Final

Sentinel and Monitoring Well Installation Work Plan, Red Hill Bulk Fuel Storage Facility

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

September 2, 2022
Revision 01

Naval Facilities Engineering Systems Command

Comprehensive Long-Term Environmental Action Navy
Contract Number N62742-17-D-1800, CTO18F0126

Final

Sentinel and Monitoring Well Installation Work Plan, Red Hill Bulk Fuel Storage Facility

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

September 2, 2022
Revision 01

Prepared for:

Defense Logistics Agency Energy
8725 John J Kingman Rd Suite 4950
Fort Belvoir, VA 22060-6222

Prepared by:

AECOM Technical Services, Inc.
1001 Bishop Street, Suite 1600
Honolulu, HI 96813-3698

Prepared under:

Comprehensive Long-Term Environmental Action Navy
Contract Number N62742-17-D-1800, CTO18F0126

CONTENTS

APPENDIXES

FIGURES

TABLES

ACRONYMS AND ABBREVIATIONS

%	percent
°C	degree Celsius
AOC	Administrative Order on Consent
API	American Petroleum Institute
APPL	Agriculture & Priority Pollutants Laboratories, Inc.
ASTM	ASTM International
bgs	below ground surface
btoc	below top of casing
BWS	Board of Water Supply, City and County of Honolulu
CF&T	contaminant fate and transport
CoC	chain of custody
COLIWASA	composite liquid waste sampler
COPC	chemical of potential concern
COR	Contracting Officer’s Representative
CSM	conceptual site model
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
DoD	Department of Defense, United States
DOH	Department of Health, State of Hawai‘i
DON	Department of the Navy, United States
DQI	data quality indicator
ELAP	Environmental Laboratory Accreditation Program
EPA	Environmental Protection Agency, United States
ft	foot/feet
GAC	granulated activated carbon
GPS	Global Positioning System
HQ	2.5-inch-diameter rock core
ID	identification
IDW	investigation-derived waste
IP	in-progress
JBPHH	Joint Base Pearl Harbor-Hickam
LNAPL	light non-aqueous-phase liquid
LOQ	limit of quantitation
msl	mean sea level
MWIWP	Monitoring Well Installation Work Plan
N/A	not applicable
NAP	natural attenuation parameter
NAVFAC	Naval Facilities Engineering Command
Navy	Department of the Navy, United States
NPDES	National Pollutant Discharge Elimination System
OD	outer diameter
ODEX	overburden drilling with eccentric drilling

oz	ounce
PAH	polynuclear aromatic hydrocarbon
PID	photoionization detector
PQ	3.35-inch-diameter rock core
psig	pounds per square inch gauge
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
QSM	*Quality Systems Manual*
RPD	relative percent difference
SMWIWP	Sentinel and Monitoring Well Installation Work Plan
SOP	standard operating procedure
SOW	statement of work
SWPPP	Storm Water Pollution Prevention Plan
TBD	to be determined
TGM	Technical Guidance Manual
TPH	total petroleum hydrocarbons
TPH-d	total petroleum hydrocarbons – diesel range organics
TPH-g	total petroleum hydrocarbons – gasoline range organics
TPH-o	total petroleum hydrocarbons – residual range organics (i.e., TPH-oil)
U.S.	United States
VOA	volatile organic analyte
WP	work plan

1. Introduction

This *Sentinel and Monitoring Well Installation Work Plan* (SMWIWP) documents the proposed approach for installing up to 10 new groundwater sentinel and monitoring wells within the Red Hill Bulk Fuel Storage Facility (the "Facility") and in adjacent areas (Figure 1). The effort will expand the current groundwater monitoring network and increase understanding of groundwater flow gradients (horizontal and vertical), formation hydraulic conductivities, subsurface geology, extent of chemicals of potential concern (COPCs), and potential lateral and vertical migration of COPCs in the project study area. The information will be used to estimate risks to potential receptors and refine the conceptual site model (CSM) and the groundwater flow and contaminant fate and transport (CF&T) models.

This SMWIWP *supersedes* the project MWIWP dated August 29, 2016 (DON 2016) and subsequent addenda (both *MWIWP Addendum 01* published on January 4, 2017 (DON 2017a) and *MWIWP Addendum 02* (DON 2017e) published on August 25, 2017). This SMWIWP contains updates to the technical approach for well installation.

The activities proposed under this SMWIWP and the project Work Plan/Scope of Work (DON 2017b) 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.

This SMWIWP also covers activities being conducted as part of the response actions to fuel releases that occurred at the Facility in May and November 2021. The May 2021 Release occurred in the upper portion of the tank farm in the vicinity of Tanks 18 and 20. The November 2021 Release occurred in the immediate vicinity of Red Hill Shaft water development tunnel (RHMW2254-01), which supplied drinking water to Pearl Harbor and the public prior to the November release, and directly impacted the water development tunnel. The Honolulu Board of Water Supply (BWS) Hālawa Shaft is the closest public water supply source located [redacted] Details regarding these releases can be found in *the Quarterly Release Response Report, May 6 and November 20, 2021 Releases, Red Hill Bulk Fuel Storage Facility, JBPHH, O'ahu, Hawai'i* (DON 2022).

2. Monitoring Well Network Expansion Design and Rationale

In accordance with AOC Statement of Work Section 7.3.2 (EPA Region 9 and DOH 2015), this section describes the proposed expansion of the monitoring well network, including the rationale used to select new well locations, and the design and rationale for drilling, unconsolidated material sampling, rock coring, and well installation and development.

2.1 Monitoring Well Locations

The current Red Hill groundwater monitoring network consists of 23 current locations inside and outside the Facility boundary (Figure 1), including one well (OWDFMW01) at the adjacent Oily Waste Disposal Facility that has been a part of the long-term monitoring program and Hālawa Deep Monitor Well (HDMW2253-01) located at Hālawa Correctional Facility. Further expansion of the groundwater monitoring network at strategic locations is recommended to fill data gaps and address the objectives outlined in Sections 6 and 7 of the AOC Statement of Work (EPA Region 9 and DOH 2015) and to meet objectives in response to the May and November 2021 Releases.

As shown on Figure 1, ten new monitoring wells are proposed for installation in the project study area: NMW24 (ZZ), NMW22 (MM), NMW25 (TT), RHMW18 (JJ), RHMW20 (BB), RHMW21 (II), NMW23 (XA), KK, PP, and QQ. Most proposed well locations shown on Figure 1 have a permanent identifier (e.g., RHMW18), while three wells include only a temporary label (i.e., KK, PP, and QQ); the order of installation for these three wells has not been finalized. The temporary labels were established during initial discussions with stakeholders on proposed well locations. Moving forward, the temporary label will be used until a permanent identifier is assigned, as access to these three drilling locations is in the process of being obtained. Wells installed within the Facility boundary will be identified with a “RHMW” prefix, and wells installed outside the Facility (Navy) boundary will be identified with a “NMW” prefix. The locations and establishment of priorities were determined during collaborative meetings between the Navy and stakeholders including Hawai‘i Department of Land and Natural Resources (DLNR) Commission on Water Resource Management (CWRM), Hawai‘i DOH, BWS, EPA Region 9, and United States Geological Survey. The agencies are working together to obtain access to drilling locations. The exact well locations will be determined in the field after access to each location is obtained, site reconnaissance is complete, and discussions with respective landowners are concluded. The well locations have been selected to provide the following data:

- Lithologic data and groundwater elevation data are needed to evaluate whether valley fill sediments and/or saprolite layers extend below the approximate elevation of the regional basal aquifer and are of low permeability and thick enough to serve as hydraulic barriers that will restrict the potential for groundwater flow between Red Hill and Hālawa Shaft.
- Additional lithologic and hydraulic data (i.e., hydraulic conductivity) of the saprolite and basalt will be used to further characterize the regional basal aquifer and the potential location of preferential pathways.
- Additional groundwater elevation data are needed between the Red Hill area and Hālawa Shaft to further evaluate groundwater flow gradients and directions in the shallow and deeper portions of the regional basal aquifer northwest of Red Hill, to assess groundwater flow conditions adjacent to and within South Hālawa Valley, and to evaluate the potential for groundwater flow to the south of Red Hill.
- Additional groundwater quality data are needed from discrete zones in the regional basal aquifer to evaluate the presence or absence of COPCs both vertically and horizontally between Red Hill and nearby water supply wells (i.e., Hālawa Shaft and Moanalua Wells).

The proposed well locations have been chosen to provide sentinel monitoring points between the Facility and potential receptors (i.e., Hālawa Shaft) that could be exposed via the drinking water supply system and vapor intrusion pathways and to obtain rock cores and subsurface unconsolidated material samples that will provide information regarding the physical properties of the subsurface. The newly installed monitoring wells will help to better characterize groundwater flow patterns, groundwater chemistry, and the geological matrix. They can also be used as potential monitoring and access points for other investigation activities, such as comparison of groundwater to EPA’s vapor intrusion screening levels to evaluate vapor intrusion concerns, if recommended. The number of locations proposed in the immediate vicinity of the Facility tanks is limited due to the need to minimize creation of migration pathways between possible vadose-zone contamination and the groundwater aquifer. Potential monitoring well locations in the vicinity of the tanks are also limited by the site’s steep topography.

Locations for the ten proposed monitoring wells (Figure 1) were chosen based on their potential to provide more information about the site’s geology and groundwater and available property access to achieve the following objectives:

1. *Sentinels:* Provide monitoring points between the Red Hill tanks and receptors potentially exposed via the drinking water supply system, and to guard against the potential for vapor intrusion concerns due to constituents in groundwater.
2. *Characterize Flow:* Provide additional groundwater elevation data to evaluate groundwater flow patterns in the vicinity of the Red Hill Facility and refine and calibrate the groundwater flow model. Hydraulic conductivity and other data may also be collected from borings during drilling or from completed wells and used to estimate potential groundwater velocities.
3. *Characterize Groundwater Chemistry:* Provide water quality data and evaluate COPC concentrations and natural attenuation parameters (NAPs) in both the shallow and deeper portions of the basal aquifer.
4. *Characterize Matrix:* Further characterize the stratigraphy and properties of the valley fill, caprock, and saprolite layers.
5. *Other Uses:* Provide potential monitoring and access points for other activities, such as limited extraction or injection, if warranted upon completion of other field activities.

The primary objective for installing these wells is to increase the monitoring well density northwest of the Facility (Red Hill Shaft and the tank farm) toward Hālawa Shaft, beyond the upper end of the tank farm, and southeast of Red Hill Shaft toward Moanalua Valley, The data obtained from these wells will provide a better understanding of groundwater flow patterns to the south and northwest of the Facility, further define the site geology and extent of valley fill and saprolite that affect groundwater flow and the potential for dissolved COPC and light nonaqueous-phase liquid (LNAPL) migration, and develop a sentinel well network between the Facility and nearby water supply wells. A matrix of the objectives that each proposed well fulfills, the rationale for its location, and how the data can be used to address existing data gaps are presented in Table 2-1.

2.2 DESIGN AND INSTALLATION OF CONVENTIONAL SINGLE-LEVEL MONITORING WELLS

All proposed wells will be installed as single-level monitoring wells screened across the approximate elevation of the regional basal aquifer or at other depths based on conditions encountered in the subsurface. Additionally, a deep and shallow single-level well pair may be required depending on location, subsurface conditions encountered, and sampling results. Well pairs will be considered if the installation of a well outside the Facility boundary reveals subsurface conditions indicating the potential presence of multiple preferential pathways. Generalized well construction diagrams for proposed outside-tunnel wells for water table conditions for shallow wells and for confined aquifer conditions are shown on Figure 2 and Figure 3, respectively.

Monitoring wells installed inside the tunnel (e.g., II) will be completed as single-level monitoring wells screened across the approximate elevation of the regional basal aquifer using design and installation procedures that accommodate the limited space. Tunnel wells will be screened across the water table to determine the presence or absence of LNAPL and assess groundwater quality underneath the fuel tanks in the upper end of the tank farm. The design of tunnel wells will be dependent on whether perched aquifer conditions are encountered requiring the use of conductor casing. Generalized well construction diagrams for tunnel wells without and with conductor casing are shown on Figure 4 and Figure 5, respectively.

Table 2-1: Objectives and Location Rationale for Proposed New Monitoring Wells

Well [a]	Meets Objective					
	1: Sentinels	2: Characterize Flow	3: Characterize Chemistry	4: Characterize Valley Fill/ Caprock/ Saprolite	5: Other Uses	Location Rationale
NMW24 (ZZ)	✓	✓	✓	✓	✓	NMW24 (ZZ) will provide groundwater elevation data to further evaluate groundwater flow patterns west of North Hālawa Valley in the vicinity of Navy 'Aiea Hālawa Shaft. Data from this well will be used to further evaluate groundwater flow patterns in and adjacent to the confluence of North and South Hālawa Valleys, and the potential for groundwater flow toward the west-northwest. Lithologic data from this location will be used to further define the geometry and extent of the volcanic tuff, valley fill sediments, caprock and saprolite layers along the western edge of Hālawa Valley. Groundwater quality data will be used to evaluate the groundwater quality proximal Navy 'Aiea Hālawa Shaft.
NMW22 (MM)	✓	✓	✓	✓	✓	NMW22 (MM) will provide groundwater elevation data between Red Hill and Hālawa 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 Hālawa Valley and the potential for groundwater flow toward the northwest. Lithologic data from this location will be used to further define the geometry (size/shape) of the valley fill sediments and saprolite layers in South Hālawa Valley. Groundwater quality data will be used to evaluate the groundwater quality to the northwest approximately halfway between Red Hill tanks and Hālawa Shaft.
NMW25 (TT)	✓	✓	✓	✓	✓	NMW25 (TT) will provide groundwater elevation data southeast of Red Hill Shaft, south of the Red Hill tanks, and adjacent to Moanalua Valley. The data from this well will be used to further evaluate groundwater flow patterns south of the Facility. Lithologic data from this location will be used to further define the geometry and extent of the Aliamanu Crater volcanic tuff, 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.
RHMW18 (JJ)	✓	✓	✓		✓	RHMW18 (JJ) is located northeast of the tank farm and will be installed to assess groundwater quality and further evaluate groundwater elevations and flow directions on Red Hill ridge upslope from the tank farm.
RHMW20 (BB)	✓	✓	✓	✓	✓	RHMW20 (BB) is located northwest of the tank farm and will be installed to assess groundwater quality and further evaluate groundwater flow directions along the southern edge of South Hālawa Valley adjacent to the tank farm.

Well [a]	Meets Objective					Location Rationale
	1: Sentinels	2: Characterize Flow	3: Characterize Chemistry	4: Characterize Valley Fill/ Caprock/ Saprolite	5: Other Uses	
RHMW21 (II)		✓	✓		✓	RHMW21 (II) is located inside the Facility lower access tunnel. RHMW28 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.
NMW23 (XA)	✓	✓	✓	✓	✓	NMW23 (XA) will provide groundwater elevation data between Red Hill and Hālawa 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 Hālawa Valley and the potential for groundwater flow toward the northwest. Lithologic data from this location will be used to further define the geometry and extent of the valley fill sediments and saprolite layers in South Hālawa Valley. Groundwater quality data will be used to evaluate the groundwater quality to the northwest approximately halfway between Red Hill Shaft/lower Red Hill tanks and Hālawa Shaft.
KK	✓	✓	✓		✓	KK is located northeast of the tank farm and will be installed to assess groundwater quality and further evaluate groundwater flow directions and groundwater quality adjacent to the upper portion of South Hālawa Valley. The well may potentially serve as a background location.
PP	✓	✓	✓	✓	✓	PP will provide groundwater elevation data west of the quarry pit to further evaluate groundwater elevations directly between Red Hill Shaft and Hālawa Shaft. The data will be used to obtain groundwater elevation data in the upper portion of North Hālawa Valley near Hālawa Shaft. Lithologic data from this location will be used to further define the geometry of the valley fill sediments and saprolite layers in North Hālawa Valley. Groundwater quality data will be used to evaluate the groundwater quality in the vicinity of Hālawa Shaft.
QQ	✓	✓	✓	✓	✓	QQ will provide groundwater elevation data between Red Hill and Hālawa Shaft to further evaluate groundwater flow patterns northwest of Red Hill Shaft. The data from this well will be used to further evaluate groundwater flow patterns in and adjacent to the H-3 Freeway Corridor in the southern portion of North Hālawa Valley and the potential for groundwater flow toward the northwest. Lithologic data from this location will be used to further define the geometry and extent of the valley fill sediments and saprolite layers in the southern portion of North Hālawa Valley. Groundwater quality data will be used to evaluate the potential for COPCs to flow to the northwest toward North Hālawa Valley and Hālawa Shaft and other receptors to the west.

