD
Acenaphthene	83-32-9	—	TBD	TBD	TBD
Acenaphthylene	208-96-8	—	TBD	TBD	TBD
Anthracene	120-12-7	—	TBD	TBD	TBD
Benz(a)anthracene	56-55-3	—	TBD	TBD	TBD
Benzo(a)pyrene	50-32-8	—	TBD	TBD	TBD
Benzo(b)fluoranthene	205-99-2	—	TBD	TBD	TBD
Benzo(e)pyrene	192-97-2	—	TBD	TBD	TBD
Benzo(g,h,i)perylene	191-24-2	—	TBD	TBD	TBD
Benzo(j)+(k)fluoranthene	BJFBKF	—	TBD	TBD	TBD
Biphenyl	92-52-4	—	TBD	TBD	TBD
C1-Chrysenes	C1_218-01-9	—	TBD	TBD	TBD
C1-D benzothiophenes BS	132-65-0C1	—	TBD	TBD	TBD
C1-Fluoranthenes/Pyrenes	PFLCA1	—	TBD	TBD	TBD
C1-Fluorenes	FLRC1	—	TBD	TBD	TBD
C1-Naphthalenes	NPHC1	—	TBD	TBD	TBD
C1-Naphthalenes	NPHC1	—	TBD	TBD	TBD
C1-Phenanthrenes/Anthracenes	C1_PHENANTH	—	TBD	TBD	TBD
C2-Chrysenes BS	C2_218-01-9	—	TBD	TBD	TBD
C2-D benzothiophenes	132-65-0C2	—	TBD	TBD	TBD
C2-Fluoranthenes/Pyrenes	PFLCA2	—	TBD	TBD	TBD
C2-Fluorenes	FLRC2	—	TBD	TBD	TBD
C2-Naphthalenes	NPHC2	—	TBD	TBD	TBD
C2-Phenanthrenes/Anthr BS	C2_PHENANTH	—	TBD	TBD	TBD

Matrix: LNAPL

Analytical Group: Alkylated PAHs (8270-SIM)

Analyte	CAS No.	PSL[a]	Laboratory-Specific Limits		
			LOQ	LOD	DL
C3-Chrysenes	C3_218-01-9	—	TBD	TBD	TBD
C3-D benzothiophenes	132-65-0C3	—	TBD	TBD	TBD
C3-Fluoranthenes/Pyrenes	PFLCA3	—	TBD	TBD	TBD
C3-Fluorenes	FLRC3	—	TBD	TBD	TBD
C3-Naphthalenes	NPHC3	—	TBD	TBD	TBD
C3-Phenanthrenes/Anthracenes	C3_PHENANTH	—	TBD	TBD	TBD
C4-Chrysenes	C4_218-01-9	—	TBD	TBD	TBD
C4-D benzothiophenes	132-65-0C4	—	TBD	TBD	TBD
C4-Fluoranthenes/Pyrenes	PFLCA4	—	TBD	TBD	TBD
C4-Naphthalenes	NPHC4	—	TBD	TBD	TBD
C4-Phenanthrenes/Anthracenes	C4_PHENANTH	—	TBD	TBD	TBD
Chrysene/Triphenylene	CHRYTRIPHEN	—	TBD	TBD	TBD
Dibenz(a,h)+(a,c)anthracene	DAHDAC	—	TBD	TBD	TBD
Dibenzofuran	132-64-9	—	TBD	TBD	TBD
Dibenzothiophene	132-65-0	—	TBD	TBD	TBD
Fluoranthene	206-44-0	—	TBD	TBD	TBD
Fluorene	86-73-7	—	TBD	TBD	TBD
Indeno(1,2,3-cd)pyrene	193-39-5	—	TBD	TBD	TBD
Naphthalene	91-20-3	—	TBD	TBD	TBD
Perylene	198-55-0	—	TBD	TBD	TBD
Phenanthrene	85-01-8	—	TBD	TBD	TBD
Pyrene	129-00-0	—	TBD	TBD	TBD
Retene	483-65-8	—	TBD	TBD	TBD

Note: Units are in mg/kg.

— not available
CAS Chemical Abstracts Service
DL detection limit
LOD limit of detection
LOQ limit of quantification
PSL Project screening level
TBD to be determined

[a] No project limits, results are only for characterization only.

Matrix: LNAPL
Analytical Group: Saturated Hydrocarbons (8015D)

Analyte	CAS No.	PSL[a]	Laboratory-Specific Limits		
			LOQ	LOD	DL
2,6,10-Trimethyldodecane (1380)	3891-98-3	—	TBD	TBD	TBD
2,6,10-Trimethyltridecane (1470)	TMTD1470	—	TBD	TBD	TBD
n-Decane (C10)	124-18-5	—	TBD	TBD	TBD
n-Docosane (C22)	629-97-0	—	TBD	TBD	TBD
n-Dodecane (C12)	112-40-3	—	TBD	TBD	TBD
n-Dotriacontane (C32)	544-85-4	—	TBD	TBD	TBD
n-Eicosane (C20)	112-95-8	—	TBD	TBD	TBD
n-Heneicosane (C21)	629-94-7	—	TBD	TBD	TBD
n-Hentriacontane (C31)	630-04-6	—	TBD	TBD	TBD
n-Heptacosane (C27)	593-49-7	—	TBD	TBD	TBD
n-Heptadecane (C17)	629-78-7	—	TBD	TBD	TBD
n-Heptatriacontane (C37)	7194-84-5	—	TBD	TBD	TBD
n-Hexacosane (C26)	630-01-3	—	TBD	TBD	TBD
n-Hexadecane (C16)	544-76-3	—	TBD	TBD	TBD
n-Hexatriacontane (C36)	630-06-8	—	TBD	TBD	TBD
n-Nonacosane (C29)	630-03-5	—	TBD	TBD	TBD
n-Nonadecane (C19)	629-92-5	—	TBD	TBD	TBD
n-Nonane (C9)	111-84-2	—	TBD	TBD	TBD
n-Nonatriacontane (C39)	7194-86-7	—	TBD	TBD	TBD
n-Octacosane (C28)	630-02-4	—	TBD	TBD	TBD
n-Octadecane (C18)	593-45-3	—	TBD	TBD	TBD
n-Octatriacontane (C38)	7194-85-6	—	TBD	TBD	TBD
Norpristane (1650)	3892-00-0	—	TBD	TBD	TBD
n-Pentacosane (C25)	629-99-2	—	TBD	TBD	TBD
n-Pentadecane (C15)	629-62-9	—	TBD	TBD	TBD
n-Pentatriacontane (C35)	630-07-9	—	TBD	TBD	TBD
n-Tetracontane (C40)	4181-95-7	—	TBD	TBD	TBD
n-Tetracosane (C24)	646-31-1	—	TBD	TBD	TBD

Matrix: LNAPL

Analytical Group: Saturated Hydrocarbons (8015D)

Analyte	CAS No.	PSL[a]	Laboratory-Specific Limits		
			LOQ	LOD	DL
n-Tetradecane (C14)	629-59-4	—	TBD	TBD	TBD
n-Tetratriacontane (C34)	14167-59-0	—	TBD	TBD	TBD
n-Triacontane (C30)	638-68-6	—	TBD	TBD	TBD
n-Tricosane (C23)	638-67-5	—	TBD	TBD	TBD
n-Tridecane (C13)	629-50-5	—	TBD	TBD	TBD
n-Tritriacontane (C33)	630-05-7	—	TBD	TBD	TBD
n-Undecane (C11)	1120-21-4	—	TBD	TBD	TBD
Phytane	638-36-8	—	TBD	TBD	TBD
Pristane	1921-70-6	—	TBD	TBD	TBD
Total Petroleum Hydrocarbons (C9-C44)	TPH	—	TBD	TBD	TBD
Total Saturated Hydrocarbons	TSATHC	—	TBD	TBD	TBD

Note: Units are in mg/kg;

— not available
CAS Chemical Abstracts Service
DL detection limit
LOD limit of detection
LOQ limit of quantification
PSL Project screening level
TBD to be determined

[a] No project limits, results are only for characterization only.

