



**Naval Facilities Engineering Systems Command Pacific
JBPHH HI**

Final

Monitoring Well Installation Work Plan

Red Hill Bulk Fuel Storage Facility

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

July 29, 2024

DISSEMINATION LIST

- United States Environmental Protection Agency Region 9, Federal Facilities Cleanup Office
- State of Hawaii Department of Health
- University of Hawaii
- AECOM Technical Services, Inc. (1001 Bishop Street, Suite 1600, Honolulu, HI 96813)



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Prepared for NAVFAC Pacific by
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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
GAC	granular activated carbon
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
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 installed with a screened interval that is in communication with and will "produce" water from the aquifer.
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.
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 distribution and elevation of confined pressure, even though the water is physically present only beneath the confining layer. 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.
Surface Casing	Near-surface conductor casing is cemented into place and serves to shut out shallow water formations and as a foundation for well control.
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 2023c)
 - 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 Hawai‘i 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 Hawai‘i *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). A quality assurance project plan (QAPP) will take 6 months to prepare and develop, and submitted separately from this MWIWP.

Table 1: Field SOPs Reference Table

Reference Number	Title ^a	Originating Organization of Sampling SOP	Equipment Type
I-A-5	<i>Utility Clearance</i>	NAVFAC Pacific	Geophysical equipment (electromagnetic, magnetic, and ground-penetrating radar)
I-A-6	<i>Investigation Derived Waste Management</i>	NAVFAC Pacific	N/A
I-A-8	<i>Sample Naming</i>	NAVFAC Pacific	N/A
I-B-1	<i>Soil Sampling</i>	NAVFAC Pacific	Split-spoon sampler and liners with hollow-stem or solid-stem auger
I-B-2	<i>Geophysical Testing</i>	NAVFAC Pacific	Low frequency electromagnetic induction, magnetometers, and ground-penetrating radar
I-B-5	<i>Surface Water Sampling</i>	NAVFAC Pacific	N/A
I-C-1	<i>Monitoring Well Installation and Abandonment</i>	NAVFAC Pacific	Continuous coring drill rig
I-C-2	<i>Monitoring Well Development</i>	NAVFAC Pacific	Surge block or submersible pump
I-D-1	<i>Drum Sampling</i>	NAVFAC Pacific	COLIWASA or glass thieving tubes
I-E	<i>Soil and Rock Classification</i>	NAVFAC Pacific	N/A
I-F	<i>Equipment Decontamination</i>	NAVFAC Pacific	N/A
I-I	<i>Land Surveying</i>	NAVFAC Pacific	Theodolite - horizontal and vertical control; GPS
III-A	<i>Laboratory QC Samples (Water, Soil)</i>	NAVFAC Pacific	N/A
III-B	<i>Field QC Samples (Water, Soil)</i>	NAVFAC Pacific	N/A
III-D	<i>Logbooks</i>	NAVFAC Pacific	N/A
III-E	<i>Record Keeping, Sample Labeling, and Chain of Custody</i>	NAVFAC Pacific	N/A
III-F	<i>Sample Handling, Storage and Shipping</i>	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 potable 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 Hawai'i 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 include, as applicable, with template forms located 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 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 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 approved well materials will be added to the borehole without prior notification to and approval by 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 approved prior to use. Drillers will use products selected from the pre-approved 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 may 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 approved 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 placed 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.

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, 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 or elevated head will be confirmed during drilling of the well borehole with air methods. Evaluation of perched groundwater, elevated heads, and contamination during corehole drilling and well borehole drilling is described in Section 4.4.3 and Section 6. Bailer jar head space PID tests will be conducted during core holes at the beginning of each day. Bailer jar head space 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 over drilled 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 or bucket auger. 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 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 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., a'ā clinker flow-top breccias [clinker sub-types], inflated pāhoehoe lobes, massive a'ā 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 msl, and the presence of inflow to the borehole will be evaluated by bailing 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 contaminated perched water, core drilling will proceed without interruption to the target depth elevation. 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 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, or pumping; with or without use of packer(s) to isolate testing zones), video logging, 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 feet msl. After the corehole is drilled 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 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, 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 equipped with rock coring and wet rotary drilling capabilities. A thin layer (0.25 to 2 ft thick) of manmade fill (fines, gravel or cobble) is anticipated to be encountered directly below the lower access tunnel floor overlying in situ basalt bedrock. In situ bedrock will range from massive a'ā 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 the corehole is drilled, it will be reamed to a diameter large enough to install a well. Multiple reaming passes may be required. Geophysical logging will 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 air rotary methods until competent bedrock is encountered. 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 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 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 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, or pumping; with or without use of packer(s) to isolate testing zones), video logging, or geophysical logging. Packers may not be appropriate in certain conditions, such as in unstable boreholes or coreholes. 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.

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 borehole (before well installation) 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, 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, 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

4.4.1 Unconfined Groundwater

Outside the tunnel, after drilling to target depth approximately 25 ft below msl, the static water level will be evaluated by removing groundwater from the well borehole by air injection (blowing) 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 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 blowing or bailing the borehole clear and measuring recovery of the water level. If groundwater elevations do not fall within this range, indicating non-water table conditions, the borehole will be extended and tested until communication with the basal basalt 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 good hydraulic communication with the basalt basal aquifer.

If confined conditions are confirmed, drilling will advance until the water level in the borehole stabilizes at approximately 16–20 ft msl, and the initial rate of water recovery in the borehole is greater than 0.5 gallon per minute (gpm) after the hole is cleared with air, 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, water levels will be measured in the corehole at the beginning and end of each day, and a transducer will be deployed overnight. 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, 4, and 6.5.

During well borehole drilling, 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 with compressed air, bailer, or other acceptable method and a jar headspace sample will be collected from the discharged water to evaluate the presence of contamination. Groundwater in the borehole will be

cleared and observations conducted at the start of each day and at approximately 40-ft intervals while drilling. If water is present in the hole at the end of the day and the hole is apparently stable, a pressure transducer will be deployed overnight. 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. Testing will include removal of water by air injection of bailing and recovery testing. Discharged water quality parameters will be evaluated and PID jar headspace tests will be conducted. If groundwater inflow is detected from perched 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, PQ coring will be conducted until the target depth is reached.
- After PQ rock 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 suspected 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 cement 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 drill 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, in accordance with well construction standards specified by 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 CONDUCTOR CASING

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 is encountered. A 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 conductor 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 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 ppmv detected above 30 ft msl 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, 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 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 potentiometric surface in an interval with good hydraulic communication with the basal aquifer
- Figure 5 for perched or elevated-head groundwater conditions with submerged screen above (perched condition) or below (elevated-head condition) the basal aquifer potentiometric surface
- Figure 6 for typical in-tunnel wells
- Figure 7 for in-tunnel wells with reamed and grouted interval for perched 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 screen. 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- to 40-ft intervals on the blank casing. Manufacturer-supplied O-rings will be installed on all threaded PVC 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-thick seal 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-thick seal 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, 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 cement to not more than 6 gallons of potable water.
- *Cement-bentonite grout:* A slurry of Portland cement, bentonite and water. The amount of bentonite added shall 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 Portland Type I 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 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) (DON 2023b). An offsite laboratory will perform the analyses specified in the CGSP (DON 2023b). 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 (DON 2023b).

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, 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 at the end of each workday. 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 from each grouping for waste characterization in accordance with Procedure I-D-1, *Drum Sampling* (DON 2015). 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 associated waste profile forms are approved by the disposal facilities. 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 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, the fluids will be labeled as waste and treated, if necessary, to reduce pH to < 12.5 pH units prior to transport.

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

Four 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 four scenarios include:

- 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
- 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

Moderate levels of contamination observed (e.g., with evidence of olfactory or visual oily staining or sheen on rock core or drill cuttings). 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.

6.4 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 >50 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.