[a] Wells are currently being identified with a temporary label (e.g., "XA") reflected in this document; however, a permanent identifier (e.g., RHMW18) will be assigned when property access is received and permission to drill has been granted.

(yellow) Well identified for highest priority installation

Table 2-2 presents estimated monitoring well dimensions based on current proposed locations.

Table 2-2: Estimated Monitoring Well Dimensions

Monitoring Well [a]	Approximate Surface Elevation (ft msl)	Estimated Depth to Bedrock (ft bgs) [b]	Estimated Depth to Groundwater (ft bgs) [c]	Monitoring Well Screen Interval (ft bgs) [d]	Estimated Total Depth (ft bgs)
NMW24 (ZZ)	110	20	90	80–110	115
NMW22 (MM)	240	20	220	210–240	245
NMW25 (TT)	215	20	195	185–215	255
RHMW18 (JJ)	625	20	605	595–265	630
RHMW20 (BB)	250	40	230	220–250	255
RHMW21 (II)	120	3	100	90–120	125
NMW23 (XA)	210	40	190	180–210	215
KK	350	30	330	320–350	355
PP	150	100	120	110–140	155
QQ	130	80	110	100–130	135

bgs below ground surface

[a] Wells are currently being identified with a temporary label (e.g., "XA") reflected in this document; however, a permanent identifier (e.g., RHMW18) will be assigned when property access is received and permission to drill has been granted. Well JJ is located on Navy property and will be the next well drilled. Therefore, it will be identified as RHMW18.

[b] Based on the available boring log data and from Figure 25 in Wentworth (1942) and recent monitoring well installation in the vicinity.

[c] Assuming a static potentiometric surface of 20 ft above mean sea level (msl).

[d] Monitoring well screen will be constructed of Schedule 80 PVC and will be 30 ft long if intersecting the water table (20 feet of screen below and 10 feet of screen above the water table) or 20 feet long if installed under confined conditions.

3. Field Project Implementation

3.1 PROJECT PROCEDURES

All drilling, monitoring well installation, and other field activities will be conducted as applicable in accordance with the DOH *Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan* (TGM) (DOH 2021) and the standard operating procedures (SOPs) from the *Project Procedures Manual, U.S. Navy Environmental Restoration Program, NAVFAC Pacific* (DON 2015), which are summarized in Table 3-1. A copy of the field SOPs will be maintained on site. 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 2021) (DON 2021).

Table 3-1: Field SOPs Reference Table

Reference Number	Title, Revision Date and/or Number [a]	Originating Organization of Sampling SOP	Equipment Type
I-A-5	*Utility Clearance*	NAVFAC Pacific	Geophysical equipment (electromagnetic, magnetic, and ground-penetrating radar)
I-A-6	*Investigation Derived Waste Management*	NAVFAC Pacific	N/A
I-A-8	*Sample Naming*	NAVFAC Pacific	N/A
I-B-1	*Soil Sampling*	NAVFAC Pacific	Split-spoon sampler and liners with hollow-stem or solid-stem auger
I-B-2	*Geophysical Testing*	NAVFAC Pacific	Low frequency electromagnetic induction, magnetometers, and ground-penetrating radar
I-B-5	*Surface Water Sampling*	NAVFAC Pacific	N/A

Reference Number	Title, Revision Date and/or Number [a]	Originating Organization of Sampling SOP	Equipment Type
I-C-1	*Monitoring Well Installation and Abandonment*	NAVFAC Pacific	Continuous coring drill rig
I-C-2	*Monitoring Well Development*	NAVFAC Pacific	Surge block or submersible pump
I-D-1	*Drum Sampling*	NAVFAC Pacific	COLIWASA or glass thieving tubes
I-E	*Soil and Rock Classification*	NAVFAC Pacific	N/A
I-F	*Equipment Decontamination*	NAVFAC Pacific	N/A
I-I	*Land Surveying*	NAVFAC Pacific	Theodolite - horizontal and vertical control; GPS
III-A	*Laboratory QC Samples (Water, Soil)*	NAVFAC Pacific	N/A
III-B	*Field QC Samples (Water, Soil)*	NAVFAC Pacific	N/A
III-D	*Logbooks*	NAVFAC Pacific	N/A
III-E	*Record Keeping, Sample Labeling, and Chain of Custody*	NAVFAC Pacific	N/A
III-F	*Sample Handling, Storage and Shipping*	NAVFAC Pacific	N/A

COLIWASA composite liquid waste sampler
GPS Global Positioning System
N/A not applicable
QC quality control
[a] Applicable procedures from the *Project Procedures Manual* (DON 2015).

3.2 SITE SURVEYS AND PREPARATION

3.2.1 Site Surveys

A licensed surveyor will establish the horizontal and vertical coordinates of each borehole and well location and other key site features. The survey will be conducted using Second Order, Class I procedures consistent with the procedures described in the *Technical Memorandum, Topographic Survey* (DON 2017c). Land survey activities will be conducted as applicable in accordance with Procedure I-I, *Land Surveying* (DON 2015).

3.2.2 Site Preparation

Site preparation will include vegetation clearance, access pathway and drill site grading, and cutting or coring of asphalt and asphaltic concrete, as required to facilitate drilling and well completion. Each borehole location will be marked once the area is cleared of utilities (Section 3.2.3) and the staging area is established. All site activities will be conducted and documented in accordance with the forthcoming *Storm Water Pollution Prevention Plan* (SWPPP) prepared for construction activities at proposed drilling locations. The SWPPP will be prepared as part of the National Pollutant Discharge Elimination System (NPDES) permitting requirement process. The requirements of the SWPPP will be reviewed and discussed with all onsite staff at the start of drilling activities at each location.

Vegetation clearance will be performed to provide access for a drill rig, support truck, or excavator to all drilling sites as needed. Details of the areas to be cleared will be obtained once final drilling locations have been determined. Minor vegetation clearance may also be required at drilling locations. Vegetation clearance, preparation, shipment, and disposal will be conducted in accordance with Navy and landowner requirements for proper disposal of green waste to prevent the spread of the coconut rhinoceros beetle. The most current JBPHH green waste policy is provided in Appendix A. The contractor will coordinate with the Navy Contract Task Order (CTO) Contracting Officer's Representative (COR) or landowner's representative to ensure that the most current guidance is obtained and followed. Stockpiling green waste for more than 24 hours is not permitted.

Grading will be performed as necessary to advance a pathway to proposed well locations. The ground surface will be stabilized for the movement of heavy equipment, and the pathway will be finished with an 8-inch-thick layer of coarse gravel no larger than 6 inches in any dimension.

An approximately 60-ft × 80-ft minimum drilling pad will be established as needed, by grading and filling to level the area, as much as practicable, to provide an even working surface or drill pad for the drill rig. The drill pad will be finished with an 8-inch-thick layer of coarse gravel no larger than 6 inches in any dimension.

Noise control measures as required by noise permits will be implemented at all proposed well installation locations and will be maintained throughout air rotary drilling activities.

Site preparation for drilling locations inside the tunnel will include cutting or coring of the concrete tunnel floor, as required to facilitate drilling and well completion.

3.2.3 Utility Clearance

Geophysical surveys will also be performed by a qualified subcontractor to locate and provide delineation of subsurface utilities in the vicinity of the soil boring/monitoring well locations using geophysical techniques through the use of instruments that may include magnetic, electromagnetic, and 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 borehole will be cleared using air knife (Section 3.2.4), hand auger, or other non-destructive methods to manually advance a borehole or three boreholes in a triangle larger than the largest drill bit or auger to be used at the site to 5 ft bgs. If necessary, the proposed well locations may be adjusted accordingly.

3.2.4 Air Knifing at Proposed Well Locations

If subsurface utilities or structures that may pose a subsurface hazard to activities at a proposed drilling site (e.g., tie-backs or fittings for nearby stream retaining walls) cannot be definitively located from historical documents, plans, and as-built drawings, then air knife technology may be employed. The air knife will use compressed air to break the soil structure and allow for removal of the soil while reducing the potential for direct contact between buried utilities and the air knife operator. The compressed air, typically 90–100 pounds per square inch gauge (psig), is converted to a supersonic jet while flowing through a specially designed nozzle. The compressed air will insulate the operator from directly contacting the buried utility or structure. If necessary, air knifing will include the use of jetting with water to facilitate advancement of the borehole.

3.3 DRILLING AND INSTALLATION OF MONITORING WELLS OUTSIDE THE TUNNEL

Solid basalt bedrock is anticipated to be contacted at shallow depths (e.g., between 0 and 75 ft bgs) underneath and in the vicinity of ridges or at deeper depths in valleys or lower topographic areas. Anticipated drilling activities may include one or more of the following drilling methods:

- Hollow-stem-auger drilling through soil overburden
- Sonic drilling through soil overburden and fractured bedrock

- Rock coring using wet rotary methods to characterize lithology
- Air rotary drilling (overburden drilling with eccentric drilling [ODEX])
- Air rotary and downhole hammer drilling using water as needed for reaming boreholes and installing casing and wells
- Mud rotary for reaming boreholes and installing casing and installing casing and wells

Prior to drilling, all onsite activities must be coordinated with the Navy CTO COR or landowner's representative to ensure that all requirements such as obtaining site access, working hours, using/accessing potable water supply sources, or other requirements are understood and followed.

3.3.1 Drilling

All drill rigs, regardless of the drilling method will be leveled prior to drilling and checked at least twice a day to prevent potential borehole deviation. Prior to using potable water during drilling and monitoring well installation activities, a minimum of two potable water samples will be collected, per drilling location, for laboratory analysis of COPCs to characterize the potable water. The first potable water sample will be collected for laboratory analysis before the water enters the granulated activated carbon (GAC) filter system. The second potable water sample will be collected for analysis at the outflow end of the GAC filter system. Additional potable water samples will be collected should the source of the water change during drilling activities. The potable water analytical results will be evaluated to determine if the potable water is a possible source of contamination to the drinking water aquifer during drilling activities. Collection of potable water samples will be conducted in accordance with Procedure I-B-5, *Surface Water Sampling* and samples will be handled in accordance with Procedure III-F, *Sample Handling, Storage, and Shipping* (DON 2015). Potable water will be collected from the water source and from drilling water pump/GAC filter system outflows directly into lab-provided sample containers as specified in Section 4. Vials for volatile organic compound (VOC) samples will be filled completely, with no headspace. Samples will be labeled with the sampling location, date and time of collection, and unique sample identifier as discussed in Section 4.1, and will be recorded in the field logbook. Sample containers will be placed in resealable plastic zip bags, kept in coolers containing wet ice, and preserved in accordance with analytical method requirements and as specified in Section 4. Samples will be shipped to the laboratory via overnight airfreight.

The overburden will be drilled using hollow-stem auger, sonic, or ODEX system drilling methods in accordance with Procedure I-C-1, *Monitoring Well Installation and Abandonment* (DON 2015), as applicable. All boreholes will initially be advanced to refusal using a minimum 4¼-inch-inner-diameter hollow-stem auger and/or ODEX system drill string or sonic core barrel with override casing that can be used as a temporary surface casing during rock coring activities. The drill string would be used to stabilize boreholes during drilling and reaming in unconsolidated materials. If hollow-stem auger methods are employed, characterization samples of unconsolidated material will be collected at 5-ft intervals beginning at 10 ft bgs with 1.5-ft-long, 2-inch-diameter split spoons. Split-spoon unconsolidated material samples will be collected after retracting the hammer and running the sampler in the open hole. Basalt cobbles and boulders may be encountered, making augering difficult for characterization sampling of unconsolidated material (i.e., poor recovery) or resulting in refusal, in which case an air hammer or rotary coring may be used. If sonic coring is employed, continuous soil samples will be collected and retrieved beginning at 10 ft bgs.

After drilling to the elected depth for setting the conductor casing, the core hole will be grouted in place with a cement-bentonite grout. The borehole will then be reamed to a larger diameter, typically with air rotary techniques, during which a pilot bit will be used below the primary bit to ensure that the boring follows and is centered over the grouted core hole. Alternatively, rock coring and geophysical logging may be conducted in one borehole, and perched water investigations and well installation may be completed in a separate borehole drilled with air rotary drilling methods at the same approximate location.

3.3.2 Bucket Auger

A bucket auger may need to be employed at sites where the presence of boulders in a clay matrix in the shallow zone (0–60 or 80 ft bgs depending on rig availability) precludes further reaming. The bucket auger procedure consists of advancing a typical 24-inch-diameter borehole with a production auger drilling rig equipped with either a 24-inch core bucket or auger bucket assembly, depending on drilling conditions. Larger-diameter augers may be used if needed.

The bucket auger would be advanced to create a 24-inch-diameter borehole with a production auger drilling rig equipped with a 24-inch core bucket assembly. Drilling will commence from ground surface, through a pre-drilled pilot borehole to the required depth no greater than 80 ft bgs. The exact depth of the borehole will be determined based on subsurface conditions encountered and consultation with the field manager. Drilling by this method will proceed until large boulders and associated clay matrix are no longer encountered allowing for the proposed drilling and coring methods described in Section 3.4 to be resumed. Techniques to ensure the drill string maintains vertical alignment will be employed, and the cored hole will be covered with a steel plate labeled “DANGER: OPEN HOLE” when work is not being conducted. If no casing is installed or the casing is abandoned, large-diameter casing (e.g., 18-inch) will be installed and properly grouted with cement-bentonite grout or the borehole will be fully grouted, as described in Section 3.5.

3.3.3 Perched Water and/or Vadose Zone Contamination

Perched water may be encountered at the proposed drilling locations. A document describing the path forward and procedures that will be followed in the event contamination is encountered during drilling is presented in Appendix B.

Frequent checks for perched water or evidence of petroleum contamination will be conducted by deploying a decontaminated bailer or water level meter within the borehole during drilling. These checks will be employed at the start of each day and as drilling progresses but also more frequently based on the presence of features that may suggest perched water (e.g., porous zones [saturated soil cuttings, sand, gravel, or clinker zones] overlying lower-permeability zones [silt, clay, or low-porosity basalt layer]) based on visual observation. Additionally, the presence of contamination may be indicated by staining on drill cuttings and recovered rock cores and by elevated photoionization detector (PID) readings. This information will be recorded in the field logbook. Any perched water, if encountered, must not be allowed to penetrate into the basal aquifer, which is a drinking water source. If perched water and/or gross contamination is encountered, the borehole may be plugged with cement-bentonite grout. If perched water conditions or evidence of contamination are not observed, drilling casing may be used as temporary casing through which further drilling will be conducted.

If perched water or evidence of contamination is observed, the driller will install 10-inch inner diameter Schedule 40 low carbon steel flush-threaded conductor casing that will be installed from ground surface slightly into bedrock. This casing will be extended if field observations indicate that perched water or soil is contaminated, and the casing will be installed to completely seal off the perched zones and/or impacted zones. The conductor casing is to prevent cross communication between the perched groundwater and the basal aquifer, which is a drinking water source.