Matrix: LNAPL

Analytical Group: PIANO (8260D)

Analyte	CAS No.	PSL [a]	Laboratory-Specific Limits		
			LOQ	LOD	DL
1,1,4-Trimethylcyclohexane	7094-27-1	—	TBD	TBD	TBD
1,1-Dimethylcyclopentane	1638-26-2	—	TBD	TBD	TBD
1,2,3,4-Tetramethylbenzene	488-23-3	—	TBD	TBD	TBD
1,2,3,5-Tetramethylbenzene	527-53-7	—	TBD	TBD	TBD
1,2,3-Trimethylbenzene	526-73-8	—	TBD	TBD	TBD
1,2,4,5-Tetramethylbenzene	95-93-2	—	TBD	TBD	TBD
1,2,4-Triethy benzene	877-44-1	—	TBD	TBD	TBD
1,2,4-Trimethylbenzene	95-63-6	—	TBD	TBD	TBD
1,2-D bromoethane	106-93-4	—	TBD	TBD	TBD
1,2-Dichloroethane	107-06-2	—	TBD	TBD	TBD
1,2-Diethylbenzene	135-01-3	—	TBD	TBD	TBD
1,2-Dimethyl-3-Ethy benzene	933-98-2	—	TBD	TBD	TBD
1,2-Dimethyl-4-Ethy benzene	934-80-5	—	TBD	TBD	TBD
1,2-Dimethylcyclohexane (cis)	112134	—	TBD	TBD	TBD
1,2-Dimethylcyclohexane (trans)	6876-23-9	—	TBD	TBD	TBD
1,3,5-Triethy benzene	102-25-0	—	TBD	TBD	TBD
1,3,5-Trimethylbenzene	108-67-8	—	TBD	TBD	TBD
1,3-Diethylbenzene	141-93-5	—	TBD	TBD	TBD
1,3-Dimethyl-2-Ethy benzene	354381	—	TBD	TBD	TBD
1,3-Dimethyl-4-Ethy benzene	874-41-9	—	TBD	TBD	TBD
1,3-Dimethyl-5-Ethy benzene	934-74-7	—	TBD	TBD	TBD
1,3-Dimethyl-5-tert-Butylbenzene	98-19-1	—	TBD	TBD	TBD
1,3-Dimethylcyclopentane (cis)	2532-58-3	—	TBD	TBD	TBD
1,4-Dimethyl-2-Ethy benzene	1758-88-9	—	TBD	TBD	TBD
1,4-Dimethylcyclohexane (trans)	112227	—	TBD	TBD	TBD
1-Decene	872-05-9	—	TBD	TBD	TBD
1-Heptene/1,2-DMCP (trans)	592-76-7/822-50-4	—	TBD	TBD	TBD
1-Hexene	592-41-6	—	TBD	TBD	TBD

Matrix: LNAPL

Analytical Group: PIANO (8260D)

Analyte	CAS No.	PSL [a]	Laboratory-Specific Limits		
			LOQ	LOD	DL
1-Methyl-2-Ethylbenzene	611-14-3	—	TBD	TBD	TBD
1-Methyl-2-Isopropylbenzene	527-84-4	—	TBD	TBD	TBD
1-Methyl-2-N-Propylbenzene	1074-17-5	—	TBD	TBD	TBD
1-Methyl-3-Ethylbenzene	620-14-4	—	TBD	TBD	TBD
1-Methyl-3-Isopropylbenzene	535-77-3	—	TBD	TBD	TBD
1-Methyl-3-N-Propylbenzene	1074-43-7	—	TBD	TBD	TBD
1-Methyl-4-Ethylbenzene	622-96-8	—	TBD	TBD	TBD
1-Methyl-4-Isopropylbenzene	99-87-6	—	TBD	TBD	TBD
1-Methyl-4-N-Propylbenzene	1074-55-1	—	TBD	TBD	TBD
1-Methylnaphthalene	90-12-0	—	TBD	TBD	TBD
1-Nonene	124-11-8	—	TBD	TBD	TBD
1-Octene	111-66-0	—	TBD	TBD	TBD
1-Pentene	109-67-1	—	TBD	TBD	TBD
2,2,3-Trimethylbutane	464-06-2	—	TBD	TBD	TBD
2,2,3-Trimethylpentane	564-02-3	—	TBD	TBD	TBD
2,2-Dimethylbutane	75-83-2	—	TBD	TBD	TBD
2,2-Dimethylhexane	590-73-8	—	TBD	TBD	TBD
2,2-Dimethylpentane	590-35-2	—	TBD	TBD	TBD
2,3,3-Trimethylpentane	560-21-4	—	TBD	TBD	TBD
2,3,4-Trimethylpentane	565-75-3	—	TBD	TBD	TBD
2,3-Dimethylbutane	79-29-8	—	TBD	TBD	TBD
2,3-Dimethylheptane	3074-71-3	—	TBD	TBD	TBD
2,3-Dimethylhexane	584-94-1	—	TBD	TBD	TBD
2,3-Dimethylpentane	565-59-3	—	TBD	TBD	TBD
2,4-Dimethylhexane	589-43-5	—	TBD	TBD	TBD
2,4-Dimethylpentane	108-08-7	—	TBD	TBD	TBD
2,5-Dimethylheptane	2216-30-0	—	TBD	TBD	TBD
2,5-Dimethylhexane	592-13-2	—	TBD	TBD	TBD

Matrix: LNAPL
Analytical Group: PIANO (8260D)