7. References

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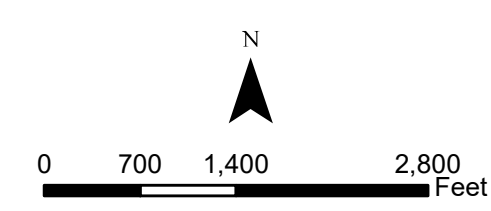
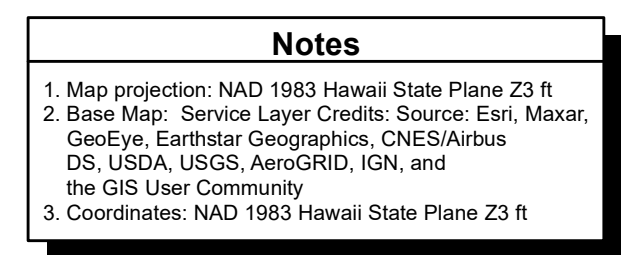
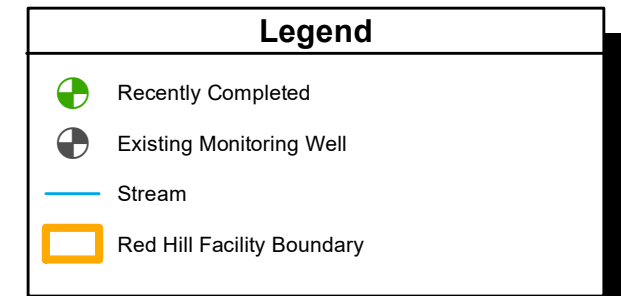
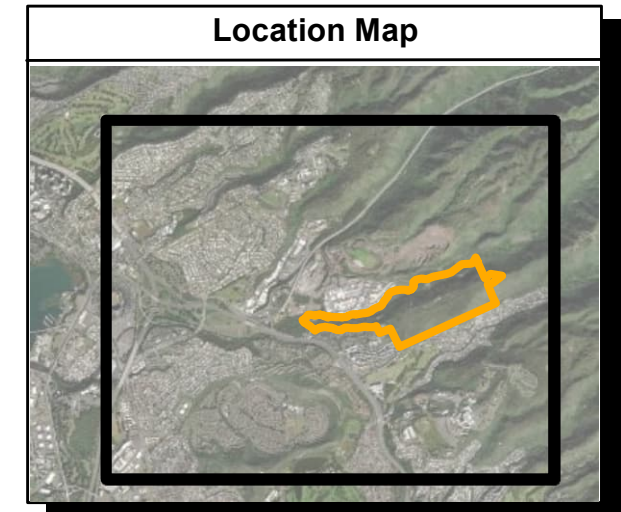
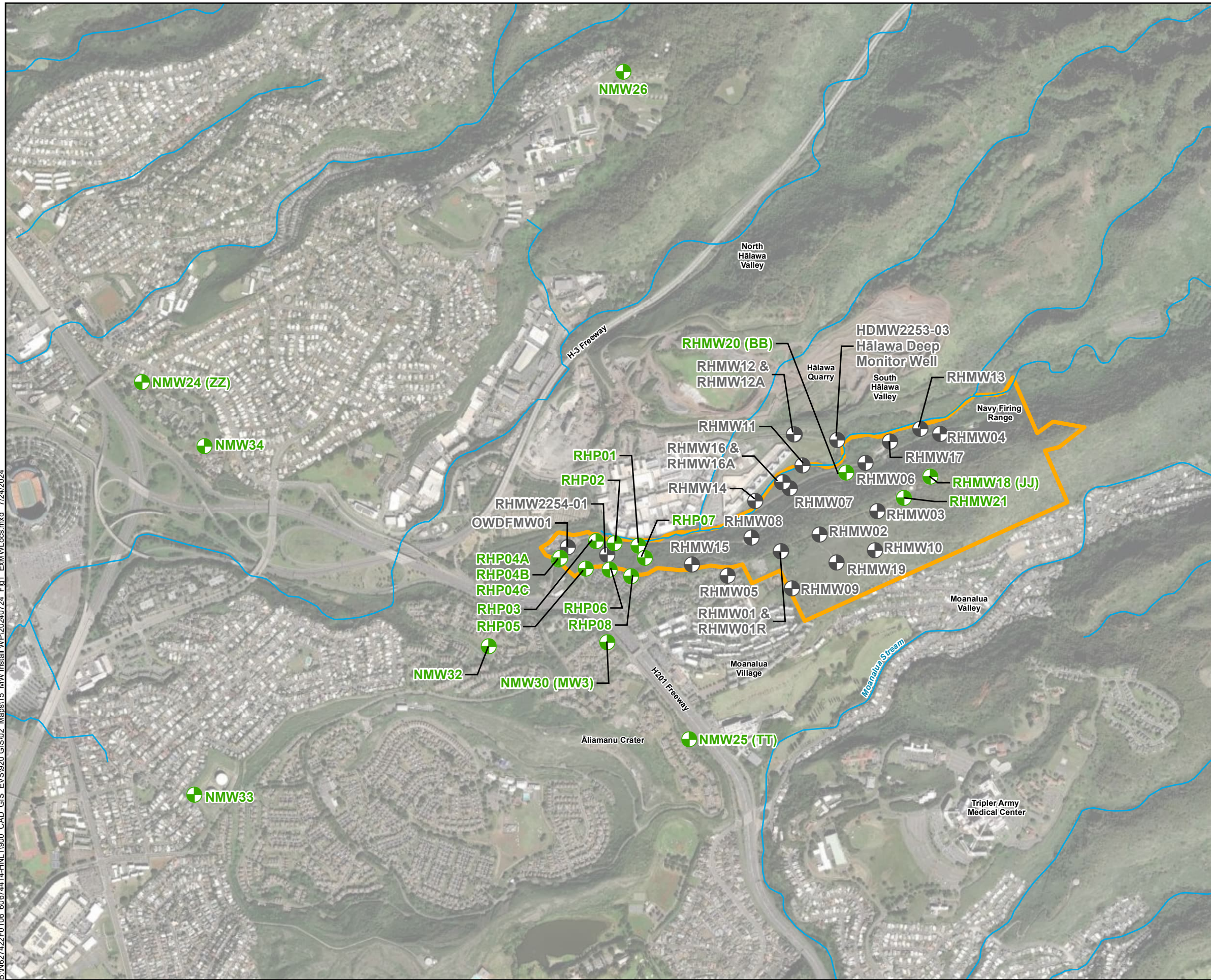


Figure 1
Existing Monitoring Well Locations
Monitoring Well Installation Work Plan
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

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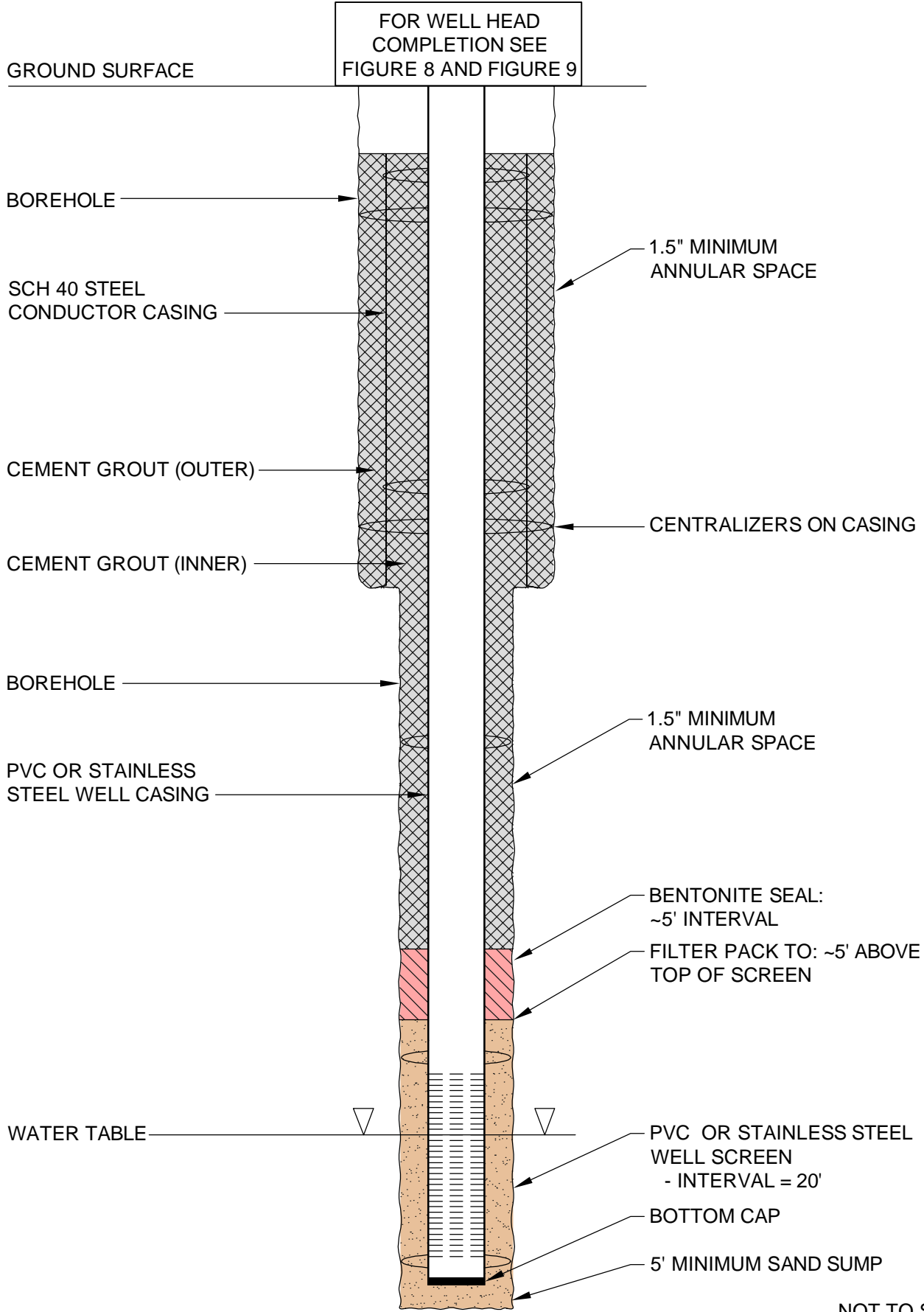
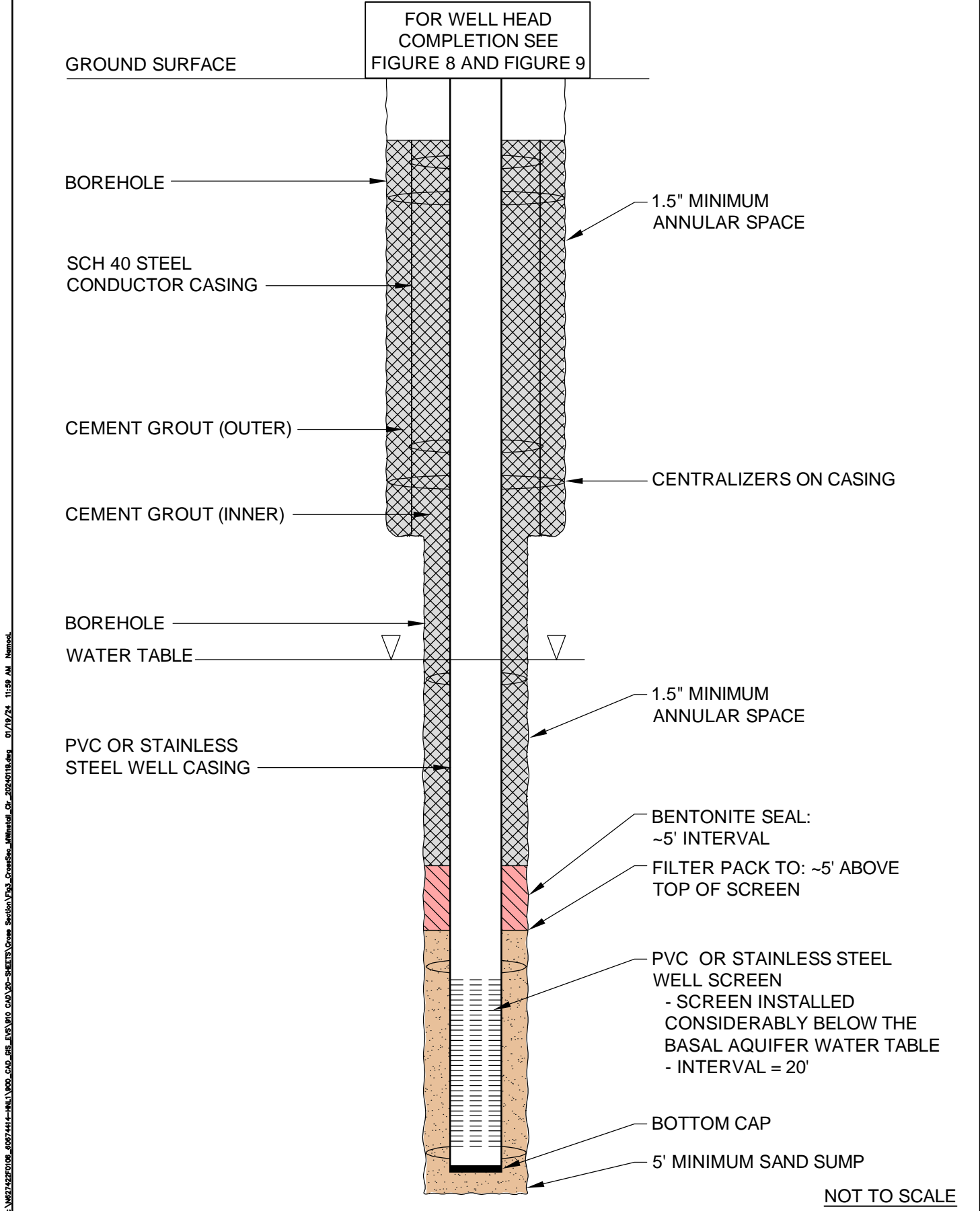
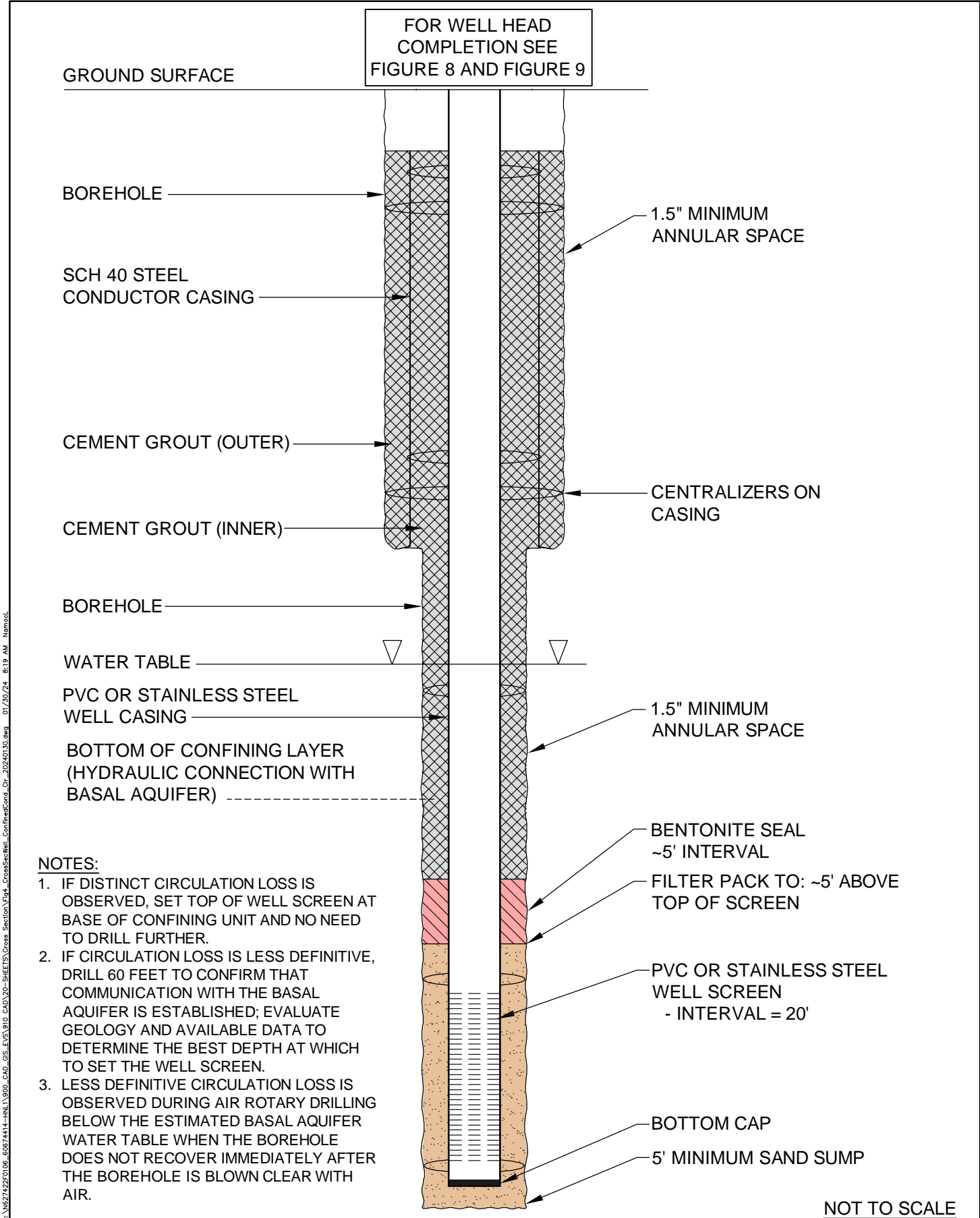