3.3.4 Subsurface Unconsolidated Material Sampling

If required, subsurface geotechnical samples of unconsolidated material will be collected if unsaturated zones of unconsolidated material or significant layers of clay or low-permeability zones are encountered during rock coring. Unconsolidated material may be collected from split-spoon samplers or sonic cores from surface and prior to encountering solid basalt, and from core barrels thereafter.

Collection of subsurface material for laboratory analysis will be conducted in accordance with Procedure I-B-1, *Soil Sampling*, and samples will be handled in accordance with Procedure III-F, *Sample Handling, Storage, and Shipping* (DON 2015).

If contamination in the vadose zone is observed at any drilling location (both inside and outside the Facility boundary), samples of subsurface unconsolidated material may be collected for laboratory analysis of COPCs to provide additional data on the level of contamination present in the area. Like the rock cores, the subsurface unconsolidated material samples will be inspected for evidence of contamination (visual, olfactory, or elevated PID readings) to characterize the lithology and evaluate the potential migration of LNAPL and associated constituents. Using the discrete sampling approach, approximately 100 grams of unconsolidated material for non-VOC analyses will be collected using disposable scoops or spoons and placed in appropriate containers for each subsurface unconsolidated material sample as specified in Section 4. Material collected for VOC analysis will be collected using 5-gram plugs using Encore, Terra Core, or equivalent samplers. To minimize VOC loss during the sampling effort, the VOC sample plugs will be collected as quickly as possible and placed in laboratory-supplied water- and methanol-preserved containers.

All sample containers will be labeled with the sampling location, date and time of collection, and unique sample identifier, as described in Section 4.1, and recorded in the field logbook. Sample containers will be placed in resealable plastic zip bags, kept in coolers containing wet ice, and preserved in accordance with analytical method requirements and as specified in Section 4. Samples will be shipped to the analytical laboratory via overnight airfreight.

Field quality control (QC) samples of unconsolidated material will be collected in accordance with the specifications presented in Table 3-2.

Table 3-2: Field Quality Control Samples for Unconsolidated Material

QC Sample	Analytical Group [a]	Frequency [b]	DQI	Measurement Performance Criteria
Field duplicate	All	10% of primary samples collected per matrix per analytical method	Precision	RPD ≤100% unconsolidated material (judgmental) [c]
Ambient blank	All	Once per potable water sampling event	Contamination during sample collection	<1/2 of LOQ
Trip blank	VOCs, TPH-g (soil/unconsolidated material)	One per cooler	Contamination during sample transport	≤2 of LOQ

% percent
DQI data quality indicator
LOQ limit of quantitation
RPD relative percent difference
TPH-g total petroleum hydrocarbons – gasoline range organics
[a] Refer to Section 4.2 for a list of all analytical groups.
[b] Per *Project Procedures Manual,* Procedure III-B, *Field QC Samples* (DON 2015).
[c] Per *Project Procedures Manual,* Procedure II-A, *Data Validation* (DON 2015).

3.3.5 Conductor Casing

Based on the potential for shallow perched water above the basal aquifer, which is a drinking water source, the driller will be prepared to install a conductor casing to isolate such zones. After encountering refusal (via hollow-stem auger, ODEX, or sonic drilling methods) for the monitoring well all boreholes will be reamed to a minimum 17.5 inches in diameter for installation of the conductor casing using a bucket auger, air, or mud rotary drilling methods. A surface conductor casing can be installed on a temporary basis to stabilize the near-surface part of the drilled hole during reaming. Surface conductor casing installed without a grouted annular space must be removed in a manner that will permit complete grouting of the annular space between the permanent well casing and drilled hole to the ground surface. Solid basalt bedrock is anticipated to be encountered starting at depths of approximately 0–70 ft bgs. A 10-inch inner diameter Schedule 40 low carbon steel flush-threaded conductor casing will be installed to required depth of approximately 75 ft bgs or deeper if isolation of deeper perched water is required. The drill rig, or other equipment, must be able to suspend the casing above the bottom of the borehole during the grouting operation, including curing time. The conductor casing must be centered within the borehole with the use of centralizers spaced at intervals no more than 40 ft apart.

The driller will grout the annular space all around the maximum dimension of the conductor casing with cement-bentonite grout, either by pressure grouting through the conductor casing using a steel tremie pipe placed through a packer assembly or by pumping through a steel tremie pipe placed on the outside of the conductor casing. Tremie grouting, if conducted, will be performed in a two-step process; first, the base of the conductor casing will be grouted in place with a 3- to 5-ft-thick cement-bentonite grout plug, then the grout plug will be left undisturbed for a minimum of 24 hours for curing before emplacing grout above the plug to the surface with a steel tremie pipe. Placing the grout in the annular space may be done in stages or lifts with time allowed for the grout to set so as to prevent distortion or collapse of the casing by heat and/or pressure. Following the grouting procedure, the grout will be left undisturbed for a minimum of 24 hours for curing.

3.3.6 Rock Coring

Coring of competent rock or bedrock will begin after refusal during hollow-stem auger methods or, alternatively, coring of competent rock or bedrock will begin through the 10-inch ID steel conductor casing a minimum of 24 hours following grout emplacement. In bedrock, subsurface material will be continuously sampled using rotary wireline coring or sonic core to record the lithologic characteristics and sample description of the subsurface material during the drilling of the monitoring wells in accordance with Procedure I-B-1, *Soil Sampling* (DON 2015). Continuous rock cores will be collected as the monitoring well boreholes are advanced through the basaltic bedrock. Rock coring will commence when the borings reach competent bedrock. All drilling in rock will be accomplished by diamond core drilling methods in general accordance with ASTM D2113 (ASTM 2014).

The drill rig will be equipped with 3.78-inch-outer-diameter (OD) core barrel (yielding a 2.5-inch-diameter rock core [HQ]). A 4.83-inch-OD core barrel (yielding a 3.35-inch-diameter rock core [PQ]) may also be used, depending on site conditions. Borings may intersect intensely fractured or faulted zones, where poor rock strength or difficult drilling conditions may be encountered. All reasonable measures to maximize core recovery will be taken, including timely replacement of worn equipment such as drill bits or core sleeves before wear-induced loss of recovery occurs, and changes in type of drill bit, rate of feed, down-pressure on the drill bit, volume of cooling water, length of coring interval, or type of coring equipment. Grinding of the core after a core barrel has become blocked will not be permitted. A blocked core barrel will be pulled regardless of the interval drilled. The blocked core barrel will be pulled out of the borehole, inspected, and cleared of all obstructions, and, if damaged, will be removed from service and replaced.

Clean water will be brought in from an offsite potable water source for use as circulation fluid during rock coring and drilling.

The cores will be inspected and logged to characterize the lithology and evaluate potential pathways for migration of LNAPL and associated constituents. The entire borehole will be logged either by the field geologist (according to the procedures described below) or by using geophysical tools including an acoustic televiewer. 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 or mineralization. Additionally, details of basalt flow and intraflow structures (e.g., aʻā clinker flow-top breccias [clinker sub-types], accretionary lava clasts, simple vesicular flow tops, vesicular flow lobes, inflated pāhoehoe lobes, spatter deposits, lava tubes, massive aʻā dense core interiors, aʻā clinker flow-bottom breccias, normal flow bottoms, and flow levees) will be included in logging of the core.

Fracture types (i.e., the difference between tectonic fractures, primary cooling joints, and drilling-induced fractures) and any mineralization within the fractures will also be noted. High-resolution photographs will be taken to photo 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). Discrete subsurface unconsolidated material sampling is described in Section 3.3.4.

Some of the borings will intersect zones, where poor rock and/or difficult drilling conditions may be encountered. Potable water will be required for circulation fluid during drilling. Potable water used for drilling activities will be collected from a water source demonstrated free of petroleum constituents. ***Note: It is imperative that contaminants are not introduced to the water used during drilling as it is pumped downhole.*** Therefore, the driller will be required to use a GAC vessel in line after the drill rig pump and before water is used in any fluid that goes downhole. Testing of the water being pumped downhole will be conducted to ensure the water is free of contaminants.

Additionally, the driller will provide a food-grade, non-petroleum-containing oil, or grease for use as water pump lubricant. Food grade lubricants will also be required on all downhole tools. Food-grade oils or lubricants must be pre-approved by field personnel before use. If water is present, water level measurements will be taken at the beginning of the day and during the day (e.g., in the middle of the day, at the end of the day). This information will be recorded in the project field book by field personnel. If water is encountered, slug-in, slug-out, and baildown tests may be conducted at the discretion of the field manager.

3.3.7 Water Level Testing

Water level testing to better understand aquifer properties and conditions will be conducted during rock coring efforts. As part of the well installation and well screen design process, a suite of downhole testing approaches (e.g., temperature and conductivity profiles) may be used prior to final determination of the depth of the well screen. These data as obtained by field personnel will be provided to the Regulatory Agencies on a daily basis.

3.3.8 Geophysical and Video Logging

As an alternative to geologic logging, portions of the borehole may be logged using geophysical tools in place of lithologic logging completed by the field geologist. Borehole geophysical and video logging may be conducted within the lower stable section of the borehole after the conductor casing has been installed. This survey may include as applicable, acoustic televiewer, optical televiewer, caliper, laser-induced or ultraviolet light fluorescence, or standard e-log suite. This survey will be deployed in the lower open-borehole saturated zone prior to installation of the monitoring well. The data will be used to obtain additional information on the hydrogeology and CF&T.

After the monitoring well is installed, a quantitative true vertical depth analysis using a gyroscopic alignment instrument will be performed so that appropriate corrections can be made to depth to water measurements. Additional methods may be deployed at the discretion of the Navy in consultation with the project team.

3.3.9 Monitoring Well Construction

The diameter of the borehole will be at least 4 inches greater than the outer diameter of the conductor casing. The borehole diameter for the installation of the 10-inch diameter Schedule 40 low carbon steel casing will be a minimum of 17.5 inches in diameter. The driller will center the conductor casing within the borehole with centralizers at approximately 40-ft intervals to ensure the casing is centered in the borehole. The centralizers will be aligned so that they do not interfere with the insertion and removal of a tremie pipe. The driller will grout the minimum (all around) 2-inch annular space around the maximum outer dimension of the conductor casing using either pressure grouting through the conductor casing using a steel tremie pipe (preferred) or by pumping through a steel tremie pipe placed in the annulus outside of the conductor casing. Tremie grouting, if conducted, will be performed in a two-step process. Tremie grouting requires the use of a steel tremie pipe, and the driller will grout the base of the conductor casing in place with a 3- to 5-ft-thick cement-bentonite grout plug as soon as possible.

The grout plug will be left undisturbed for a minimum of 24 hours for curing before emplacing grout above the plug to the surface with a steel tremie pipe. The driller will sound the annulus to check for settling of the grout within 24 hours of placement. Placing the grout in the annular space may be done in stages or lifts with time allowed for the grout to set so as to prevent distortion or collapse of the casing by heat and/or pressure. Following the grouting procedure, the grout will be left undisturbed for a minimum of 24 hours for curing.

The field manager and/or field geologist will oversee all monitoring well construction and development activities. The driller will install monitoring wells with a conductor surface casing in conformance with Naval Facilities Engineering Systems Command (NAVFAC), Pacific Environmental Restoration Program Procedure I-C-1, *Monitoring Well Installation and Abandonment* (DON 2015) (see SOW Attachment 2). Monitoring well completion will include (but not be limited to) the following:

- Four-inch diameter monitoring wells: Schedule 80 PVC with 20–30 ft of 0.02-inch slotted screens, respectively. Manufacturer-supplied O-rings will be installed on all threaded PVC joints.
- 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 40-ft intervals on the blank casing. Centralizers will be aligned from top to bottom of the casing so that they do not interfere with the insertion and removal of a tremie pipe. All devices used to affix centralizers to the casing shall not puncture the casing or contaminate the groundwater with which they come in contact.
- To ensure even distribution of filter pack, bentonite seal, and grout materials around the monitoring well within the borehole, the casing and screen will be suspended with a threaded hoisting plug that does not allow the casing and screen to rest on the bottom of the borehole.
- Coarse #3 Monterey silica sand will be tremied into the borehole annulus from the bottom of the screen to approximately 5 ft above the monitoring well screen. The filter pack will be surged following placement, and additional material will be added if settling occurs. Following filter pack

placement, a slow-hydrating bentonite pellet seal and then cement-bentonite grout will be tremied in stages or lifts to the base of the casing. If large voids are encountered, then bentonite chips may be required to seal the voids. Dry bentonite chips, where used, will be tremied and hydrated with clean potable water using at least 5 gallons of water per 50-pound bag of chips.

- Because the rock formation is not pressured, blowouts are not anticipated to occur. However, as described above, voids are anticipated to be encountered and need to be taken into consideration during well installation. In the event that voids or blowouts are encountered, bentonite chips will be emplaced down hole to close out or plug the void.
- The annular space between the monitoring well and the conductor casing will be filled in stages or lifts by pressure grouting or by tremie, with cement-bentonite grout to near surface (to within 1 ft of the top of surface casing).

3.4 DRILLING AND INSTALLATION OF MONITORING WELLS INSIDE THE TUNNEL

3.4.1 Tunnel Well Drilling

Drilling for tunnel wells will be conducted in accordance with Procedure I-C-1, *Monitoring Well Installation and Abandonment* (DON 2015). Drilling will be conducted using an electrically operated drill rig equipped with rock coring and wet rotary drilling capabilities. Solid basalt bedrock is anticipated to be encountered directly below the lower access tunnel floor. Coring will be conducted once competent bedrock is encountered. In bedrock, subsurface material will be continuously sampled using wet rotary wireline coring to record the lithologic characteristics and sample description of the subsurface material during the drilling of the well in accordance with Procedure I-B-1, *Soil Sampling* (DON 2015). Continuous rock coring will be conducted as the monitoring well borehole is advanced through the basaltic bedrock. Rock coring will commence when the boring reaches competent bedrock, which is anticipated to occur just beneath the lower-access tunnel concrete floor. All drilling in rock will be accomplished by diamond core drilling methods in general accordance with ASTM D2113 (ASTM 2014).

The drill rig will be equipped with 2.5-ft or 5-ft-long, 3.78-inch-OD core barrels (yielding a 3.35-inch-diameter rock core [PQ bit size]), and the cores will be recovered with a wireline and quad-latch retrieval system. Clean potable water (and environmentally safe drilling foam, only if pre-approved by the Navy) and de minimis amounts of bentonite drilling mud will be injected as needed during drilling to mitigate dust, lubricate downhole tools, stabilize the borehole, and remove cuttings from the borehole. Only approved food-grade grease will be used in downhole tools. Use of other chemicals must be approved by the Navy prior to use; however, due to the organic nature of these products, they may show up as total petroleum hydrocarbons (TPH) detections in samples collected during drilling or after the wells are installed. Attempts will be made to limit fluids injected during drilling, but the amount of fluid used will be dependent on the porosity of the formation being drilled. Prior to use, potable water for drilling will be sampled and analyzed for COPCs as described in Section 3.3.1. Cuttings removed from the borehole will be collected in 55-gallon drums and roll-off bins. Use of wet rotary drilling methods and injection of water during drilling will significantly reduce the generation of dust during drilling.

The boring may intersect zones where poor rock strength or difficult drilling conditions may be encountered. All reasonable measures to maximize core recovery will be taken, including timely replacement of worn equipment such as drill bits or core sleeves before wear-induced loss of recovery occurs, and changes in type of drill bit, rate of feed, down-pressure on the drill bit, volume of cooling water, length of coring interval, or type of coring equipment. Grinding of the core after a core barrel has become blocked will not be permitted. A blocked core barrel will be pulled regardless of the interval drilled. The blocked core barrel will be pulled out of the borehole, inspected and cleared of all obstructions; and, if damaged, will be removed from service and replaced.