Analyte	CAS No.	PSL [a]	Laboratory-Specific Limits		
			LOQ	LOD	DL
2-Ethylthiophene	872-55-9	—	TBD	TBD	TBD
2-Methyl-1-Butene	563-46-2	—	TBD	TBD	TBD
2-Methyl-2-pentene	625-27-4	—	TBD	TBD	TBD
2-Methylheptane	592-27-8	—	TBD	TBD	TBD
2-Methylhexane	591-76-4	—	TBD	TBD	TBD
2-Methylnaphthalene	91-57-6	—	TBD	TBD	TBD
2-Methylnonane	871-83-0	—	TBD	TBD	TBD
2-Methyloctane	3221-61-2	—	TBD	TBD	TBD
2-Methylpentane	107-83-5	—	TBD	TBD	TBD
2-Methylthiophene	554-14-3	—	TBD	TBD	TBD
2-Nonene	6434-77-1	—	TBD	TBD	TBD
3,3-Diethylpentane	1067-20-5	—	TBD	TBD	TBD
3,3-Dimethylheptane	4032-86-4	—	TBD	TBD	TBD
3,3-Dimethyloctane	4110-44-5	—	TBD	TBD	TBD
3,3-Dimethylpentane	562-49-2	—	TBD	TBD	TBD
3,4-Dimethylheptane	922-28-1	—	TBD	TBD	TBD
3,5-Dimethylheptane	926-82-9	—	TBD	TBD	TBD
3-Ethylhexane	619-99-8	—	TBD	TBD	TBD
3-Ethylpentane	617-78-7	—	TBD	TBD	TBD
3-Methyl-1-butene	563-45-1	—	TBD	TBD	TBD
3-Methylheptane	589-81-1	—	TBD	TBD	TBD
3-Methylhexane	589-34-4	—	TBD	TBD	TBD
3-Methylnonane	1465084	—	TBD	TBD	TBD
3-Methyloctane	2216-33-3	—	TBD	TBD	TBD
3-Methylpentane	96-14-0	—	TBD	TBD	TBD
3-Methylthiophene	616-44-4	—	TBD	TBD	TBD
4-Methyl-1-pentene	691-37-2	—	TBD	TBD	TBD
4-Methylheptane	589-53-7	—	TBD	TBD	TBD

Matrix: LNAPL

Analytical Group: PIANO (8260D)

Analyte	CAS No.	PSL [a]	Laboratory-Specific Limits		
			LOQ	LOD	DL
4-Methyloctane	2216-34-4	—	TBD	TBD	TBD
Benzene	71-43-2	—	TBD	TBD	TBD
Benzothiophene	95-15-8	—	TBD	TBD	TBD
cis-2-Heptene	6443-92-1	—	TBD	TBD	TBD
cis-2-Hexene	7688-21-3	—	TBD	TBD	TBD
cis-2-Octene	2097322	—	TBD	TBD	TBD
cis-2-Pentene	627-20-3	—	TBD	TBD	TBD
cis-3-Nonene	20237-46-1	—	TBD	TBD	TBD
Cyclohexane	110-82-7	—	TBD	TBD	TBD
Cyclopentane	287-92-3	—	TBD	TBD	TBD
Decane (C10)	124-18-5	—	TBD	TBD	TBD
Dodecane (C12)	112-40-3	—	TBD	TBD	TBD
Ethylbenzene	100-41-4	—	TBD	TBD	TBD
Ethylcyclopentane	1640-89-7	—	TBD	TBD	TBD
Ethyl-Tert-Butyl-Ether	637-92-3	—	TBD	TBD	TBD
Heptane	142-82-5	—	TBD	TBD	TBD
Hexylbenzene	1077-16-3	—	TBD	TBD	TBD
Indane	496-11-7	—	TBD	TBD	TBD
Indene	95-13-6	—	TBD	TBD	TBD
Isobutylbenzene	538-93-2	—	TBD	TBD	TBD
Isobutylcyclohexane	1678-98-4	—	TBD	TBD	TBD
Isooctane	540-84-1	—	TBD	TBD	TBD
Isopentane	78-78-4	—	TBD	TBD	TBD
Isoprene	78-79-5	—	TBD	TBD	TBD
Isopropyl Ether	108-20-3	—	TBD	TBD	TBD
Isopropy benzene	98-82-8	—	TBD	TBD	TBD
Isopropylcyclohexane	696-29-7	—	TBD	TBD	TBD
Isopropylcyclopentane	3875-51-2	—	TBD	TBD	TBD

Matrix: LNAPL
Analytical Group: PIANO (8260D)

Analyte	CAS No.	PSL [a]	Laboratory-Specific Limits		
			LOQ	LOD	DL
Methyl tert butyl ether	1634-04-4	—	TBD	TBD	TBD
Methylcyclohexane	108-87-2	—	TBD	TBD	TBD
Methylcyclopentane	96-37-7	—	TBD	TBD	TBD
MMT	12108-13-3	—	TBD	TBD	TBD
Naphthalene	91-20-3	—	TBD	TBD	TBD
n-Butylbenzene	104-51-8	—	TBD	TBD	TBD
n-Hexane	110-54-3	—	TBD	TBD	TBD
Nonane (C9)	111-84-2	—	TBD	TBD	TBD
N-Pentylbenzene	538-68-1	—	TBD	TBD	TBD
n-Propylbenzene	103-65-1	—	TBD	TBD	TBD
Octane	111-65-9	—	TBD	TBD	TBD
o-Xylene	95-47-6	—	TBD	TBD	TBD
p/m-Xylene	M+P-XYLENE	—	TBD	TBD	TBD
Pentadecane	629-62-9	—	TBD	TBD	TBD
Pentane	109-66-0	—	TBD	TBD	TBD
sec-Butylbenzene	135-98-8	—	TBD	TBD	TBD
Styrene	100-42-5	—	TBD	TBD	TBD
tert-Butylbenzene	98-06-6	—	TBD	TBD	TBD
Tertiary Butanol	75-65-0	—	TBD	TBD	TBD
Tertiary-Amyl Methyl Ether	994-05-8	—	TBD	TBD	TBD
Tetradecane (C14)	629-59-4	—	TBD	TBD	TBD
Thiophene	110-02-1	—	TBD	TBD	TBD
Toluene	108-88-3	—	TBD	TBD	TBD
trans-2-Heptene	14686-13-6	—	TBD	TBD	TBD
trans-2-Hexene	4050-45-7	—	TBD	TBD	TBD
trans-2-Pentene	646-04-8	—	TBD	TBD	TBD
trans-3-Heptene	14686-14-7	—	TBD	TBD	TBD
trans-3-Nonene	20063-92-7	—	TBD	TBD	TBD

Matrix: LNAPL

Analytical Group: PIANO (8260D)

Analyte	CAS No.	PSL [a]	Laboratory-Specific Limits		
			LOQ	LOD	DL
Tridecane	629-50-5	—	TBD	TBD	TBD
Undecane	1120-21-4	—	TBD	TBD	TBD
Xylene (Total)	1330-20-7	—	TBD	TBD	TBD

Note: Units are in mg/kg

— not available
CAS Chemical Abstracts Service
DL detection limit
LOD limit of detection
LOQ limit of quantification
PSL Project screening level
TBD to be determined

[a] No project limits, results are only for characterization only.