Figure 2
Typical Well Construction Diagram for Monitoring Well (Unconfined Conditions)
Monitoring Well Installation Work Plan
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i



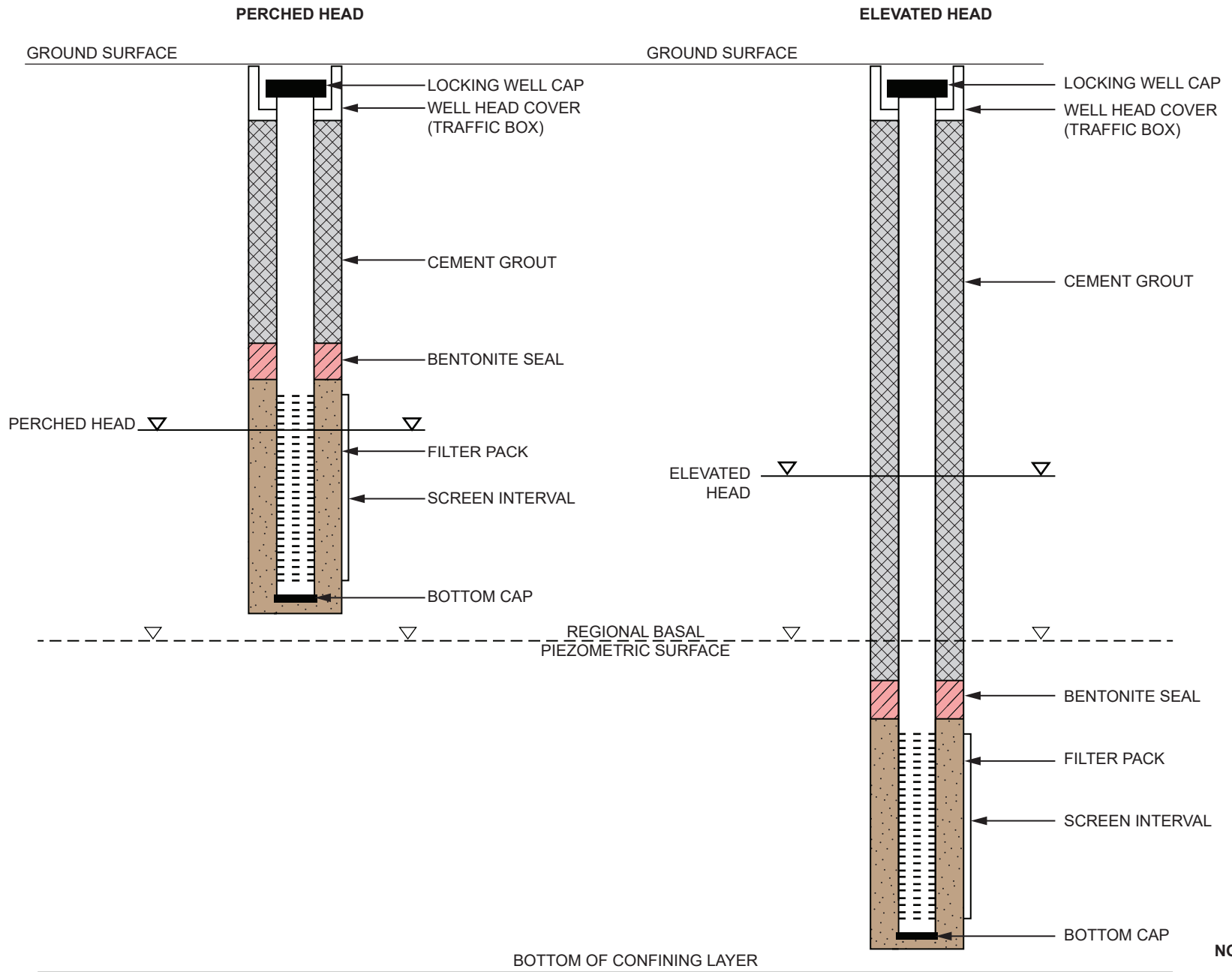
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Figure 3
Typical Well Construction Diagram for Monitoring Well (Unconfined Conditions - Deep Well)
Monitoring Well Installation Work Plan
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i



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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



NOT TO SCALE

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

TUNNEL FLOOR SURFACE

CONCRETE FLUSH-TO-GRADE

WELL HEAD COVER FOR
FLUSH-TO-GRADE (TRAFFIC BOX)

EXPANSION PLUG

CENTRALIZERS ON CASING

2" SCH 80 PVC WELL CASING

PQ COREHOLE DIAMETER OF
4.875" REAMED TO 5.375"
MINIMUM DIAMETER FOR TOTAL
DEPTH OF THE WELL

1.5" ANNULAR SPACE

CEMENT GROUT

BENTONITE SEAL
~5' INTERVAL

WELL SCREEN INTERVAL
~ 10' ABOVE WATER TABLE
TO ~ 10' BELOW WATER TABLE

FILTER PACK TO ~ 5' ABOVE
TOP OF SCREEN

2" SCH 80 PVC WELL SCREEN
- INTERVAL = 20'