The cores will be inspected and logged to characterize the lithology and evaluate potential pathways for migration of LNAPL and associated constituents. 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 orientation of fracturing; shape, size and volume of voids; weathering; and secondary staining or mineralization. Additionally, details of basalt flow and intraflow structures will be included in logging of the core. Fracture types (i.e., the difference between tectonic fractures, primary cooling joints, and drilling-induced fractures) will also be noted. High-resolution photographs will be taken to photo-document the cores, and detailed photo logs will be prepared. The Geological Society of America rock color chart with Munsell color chips will be used for color characterization (Munsell 2009). Lithologic descriptions, photoionization detector screening results, and other observations will be recorded on the geologic logs in conformance with Procedure I-E, *Soil and Rock Classification* (DON 2015). Discrete subsurface unconsolidated material sampling is described in Section 3.3.4.

Cores will be stored in a secure on-island location so that they are available for inspection until the work conducted under AOC Sections 6 and 7 is complete. Storage required beyond the completion of AOC Sections 6 and 7 will be evaluated by the Navy.

Checks will be made to identify the presence of perched groundwater or contaminated unconsolidated material while drilling, as described in Section 3.3.3.

- If perched water or zones of contamination are identified, then permanent conductor casing will be installed using 5-inch Schedule 40 low-carbon steel conductor casing to minimize the potential for perched water or contaminated media to migrate downward and impact the basal aquifer, which is a drinking water source. An 8-inch-diameter borehole will be required for the length of the conductor casing (length to be determined), and a 4.88-inch-diameter borehole will be required below the conductor casing (Figure 5). The conductor casing will be centered within the borehole using welded low-carbon steel centralizers spaced at approximately 20-ft intervals. The centralizers will be aligned so that they do not interfere with the insertion and removal of the tremie pipe, if necessary. The annular space to be grouted will be a minimum of 1.5 inches beyond the casing. The conductor casing will be pressure-grouted in place with cement-bentonite grout as soon as possible after installation, either by using a packer assembly and tremie pipe installed inside of the conductor casing that will allow the grout to be pumped through the packer assembly until it rises to the ground surface around the casing, or with a tremie pipe placed in the annular space around the casing. The annulus will be sounded to check for settling of the cement-bentonite grout within 24 hours of placement. Following the grouting procedure, the grout will be left undisturbed for a minimum of 24 hours for curing. Drilling activities will then be resumed until the target depth is reached.

  If permanent casing is installed and 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 groundwater are subsequently observed, the boring will be abandoned by grouting as described in Section 3.5. 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) so that multiple contaminated zones can be cased off.

- Water level testing will be conducted as described in Section 3.3.7. If perched water or evidence of contamination is not observed, coring will be conducted until the target depth (approximately 125 ft bgs) is reached. After rock coring is complete, the borehole will be reamed to total depth with a conventional rotary drilling rig to increase the borehole diameter to a minimum of 5.375 inches (Figure 4). Clean potable water (and environmentally safe drilling foam, only if pre-approved by the Navy) and bentonite drilling mud will be injected as needed during drilling to mitigate dust, lubricate downhole tools, stabilize the borehole, and remove cuttings from the borehole. Attempts will be made to limit fluids injected during drilling, but the amount of fluid used will be dependent on the porosity of the formation being drilled. Prior to use, potable water for drilling will be sampled and analyzed for COPCs as described in Section 3.3.1. Cuttings removed from the borehole will be collected in 55-gallon drums. Use of wet rotary drilling methods and injection of water during drilling will significantly reduce the generation of dust during drilling.

- Geophysical testing and borehole video logging will be conducted as described in Section 3.3.8.

3.4.2 Tunnel Well Installation Procedures

After the borehole has been reamed using wet rotary drilling methods, the monitoring well will be installed in accordance with Procedures I-C-1, *Monitoring Well Installation and Abandonment* and I-C-2, *Monitoring Well Development* (DON 2015). Groundwater in the basal aquifer is expected to be encountered at approximately 15–20 ft msl. Within the borehole, 4-inch-diameter, Schedule 80 PVC-casing with 30 ft of 0.02-inch slotted screen will be constructed (Figure 4). However, if a 5-inch-diameter Schedule 40 low-carbon steel conductor casing is required, then a 1.5-inch-diameter Schedule 80 PVC monitoring well will be installed inside the conductor casing (Figure 5). The well will be screened within the basal aquifer approximately 10 ft above and 20 ft below the groundwater surface. The estimated total depth for well II is approximately 125 ft below the tunnel floor.

To ensure that the well casing is centered in the borehole, centralizers will be installed at the top and bottom of screened sections and also placed at 20-ft intervals on any PVC well casing. If installation of a conductor casing is required, welded low-carbon steel centralizers at 40-ft intervals will be used on 5-inch-diameter Schedule 40 low-carbon steel conductor casing. The centralizers will be aligned from top to bottom of the casing so that they do not interfere with the insertion and removal of the steel tremie pipe. All devices and/or welds used to affix centralizers to the casing shall not be allowed to puncture the casing or contaminate the groundwater with which they come in contact. To ensure even distribution of filter pack, bentonite seal, and grout materials around the well within the borehole, the well casing and screen will be suspended with a threaded hoisting plug and not allowed to rest on the bottom of the borehole. If installation of a conductor casing is required, the well will be installed through the length of the conductor casing and within the open borehole below the bottom of the conductor casing (Figure 5).

Coarse #3 Monterey silica sand will be emplaced via steel tremie pipe into the borehole annulus to approximately 2 ft above the slotted well screen, followed by a 3- to 5-ft thick bentonite pellet seal, then cement-bentonite grout to within 2 ft of the tunnel floor. If large voids are encountered, then bentonite chips may be required to seal the voids. The proposed well construction details for single-level wells are shown on Figure 4 for the standard 2-inch-diameter well, and on Figure 5 in the event a conductor casing is required. Dry bentonite chips, where used, will be tremied and hydrated with clean potable water using at least 5 gallons of water per 50-pound bag of chips. Well construction information will be provided in the geologic logs.

Because the rock formation is not pressured, blowouts are not anticipated to occur. However, as described above, voids are anticipated to be encountered and need to be taken into consideration during well installation. In the event that voids or blowouts are encountered, bentonite chips will be emplaced down hole to close out or plug the void.

3.5 Borehole Abandonment

Boreholes will be properly abandoned if drilling refusal occurs prior to reaching the target depth for sampling and/or monitoring well construction. Abandonment will be performed in accordance with

NAVFAC Pacific ER Program Procedure I-C-1, *Monitoring Well Installation and Abandonment* (DON 2015) (SOW Attachment 2), and will involve sealing the borehole with cement-bentonite grout. The grout will be emplaced with a tremie pipe in one operation from the bottom of the boring to within a minimum of 2 ft of the ground surface. Additional grout may need to be placed if significant settlement occurs.

3.6 MONITORING WELL 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). 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 6. 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, security, and to provide a continuous cement surface seal.

1. If a PVC well casing joint occurs above 2 ft bgs, a 5-ft piece of well casing will be used. The PVC well casing will be suspended under tension by a threaded coupling during installation of all annular materials.
2. The cement seal will be installed to a depth no higher than 3 ft bgs to allow installation of the steel protective casing.
3. The Schedule 40 steel conductor casing will be cut off at a level not more than 6 inches above land surface.
4. The PVC well casing will be cut off square at a level 3 ft above ground surface.
5. The PVC well casing will be capped with an approved expansion plug. No slip joint fittings will be attached to the well casing.
6. The steel protective casing will be installed inside the Schedule 40 steel conductor casing extending 3.5 ft above ground and 2 feet below ground surface, providing 6 inches of clearance between the locking cap and the top of the PVC well casing.
7. The steel protective casing will be held in place with cement grout extending to a level 6 inches below the top of the PVC well casing. The casing will be stabilized and checked for plumbness while setting.
8. After the cement has set, a drain hole will be drilled at the top of the cement level on the steel casing.
9. A 2-ft thick, 3.5-ft × 3.5-ft square concrete pad will be installed around each protective steel casing, using forms that will not warp under the weight of the cement, as approved by AECOM. Approximately 1 ft of the concrete pad will extend above the ground surface, and 1 ft of the pad will extend below ground surface.
10. Four steel bollards will be placed slightly beyond each corner of the concrete pads. The bollards will extend approximately 2 ft bgs and approximately 3 ft above ground surface, and each will be individually set in concrete. The bollards and protective steel casing will be painted bright yellow for high visibility. If the area where the well is installed has an obstruction (e.g., steep bank) or other feature that prevents vehicles from driving toward the well from a specific direction, then the number of bollards installed may be reduced with Navy approval.

Depending on the specific conditions surrounding a well, some outdoor-location wells may require a flush-mount traffic-rated steel cover. Flush-mounted covers are anticipated to be either a 12-inch flush mount or a stainless-steel or aluminum vault with dimensions of 24 inches × 24 inches in area and 18 inches in height (or depth if completed as a vault). The covers will be corrosion resistant, leak resistant, and lockable. The concrete pad surrounding traffic-rated covers will extend at least 1 ft beyond the edge of the cover and will be at least 1 ft thick.

Tunnel monitoring wells will be completed as a flush-mount to avoid obstructing any portion of the lower access tunnel. The flush-mount surface completion will consist of a 12-inch-diameter, circular steel skirt or rectangular utility-type box with a gasket to prevent leaks and traffic-rated locking lid over the recessed well. The circular skirt or box will be set in concrete flush with the grade surface of the tunnel to provide strength and a watertight surface seal.

The size and dimension of the covers will be reviewed by the Navy team to ensure they can withstand the site-specific demands of traffic or other potential damaging conditions and have sufficient room to contain all equipment, hoses, and tubing associated with the well.

3.7 EQUIPMENT DECONTAMINATION

Equipment will be decontaminated in accordance with Procedure I-F, *Equipment Decontamination* (DON 2015).

3.8 INVESTIGATION-DERIVED WASTE MANAGEMENT AND DISPOSAL

Green waste generated during vegetation clearance will be processed in accordance with the most recent Navy direction on green waste disposal to prevent the spread of the coconut rhinoceros beetle. AECOM will need to coordinate with the Navy CTO COR to ensure that the most current guidance is obtained and followed. The most recent direction at the time of this SMWIWP's publication (*JBPHH Green Waste Disposal Direction* (2022) is provided in Appendix A. Processed green waste will be collected each day and will be transported to and disposed of at the designated disposal facility no more than 24 hours from the time of generation.

Unconsolidated material and liquid investigation-derived waste (IDW) generated during monitoring well installation and development activities will be collected at the end of each day. The IDW will be evaluated based on the corresponding unconsolidated material and groundwater sampling data and IDW samples (including liquid wastes generated during drilling operations, well development water, and decontamination liquids) to select appropriate disposal methods. Well development water will be stored in larger portable (frac) tanks capable of containing up to 6,000 gallons of liquids if feasible. With the exception of well development water in large portable tanks, IDW will be stored in U.S. Department of Transportation-approved 55-gallon steel drums, placed on pallets, covered with tarps, and temporarily stored at a secure, Navy-designated staging area. As an alternative and to facilitate drilling activities, drill cuttings may be placed in roll-off containers. Roll-off containers will be covered with a tarp to prevent them from filling up with precipitation.

The IDW will be handled, stored, and labeled in accordance with Procedure I-A-6, *Investigation-Derived Waste Management* (DON 2015). The drums will be segregated according to source and matrix, and at least one representative composite IDW samples 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 (DoD) Environmental Laboratory Accreditation Program (ELAP). Waste profile forms will be prepared and submitted to potential disposal facilities for approval. The IDW will be kept at the 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, 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.

4. Sample Details

Details of subsurface unconsolidated material, geotechnical, and potable water samples are presented in Table 4-1, Table 4-2, and Table 4-3, respectively. Additional analytical details are presented in Appendix C.

Table 4-1: Subsurface Unconsolidated Material Sample Details

				Analysis Group:	TPH-d/ TPH-o+SGC	TPH-g	BTEX	1-Methylnaphthalene, 2-Methylnaphthalene, naphthalene	VOCs	PAHs	PCB Aroclors	TCLP RCRA 8 Metals	Total RCRA 8 Metals
				Analytical Method:	SW-846 8015	SW-846 8260	SW-846 8260	SW-846 8270 SIM	SW-846 8260	SW-846 8270 SIM	SW-846 8082	SW-846 1311/6010/ 7470	SW-846 6010/7470
				Container Type:	8-oz clear borosilicate wide-mouth jar, with Teflon-lined lid	Pre-weighed 40-mL clear borosilicate VOA vial, with Teflon septum-lined cap	Pre-weighed 40-mL clear borosilicate VOA vial, with Teflon septum-lined cap	8-oz clear borosilicate wide-mouth jar, with Teflon-lined lid	Pre-weighed 40-mL clear borosilicate VOA vial, with Teflon septum-lined cap	8-oz clear borosilicate wide-mouth jar, with Teflon-lined lid	8-oz clear borosilicate wide-mouth jar, with Teflon-lined lid	8-oz clear borosilicate wide-mouth jar, with Teflon-lined lid	8-oz clear borosilicate wide-mouth jar, with Teflon-lined lid
				Preservative:	≤6 °C	1 × 5mL methanol-preserved; ≤6 °C	Non-IDW: 2 × 10mL water-preserved; 1 × 5mL methanol-preserved; IDW soil: 6 × 25mL methanol-preserved; Water: 3 × 40mL HCl-preserved; ≤6 °C	≤6 °C	Non-IDW: 2 × 10mL water-preserved; 1 × 5mL methanol-preserved; IDW soil: 6 × 25mL methanol-preserved; Water: 3 × 40mL HCl-preserved; ≤6 °C	≤6 °C	≤6 °C	≤6 °C	HNO3; ≤6 °C
Eurofins TestAmerica Seattle				Holding Time (Preparation/ Analysis):	14 days	14 days	7 days (water); 14 days (methanol)	14 days	7 days (water); 14 days (methanol)	14 days	365 days	28 days (Hg), 180 days	28 days (Hg), 180 days
Site	Matrix	Sampling Point [d]	Sample ID	Depth/ Sampling Interval									
Red Hill	Unconsolidated Material [a,b]	NMW24 (ZZ)	NMW24-BS01-S01-Dff.f	TBD	✓	✓	✓	✓		—	—	—	—
Red Hill	Unconsolidated Material [a,b]	NMW22 (MM)	NMW22-BS01-S01-Dff.f	TBD	✓	✓	✓	✓		—	—	—	—
Red Hill	Unconsolidated Material [a,b]	NMW25 (TT)	NMW25-BS01-S01-Dff.f	TBD	✓	✓	✓	✓		—	—	—	—
Red Hill	Unconsolidated Material [a,b]	RHMW18 (JJ)	RHMW18-BS01-S01-Dff.f	TBD	✓	✓	✓	✓		—	—	—	—
Red Hill	Unconsolidated Material [a,b]	RHMW20 (BB)	RHMW20-BS01-S01-Dff.f	TBD	✓	✓	✓	✓		—	—	—	—
Red Hill	Unconsolidated Material [a,b]	RHMW21 (II)	RHMW21-BS01-S01-Dff.f	TBD	✓	✓	✓	✓		—	—	—	—
Red Hill	Unconsolidated Material [a,b]	NMW23 (XA)	NMW23-BS01-S01-Dff.f	TBD	✓	✓	✓	✓		—	—	—	—
Red Hill	Unconsolidated Material [a,b]	KK	KK-BS01-S01-Dff.f	TBD	✓	✓	✓	✓		—	—	—	—
Red Hill	Unconsolidated Material [a,b]	PP	PP-BS01-S01-Dff.f	TBD	✓	✓	✓	✓		—	—	—	—
Red Hill	Unconsolidated Material [a,b]	QQ	QQ-BS01-S01-Dff.f	TBD	✓	✓	✓	✓		—	—	—	—