Table D.1-3: Preparation and Analytical Requirements for Field and QC Samples

Matrix	Analytical Group	Preparation Reference/Method SOP Analytical Reference/Method SOP	Containers	Sample Volume	Preservation Requirement	Maximum Holding Time (preparation/analysis)
Unconsolidated Material (Soil) by ISM						
Surface/Subsurface Soil [a, b] (ISM)	VOCs	Preparation Method: EPA 5035A Preparation SOP: OP020.17 Analysis Method: EPA 8260B or 8260C Analysis SOP: MS 020.5	12 – 4oz wide-mouth amber glass with 25 mL of methanol, Teflon-lined lid	25 g per amber glass	Methanol ratio of 1 g soil to 1 ml methanol	Samples analyzed within 14 days of collection.
Surface/Subsurface Soil [a, b] (ISM)	TPH-GRO	Preparation Method: EPA 5035A Preparation SOP: OP020.17 Analysis Method: EPA 8015C Analysis SOP: GC 010.16	12 – 4oz wide-mouth amber glass with 25 mL of methanol, Teflon-lined lid	25 g per amber glass	Methanol ratio of 1 g soil to 1 ml methanol and frozen	14 days when shipped to laboratory
Surface/Subsurface Soil [a] (ISM)	TPH-DRO/ORO	Preparation Method: EPA 3550C Prep SOPs: OP011.14MW Analysis Method: EPA 8015C Analysis SOP: GC 011.19	1 – 1 gallon-size plastic bag, unpreserved	1 kg	Store in dark. Cool to ≤6°C	Samples extracted within 14 days and analyzed within 40 days following extraction.
Surface/Subsurface Soil [a] (ISM)	PAHs	Preparation Method: EPA 3550C Prep SOPs: OP060.04MW Analysis Method: EPA 8270D SIM Analysis SOP: MS 015.08	1 – 1 gallon-size plastic bag, unpreserved	1 kg	Store in dark. Cool to ≤6°C. Frozen after extraction.	Samples extracted within 14 days and analyzed within 40 days following extraction.
Surface/Subsurface Soil	Atterberg Limits	Preparation/Analysis Method: ASTM D4318 Preparation/Analysis SOP: ASTM D4318	1 × core section, or 4 × 8-oz glass jar, Teflon-lined lid	Core	None	None
	Effective Porosity	Preparation/Analysis Method: ASTM D6836M Preparation/Analysis SOP: ASTM D6836M				
	Permeability	Preparation/Analysis Method: ASTM D5084 Preparation/Analysis SOP: ASTM D5084				
	Moisture Content and Density	Preparation/Analysis Method: ASTM D2937 Preparation/Analysis SOP: ASTM D2937				
	Grain Size Distribution	Preparation/Analysis Method: ASTM D422 Preparation/Analysis SOP: ASTM D422				
	Cation Exchange Capacity	Preparation/Analysis Method: EPA 9081 Preparation/Analysis SOP: ANA9081				
	pH	Preparation/Analysis Method: EPA 9045 Preparation/Analysis SOP: ANA9045				
	Total Organic Carbon	Preparation/Analysis Method: Walkley Black Preparation/Analysis SOP: ANAWALKLEY				

Matrix	Analytical Group	Preparation Reference/Method SOP Analytical Reference/Method SOP	Containers	Sample Volume	Preservation Requirement	Maximum Holding Time (preparation/analysis)
LNAPL						
LNAPL	Dynamic Viscosity	Preparation/Analysis Method: ASTM D445 Preparation/Analysis SOP: Kinematic Viscosity	4 × 40-mL vial, Teflon-lined lid	40 mL	None	None.
LNAPL	Density	Preparation/Analysis Method: ASTM D971 Preparation/Analysis SOP: Density of Viscous Materials				
LNAPL	Interfacial Tension	Preparation/Analysis Method: ASTM D1481 Preparation/Analysis SOP: Interfacial Tension				
LNAPL	Saturated Hydrocarbons	Preparation Method: 3510C Preparation SOP: 2165 Analysis Method: EPA 8015 Analysis SOP: 2246				
LNAPL	Alkylated PAHs	Preparation Method: 3510C Preparation SOP: 2165 Analysis Method: EPA 8270 Analysis SOP: 2247				
LNAPL	PIANO	Preparation Method: EPA 5035 Preparation SOP: 2255 Analysis Method: EPA 8260D Analysis SOP: 2255				

°C degree Celsius
DRO diesel range organics
EPA Environmental Protection Agency, United States
g gram
GRO gasoline range organics
HCl hydrogen chloride
ISM incremental sampling methodology
kg kilogram
L liter
LRO lube oil range organics
mL milliliter
N/A not applicable
oz ounce
PAH polynuclear aromatic hydrocarbon
SIM selective ion monitoring
SOP standard operating procedure
SVOC semivolatile organic compound
TGM Technical Guidance Manual
TPH total petroleum hydrocarbons
VOA volatile organic analyte
VOC volatile organic compound

[a] Sample results will be reported on a dry weight basis.
[b] Volatiles (VOCs, TPH-GRO) are not typically sampled for surface soils using ISM; refer to TGM Section 4.2.7 (DOH 2017).

Table D.1-4: Analytical Services

Matrix	Analytical Group	Sampling Locations/ ID Numbers	Analytical SOP	Data Package Turnaround Time	Laboratory/Organization [a] (name and address, contact person and telephone number)	Backup Laboratory/Organizat (name and address, contac person and telephone numbe
Unconsolidated Material	VOCs TPH-G, TPH-D, TPH-O PAHs	See Table D.1-1	MS 020.5, GC 010.16, GC 011.19, MS 015.08	14 days after samples are received at laboratory	Elvin Kumar SGS North America Inc. 4405 Vineland Road Suite C015 Orlando, Florida 32811 407-425-6700	Tracy Dutton Eurofins Environmental Testir Northwest 5755 8th St. E Fife, Washington 98424 253-380-6574
Unconsolidated Material	Atterberg Limits, Effective Porosity, Permeability, Moisture Content and Density, Grain Size Distribution, Cation Exchange Capacity, pH, Total Organic Carbon	See Table D.1-1	ASTM D4318, ASTM D6836M, ASTM D5084, ASTM D2937, ASTM D422, TBD	30 days after samples are received at laboratory	Tracy Dutton Eurofins Environmental Testing – Northwest 5755 8th St. E Fife, Washington 98424 253-380-6574	
Product	PIANO, alkylated PAHs, SVOCs, saturated hydrocarbons	As Needed	2255, 2155, 2246, 2247	14 days after samples are received at laboratory	Susan O'Neil Pace Analytical 320 Forbes Boulevard Mansfield, MA 02048 508-844-4117	
Product	Dynamic viscosity, density, interfacial tension	As Needed	ASTM D445, ASTM D971, ASTM D1481	30 days after samples are received at laboratory	Core Lab – Petroleum Services Division 3437 Landco Drive Bakersfield, CA 93308	

ID identification
SOP standard operating procedure
[a] Laboratory meets accreditation requirements to support project needs.

Table D.1-5: Analytical SOP References

Laboratory Name and Address: SGS North America Inc., 4405 Vineland Rd Suite C-15, Orlando, FL 32811
Laboratory Contact Name: Michael Eger
Laboratory Contact Number: +1 407 473 6177

Lab SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Variance to QSM (Yes/No)	Modified for Project Work? (Yes/No)
Misc. & Preparatory Methods – SGS Labs						
OP020.17	Introduction of volatiles organics analytes in soil using closed system purge-and-trap Revision: 09/2024	Definitive	VOCs and TPH-GRO (Soil)	Preparation	No	No
OP011.14MW	Extraction of diesel range organics (DRO) from solid samples—microwave option Revision: 06/2024	Definitive	TPH-DRO/ORO (Soil)	Preparation	No	No
OP060.04MW	Extraction of PAHs and select analytes from solid samples for analysis by GC/MS SIM—microwave option Revision: 06/2024	Definitive	PAHs and SVOCs (Soil)	Preparation	No	No
Analytical Methods – SGS Labs						
MS 020.5	Analysis of volatile organics by GC/MS Revision: 01/2024	Definitive	VOC (Soil)	GC-MS	No	No
GC 010.16	Analysis of gasoline range organics by gas chromatography using flame ionization detector Revision: 05/2023	Definitive	TPH-GRO (Soil)	GC-FID	No	No
GC 011.19	Analysis of diesel range organics by gas chromatography using flame ionization detector Revision: 06/2024	Definitive	TPH-DRO/ORO (Soil)	GC-FID	No	No
MS 015.08	Analysis of semivolatile organics by GC/MS select ion monitoring (SIM) and large volume injection	Definitive	PAHs and SVOCs (Soil)	GC-MS-SIM	No	No
GN 161.16	Percent Solids Revision: 10/2024	Definitive	Percent Solids (Soil)	N/A	No	No

Note: The laboratory SOPs listed in Table D.1-5 are the most current revisions at the time of publication of this WP. AECOM will review the laboratory SOPs immediately prior to sample submittal to ensure that the laboratory uses SOPs that are in compliance with the DoD QSM annual review requirement.