WATER TABLE

BOTTOM CAP

5' MINIMUM SAND SUMP

NOT TO SCALE

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

TUNNEL FLOOR SURFACE

CONCRETE FLUSH-TO-GRADE

WELL HEAD COVER FOR
FLUSH-TO-GRADE (TRAFFIC BOX)

EXPANSION PLUG

CENTRALIZERS ON CASING

2" SCH 80 PVC WELL CASING

ISOLATION BOREHOLE

REAMED BOREHOLE

CEMENT GROUT

REAMED BOREHOLE

1.5" ANNULAR SPACE

WELL SCREEN INTERVAL
~ 10' ABOVE WATER TABLE
TO ~ 10' BELOW WATER TABLE

BENTONITE SEAL
~ 5' INTERVAL

FILTER PACK TO ~ 5' ABOVE
TOP OF SCREEN

2" SCH 80 PVC WELL SCREEN
- INTERVAL = 20'

WATER TABLE

BOTTOM CAP

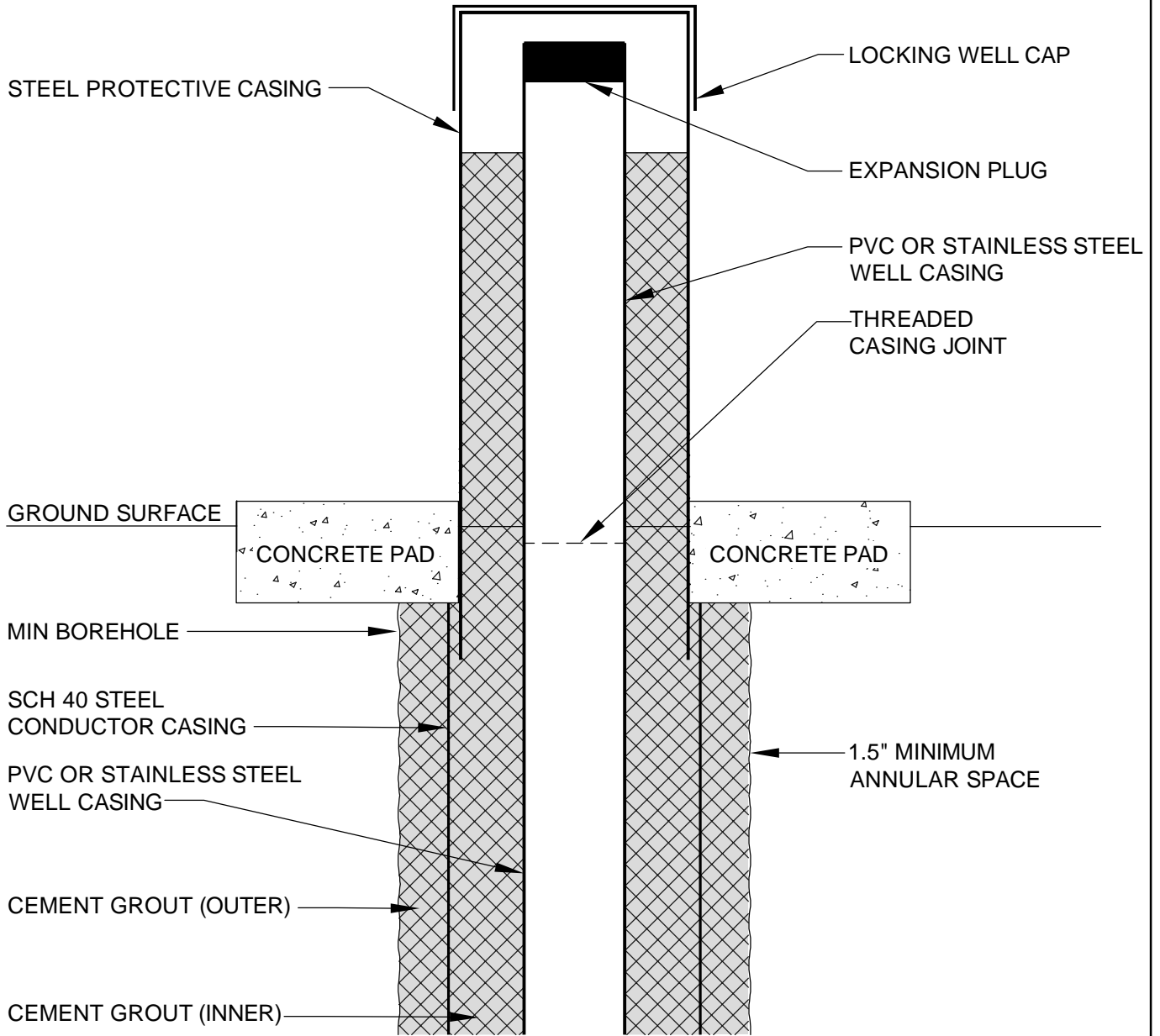
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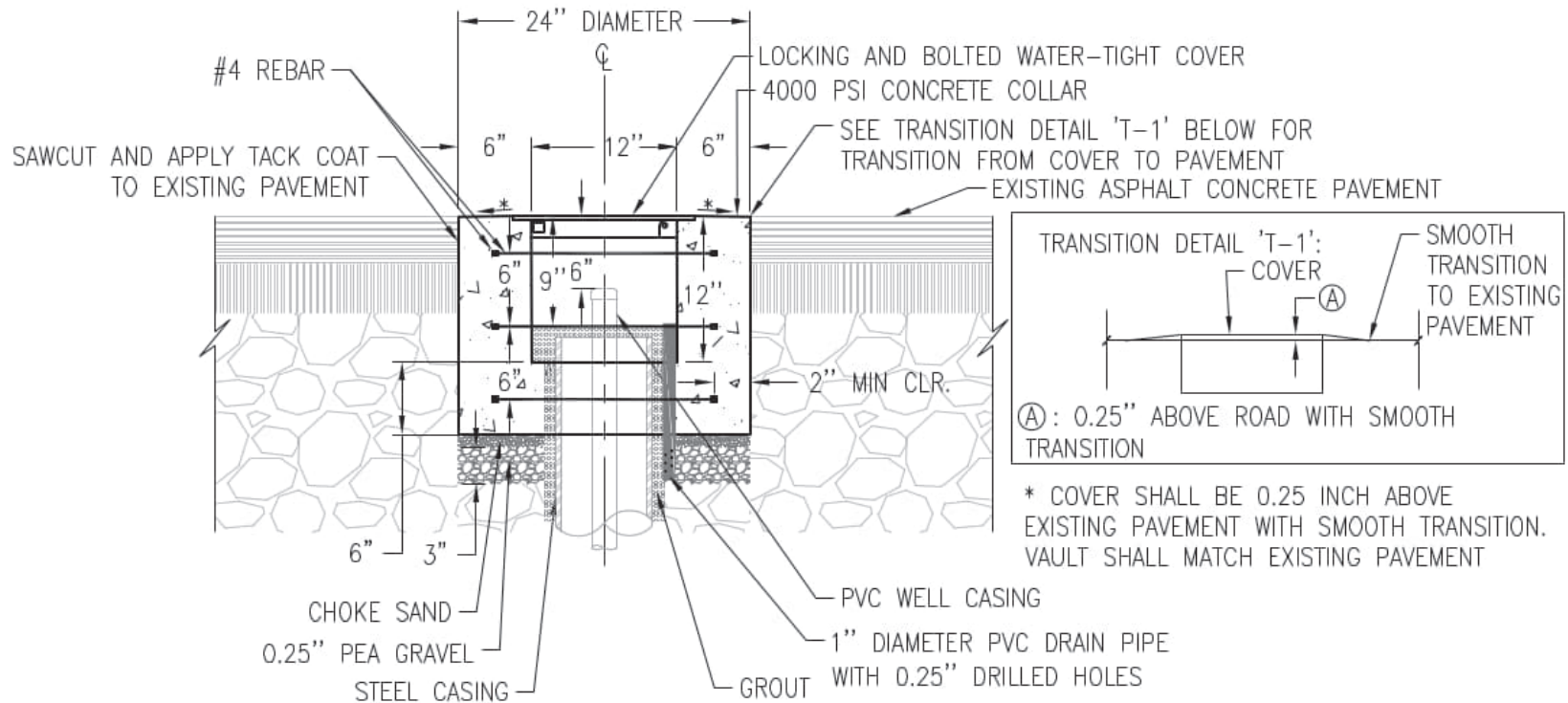
Figure 7
Tunnel Well Construction Diagram with Reamed and Grouted Interval
Monitoring Well Installation Work Plan
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

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NOT TO SCALE

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

MINGXUN DING

LICENSED PROFESSIONAL ENGINEER

NO. 9246-C

HAWAII, U.S.A.