				Analysis Group:	TPH-d/ TPH-o+SGC	TPH-g	BTEX	1-Methylnaphthalene, 2-Methylnaphthalene, naphthalene	VOCs	PAHs	PCB Aroclors	TCLP RCRA 8 Metals	Total RCRA 8 Metals
				Analytical Method:	SW-846 8015	SW-846 8260	SW-846 8260	SW-846 8270 SIM	SW-846 8260	SW-846 8270 SIM	SW-846 8082	SW-846 1311/6010/ 7470	SW-846 6010/7470
				Container Type:	8-oz clear borosilicate wide-mouth jar, with Teflon-lined lid	Pre-weighed 40-mL clear borosilicate VOA vial, with Teflon septum-lined cap	Pre-weighed 40-mL clear borosilicate VOA vial, with Teflon septum-lined cap	8-oz clear borosilicate wide-mouth jar, with Teflon-lined lid	Pre-weighed 40-mL clear borosilicate VOA vial, with Teflon septum-lined cap	8-oz clear borosilicate wide-mouth jar, with Teflon-lined lid	8-oz clear borosilicate wide-mouth jar, with Teflon-lined lid	8-oz clear borosilicate wide-mouth jar, with Teflon-lined lid	8-oz clear borosilicate wide-mouth jar, with Teflon-lined lid
				Preservative:	≤6 °C	1 × 5mL methanol-preserved; ≤6 °C	Non-IDW: 2 × 10mL water-preserved; 1 × 5mL methanol-preserved; IDW soil: 6 × 25mL methanol-preserved; Water: 3 × 40mL HCl-preserved; ≤6 °C	≤6 °C	Non-IDW: 2 × 10mL water-preserved; 1 × 5mL methanol-preserved; IDW soil: 6 × 25mL methanol-preserved; Water: 3 × 40mL HCl-preserved; ≤6 °C	≤6 °C	≤6 °C	≤6 °C	HNO3; ≤6 °C
Eurofins TestAmerica Seattle				Holding Time (Preparation/ Analysis):	14 days	14 days	7 days (water); 14 days (methanol)	14 days	7 days (water); 14 days (methanol)	14 days	365 days	28 days (Hg), 180 days	28 days (Hg), 180 days
Site	Matrix	Sampling Point [d]	Sample ID	Depth/ Sampling Interval									
Field QC Samples													
Red Hill	Field Duplicate	TBD	Aaaaaa-BScc-Dee-Dff.f	TBD	✓	✓	✓	✓			—	—	—
Red Hill	Matrix Sp ke/ Matrix Spike Duplicate	TBD	Aaaaaa-BScc-See-Dff.f	TBD	✓	✓	✓	✓			—	—	—
Red Hill	Ambient Blank	TBD	Aaaaaa-WQ-Aee-ffffff	—	✓	✓	✓	✓			—	—	—
Red Hill	Trip Blank	TBD	Aaaaaa-WQ-Tee-ffffff	—	—	✓	✓	—			—	—	—
Miscellaneous Samples													
Red Hill	IDW Soil [c]	TBD	Aaaaaa-IDW-See-ffffff	—	✓	✓	—	—	✓	✓	✓	✓	—
Red Hill	IDW Water	TBD	Aaaaaa-IDW-W01-ffffff	—	✓	✓	—	—	✓	✓	✓	—	✓
Total Number of Samples to the Laboratory													20 (minimum)

✓ analysis is applicable to sample
— analysis is not applicable to sample
°C degree Celsius
Aaaaaa sampling point
APPL Agriculture & Priority Pollutants Laboratories, Inc.
908 N Temperance Ave., Clovis, CA 93611
cc consecutive sampling location number
ee chronological sample number from a particular sampling location
ff.f depth of sample in ft bgs (measured to the tenth of a ft)
ffffff sample collection date (e.g., "021519" for February 15, 2019)
oz ounce
PAH polynuclear aromatic hydrocarbon
TBD to be determined
TPH-d total petroleum hydrocarbons – diesel range organics
TPH-g total petroleum hydrocarbons – gasoline range organics
TPH-o total petroleum hydrocarbons – residual range organics (i.e., TPH-oil)
VOA volatile organic analyte

[a] Unconsolidated material includes soil, coarse-grained sand, and smaller grain size material, such as clay, sands, and clinker zone sand.
[b] Unconsolidated material will be sampled as described in Section 3.3.1.
[c] IDW soil samples will be collected in the field and processed in the laboratory in accordance with the DOH TGM Section 4.2, *Use of Multi Increment Samples to Characterize DU's* (DOH 2016).
[d] Wells are currently being identified with a temporary label (e.g., "XA") reflected in this document; however, a permanent identifier (e.g., RHMW18) will be assigned when property access is received and permission to drill has been granted.

Table 4-2: Geotechnical Sample Details

				Analysis Group:	Atterberg Limits	Effective Porosity	Permeability	Moisture Content and Density
				Analytical Method: [a]	ASTM D4318	API RP40	ASTM D5084	ASTM D2937
				Container Type:	Core	Core	Core	Core
				Preservative:	≤6 °C	≤6 °C	≤6 °C	≤6 °C
Eurofins TestAmerica Seattle				Holding Time (Preparation/Analysis):	N/A	N/A	N/A	N/A
Site	Matrix	Sampling Point [c]	Sample ID	Depth/Sampling Interval				
Red Hill	Unconsolidated Material [a,b]	NMW24 (ZZ)	NMW24-BS01-S01-Dff.f	TBD	✓	✓	✓	✓
Red Hill	Unconsolidated Material [a,b]	NMW22 (MM)	NMW22-BS01-S01-Dff.f	TBD	✓	✓	✓	✓
Red Hill	Unconsolidated Material [a,b]	NMW25 (TT)	NMW25-BS01-S01-Dff.f	TBD	✓	✓	✓	✓
Red Hill	Unconsolidated Material [a,b]	RHMW18 (JJ)	RHMW18-BS01-S01-Dff.f	TBD	✓	✓	✓	✓
Red Hill	Unconsolidated Material [a,b]	RHMW20 (BB)	RHMW20-BS01-S01-Dff.f	TBD	✓	✓	✓	✓
Red Hill	Unconsolidated Material [a,b]	RHMW21 (II)	RHMW21-BS01-S01-Dff.f	TBD	✓	✓	✓	✓
Red Hill	Unconsolidated Material [a,b]	NMW23 (XA)	NMW23-BS01-S01-Dff.f	TBD	✓	✓	✓	✓
Red Hill	Unconsolidated Material [a,b]	KK	TT-BS01-S01-Dff.f	TBD	✓	✓	✓	✓
Red Hill	Unconsolidated Material [a,b]	PP	BB-BS01-S01-Dff.f	TBD	✓	✓	✓	✓
Red Hill	Unconsolidated Material [a,b]	QQ	II-BS01-S01-Dff.f	TBD	✓	✓	✓	✓

Note: Geotechnical analytical services will be subcontracted by APPL to: Hushmand Associates, Inc., 250 Goddard, Irvine, CA 92618.
✓ analysis is applicable to sample
ff.f depth of sample in ft bgs (measured to the tenth of a ft)
API American Petroleum Institute
ASTM ASTM International
N/A not applicable
TBD to be determined
[a] Unconsolidated material includes soil, coarse-grained sand, and smaller grain size material, such as clay, sands, and clinker zone sand.
[b] Unconsolidated material will be sampled as described in Section 3.3.1.
[c] Wells are currently being identified with a temporary label (e.g., "XA") reflected in this document; however, a permanent identifier (e.g., RHMW18) will be assigned when property access is received and permission to drill has been granted.

Table 4-3: Potable Water Sample Details

				Analysis Group:	TPH-d/TPH-o+SGC	TPH-g	VOCs	PAHs
				Analytical Method:	SW-846 8015	SW-846 8260	SW-846 8260	SW-846 8270
				Container Type:	2 × 500-mL amber borosilicate wide- or narrow-mouth bottle, with Teflon-lined lid	3 × 40-mL clear or amber borosilicate VOA vial, with Teflon septum-lined cap	3 × 40-mL clear or amber borosilicate VOA vial, with Teflon septum-lined cap	2 × 1-L amber borosilicate wide- or narrow-mouth bottle, with Teflon-lined lid
				Preservative:	≤6 °C	HCl-preserved; ≤6 °C	HCl-preserved; ≤6 °C	≤6 °C
Analytical laboratory: Eurofins Seattle.				Holding Time (Preparation/Analysis):	7 days	14 days	14 days	7 days
Site	Matrix	Sampling Point	Sample ID	Depth/Sampling Interval				
Red Hill	Water	Potable Water [a]	Aaaaaa-PW01-S01-ffffff	TBD	✓	✓	✓	✓
Total Number of Samples to the Laboratory					1			

Notes:
✓ analysis is applicable to sample
Aaaaaa sampling point
ffffff sample collection date (e.g., "021519" for February 15, 2019)
TBD to be determined
[a] Potable water will be sampled prior to potable water use during drilling activities as described in Section 3.3.1.

4.1 SAMPLE CUSTODY REQUIREMENTS

Each sample will be assigned a CoC sample identification (ID) number and a descriptive ID number in accordance with NAVFAC Pacific Environmental Restoration Program Procedure I-A-8, *Sample Naming* (DON 2015). All sample ID numbers will be recorded in the field logbook in accordance with Procedure III-D, *Logbooks* (DON 2015). The CoC sample ID number (the only ID number submitted to the analytical laboratory) is used to facilitate data tracking and storage. The CoC sample ID number allows all samples to be submitted to the laboratory without providing information on the sample type or source. The descriptive ID number is linked to the CoC sample ID number, which provides information regarding sample type, origin, and source.

4.1.1 CoC Sample Identification Number

A CoC sample ID number will be assigned to each sample as follows, to facilitate data tracking and storage:

ERHxxx

Where:

ERH = Designates the samples for the Red Hill Bulk Fuel Storage Facility

xxx = Chronological number, starting with next consecutive number (will be determined prior to field work and is dependent on the last number used in the most recent sampling event)

QC samples will be included in the chronological sequence.

4.1.2 Descriptive Identification Number

A descriptive ID number (for internal use only) will identify the sampling location, type, sequence, matrix, and depth. The descriptive ID number is used to provide sample-specific information (e.g., location, sequence, and matrix). The descriptive identifier is not revealed to the analytical laboratory. The descriptive ID number for all samples is assigned as follows:

Aaaaaa-bbcc-dee-Dff.f

Where:

Aaaaaa = Site area (Table 4-4)

bb = Sample type and matrix (Table 4-5)

cc = Location number (e.g., borehole 01, 02, 03)

d = Field QC sample type (Table 4-6)

ee = Chronological sample number from a particular sampling location (e.g., 01, 02)

D = The letter “D” denoting depth

ff.f = Depth of sample in ft bgs (measured to the tenth of a ft). For water matrix samples, the depth field will contain the month, day, and year of collection (e.g., 021519 for February 15, 2019).

For example, the sample number RHMW18-BS01-S01-D20.0 would indicate that the sample is the first sample collected from the first subsurface unconsolidated material location, encountered at 20 ft bgs, from the borehole advanced for monitoring well RHMW18. The duplicate sample would be designated as RHMW18-BS01-D01-D20.0. These characters will establish a unique descriptive identifier that will be used during data evaluation.

Table 4-4: Area Identifiers

Temporary Identifier [a]	Site Area
NMW24 (ZZ)	Monitoring Well NMW24
NMW22 (MM)	Monitoring Well NMW22
NMW25 (TT)	Monitoring Well NMW25
RHMW18 (JJ)	Monitoring Well RHMW18
RHMW20 (BB)	Monitoring Well RHMW20
RHMW21 (II)	Monitoring Well RHMW21
NMW23 (XA)	Monitoring Well NMW23
KK	Monitoring Well KK
PP	Monitoring Well PP
QQ	Monitoring Well QQ

[a] Wells are currently being identified with a temporary label (e.g., "XA") reflected in this document; however, a permanent identifier (e.g., RHMW18) will be assigned when property access is received and permission to drill has been granted.

Table 4-5: Sample Type and Matrix Identifiers

Identifier	Sample Type	Matrix
BS	Subsurface Unconsolidated Material	Unconsolidated Material
WQ	Water Blanks	Water
PW	Potable Water	Water
CO	Rock Core	Core
PR	Jet Fuel	Product

Table 4-6: Field QC Sample Type Identifiers

Identifier	Field or QC Sample Type	Description
S	Primary Sample	All field samples, except QC samples
D	Duplicate	Co-located for unconsolidated material
E	Equipment Blank	Water
B	Field Blank	Water
T	Trip Blank	Water
A	Ambient Blank	Water

4.1.3 Handling, Shipping, and Custody

All samples collected for analysis will be recorded in the field logbook in accordance with Procedure III-D, *Logbooks* (DON 2015). All samples will be labeled and recorded on CoC forms in accordance with Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody* (DON 2015). Samples will be handled, stored, and shipped in accordance with Procedure III-F, *Sample Handling, Storage, and Shipping* (DON 2015). All samples collected on this project will be shipped to the analytical laboratory via overnight airfreight.

All samples received at the analytical laboratory will be managed in accordance with laboratory SOPs for receiving samples, archiving data, and sample disposal and waste collection, as well as, storage and disposal per Section 5.8, "Handling of Samples" of the DoD *Quality Systems Manual (QSM)* v. 5.4 (DoD and DOE 2021).

4.2 LABORATORY QC SAMPLES

Laboratory QC samples will be prepared and analyzed in accordance with the methods and procedures listed Table C-5 in Appendix C.2.

5. Data Verification and Validation

Table 5-1 displays the Steps I and IIa/IIb data verification and validation process.

Table 5-1: Data Verification and Validation (Steps I and IIa/IIb) Process Table

Data Review Input	Description	Responsible for Verification (title)	Step I/IIa/IIb [a]	Internal/External
Field procedures	Determine whether field procedures are performed in accordance with this SMWIWP and prescribed procedures.	QA Program Manager	Step I	Internal
Field logbook and notes	Review the field logbook and any field notes on a weekly basis and place them in the project file. Copies of the field logbook and field notes will be provided to the CTO manager and included in the Field Audit Report.	Field Manager	Step I	Internal
CoC and field QC logbook	Examine data traceability from sample collection to project data generation.	Project Chemist	Step IIa	Internal
Sampling plan	Determine whether the number and type of unconsolidated material and potable water samples specified in Table 4-1, Table 4-2, and Table 4-3 were collected.	Project Chemist and Field Manager	Step IIb	Internal
Field QC samples	Establish that the number of QC samples specified in Table 4-1, Table 4-2, and Table 4-3 were collected.	Project Chemist	Step IIb	Internal

[a] IIa Compliance with methods, procedures, and contracts. See Table 10, page 117, UFP-QAPP Manual, V.1 (DoD 2005).
IIb Comparison with measurement performance criteria in the project SAP (DON 2017d). See Table 11, page 118, UFP-QAPP Manual, V.1 (DoD 2005).

6. References

ASTM International (ASTM). 2014. *Standard Practice for Rock Core Drilling and Sampling of Rock for Site Exploration*. D2113-14. West Conshohocken, PA.

Department of Defense and Department of Energy, United States (DoD and DOE). 2021. *Department of Defense (DoD) and Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories*. DoD/DOE QSM Ver. 5.4. Prepared by DoD Environmental Data Quality Workgroup and DOE Consolidated Audit Program Operations Team.

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U.S. Environmental Protection Agency and the Department of Energy. Washington, DC: Intergovernmental Data Quality Task Force. March.

Department of Health, State of Hawaii (DOH). 2017. *Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater, Hawai‘i Edition*. Hazard Evaluation and Emergency Response. Revised 2017. Fall.

———. 2021. *Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan*. Interim Final. Honolulu, HI: Hazard Evaluation and Emergency Response Office. November 12, 2008. Latest Update: July 2021.

Department of the Navy (DON). 2015. *Final Project Procedures Manual, U.S. Navy Environmental Restoration Program, NAVFAC Pacific*. JBPHH HI: Naval Facilities Engineering Command, Pacific. May.