DRO diesel range organics
EPA Environmental Protection Agency, United States
GC-FID gas chromatography-flame ionization detector
GC-MS gas chromatography-mass spectrometry
GRO gasoline range organics
ORO oil range organics
PAH polynuclear aromatic hydrocarbon
QSM Quality Systems Manual
SIM selective ion monitoring

SOP	standard operating procedure
SVOC	semivolatile organic compound
TOC	total organic carbon
TPH	total petroleum hydrocarbons
VOC	volatile organic compound

Table D.1-6: Laboratory QC Samples for Chemistry Analyses

Matrix	**Unconsolidated Material(Soil)**
Analytical Group	**VOCs, TPH-G**
Analytical Method/SOP Reference	Analytical Method: EPA 8260, 8015 Preparation Method: EPA 5035A, EPA 5030B Laboratory SOPs: MS 020.5, GC 010.16,
Analytical Organization	SGS Orlando

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
LOD determination and verification	At initial set-up and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each.	The apparent signal to noise ratio must be at least 3 and the results must meet all method requirements for analyte identification.	If the LOD verification fails, the laboratory must: 1) Repeat the detection limit determination and LOD verification at a higher concentration; or 2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration.	Analyst Lab QA Officer Project Chemist	Bias/ Representativeness	QC acceptance criteria as specified by Lab SOP.
LOQ establishment and verification	At initial setup: 1) Verify LOQ; and 2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each.	1) The LOQ and associated precision and bias must meet client requirements and must be reported; or 2) In the absence of client requirements, must meet control limits of the LCS. 3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Volume 1, Module 4, Section 1.5.2 of the DoD QSM 5.4(DoD and DOE 2021).	If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	QC acceptance criteria as specified by Lab SOP and at least as stringent as specified by DoD QSM 5.4(DoD and DOE 2021).
Tune check	Prior to the ICAL and prior to each 12-hour period of sample analysis.	Specific ion abundance criteria of BFB or DFTPP from method.	Retune instrument and verify.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	No samples may be analyzed without a passing tune.

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
CCV	Before sample analysis, after every 10 field samples, after every 12 hours of analysis time, and at the end of the analysis sequence.	All reported analytes and surrogates within established RT windows. All reported analytes and surrogates within ±20% of true value. All reported analytes and surrogates within ±50% for the end of the analytical batch CCV.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Analyst Lab QA Officer Project Chemist	Accuracy/ Precision	Results may not be reported without a valid CCV. If reanalysis cannot be performed, data must be qualified and explained in the case narrative. If the specific version of a method requires additional evaluation (e.g., average response factors) these additional requirements must also be met.
MB	Each time analytical batch.	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common lab contaminants, no analytes detected >LOQ.	Correct problem. If required, re-prep and reanalyze MB and all samples processed with the contaminated blank.	Analyst Lab QA Officer Project Chemist	Bias	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ.
LCS	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	Per DoD QSM Appendix C Limits, Method SW-846 8260C and Lab SOP.	Correct problem. If required, re-prep and reanalyze the LCS and all samples processed in the associated preparatory batch for the failed analytes. Results may not be reported without a valid LCS.	Analyst Lab QA Officer Project Chemist	Accuracy	QC acceptance criteria at least as stringent as specified by DoD QSM 5.4(DoD and DOE 2021).
MS/MSD pair	One per analytical method for each batch of at most 20 samples.	Per DoD QSM Appendix C Limits, Method SW-846 8260C and Lab SOP. MSD or Matrix Duplicate: RPD of all analytes ≤20%.	Examine the PQOs. Notify Lab QA officer and project chemist about additional measures to be taken.	Analyst Lab QA Officer Project Chemist	Accuracy/ Precision	For matrix evaluation, use QC acceptance criteria at least as stringent as specified by DoD QSM 5.4(DoD and DOE 2021).
Internal standards verification	Every field sample, standard, and QC sample.	Retention time ±10 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard.	Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	Analyst Lab QA Officer Project Chemist	Accuracy/ Precision/ Representativeness	Laboratory in-house method manual to be followed for acceptance criteria.

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
Surrogate spike	All field and QC samples.	Per DoD QSM Appendix C Limits, Method SW-846 8260C and Lab SOP.	For QC and field samples, correct problem then re-prep and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Analyst Lab QA Officer Project Chemist	Accuracy/ Precision/ Representativeness	QC acceptance criteria at least as stringent as specified by DoD QSM 5.4(DoD and DOE 2021).
Trip blank	1 per cooler.	Target analytes ≤1/2 LOQ.	Reanalyze for confirmation through a second analysis of the trip blank. Examine the PQOs.	Analyst Lab QA Officer Project Chemist	Accuracy/Bias, Representative-ness/Contamination	Target analytes ≤1/2 LOQ.

Matrix	**Unconsolidated Material (Soil)**
Analytical Group	**TPH-D, TPH-O**
Analytical Method/SOP Reference	Analytical Method: EPA 8015 Preparation Method: EPA 3546, EPA3550C, EPA 3510C Laboratory SOPs: GC011.19
Analytical Organization	SGS Orlando