[Signature]

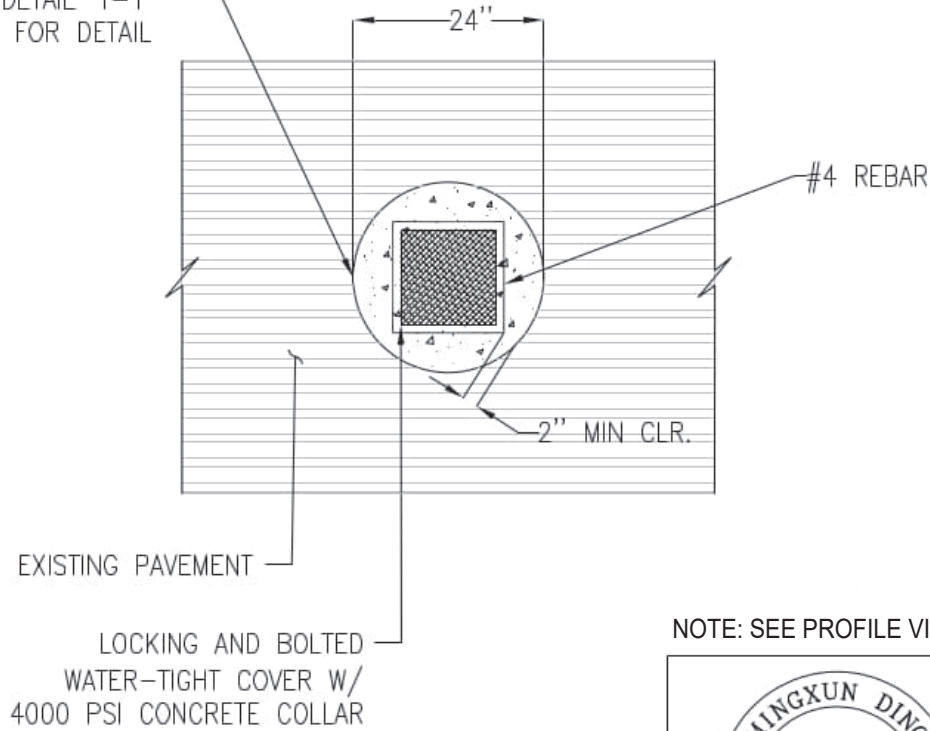
4/30/24

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

PROVIDE SMOOTH TRANSITION
FROM COVER TO PAVEMENT,
SEE TRANSITION DETAIL 'T-1'
IN FIGURE 7 FOR DETAIL

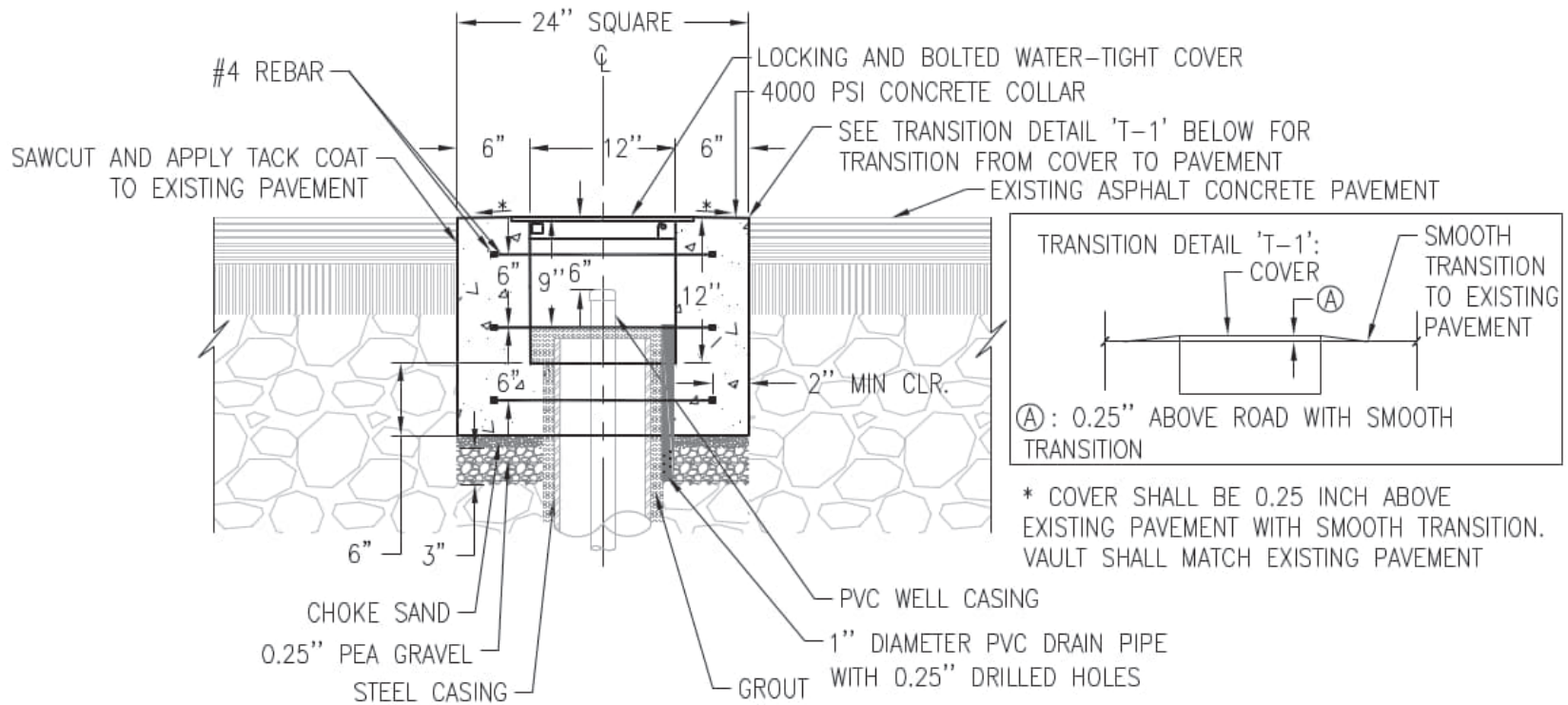


NOTE: SEE PROFILE VIEW

		4/30/24
	SIGNATURE	
THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION AND CONSTRUCTION OF THIS PROJECT WILL BE UNDER MY OBSERVATION.		

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

PROFILE VIEW (SQUARE)

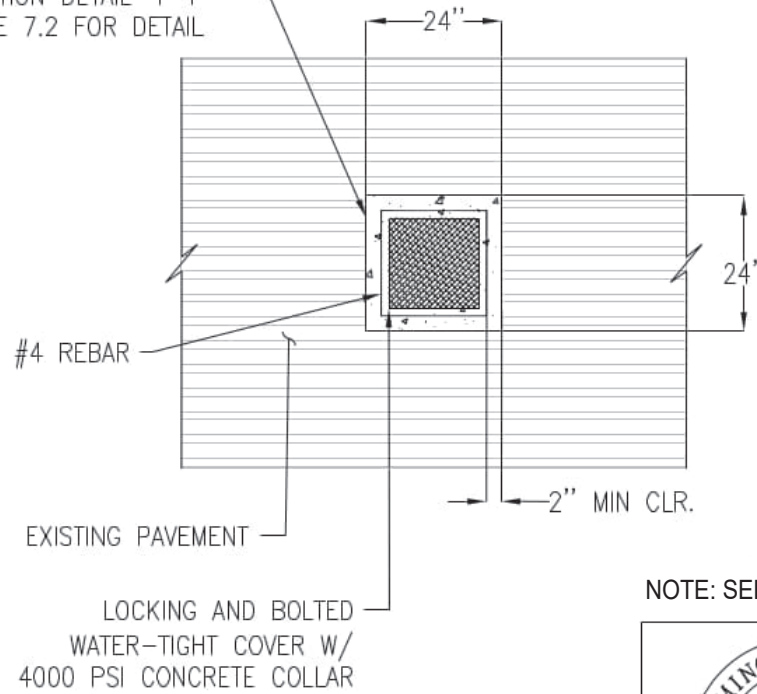
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SIGNATURE

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
 JBPBH, O'ahu, Hawai'i**

PROVIDE SMOOTH TRANSITION
FROM COVER TO PAVEMENT,
SEE TRANSITION DETAIL 'T-1'
IN FIGURE 7.2 FOR DETAIL



NOTE: SEE PROFILE VIEW (SQUARE)

PLAN VIEW (SQUARE)

		4/30/24
	SIGNATURE	
<p>THIS WORK WAS PREPARED BY ME OR UNDER MY SUPERVISION AND CONSTRUCTION OF THIS PROJECT WILL BE UNDER MY OBSERVATION.</p>		

**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:
Approved Drilling Materials and Additives
(As of: February 20, 2024)**

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. Figure B-2 depicts existing, recently completed, and 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)
NMW27A	North Hālawā Valley	✓	✓	<p>NMW27A will provide groundwater elevation data between Red Hill and BWS Hālawā 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 Hālawā 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 Hālawā Valley. Groundwater quality data will be used to evaluate the potential for COPCs to flow to the northwest toward North Hālawā Valley and BWS Hālawā Shaft.</p> <p>This well is co-located with NMW27 and is anticipated to be a deeper confined basal well. The submerged well screen will be 20 ft long.</p>	127	107	Screen interval to be determined during drilling. ^a	Total drilled depth to be determined during drilling. ^a
NMW28 (PP)	North Hālawā Valley	✓	✓	<p>NMW28 will provide groundwater elevation data west of the quarry pit to further evaluate groundwater elevations directly between Red Hill Shaft and BWS Hālawā Shaft. The data will be used to obtain groundwater elevation data in the upper portion of North Hālawā Valley near BWS Hālawā Shaft. Lithologic data from this location will be used to further define the geometry of the valley fill sediments and saprolite layers in North Hālawā Valley. Groundwater quality data will be used to evaluate the groundwater quality in the vicinity of BWS Hālawā Shaft.</p> <p>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.</p>	150	130	Screen interval to be determined during drilling. ^a	Total drilled depth to be determined during drilling. ^a
NMW28A	North Hālawā Valley	✓	✓	<p>NMW28 will provide groundwater elevation data west of the quarry pit to further evaluate groundwater elevations directly between Red Hill Shaft and BWS Hālawā Shaft. The data will be used to obtain groundwater elevation data in the upper portion of North Hālawā Valley near BWS Hālawā Shaft. Lithologic data from this location will be used to further define the geometry of the valley fill sediments and saprolite layers in North Hālawā Valley. Groundwater quality data will be used to evaluate the groundwater quality in the vicinity of BWS Hālawā Shaft.</p> <p>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.</p>	150	130	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)
NMW29 (MW1)	North Hālawā Valley	✓		<p>NMW29 will provide groundwater elevation data west of the Hālawā 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 Hālawā Valley, toward Navy 'Aiea Hālawā Shaft. Lithologic data from this location will be used to further define the properties of the basalt in the southern portion of North Hālawā Valley. Groundwater quality will be used to evaluate groundwater quality south of BWS Hālawā Shaft and prior to Navy 'Aiea Hālawā Shaft.</p> <p>This well is co-located with NMW29A and is planned to be installed across the basal water table.</p>	147	127	117–147	152
NMW29A	North Hālawā Valley	✓		<p>NMW29A will provide groundwater elevation data west of the Hālawā 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 Hālawā Valley, toward Navy 'Aiea Hālawā Shaft. Lithologic data from this location will be used to further define the properties of the basalt in the southern portion of North Hālawā Valley. Groundwater quality will be used to evaluate groundwater quality south of BWS Hālawā Shaft and prior to Navy 'Aiea Hālawā Shaft.</p> <p>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.</p>	147	127	407–427	452
RHP08B	Lower Red Hill Ridge	✓		<p>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.</p> <p>This well 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.</p>	310	290	420–440	465