———. 2016. *Monitoring Well Installation Work Plan, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i; August 29, 2016*. Prepared by AECOM Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy, Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI.

———. 2017a. *Monitoring Well Installation Work Plan Addendum 01, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i; January 4, 2017, Revision 00*. Prepared by AECOM Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy, Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI.

———. 2017b. *Work Plan / Scope of Work, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i; January 4, 2017, Revision 02*. Prepared by AECOM Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy, Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI.

———. 2017c. *Technical Memorandum, Second Order, Class I Topographic Survey at Groundwater Monitoring Well Locations for the Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i*. [Draft] March. JBPHH HI: Naval Facilities Engineering Command, Hawaii.

———. 2017d. *Sampling and Analysis Plan, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i; April 20, 2017, Revision 01*. Prepared by AECOM Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy, Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI.

———. 2017e. *Monitoring Well Installation Work Plan Addendum 02, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i; August 25, 2017, Revision 00*. Prepared by AECOM Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy, Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI.

———. 2021. *Accident Prevention Plan, Investigation at Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam O'ahu, HI*. Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Hawaii. January.

———. 2022. *Quarterly Release Response Report, May 6 and November 20, 2021 Releases, Red Hill Bulk Fuel Storage Facility, JBPHH, O'ahu, Hawai'i*. Prepared for NAVFAC Hawaii by AECOM Technical Services, Inc. DOH Facility ID No. 9-102271; DOH UST Release ID No. 210012; DOH HEER Release Incident Case Nos. 20210507-0852, 20211120-2330. JBPHH HI: Naval Facilities Engineering Systems Command, Hawaii. April 6.

Environmental Protection Agency, United States, Region 9; and Department of Health, State of Hawaii (EPA Region 9 and DOH). 2015. *Administrative Order on Consent In the Matter of Red Hill Bulk Fuel*

Storage Facility, EPA Docket No: RCRA 7003-R9-2015-01; DOH Docket No: 15-UST-EA-01. September.

Munsell, Munsell Color Company (Munsell). 2009. *Geological Rock-Color Chart with Genuine Munsell Color Chips. Revision of Geological Society of America (GSA) Rock-Color Chart*. Produced in cooperation with GSA. Baltimore, MD.

Wentworth, C. K. 1942. *Geology and Ground-Water Resources of the Moanalua-Halawa District*. Honolulu, HI: Board of Water Supply.

Location Map

Legend

- Existing Monitoring Well
- Proposed Sentinel Well
- Proposed Monitoring Well
- Water Supply Well
- Stream
- Red Hill Facility Boundary

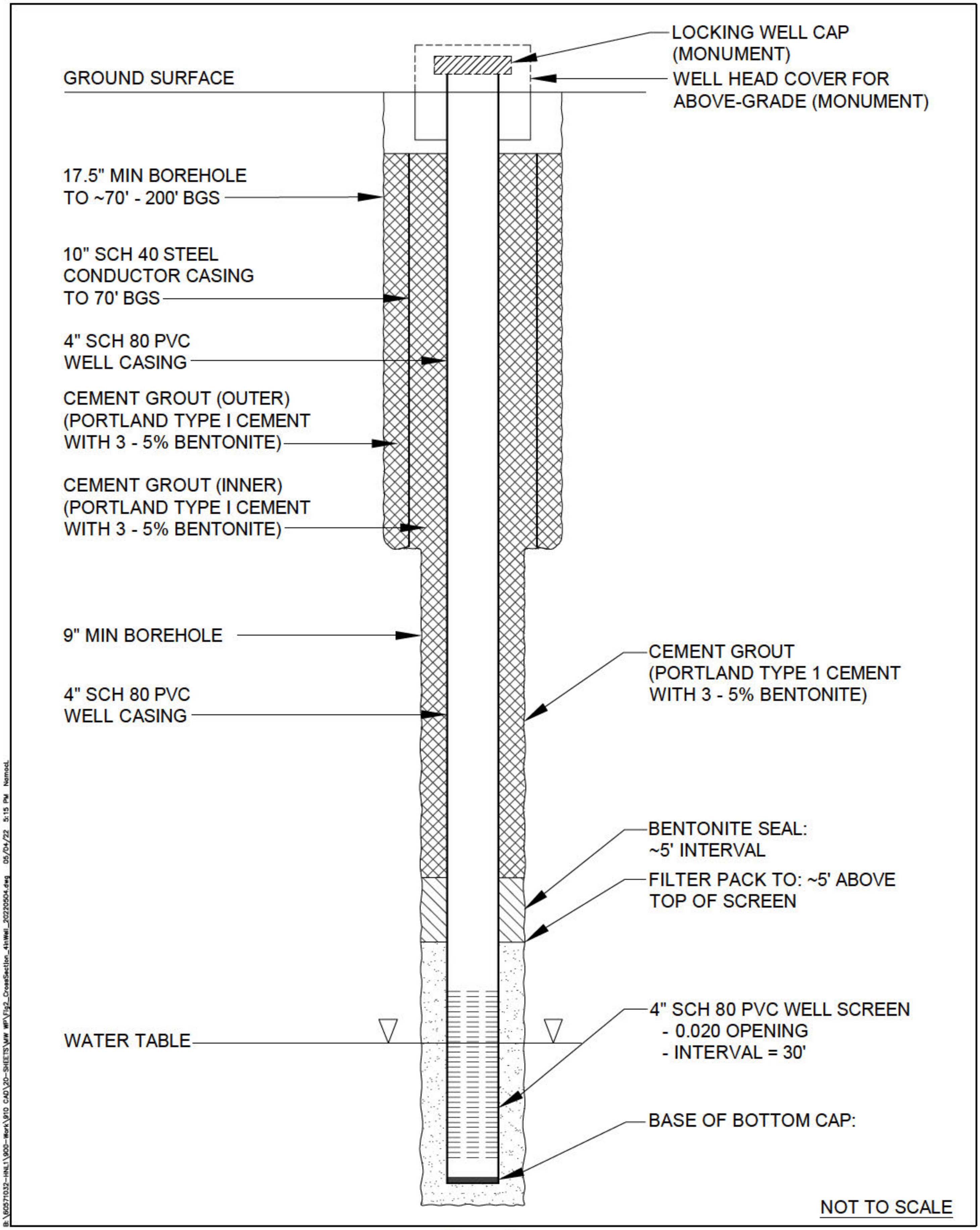
Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Base Map: Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
3. Coordinates: NAD 1983 Hawaii State Plane Z3 ft
4. **Revised August 2022.**

N

0 600 1,200 2,400 Feet

Figure 1
Proposed Sentinel and Monitoring Well Locations
Sentinel and Monitoring Well
Installation Work Plan Rev.01
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i



B:\60571032-HNL1\900-Work\910 CAD\20-SHEETS\MW WP\Fig2_CrossSection_4inWell_20220504.dwg 05/04/22 5:15 PM Nomod.

Figure 2
Typical Well Construction Diagram for 4-Inch Monitoring Well (Water Table Condition)
Sentinel and Monitoring Well Installation Work Plan
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

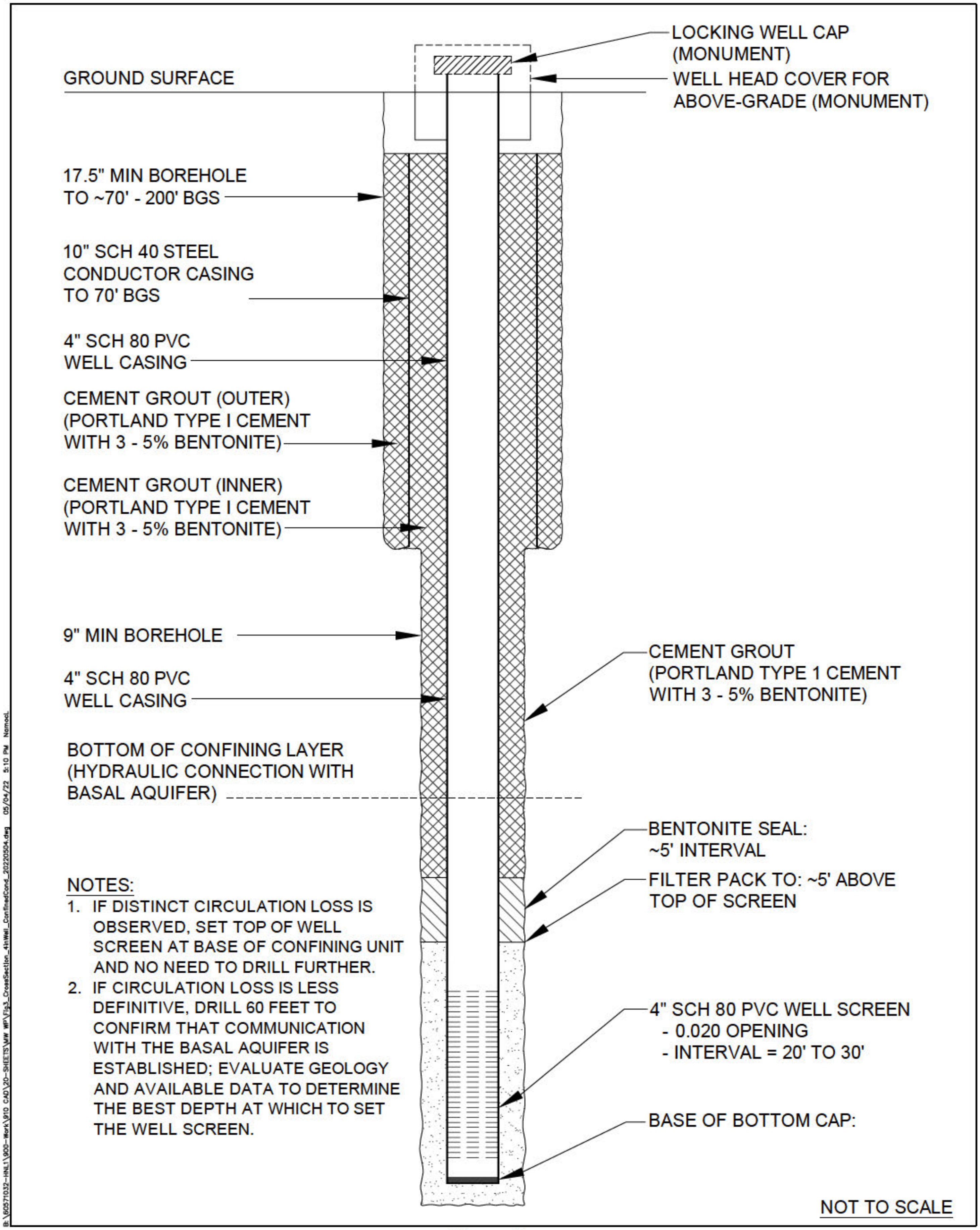


Figure 3
Typical Well Construction Diagram for 4-Inch Monitoring Well (Confined Condition)
Sentinel and Monitoring Well Installation Work Plan
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

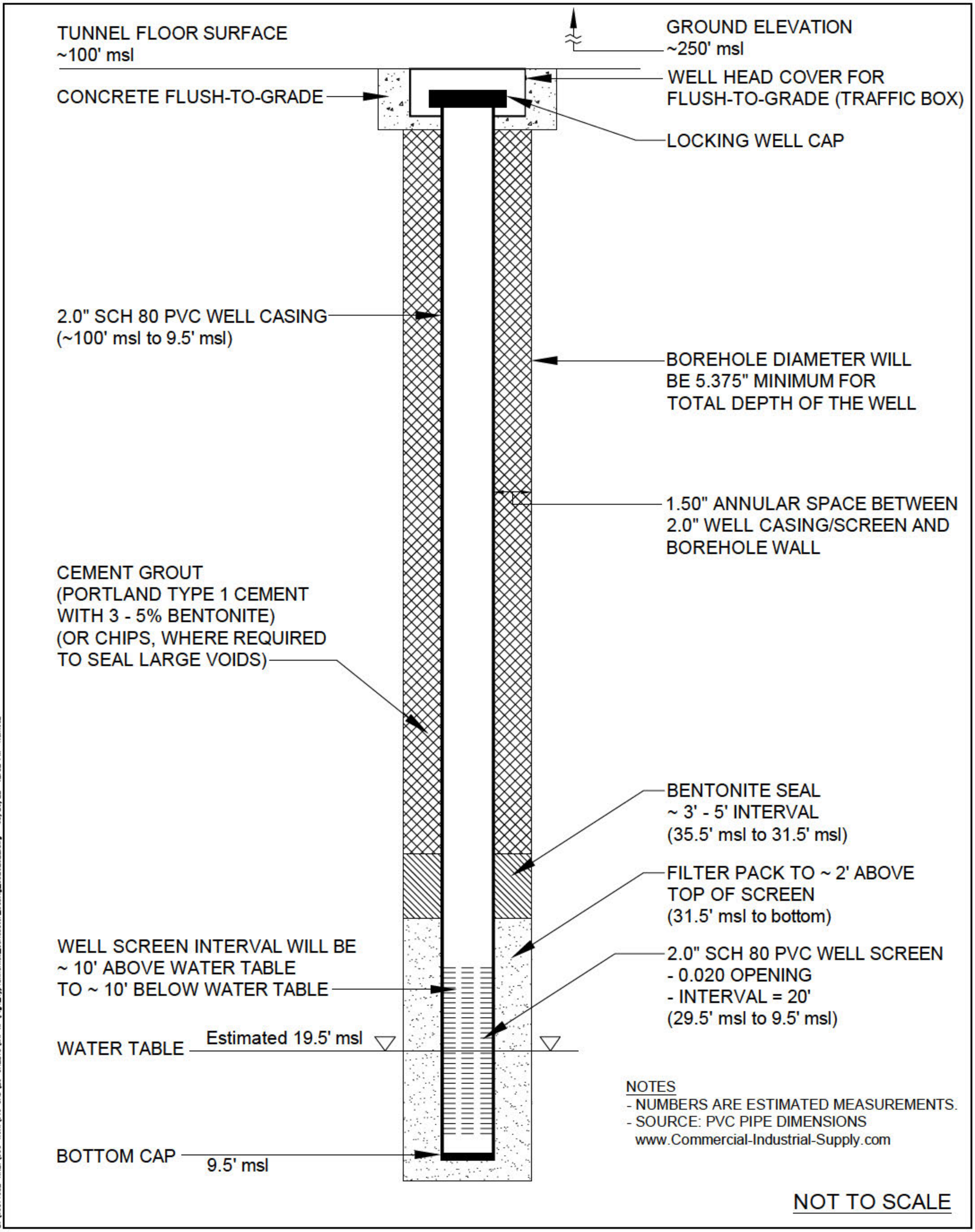
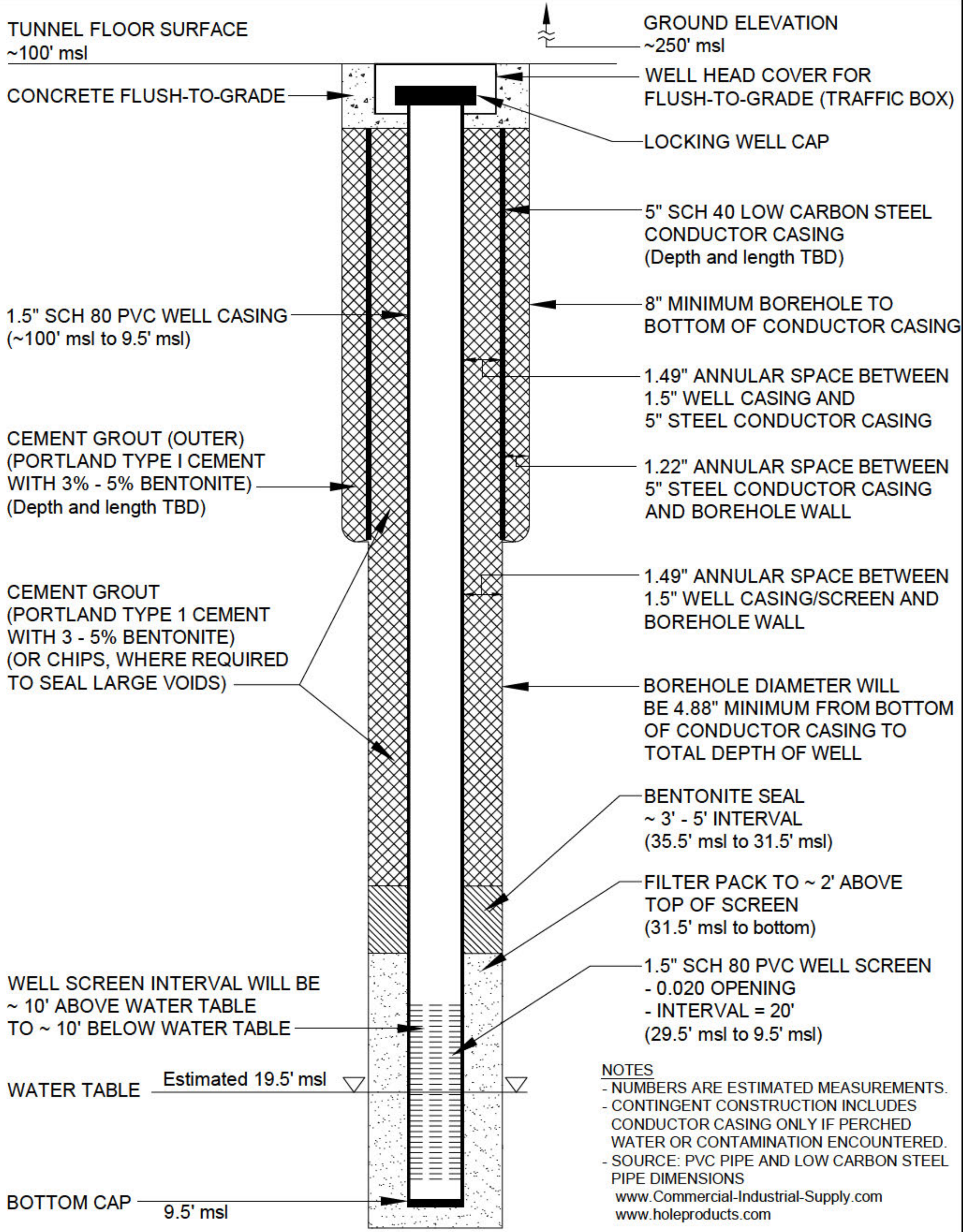