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
LOD determination and verification	At initial set-up and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each.	The apparent signal to noise ratio must be at least 3 and the results must meet all method requirements for analyte identification.	If the LOD verification fails, the laboratory must: 1) Repeat the detection limit determination and LOD verification at a higher concentration; or 2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration.	Analyst Lab QA Officer Project Chemist	Bias/ Representativeness	QC acceptance criteria as specified by Lab SOP.
LOQ establishment and verification	At initial setup: 1) Verify LOQ; and 2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each.	1) The LOQ and associated precision and bias must meet client requirements and must be reported; or 2) In the absence of client requirements, must meet control limits of the LCS. 3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Volume 1, Module 4, Section 1.5.2 of the DoD QSM 5.4(DoD and DOE 2021).	If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	QC acceptance criteria as specified by Lab SOP, and at least as stringent as specified by DoD QSM 5.4(DoD and DOE 2021).
CCV	Before sample analysis, after every 10 field samples, and at the end of the analysis sequence.	All reported analytes and surrogates within established RT windows. All reported analytes and surrogates within ±20% of true value.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision	Results may not be reported without a valid CCV. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
MB	Each time samples are extracted and one per matrix per analytical method for each batch of at most 20 samples.	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common lab contaminants, no analytes detected >LOQ.	Correct problem. If required, re-prep and reanalyze MB and all samples processed with the contaminated blank.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ.
LCS	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	Per DoD QSM Appendix C Limits, Method 8015C and Lab SOP.	Correct problem. If required, re-prep and reanalyze the LCS and all samples processed in the associated preparatory batch for the failed analytes.	Analyst Lab QA Officer Project Chemist	Accuracy	QC acceptance criteria at least as stringent as specified by DoD QSM 5.4.
Internal standards verification	Every field sample, standard, and QC sample.	Retention time ±30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard.	Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	Analyst Lab QA Officer Project Chemist	Accuracy/ Precision/ Representativeness	Laboratory in-house method manual to be followed for acceptance criteria.
Surrogate spike	All field and QC samples.	Per DoD QSM Appendix C Limits, Method 8015C and Lab SOP.	For QC and field samples, correct problem then re-prep and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Analyst Lab QA Officer Project Chemist	Accuracy/ Precision/ Representativeness	QC acceptance criteria at least as stringent as specified by DoD QSM 5.4.
MS/MSD pair	One per analytical method for each batch of at most 20 samples.	Per DoD QSM Appendix C Limits, Method 8015C and Lab SOP. MSD or Matrix Duplicate: RPD of all analytes ≤30%.	Examine the PQOs. Notify Lab QA officer and project chemist about additional measures to be taken.	Analyst Lab QA Officer Project Chemist	Accuracy/ Precision	For matrix evaluation, use QC acceptance criteria at least as stringent as specified by DoD QSM 5.4.

Matrix	**Unconsolidated Material (Soil)**
Analytical Group	**PAHs**
Analytical Method/SOP Reference	Analytical Method: 8270SIM Preparation Method: EPA 3546, EPA3550C, EPA 3510C Laboratory SOPs: MS 015.08
Analytical Organization	SGS-O

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Respons ble for Corrective Action	DQI	Measurement Performance Criteria
LOD determination and verification	At initial set-up and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each.	The apparent signal to noise ratio must be at least 3 and the results must meet all method requirements for analyte identification.	If the LOD verification fails, the laboratory must: 1) Repeat the detection limit determination and LOD verification at a higher concentration; or 2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration.	Analyst Lab QA Officer Project Chemist	Bias/ Representativeness	QC acceptance criteria as specified by Lab SOP.
LOQ establishment and verification	At initial setup: 1) Verify LOQ; and 2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each.	1) The LOQ and associated precision and bias must meet client requirements and must be reported; or 2) In the absence of client requirements, must meet control limits of the LCS. 3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Volume 1, Module 4, Section 1.5.2 of the DoD QSM 5.4.	If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	QC acceptance criteria as specified by Lab SOP, and at least as stringent as specified by DoD QSM 5.4.
Performance check	Before ICAL and sample analysis, and at the beginning of each 12-hour shift.	Degradation of DDT must be ≤20%. Benzidine and pentachlorophenol will be present at their normal responses and will not exceed a tailing factor of 2.	Correct problem, then repeat performance checks.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	Degradation of DDT must be ≤20%; and benzidine and pentachlorophenol must be present at normal responses and tailing factor is ≤2. No samples must be analyzed until performance check is within criteria.
Tune Check	Prior to the ICAL and prior to each 12-hour period of sample analysis.	Specific ion abundance criteria of BFB or DFTPP from method.	Retune instrument and verify	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	No samples may be analyzed without a passing tune.

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Respons ble for Corrective Action	DQI	Measurement Performance Criteria
CCV	Before sample analysis, after every 10 field samples, after every 12 hours of analysis time, and at the end of the analysis sequence.	All reported analytes and surrogates within established RT windows. All reported analytes and surrogates within ±20% of true value.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Analyst Lab QA Officer Project Chemist	Accuracy/ Precision	Results may not be reported without a valid CCV. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.
MB	Each time samples are extracted and one per matrix per analytical method for each batch of at most 20 samples.	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common lab contaminants, no analytes detected >LOQ.	Correct problem. If required, re-prep and reanalyze MB and all samples processed with the contaminated blank.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ.
LCS	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	Per DoD QSM Appendix C Limits, Method 8270D SIM and Lab SOP.	Correct problem. If required, re-prep and reanalyze the LCS and all samples processed in the associated preparatory batch for the failed analytes.	Analyst Lab QA Officer Project Chemist	Accuracy	QC acceptance criteria at least as stringent as specified by DoD QSM 5.4.
Internal standards verification	Every field sample, standard, and QC sample.	Retention time ±10 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard.	Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	Analyst Lab QA Officer Project Chemist	Accuracy/ Precision/ Representativeness	Laboratory in-house method manual to be followed for acceptance criteria.
Surrogate spike	All field and QC samples.	Per DoD QSM Appendix C Limits, Method 8270D SIM and Lab SOP.	For QC and field samples, correct problem then re-prep and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Analyst Lab QA Officer Project Chemist	Accuracy/ Precision/ Representativeness	QC acceptance criteria at least as stringent as specified by DoD QSM 5.4.

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Respons ble for Corrective Action	DQI	Measurement Performance Criteria
MS/MSD pair	One per analytical method for each batch of at most 20 samples.	Per DoD QSM Appendix C Limits, Method 8270D SIM and Lab SOP. MSD or Matrix Duplicate: RPD of all analytes ≤20%.	Examine the PQOs. Notify Lab QA Officer and project chemist about additional measures to be taken.	Analyst Lab QA Officer Project Chemist	Accuracy/ Precision	For matrix evaluation, use QC acceptance criteria at least as stringent as specified by DoD QSM 5.4.

Note: No laboratory QC samples are generated for geotechnical and petrographic analyses.

BFB 4-bromofluorobenzene
CCV decafluorotriphenylphosphine
DoD Department of Defense
DQI data quality indicator
EICP extracted ion current profile
ICAL initial calibration
LCS laboratory control sample
MB method blank
MS matrix spike
MSD matrix spike duplicate
PQO project quality objective
QA quality assurance
QC quality control
RPD relative percent difference
RT retention time

Table D.1-7: Analytical Instrument and Equipment Maintenance, Testing, and Inspection

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference [a]
GC-FID and GC-MS	Change gas purifier.	N/A.	Visually inspect if traps are changing color.	Every 6–12 months	No moisture	Replace indicating traps.	Analyst or certified instrument technician	GC 010.16, GC 011.19, MS 020.5, and MS 015.08
	Change syringes/syringe needles.	N/A.	Visually inspect for wear or damage.	Every 3 months	N/A	Replace syringe if dirt is noticeable in the syringe.	Analyst or certified instrument technician	
	Change inlet liner, liner O-rings, and inlet septum.	N/A.	Visually inspect for dirt or deterioration.	Weekly for liner Monthly for O-rings Daily for septum	N/A	Replace and check often.	Analyst or certified instrument technician	
	Change front-end column.	N/A.	Check peak tailing, decreased sensitivity, retention time changes, etc.	Weekly, monthly, or when needed	N/A	Remove 1/2 to 1 meter from the front of the column when experiencing problems.	Analyst or certified instrument technician	
	Clean injector ports.	N/A.	N/A.	As needed	N/A	N/A	Analyst	
	Replace trap on purge-and-trap systems.	N/A.	N/A.	Bi-monthly or as needed	N/A	N/A	Analyst	
	Replace columns.	N/A.	N/A.	If chromatograms indicate possible contamination	N/A	N/A	Analyst	
GC-FID	Replace detector jets.	N/A.	N/A.	As needed	N/A	N/A	Analyst	GC 010.16 and GC 011.19
	Replace hydrocarbon traps and oxygen traps on helium and hydrogen gas lines.	N/A.	N/A.	Every 4–6 months	N/A	N/A	Analyst	
	Replace chemical trap.	N/A.	N/A.	Yearly or as needed	N/A	N/A	Analyst	
	Replace converter tube in gas purifier system.	N/A.	N/A.	Yearly or as needed	N/A	N/A	Analyst	
GC-MS	Change tune MSD, check the cal bration vial, and replace the foreline pump oil.	N/A.	Visually inspect and monitor the fluid becoming discolored.	As needed or every 6 months	In accordance with manufacturer's recommendation or lab SOP	Keep plenty of PFTBA; refill the vial and check the fluid; change when the fluid becomes discolored.	Analyst or certified instrument technician	MS 020.5 and MS 015.08