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)
SS	Moanalua Valley	✓	✓	<p>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.</p> <p>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.</p>	337	317	Screen interval to be determined during drilling. ^a	Total drilled depth to be determined during drilling. ^a
NMW22 (MM)	South Hālawā Valley	✓	✓	<p>NMW22 will provide groundwater elevation data between Red Hill and BWS Hālawā Shaft to further evaluate groundwater flow patterns southeast of the quarry pit. The data from this well will be used to further evaluate groundwater flow patterns in and adjacent to South Hālawā 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 Hālawā Valley. Groundwater quality data will be used to evaluate the groundwater quality to the northwest approximately halfway between Red Hill tanks and BWS Hālawā Shaft. This location has been slightly revised from previous depictions based on site access issues.</p> <p>This well is anticipated to be a confined basal well. The submerged well screen will be 20 ft long.</p>	237	217	Screen interval to be determined during drilling. ^a	Total drilled depth to be determined during drilling. ^a
NMW23 (XA)	South Hālawā Valley	✓	✓	<p>NMW23 will provide groundwater elevation data between Red Hill and BWS Hālawā Shaft to further evaluate groundwater flow patterns southwest of the quarry pit. The data from this well will be used to further evaluate groundwater flow patterns in and adjacent to South Hālawā 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 Hālawā 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 Hālawā Shaft. This location has been slightly revised from previous depictions based on site access issues.</p> <p>This well is anticipated to be a confined basal well. The submerged well screen will be 20 ft long.</p>	209	189	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)
XE	South Hālawā Valley	✓	✓	<p>XE will provide groundwater elevation data between Red Hill and BWS Hālawā 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 Hālawā Valley and North Hālawā Valley. Lithologic data from this location will be used to further define the geometry of the valley fill sediments and saprolite layers in South Hālawā Valley. Groundwater quality data will be used to evaluate the groundwater quality to the northwest approximately halfway between upper Red Hill tanks and BWS Hālawā Shaft. The XE location was selected to provide (a) hydraulic data in response to pumping of BWS Hālawā Shaft, and (b) monitoring of potential migration from the Facility toward BWS Hālawā 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.</p> <p>The well screen is planned to be installed across the basal water table.</p>	374	354	344–374	379
NMW42 (LL)	South Hālawā Valley	✓	✓	<p>NMW42 will provide groundwater elevation data between Red Hill and BWS Hālawā Shaft to further evaluate groundwater flow patterns southeast of the quarry pit. Groundwater elevation data from this well will help to further evaluate groundwater flow patterns in and adjacent to South Hālawā 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 Hālawā 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 Hālawā Shaft, and (b) monitoring of potential migration from the Facility toward BWS Hālawā Shaft with ample remaining travel time as to enable response actions.</p> <p>This well is co-located with NMW42A and is anticipated to be an elevated head well. The well screen will be 30 ft long.</p>	261	TBD	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)
NMW42A	South Hālawā Valley	✓	✓	<p>NMW42A will provide groundwater elevation data between Red Hill and BWS Hālawā Shaft to further evaluate groundwater flow patterns southeast of the quarry pit. Groundwater elevation data from this well will help to further evaluate groundwater flow patterns in and adjacent to South Hālawā 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 Hālawā 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 Hālawā Shaft, and (b) monitoring of potential migration from the Facility toward BWS Hālawā Shaft with ample remaining travel time as to enable response actions.</p> <p>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.</p>	261	241	Screen interval to be determined during drilling. ^a	Total drilled depth to be determined during drilling. ^a
XC	South Hālawā Valley	✓	✓	<p>XC will provide groundwater elevation data between Red Hill and BWS Hālawā Shaft to further evaluate groundwater flow patterns southwest of the quarry pit. The data from this well will be used to further evaluate groundwater flow patterns in and adjacent to South Hālawā 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 Hālawā 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.</p> <p>This well is anticipated to be a confined basal well. The submerged well screen will be 20 ft long.</p>	242	222	Screen interval to be determined during drilling. ^a	Total drilled depth to be determined during drilling. ^a
NMW40 (OO)	North Hālawā Valley	✓	✓	<p>NMW40 is located near BWS Hālawā 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 Hālawā Valley. Groundwater elevation data from this well will improve understanding of hydraulic characteristics in this area due to BWS Hālawā Shaft pumping. It will provide groundwater elevation data northwest of the quarry pit to further evaluate groundwater elevations directly between Red Hill Shaft and BWS Hālawā Shaft. Lithologic data from this location will be used to further define the geometry of the valley fill sediments and saprolite layers in North Hālawā Valley and evaluate the existence of confining conditions in North Hālawā Valley similar to those that existing in South Hālawā Valley. Groundwater quality data will be used to evaluate the groundwater quality in the vicinity of BWS Hālawā Shaft. Original location OO has been re-located to the current location due to site access at Halawa Quarry.</p> <p>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.</p>	154	134	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)
NMW40A	North Hālawala Valley			<p>NMW40A will provide groundwater elevation data west of the quarry pits to further evaluate groundwater elevations directly between Red Hill Shaft and BWS Hālawala Shaft. The data will be used to evaluate groundwater flow patterns across South Hālawala Valley and North Hālawala 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 Hālawala Valley. Groundwater quality data will be used to evaluate the groundwater quality to the north between Red Hill Shaft and BWS Hālawala Shaft.</p> <p>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.</p>	169	149	Screen interval to be determined during drilling. ^a	Total drilled depth to be determined during drilling. ^a
NMW35	South Hālawala Valley	✓	✓	<p>NMW35 will provide groundwater elevation data between Red Hill and BWS Hālawala Shaft to further evaluate groundwater flow patterns southwest of the quarry pit. The data from this well will be used to further evaluate groundwater flow patterns in and adjacent to South Hālawala 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 Hālawala Valley. Locations NMW23 and NMW35 will meet many of the objectives of the original XC.</p> <p>This well is anticipated to be a confined basal well. The submerged well screen will be 20 ft long.</p>	195	175	Screen interval to be determined during drilling. ^a	Total drilled depth to be determined during drilling. ^a
NMW36	South Hālawala Valley	✓	✓	<p>NMW36 will provide groundwater elevation data between Red Hill and BWS Hālawala Shaft to further evaluate groundwater flow patterns southwest of the quarry pit. The data from this well will be used to further evaluate groundwater flow patterns in and adjacent to South Hālawala 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 Hālawala 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 Hālawala Shaft. Location NMW36 will meet many of the objectives of the original XC.</p> <p>This well is anticipated to be a confined basal well. The submerged well screen will be 20 ft long.</p>	173	153	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)
NMW31	North Hālawā Valley	✓	✓	<p>NMW31 is located near BWS Hālawā 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 Hālawā Valley. Groundwater elevation data from this well will improve understanding of hydraulic characteristics in this area due to BWS Hālawā Shaft pumping. It will provide groundwater elevation data northwest of the quarry pit to further evaluate groundwater elevations directly between Red Hill Shaft and BWS Hālawā Shaft. Lithologic data from this location will be used to further define the geometry of the valley fill sediments and saprolite layers in North Hālawā Valley and evaluate the existence of confining conditions in North Hālawā Valley similar to those that existing in South Hālawā Valley. Groundwater quality data will be used to evaluate the groundwater quality in the vicinity of BWS Hālawā Shaft.</p> <p>This well is anticipated to be a confined basal well. The submerged well screen will be 20 ft long.</p>	200	180	Screen interval to be determined during drilling. ^a	Total drilled depth to be determined during drilling. ^a
NMW37	Āliamanu Crater		✓	<p>NMW37 will provide groundwater elevation data SSW of Red Hill Shaft, south SW 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.</p> <p>This well is anticipated to be a confined basal well. The submerged well screen will be 20 ft long.</p>	68	48	Screen interval to be determined during drilling. ^a	Total drilled depth to be determined during drilling. ^a
NMW39	Āliamanu Crater		✓	<p>NMW39 will provide groundwater elevation data southwest of Red Hill Shaft, southwest of the Red Hill tanks, and south of Hālawā 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 Hālawā 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.</p> <p>This well is anticipated to be a confined basal well. The submerged well screen will be 20 ft long.</p>	167	147	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)
NMW38	South Hālawā Valley		✓	<p>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 Hālawā 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 Hālawā Valley.</p> <p>This well is co-located with NMW38A and is anticipated to be an elevated head well. The well screen will be 30 ft long.</p>	93	TBD	Screen interval to be determined during drilling. ^a	Total drilled depth to be determined during drilling. ^a
NMW38A	South Hālawā Valley		✓	<p>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 Hālawā 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 Hālawā Valley.</p> <p>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.</p>	93	73	Screen interval to be determined during drilling. ^a	Total drilled depth to be determined during drilling. ^a
NMW41	North Hālawā Valley		✓	<p>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 Hālawā 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 Hālawā Shaft.</p> <p>This well is anticipated to be a confined basal well. The submerged well screen will be 20 ft long.</p>	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		✓	<p>NMW33A will provide groundwater elevation data southwest of Red Hill Shaft, southwest of the Red Hill tanks, and south of Hālawā 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 Hālawā 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.</p> <p>This well is anticipated to be a confined basal well. The submerged well screen will be 20 ft long.</p>	132	122	Screen interval to be determined during drilling. ^a	Total drilled depth to be determined during drilling. ^a
NMW43 (MW4)	Moanalua Valley			<p>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.</p> <p>This well is co-located with NMW43A and is anticipated to be an elevated head well. The well screen will be 30 ft long.</p>	120	TBD	Screen interval to be determined during drilling. ^a	Total drilled depth to be determined during drilling. ^a
NMW43A	Moanalua Valley			<p>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.</p> <p>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.</p>	120	100	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)
KK	South Hālawā 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 Hālawā 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 Hālawā 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-1: 380	KK-1: 370–400	KK-1: 405
					KK-2: 750	KK-2: 730	KK-2: 720–750	KK-2: 755
					KK-3: 250	KK-3: 230	KK-3: 220–250	KK-3: 255

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.