Figure 4
Typical Tunnel Well Construction Diagram without Conductor Casing
Sentinel and Monitoring Well Installation Work Plan
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i



NOTES
- NUMBERS ARE ESTIMATED MEASUREMENTS.
- CONTINGENT CONSTRUCTION INCLUDES CONDUCTOR CASING ONLY IF PERCHED WATER OR CONTAMINATION ENCOUNTERED.
- SOURCE: PVC PIPE AND LOW CARBON STEEL PIPE DIMENSIONS
www.Commercial-Industrial-Supply.com
www.holeproducts.com

NOT TO SCALE

Figure 5
Typical Tunnel Well Construction Diagram with Conductor Casing
Sentinel and Monitoring Well Installation Work Plan
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

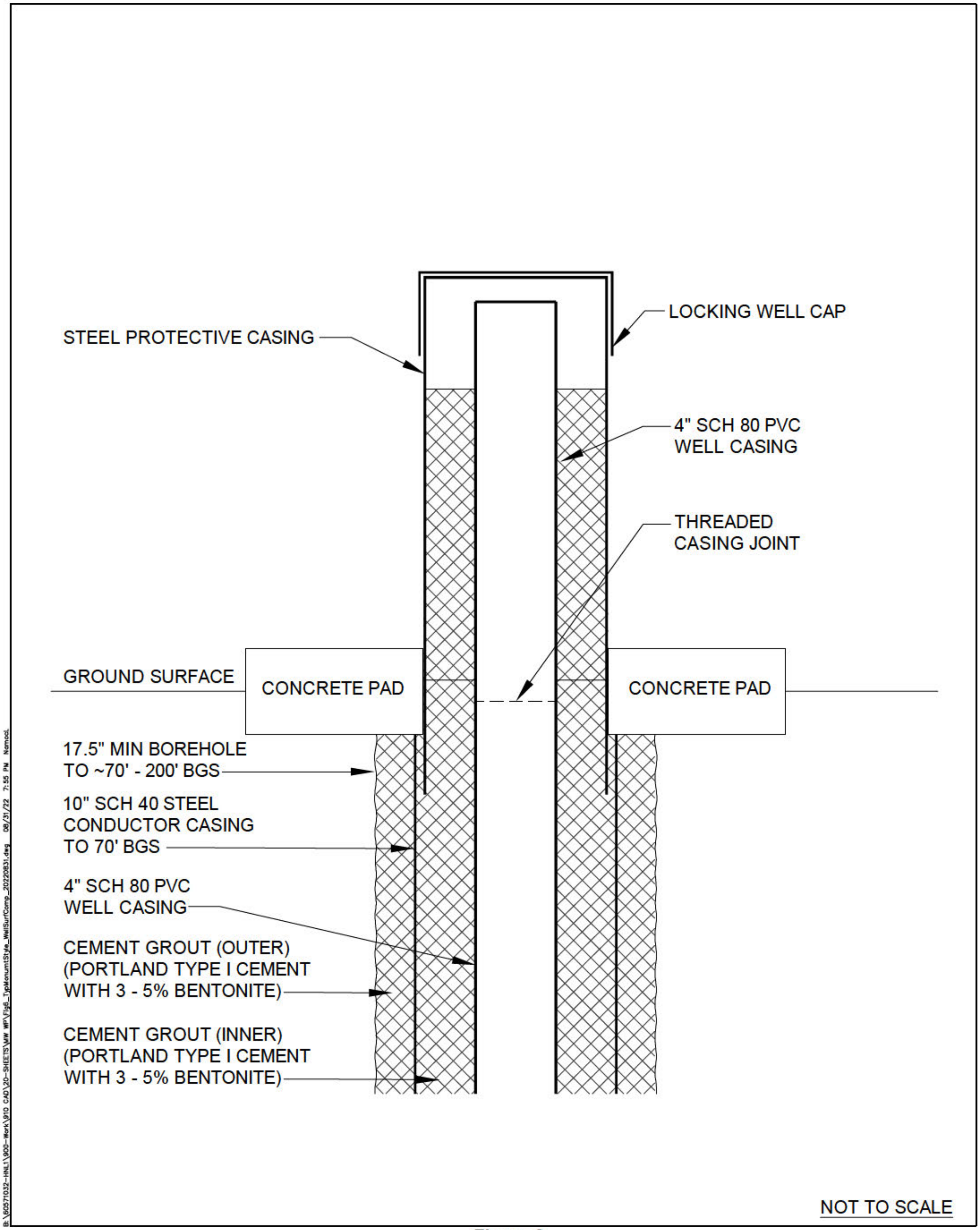


Figure 6
Typical Monument-Style Well Surface Completion
Sentinel and Monitoring Well Installation Work Plan Rev.01
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

Appendix A:
JBPHH Green Waste Disposal Direction (2022)

DEPARTMENT OF THE NAVY
JOINT BASE PEARL HARBOR-HICKAM
850 TICONDEROGA ST STE 100
PEARL HARBOR HI 96860-5102

5090
JB4/Ser305
22 Mar 2022

From: Commander, Joint Base Pearl Harbor-Hickam

Subj: JOINT BASE PEARL HARBOR-HICKAM GREEN WASTE POLICY

Encl: (1) Map for Green Waste Disposal

1. All green waste cleared or generated on any Joint Base Pearl Harbor-Hickam (JBPHH) property (to include all outlying annexes and properties) must remain on JBPHH property. Follow below specifications regarding drop-off site as well as whether or not green waste can be chipped or left whole. Green waste generated on JBPHH cannot be taken to other non-JBPHH work site(s). Additionally, no inter-mixing of green waste from any non-JBPHH source is allowed. To the greatest extent practicable, contractor vehicles leaving JBPHH shall be fully emptied and swept of green waste before traveling to other properties. If any life stage of Coconut Rhinoceros Beetle (CRB) or suspected CRB is found, stop green waste clearing and call Hawaii Department of Agriculture Pest Hotline at 808-643-PEST (7378).

2. Zones for Whole vs. Chipped Green Waste - Enclosure (1).

a. WHOLE (Main base facility includes Hickam and Pearl Harbor Waterfront and Shipyard). No excess soil. Other than grass, loose leaves and monkey pods, all green waste generated in this zone must be kept whole and delivered within 24 hours to the Air Curtain Burner (ACBs) at the Fire Training Area (FTA). See FTA location on map. Air permit for ACBs allows combustion of green waste from the main base facility. To maximum extent practicable grass, loose leaves and monkey pods should be minimized and not be delivered to FTA to limit visible emissions from ACBs but instead be delivered to Bio-Solid Treatment Facility (BTF). During 24-hour period, material must be contained using an approved cover/tarp. No stockpiling/staging of any form of green waste is allowed outside of the FTA. No chipping in this zone allowed. Once cleared, no form of green waste can be left on the ground. All trees (including palms) should be cut in 3-feet sections with fronds/small branches left whole. Oversized trunks may need a waiver. Stump grinding protocol is defined in section 4.

b. CHIPPED (Other than main base facility includes Navy Marine Golf Course, Navy Makalapa area, Navy Moanalua area, McGrew Point, Ford Island, Pearl City Peninsula, Waipio Peninsula, West Loch, Lualualei, Navy-retained area at Barbers Point/Kalaeloa, and Wahiawa Annex). No excess soil. All green waste generated in this zone must be chipped and transported to the Bio-Solid Treatment Facility (BTF) at Kalaeloa within 24 hours. See map for BTF location. If 24-hour period includes overnight, material must stay on JBPHH and in a fully enclosed container/vehicle with immediate next-day delivery to BTF.

During transport to BTF, if vehicle is not fully enclosed, the vehicle must use an approved cover/tarp to cover an open top/back truck bed during transport. No stockpiling or staging of any form of green waste is allowed outside of the BTF. Once cleared, no form of green waste can be left on the ground. Stump grinding protocol is defined in section 4.

3. Waivers to Policy.

a. Any waiver to the above policy must be approved via waiver application point of contact. Waivers may be granted that allow for changes to the form of green waste, i.e., chipped versus whole or to the specific drop-off location that can be used. No JBPHH green waste can go to off-site treatment facilities (HECO and/or Hawaiian Earth Products) unless advanced approval is granted via waiver application.

b. If no waiver is granted, then above guidelines must be followed.

4. Stump Grinding: All stump grinding on JBPHH (including all outlying properties and annexes) shall follow contract specific guidance in addition to grind stump 12-18 inches down. Ground material will be delivered to an approved composting facility within 24 hours. Stump hole will be filled with topsoil and covered with sod.

5. If there are any questions, please contact the JBPHH Natural Resources Program Manager at (808) 471-0378 or (808) 722-7285.

[redacted] (b) (6)
CAPT, CEC, U.S. Navy
By direction

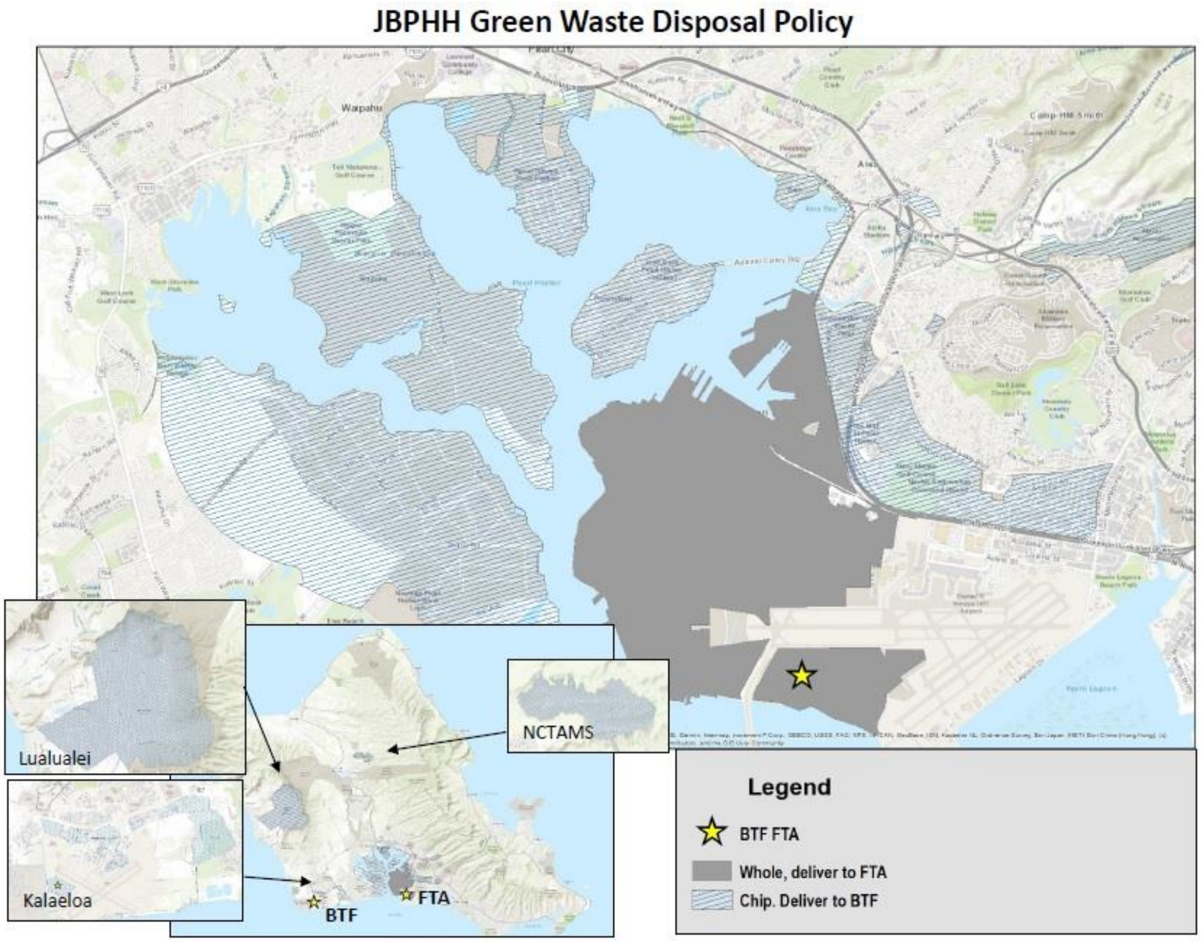
FOR INQUIRIES REGARDING GREEN WASTE POLICY/WAIVER APPLICATION, CONTACT:

JBPHH NATURAL RESOURCES PROGRAM MANAGER AT (808) 471-0378 OR (808) 722-7285

FIRE TRAINING AREA (FTA) AND BIO-SOLID TREATMENT FACILITY (BTF) CONTACTS:

JBPHH ENVIRONMENTAL SERVICES BRANCH AT (808) 347-2645 OR (808)-347-2639

NOTE: BTF CAN RECEIVE NON-NAVY DOD CHIPPED GREEN WASTE ON A CASE BY CASE BASIS. CONTACT BTF POC FOR APPROVAL



BTF

BIO-SOLID TREATMENT FACILITY @ BARBERS POINT
LAKE CHAMPLAIN ST.
KAPOLEI, HI 96707

FTA

FIRE TRAINING AREA @ HICKAM
WORCHESTER DRIVE
(ACROSS STREET FROM MAMALA BAY GOLF COURSE)

Enclosure (1)

Appendix B:
Proposed Path Forward
for 4-inch Monitoring Wells

Proposed Path Forward for 4-inch Monitoring Wells
Red Hill Bulk Fuel Storage Facility,
Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i

Naval Facilities Engineering Systems Command, Hawaii, JBPHH HI

1. Introduction

This document describes a path forward on how the United States (U.S.) Navy will inform Regulatory Agencies and stakeholders of conditions encountered in the field during the drilling and installation of monitoring wells needed to characterize the November 20, 2021 Jet Propellant 5 (JP-5) release in the Adit 3 tunnel of the Red Hill Bulk Fuel Storage Facility (Facility), Joint Base Pearl Harbor-Hickam, Oahu, Hawaii. This phase of response activity will result in the completion of ten 4-inch monitoring wells to be located within the Facility boundaries and adjacent areas. The effort will expand the current monitoring network and will increase the understanding of groundwater flow gradients (horizontal and vertical), formation hydraulic conductivities, subsurface geology, extent of chemicals of potential concern (COPCs), and potential lateral and vertical migration of COPCs in the project study area. The information will be used to estimate risks to potential receptors and refine the conceptual site model (CSM) and the groundwater flow and contaminant fate and transport (CF&T) models.