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference [a]
GC-MS (cont'd)	Run tuning program to determine if source is functioning properly.	N/A	N/A	Daily	N/A	Cool system, vent, disassemble, and clean.	Analyst	
	N/A	Tune instrument.	N/A	Daily or every 12 hours	Per method	Liner and septa are replaced; tune file used is manually adjusted.	Analyst	
	Vacuum rough pump oil level is checked.	N/A.	N/A	Every 4–6 weeks	N/A	Add oil if needed.	Analyst	
	Replace/refill carrier gas line oxygen and moisture traps.	N/A.	N/A	Yearly or as needed	N/A	N/A.	Analyst	
Water Bath (Precision Microprocessor controlled)	Check instrument connections, water level, and thermometer.	Measure water temperature against a calibrated thermometer.	Visually inspect for wear or damage and indicator from computer controls.	Daily and annual maintenance from manufacturer	Refer to manufacturer's recommendation	Return to manufacturer for recalibration or call for maintenance service.	Analyst or certified instrument technician	See QA Manual
Drying Oven	Thermometer indicator.	Measure oven temperature against a calibrated thermometer.	Visually inspect for wear or damage and indicator from computer controls.	Daily and annual maintenance from manufacturer	Refer to manufacturer's recommendation	Return to manufacturer for recalibration or call for maintenance service.	Analyst or certified instrument technician	See QA Manual
Analytical Balance	Check digital LCD display and ensure a flat base for the Instrument.	Calibrate against verified (NIST) mass.	Visually inspect for wear or damage and indicator from computer controls.	Daily and annual maintenance from manufacturer	Refer to manufacturer's recommendation	Return to manufacturer for recalibration or call for maintenance service.	Analyst or certified instrument technician	See QA Manual
pH Meter	Check LCD display and pH probe.	3 point calibration using known standards.	Visually inspect for wear or damage and indicator from computer controls.	Daily and annual maintenance from manufacturer	±0.05 units	Return to manufacturer for recalibration or call for maintenance service.	Analyst or certified manufacture instrument technician	See QA Manual

Note: No instrument and equipment maintenance, testing, and inspection criteria for geotechnical and petrographic analyses.

N/A not applicable

NIST National Institute of Standards and Technology

PFTBA perfluorotributylamine

[a] See Analytical SOP References table (D.1-5)

Table D.1-8: Analytical Instrument Calibration

Instrument	Calibration Procedure	Frequency of Cal bration	Acceptance Criteria	Corrective Action	Person Respons ble for Corrective Action	SOP Reference [a]
GC-MS EPA Methods 8260C, 8720D SIM	Tuning	Prior to ICAL and at the beginning of each 12-hour period.	Refer to method for specific ion criteria.	Retune instrument and verify. Rerun affected samples.	Lab Manager/Analyst or certified instrument technician.	EFGS-T-VOA-SOP41085, EFGS-T-VOA-SOP41119, T-SVOA-WI9617, MS 008 ANA8270
	Breakdown check (DDT-Method 8270 only)	At the beginning of each 12-hour period, prior to analysis of samples.	Degradation ≤20% for DDT. Benzidine and pentachlorophenol should be present at their normal responses and should not exceed a tailing factor of 2.	Correct problem, then repeat breakdown checks.	Lab Manager/Analyst or certified instrument technician.	
	Minimum 5-point ICAL for linear calibration Minimum 6-point ICAL for quadratic cal bration	Prior to sample analysis.	RSD for each analyte ≤15% or least square regression ≥0.995. Non-linear least squares regression (quadratic) for each analyte ≤0.995.	Correct problem then repeat ICAL.	Lab Manager/Analyst or certified instrument technician.	
	Second source calibration verification	After ICAL.	All analytes within ±20% of expected value.	Correct problem and verify second source standard; rerun second source verification. If fails, correct problem and repeat ICAL.	Lab Manager/Analyst or certified instrument technician.	
	RT window position for each analyte and surrogate	Once per ICAL.	Position will be set using the midpoint standard for the ICAL.	N/A	Lab Manager/Analyst or certified instrument technician.	
	RRT	With each sample.	RRT of each target analyte in each calibration standard within ±0.06 RRT units of ICAL.	Correct problem, then reanalyze all samples analyzed since the last RT check. If fails, then rerun ICAL and samples.	Lab Manager/Analyst or certified instrument technician.	
GC-MS EPA Methods 8260C, 8720D SIM (cont'd)	CCV	Daily, before sample analysis, unless ICAL performed same day and after every 10 samples and at the end of the analysis sequence.	All analytes within ±20% of expected value (%D). All reported analytes and surrogates within ±50% for end of analytical batch CCV.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Lab Manager/Analyst or certified instrument technician.	EFGS-T-VOA-SOP41085, EFGS-T-VOA-SOP41119, T-SVOA-WI9617, MS 008 ANA8270
	IS	Each CCV and sample.	RT ±10 seconds from RT of the ICAL mid-point standard. EICP area within -50% to +100% of area from IS in ICAL mid-point standard.	Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed during failure is mandatory.	Lab Manager/Analyst or certified instrument technician.	