^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, recently completed, and 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)	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 was installed across the basal water table.	132	114	104–124	130
RHP08C	Lower Red Hill Ridge	✓		RHP08C, currently under construction, 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 proposed 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.	310	290	570–590	615
NMW27 (QQ)	North Hālawā Valley	✓	✓	NMW27, currently under construction, will provide groundwater elevation data between Red Hill and BWS Hālawā 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 Hālawā 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 Hālawā Valley. Groundwater quality data will be used to evaluate the potential for COPCs to flow to the northwest toward North Hālawā Valley and BWS Hālawā Shaft. This well is co-located with proposed NMW27A and is anticipated to be a confined basal well. The submerged well screen will be 20 ft long.	127	57 (perched/elevated head, above confining unit), 109 (confined basal aquifer head)	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)	Total Depth (ft bgs)
NMW24		✓	✓	NMW24 provides groundwater elevation data to further evaluate groundwater flow patterns west of North Hālawā Valley in the vicinity of Navy 'Aiea Hālawā Shaft. Data from this well will be used to further evaluate groundwater flow patterns in and adjacent to the confluence of North and South Hālawā 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 Hālawā Valley. Groundwater quality data are used to evaluate the groundwater quality proximal Navy 'Aiea Hālawā Shaft. This location was added to the plan with the goal of restoring production at Navy 'Aiea Hālawā Shaft. The well screen was installed across the basal water table.	106	91.18	80–110	117.7
RHMW20		✓	✓	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 Hālawā 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 Hālawā Valley. Groundwater quality data will be used to evaluate the potential for COPCs to flow to the northwest toward North Hālawā Valley and Hālawā Shaft. The well screen was installed across the basal water table.	252.2	234.5	223–253	261.4
NMW25		✓	✓	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 is 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 Aliamanu 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 was installed across the basal water table.	208.5	190.7	81–211	216
NMW32		✓	✓	NMW32 provides groundwater elevation data southwest of Red Hill Shaft, southwest of the Red Hill tanks, and between Moanalua and Hālawā 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 Aliamanu 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 was installed across the basal water table.	188.5	171.13	161–191	211

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)
NMW33		✓	✓	NMW33 provides groundwater elevation data southwest of Red Hill Shaft and the Red Hill tanks, and south of Hālawā Valley. Lithologic data from this location will be used to further define the geometry and extent of the Aliamanu Crater volcanic tuffs, valley fill sediments and saprolite layers along the southern edge of Hālawā 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 was installed across a perched water table in volcanic tuff.	131	117.53	108–138	143.7
NMW30		✓	✓	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 RHBFSF. Lithologic data from this location will be used to further define the geometry and extent of the Aliamanu 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 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 original objectives of the SS location, even though different stratigraphy may be encountered. The well screen was 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. It's 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 was installed across the basal water table.	621.8	601.83	592–622	633.5
NMW26	North Hālawā Valley	✓		NMW26 is located northwest of North Hālawā 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 Hālawā Valley. The well will provide geologic and hydrogeologic information at higher elevations relative to the site. The well screen was installed across the basal water table.	767	750.36	741–771	790.5

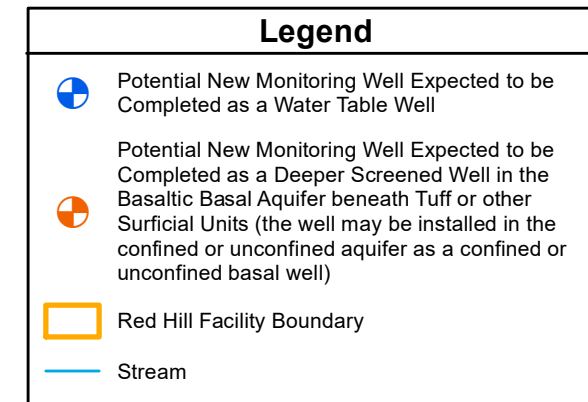
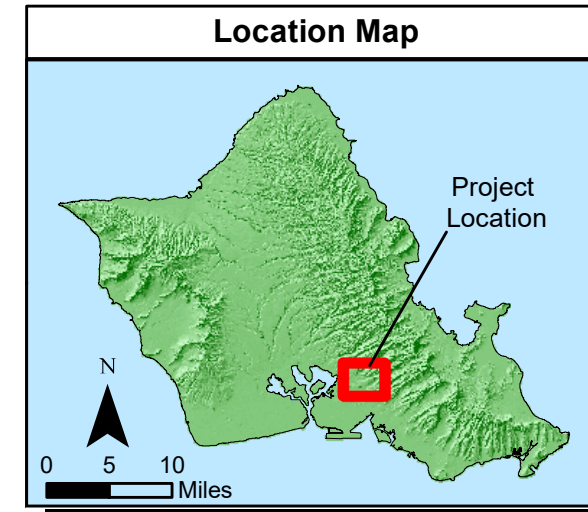
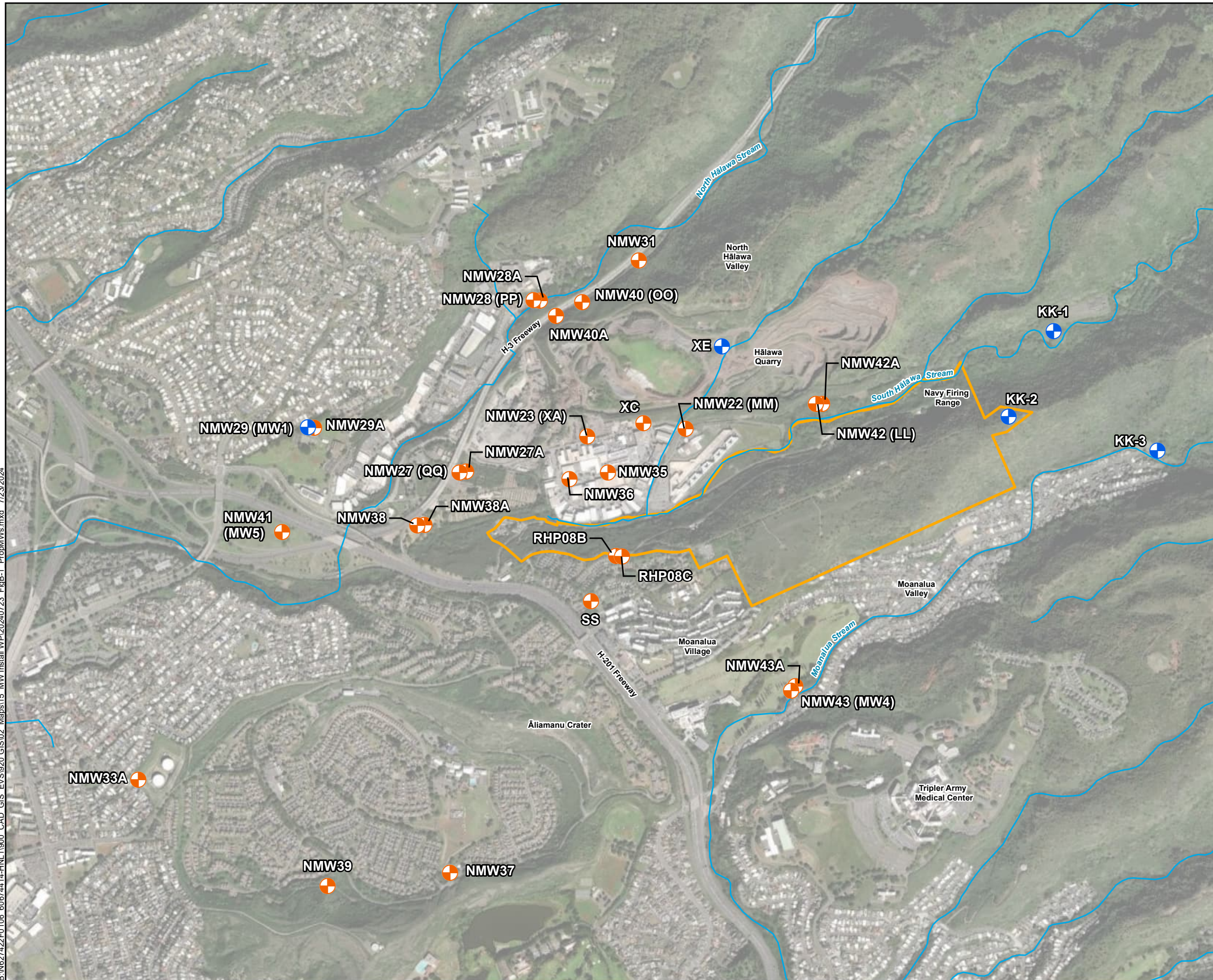
Well	Area	Monitoring Well	Caprock / Saprolite	Data Objectives and Rationale	Well Installation Parameters			
					Surface Elevation (ft msl)	Depth to Groundwater (ft bgs)	Monitoring Well Screen Interval (ft bgs)	Total Depth (ft bgs)
NMW34	North Hālawā Valley	✓	✓	NMW34 provides groundwater elevation data to further evaluate groundwater flow patterns west of North Hālawā Valley in the vicinity of Navy 'Aiea Hālawā Shaft, as well as groundwater flow patterns in and adjacent to the confluence of North and South Hālawā 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 Hālawā Valley. Groundwater quality data will be used to evaluate the groundwater quality proximal Navy 'Aiea Hālawā Shaft. The well screen was installed across the basal water table.	82.3	65.7	56–86	95

Well currently under construction.

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.

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Notes

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

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

Candidates for co-located wells:

- NMW27/NMW27A - confined basal well and deeper confined basal well
- 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
- RHP08B/RHP08C - deep unconfined basal well and deeper unconfined basal well

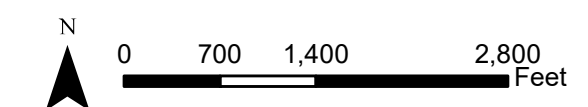
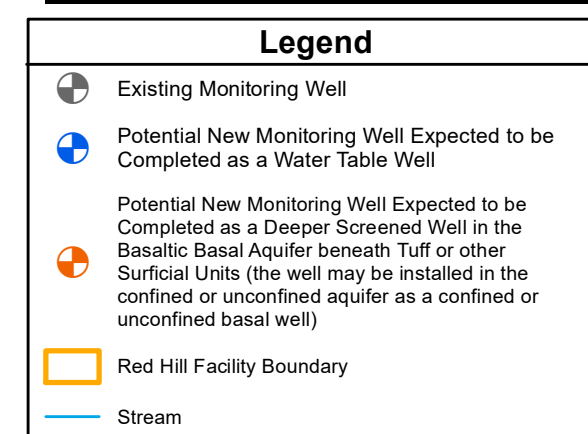
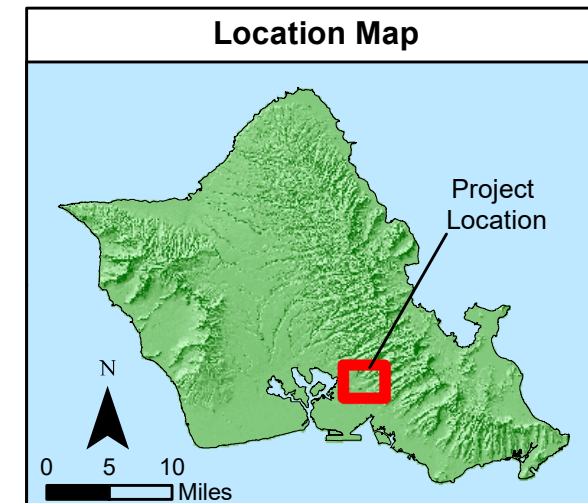
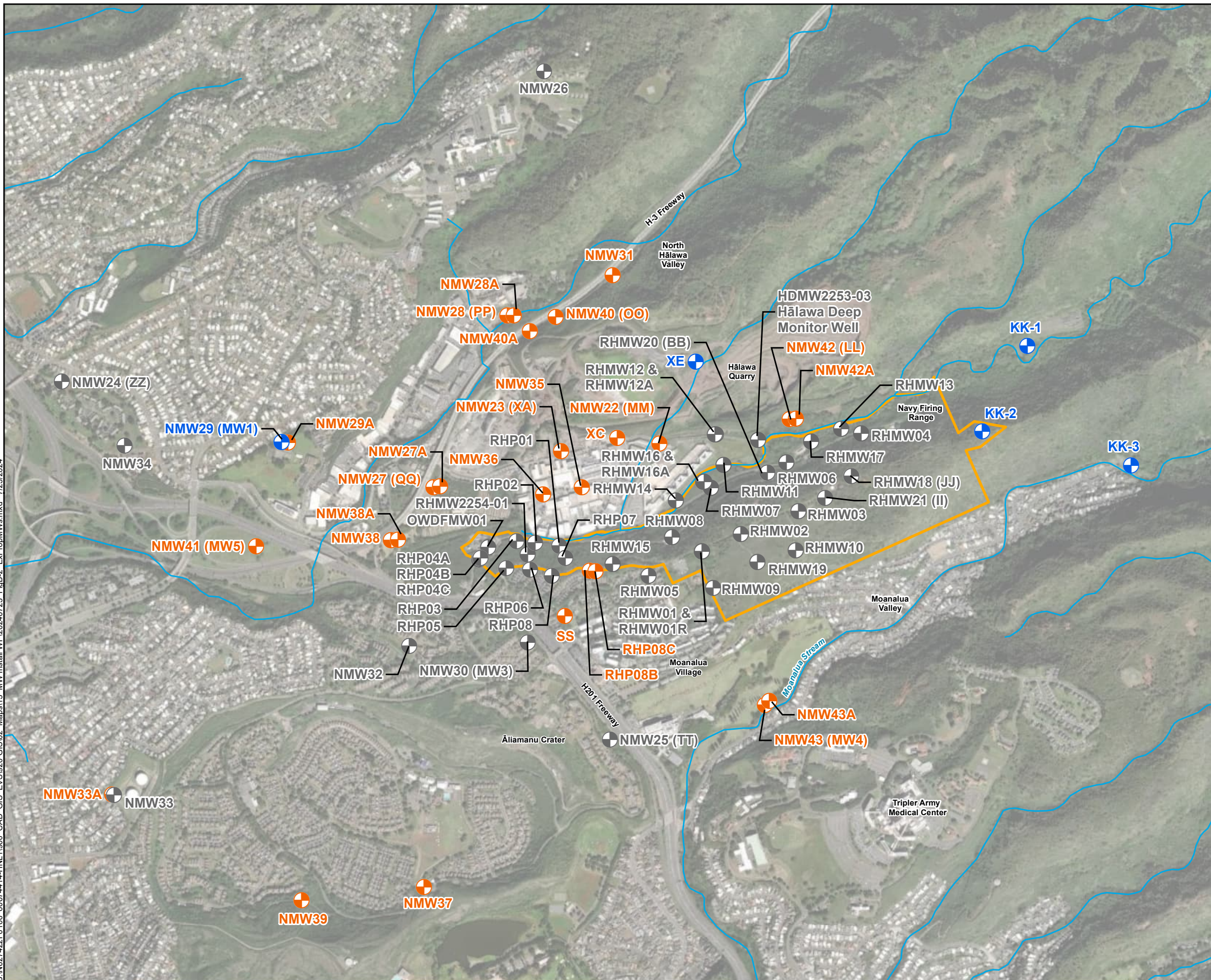


Figure B-1
Potential New Monitoring Well Locations
Monitoring Well Installation Work Plan
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

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Notes

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

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
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- NMW42/NMW42A - elev head well and confined basal well
- NMW43/NMW43A - elev head well and confined basal well
- RHP08B/RHP08C - deep unconfined basal well and deeper unconfined basal well

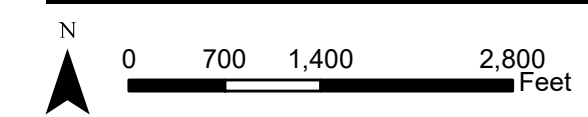
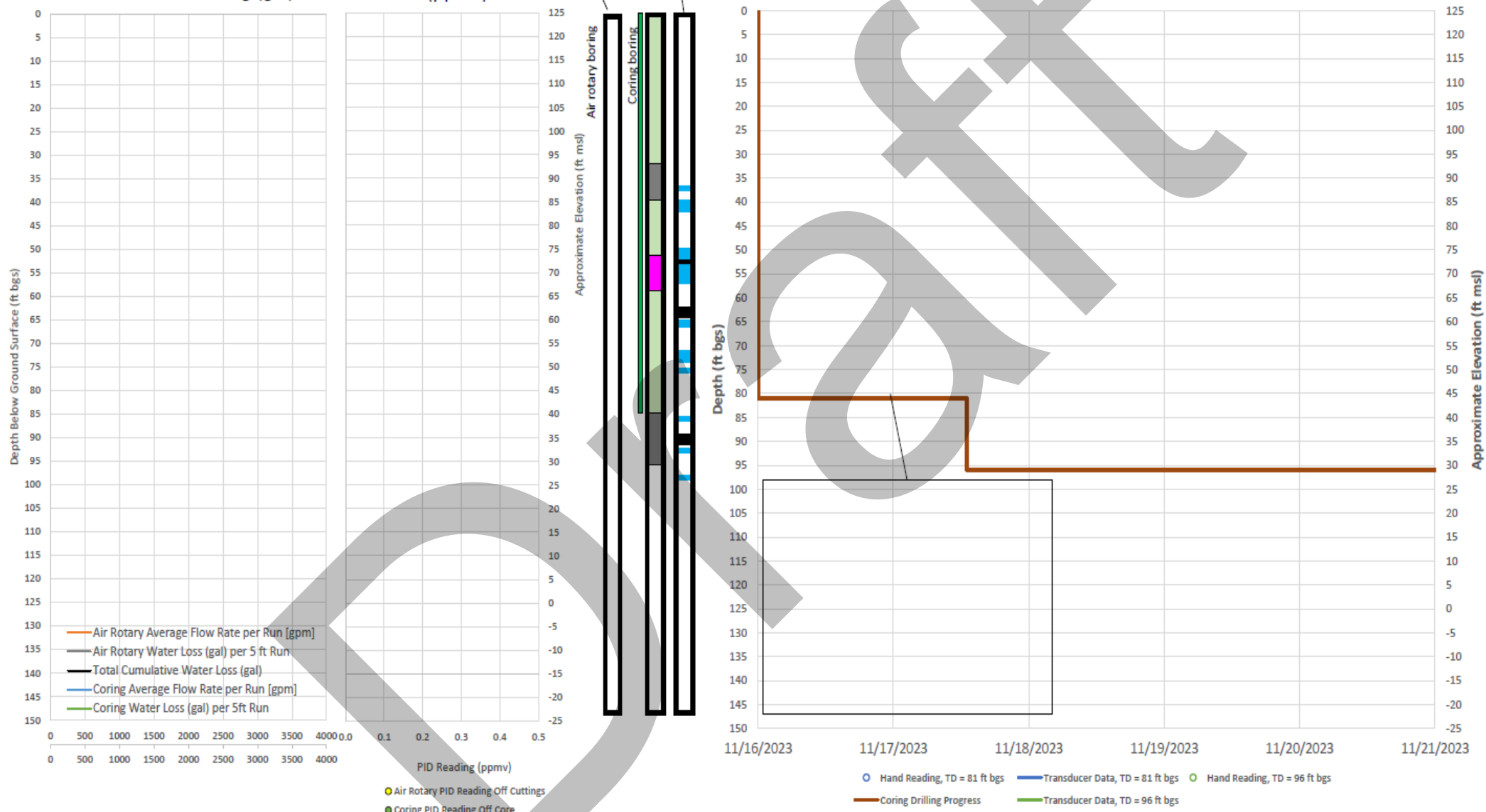


Figure B-2
Existing and Potential
New Monitoring Well Locations
Monitoring Well Installation Work Plan
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

**Appendix C:
Weekly Drilling and Well Installation Notifications**

Well # Water Lost During Drilling (gal) PID Readings (ppmv) Generalized Geology by Relative Permeability Fracture Zones and No Recovery Zones Well # - Borehole Water Levels



Lithology in order of generally decreasing relative permeabilities to the right:

- Loose a'a clinker
- Pahoehoe
- Massiv A'a
- Valley Fill
- Alluvium
- Saprolite
- Welded/weathered a'a clinker
- Tuff
- Intensely fractured zone
- No recovery