Instrument	Calibration Procedure	Frequency of Cal bration	Acceptance Criteria	Corrective Action	Person Respons ble for Corrective Action	SOP Reference [a]
GC-FID EPA Method 8015C	Minimum 5-point ICAL for linear calibration Minimum 6-point ICAL for quadratic cal bration	Prior to sample analysis.	RSD for each analyte ≤20% or least square regression ≥0.995. Non-linear least squares regression (quadratic) for each analyte ≤0.995.	Correct problem then repeat ICAL.	Lab Manager/Analyst or certified instrument technician.	GC 010.15, GC 023.13, EFGS-T-GCS-SOP40900
	Second source calibration verification	Once after each ICAL.	Analytes within ±20% of expected value (initial source), and within established RT windows.	Correct problem and verify second source standard. Rerun second source verification. If fails, correct problem and repeat ICAL.	Lab Manager/Analyst or certified instrument technician.	
GC-FID EPA Method 8015C (cont'd)	RT window width	At method set-up and after major maintenance.	RT width is ±3 times standard deviation for each analyte RT from 72-hour study. For TPH-d: calculate RT based on C12 and C25 a kanes.	N/A.	Lab Manager/Analyst or certified instrument technician.	GC 010.15, GC 023.13, EFGS-T-GCS-SOP40900
	Establishment and verification of the RT window for each analyte and surrogate	Once per ICAL and at the beginning of the analytical shift for establishment of RT; and with each CCV for verification of RT.	Using the midpoint standard or the CCV at the beginning of the analytical shift for RT establishment; and analyte must fall within established window during RT verification.	N/A.	Lab Manager/Analyst or certified instrument technician.	
	Run second source cal bration verification (ICV)	ICV: Daily, before sample analysis, unless ICAL performed same day.	All analytes within ±20% of expected value (%D).	Correct problem and rerun ICV. If fails, repeat ICAL.	Lab Manager/Analyst or certified instrument technician.	
	CCV	Daily, before sample analysis, unless ICAL performed same day and after every 10 samples and at the end of the analysis sequence.	All analytes within ±20% of expected value (%D).	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Lab Manager/Analyst or certified instrument technician.	
Water Bath	Measure water temperature against a calibrated thermometer	Annually	In accordance with unit model and manufacturer's recommendation or laboratory SOP.	Terminate analysis, recal brate, and verify before sample analysis.	Lab Manager/Analyst or certified instrument technician	See QA/User Manual
Drying Oven	Measure oven temperature against a calibrated thermometer	Annually	In accordance with unit model and manufacturer's recommendation or laboratory SOP.	Terminate analysis, recalibrate, and verify before sample analysis.	Lab Manager/Analyst or certified instrument technician	See QA/User Manual

Instrument	Calibration Procedure	Frequency of Cal bration	Acceptance Criteria	Corrective Action	Person Respons ble for Corrective Action	SOP Reference [a]
Analytical Balance	Calibrate against verified (NIST) mass	Daily or prior to analyzing samples	In accordance with unit model and manufacturer's recommendation or laboratory SOP.	Terminate analysis, recalibrate, and verify before sample analysis.	Lab Manager/Analyst or certified instrument technician	See QA/User Manual
pH Meter	Run a minimum 3-point cal bration; run CCV	Daily or prior to analyzing samples; one CCV for every 10 samples	±0.05 unit.	Terminate analysis, recalibrate, and verify before sample analysis.	Lab Manager/Analyst or certified instrument technician	See QA/User Manual

Note: No instrument cal bration procedures for geotechnical and petrographic analyses.

%D percent difference
CA corrective action
CCV continued calibration verification
D difference
DDT dichlorodiphenyltrichloroethane
ICAL initial calibration
ICV initial calibration verification
IS internal standard
RRT relative retention time
RSD relative standard deviation
RT retention time

[a] See Analytical SOP References table (Table D.1-5).

Table D.1-9: Data Verification and Validation (Steps I and IIa/IIb) Process

Data Review Input	Description	Responsible for Verification (name, organization)	Step I/IIa/IIb [a]	Internal/External
Laboratory system audits	Determine whether the laboratory holds a current DoD ELAP certification for all analyses to be performed for the project.	Project Chemist (Devin Kim, AECOM)	Step I	Internal
Field procedures	Determine whether field procedures are performed in accordance with this SAP and prescribed procedures.	QA Program Manager (Scott Lewis, AECOM)	Step I	Internal
Field logbook and notes	Review the field logbook and any field notes on a weekly basis and place them in the project file. Copies of the field logbook and field notes will be provided to the Navy consultant CTO manager and included in the Field Audit Report.	Field Manager (TBD, AECOM)	Step I	Internal
Instrument calibration sheets	Determine whether instruments are calibrated and used in accordance with manufacturer's' requirements.	Project Chemist (Devin Kim, AECOM) & Data Validator (Diane Waldschmidt, EDS)	Step I	Internal & External
CoC forms	Review CoC completed forms and verify them against the corresponding packed sample coolers. A copy of each CoC will be placed in the project file. The original CoC will be taped inside the cooler for shipment to the analytical laboratory.	Project Chemist (Devin Kim, AECOM)	Step I	Internal
Sampling analytical data package	Verify all analytical data packages for completeness prior to submittal of the data to the data validator.	Laboratory Project Manager (Elvin Kumar, SGS; Tracy Dutton, Eurofins)	Step I	External
Analytes	Determine whether all analytes specified in Table B.1-2 were analyzed and reported on by the laboratory.	Project Chemist (Devin Kim, AECOM)	Step IIa	Internal
CoC and field QC logbook	Examine data traceability from sample collection to project data generation.	Project Chemist (Devin Kim, AECOM)	Step IIa	Internal
Laboratory data and SAP requirements	Assess and document the performance of the analytical process. A summary of all QC samples and results will be verified for measurement performance criteria and completeness. Full Validation will be performed on 10% of the data and Standard Validation will be performed on 90% of the data. A report will be prepared within 21 days of receipt.	Data Validator (Diane Waldschmidt, EDS) & Project Chemist (Devin Kim, AECOM)	Steps IIa & IIb	Internal & External
VOCs	Complete Procedure II-B, *Level C and Level D Data Validation Procedure for GC/MS Volatile Organics by SW-846 8260B* (DON 2015).	Data Validator (Diane Waldschmidt, EDS)	Step IIa	External

Data Review Input	Description	Responsible for Verification (name, organization)	Step I/IIa/IIb [a]	Internal/External
PAHs	Complete Procedure II-C, *Level C and Level D data Validation Procedure for GC/MS Semivolatile Organics by SW-846 8270C* (Full Scan and SIM) (DON 2015).	Data Validator (Diane Waldschmidt, EDS)	Step IIa	External
TPH	Complete Procedure II-H, *Level C and Level D Data Validation Procedure for Extractable Total Petroleum Hydrocarbons by SW-846 8015B* (DON 2015).	Data Validator (Diane Waldschmidt, EDS)	Step IIa	External
Sampling plan	Determine whether the number and type of samples specified in Table B.1-2 were collected and analyzed.	Project Chemist (Devin Kim, AECOM) & Field Manager (TBD, AECOM)	Step IIb	Internal
Field QC samples	Establish that the number of QC samples specified in Table B.1-6 were collected and analyzed.	Project Chemist (Devin Kim, AECOM)	Step IIb	Internal
Project quantitation limits and data qualifiers	Establish that sample results met the project quantitation limits and qualify the data in accordance with Procedure II-A, *Data Validation Procedure* (DON 2015).	Data Validator (Diane Waldschmidt, EDS)& Project Chemist (Devin Kim, AECOM)	Step IIb	Internal & External
Validation report	Summarize outcome of data comparison to MPC in the SAP. Include qualified data and an explanation of all data qualifiers.	Data Validator (Diane Waldschmidt, EDS)	Step IIa	External

COC chain of custody
CTO contract task order
DoD Department of Defense
ELAP Environmental Laboratory Accreditation Program
GC/MS gas chromatography/mass spectrometry
MPC measurement performance criteria
PAH polynuclear aromatic hydrocarbon
QA quality assurance
QC quality control
SIM selective ion monitoring
TPH total petroleum hydrocarbons
VOC volatile organic compound
WP work plan
[a] IIa Compliance with methods, procedures, and contracts. See Table 10, page 117, UFP-QAPP manual, V.1 (IDQTF 2005).
IIb Comparison with measurement performance criteria in the SAP. See Table 11, page 118, UFP-QAPP manual, V.1 (IDQTF 2005).