2. Sampling Plan

The Navy will follow Table 9-5 in the State of Hawaii Department of Health (DOH) Hazard Evaluation and Emergency Response (HEER) Office's *Technical Guidance Manual for Implementation of the Hawaii State Contingency Plan* (TGM) for laboratory analyses required for JP-5 (a middle distillate) and guidance for sampling.[1] The sampling plan described in the *Sentinel and Monitoring Well Installation Work Plan* (SMWIWP) (to which this document is an appendix) will help facilitate the identification and characterization of contamination encountered during the drilling described herein. The proposed monitoring well locations are identified on Figure 1 of the SMWIWP.

2.1 Hollow-Stem Auger or Rock Core Drilling and Subsurface Soil Sampling

Based on historical experience installing wells in similar geologic surface conditions at the Facility and adjacent areas, extensive hollow stem auger drilling may be required in the valley fill and saprolite strata before HQ or PQ rock coring is conducted. Multiple perched water layers may be encountered in these weathered saprolite and colluvial zones. Such conditions may be encountered in proximity to South Halawa Stream. For the 4-inch monitoring wells, subsurface soil samples will be collected at 5-foot depth intervals. These samples will be screened with a field organic vapor detector such as a photoionization detector (PID) using soil headspace screening techniques. HQ or PQ rock cores collected in 5-foot runs will be inspected for signs of contamination and screened with a PID.

Section 5 provides four scenarios anticipated to be encountered during drilling, three of which include the identification of contamination. During hollow-stem auger drilling, if one of the three scenarios in which screening identifies contamination in the subsurface occurs, continuous subsurface soil sampling and screening will be conducted until there is no longer evidence of contamination in the soil samples. Screening observations and actions will include:

- Visual and olfactory evidence of contamination will be recorded on the field log.

[1] https://health hawaii.gov/heer/tgm

- Volatile organic compounds will be measured with a PID using the Bag Headspace Test (TGM Section 8.4.2) and recorded on the log form.
- Soil intervals where screening exceeds 10 parts per million by volume (ppmv) in headspace measurements, along with visual and olfactory evidence, will be evaluated with samples for fixed-base laboratory analysis of the following constituents:
  - Total petroleum hydrocarbons (TPH) in the diesel (d), and residual oil (o) ranges by U.S. Environmental Protection Agency (EPA) 8015 Modified
  - TPH-gasoline (g), benzene, toluene, ethylbenzene, and total xylenes (BTEX) by EPA Method 8260 Method 5035 (Trademarked Terra Core or Encore sampling methods)
  - Naphthalene, 1-methylnaphthalene, 2-methylnaphthalene (N, 1-mN, 2-mN) by EPA Method 8270 Selected Ion Monitoring
- Soil samples will be collected:
  - At top of contaminated interval
  - At location of highest PID result
  - Below contaminated interval
  - At capillary fringe if perched water is encountered within the soil regime

2.2 Hollow-Stem Auger Drilling or Rock Coring and Perched Water Sampling

Prior to commencing hollow-stem auger drilling or rock coring each morning, the following sampling activities will be conducted:

- Water in the borehole will be collected with a clear bailer to observe the presence or absence of free product.
- Four (4) ounces of first bailer deposited in 8-ounce clear jar and capped:
  - Allow to set for 10 minutes, observe surface for sheen.
  - Uncap slightly and screen with PID and record headspace measurement.

Additionally, if perched water is observed, the following sampling activities will be conducted:

- A bailer of water will be collected from the zone containing perched water.
- Four (4) ounces of first bailer deposited in 8-ounce clear jar and capped:
  - Allow to set for 10 minutes, observe surface for sheen.
  - Uncap slightly and screen with PID and record headspace measurement.

If PID headspace measurements (above baseline of 10 ppmv) from either of the exercises described above and professional judgement indicate potential contamination is present, additional water will be bailed from the interval (until water quality parameters indicate stabilization), and a groundwater sample will be collected for fixed laboratory analyses of the following:

- TPH-g/-d/-o
- BTEX
- N, 1-mN, 2-mN

3. Drilling and Isolating Contaminated Media Above the Basal Aquifer

If encountering refusal during hollow-stem auger drilling, rock core drilling will continue to advance the borehole. If evidence of a perched water body or potential contamination is encountered, drilling operations will stop for notification (Section 5). The Navy has included isolation casing in the design of the wells to isolate perched water and potential contamination encountered during drilling in the zones of origin to protect the underlying basal aquifer from cross-contamination.

The 10-inch isolation casing will be installed from ground surface to a depth of approximately 30 feet mean sea level (msl) (approximately 10 feet above the basal groundwater surface). If perched water or contamination is not encountered in the shallow subsurface, a larger-diameter isolation casing may not be required.

A 10-inch-diameter isolation casing will then be installed in a minimum 17.5-inch-diameter borehole from ground surface to a depth below the extent of contamination, or to a depth of approximately 30 feet msl, above the basal aquifer (the depth of the casing will be determined based on borehole conditions and outcome of communication with the Regulatory Agencies):

- Ream open the borehole to 17.5 inches and install a 10-inch casing to a depth determined based on HQ core hole conditions (e.g., perched conditions, evidence of contamination) using air or mud rotary methods.
- The bottom of the casing will be installed into a low-permeability zone of clay, silty clay, saprolite, weathered basalt (a‘a, clinker, pahoehoe), or massive a‘a.
- The outer annulus will be grouted from the bottom, sealing off any contaminated or perched water zones above the bottom of the outer casing from the basal aquifer.

4. Basal Monitoring Well Installation

After installation of the 10-inch casing, drilling will resume to a total depth to install a 4-inch monitoring well.

- HQ coring total depth will be determined based on results of core logging and depth to water, bailing, and headspace monitoring. Measure depth to water, bail, and sample any apparent perched water.
- Submit any groundwater samples to fixed-base laboratory for analysis of:
  - TPH-g/-d/-o
  - BTEX
  - N, 1-mN, 2-mN
- Continue HQ coring to total depth (TD), i.e., below the depth of lost circulation beneath the regional basal piezometric head at ~ 17–20 feet msl.
- Ream open the borehole with 9.5-inch bit to TD for installation of a 2-inch conventional monitoring well.
- Install a 4-inch conventional monitoring well. Install the well screen in the upper part of the basal aquifer below the base of the confining layer, if present. If circulation is lost near or at the basal piezometric head, install the well screen across the basal piezometric surface.

5. 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. The four scenarios include:

- *Scenario 1:* No contamination observed and PID reading < 10 ppmv
- *Scenario 2:* Verified but moderate levels of contamination observed: 10 ppmv < PID reading < 50 ppmv, with evidence of olfactory and/or visual oily staining and/or sheen
- *Scenario 3:* Gross contamination observed: PID reading > 50 ppmv, strong olfactory and visual oily staining, and/or sheen/observation of mobile fuel product
- *Scenario 4:* New Release Not Associated with November 20, 2021 JP-5 Release: DOH Notification and Investigation Requirements (TGM and Hawaii Administrative Rules [HAR])

Details regarding notification requirements and response actions for each scenario are summarized below.

Scenario 1: No contamination observed and PID reading < 10 ppmv.

- Drilling efforts will continue.
- AECOM will provide daily progress and observations to Navy NFH EV1.
- Navy will notify the Regulatory Agencies weekly via email regarding progress and observations.
- Field screening and sampling procedures will continue to the basal aquifer.
- Conductor casing will be used to isolate perched water.

Scenario 2: Verified but moderate levels of contamination observed: 10 ppmv < PID reading < 50 ppmv, with evidence of olfactory and/or visual oily staining and/or sheen.

- Drilling efforts will continue.
- AECOM will provide daily progress and observations to Navy NFH EV1; Navy will notify the Regulatory Agencies via email within 24 hours after contamination is encountered and provide sampling and field observations.
- Soil and/or groundwater sampling will be conducted.
- Isolation casing will be used to isolate perched water and potentially contaminated zones.
- AECOM will provide daily sampling and field observations to Navy NFH EV1.
- If sampling results exceed DOH Environmental Action Levels (EALs), EV will verbally notify Navy Leadership within 24 hours of receiving preliminary results and the Regulatory Agencies within 24 hours of receiving the validated results, followed by written confirmation within 30 days of sample validation; sent with proof of delivery.

Scenario 3: Gross contamination observed: PID reading > 50 ppmv, strong olfactory and visual oily staining, and/or sheen/observation of mobile fuel product.

- Drilling will be discontinued, borehole will be stabilized, and AECOM will immediately contact Navy NFH EV1 for collaboration.

- Upon discovery of oily staining and/or sheen/observation of mobile fuel product, the Navy will verbally notify Navy Leadership and Regulatory Agencies within 24 hours of discovery and before advancing the boring further for collaboration to determine next steps.
- Soil and groundwater sampling will occur.
- Navy will provide Navy Leadership and Regulatory Agencies with written confirmation within 30 days of the discovery of the release; sent with proof of delivery.

Scenario 4: New Release Not Associated with November 20, 2021 JP-5 Release: Implement DOH Notification and Investigation Requirements (TGM and HAR). If a new release is identified, a more extensive list of notification and reporting is required. These notifications and reports are either completed or ongoing for the current November 20 Release and do not need to be addressed in this document. The notification procedures are briefly described below.

- The Navy will follow HAR requirements to immediately investigate and confirm all suspected releases of regulated substances requiring reporting within seven days following the discovery of the suspected release unless a written request for extension of time is granted by the director.
- Notifications required by HAR:
  - Immediately phone the DOH HEER Office, the local Fire Department (i.e., Fed Fire), their County Local Emergency Planning Committee, and the National Response Center to notify them regarding a hazardous substance release that is equal to or exceeds the reportable quantity criteria.[2]
  - Within 30 days, follow up with a written notification to the HEER office.[3]
- Oil is considered a hazardous substance in the HAR with more specific notification criteria:
  - HAR 11-451 State Contingency Plan, Section 11-451-6 addressed Determination of reportable quantities and Section 11-451-7 provides Notification requirements.[4]
  - Any amount of oil causing a sheen to appear on surface water or any navigable water of the State (sheens resulting from discharge of oil from a properly functioning vessel engine are exempt).
  - Any free product that appears on groundwater.
  - Any amount of oil greater than 25 gallons released to the environment.
  - Any amount of oil less than 25 gallons released to the environment and not contained and remediated within 72 hours. Such releases are exempt from immediate notification requirements but must be reported in written form only within 30 days of the discovery of the release.

[2] How To Report A Release/Spill – HEER Office (hawaii.gov)
[3] Microsoft Word – TGM Section 2-Interim Final-12Nov08 wo links.doc (hawaii.gov)
[4] https://health hawaii.gov/opppd/files/2015/06/11-4511.pdf

Appendix C:
Analytical Documentation

Appendix C.1:
Analytical Data Package Requirements for Chemical Analyses

GC-FID Stage 4 Deliverables

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

Note: The data deliverable package must have a table of contents and be paginated.
%D percent difference
%RSD percent relative standard deviation
GC-FID gas chromatography-flame ionization detector
MS matrix spike
MSD matrix spike duplicate
LCS laboratory control sample
LCSD laboratory control sample duplicate
RF response factor

GC-MS Stage 4 Deliverables

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

Note: The data deliverable package must have a table of contents and be paginated.
GC-MS gas chromatography-mass spectrometry
RRF relative response factor

Trace Metals "Full" Deliverables

Item No.	Deliverable
1	Chain of Custody and Laboratory Receipt Checklist
2	Sample results with analysis and extraction/preparation dates
3	Summary of MS/MSD/Duplicate recoveries and control limits (listing or link with associated samples)
4	Summary of LCS/LCSD recoveries and control limits (listing or link with associated samples)
5	Method blanks (listing or link with associated samples)
6	Summary of instrument blanks (listing or link with associated samples)
7	Summary of initial calibration data (% recovery - ICP) or (correlation coefficient, r - GFAA)
8	Summary of continuing cal bration (%D or % recovery)
9	Injection logs
10	Extraction/preparation logs
11	Summary of ICP interference check (listing or link with associated samples)
12	Summary of graphite furnace AA, ICP post digestion spike, and serial dilution results
13	Summary of graphite furnace AA standard addition results (as required)
14	Case narrative to discuss anomalies
15	Raw data associated with the summary forms listed above
16	Raw data for item #2 which includes log books, quantitation reports, and spectra

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

General Chemistry Stage 4 Deliverables

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

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

HARD COPY DATA DELIVERABLES COMPACT DISK REQUIREMENTS

The compact disk (CD) will contain exactly the same information as the hard copy data deliverables (HDD) including amended and additional pages requested during data review and validation. Upon completion of data review and validation by AECOM Technical Services, Inc. or third-party, the laboratory will be required to provide the CD with the following:

- The images will be clear and legible.
- The images will be right side up.
- The images will be straight.
- The images will be in the same order as the HDD.
- Images may be submitted in PDF, TIFF, or other equivalent imaging format. Files will be burned for each page and each CD will be indexed. The laboratory will log in samples based on project number, project name and sample delivery group (also known as batch or work order).
- If the images are not clear, legible, right side up, straight or in order, then the laboratory will resubmit the CD.
- The CD label will contain the following information:
  - Navy contract number
  - Contract task order name and number
  - Sample delivery group number
  - Matrices and methods
  - Date of submittal

Appendix C.2:
Field Sampling, Analytical, and
Quality Management Reference Tables

ACRONYMS AND ABBREVIATIONS

%D	percent difference
BFB	4-bromofluorobenzene
CA	corrective action
CAS	Chemical Abstracts Service
CCB	continuing calibration blank
CCV	continued calibration verification
D	difference
DFTPP	decafluorotriphenylphosphine
DoD	Department of Defense
DQI	data quality indicator
DQO	data quality objective
EICP	extracted ion current profile
EPA	Environmental Protection Agency, United States
g	gram
GC	gas chromatography
GC-FID	gas chromatography-flame ionization detector
GC-MS	gas chromatography-mass spectrometry
H_2SO_4	sulfuric acid
HCl	hydrogen chloride
HNO_3	nitric acid
ICAL	initial calibration
ICP-AES	inductively coupled plasma-atomic emission spectroscopy
ICV	initial calibration verification
IS	internal standard
L	liter
LCS	laboratory control sample
LDC	Laboratory Data Consultants, Inc.
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
mg/kg	milligram per kilogram
mL	milliliter
MPC	measurement performance criteria
MS	matrix spike
MSD	matrix spike duplicate
N/A	not applicable
$NaHSO_4$	sodium bisulfate
NAPL	non-aqueous-phase liquid
NIST	National Institute of Standards and Technology
oz	ounce
PFTBA	perfluorotributylamine
QA	quality assurance
QC	quality control
QSM	*Quality Systems Manual*
RPD	relative percent difference

RRT	relative retention time
RSD	relative standard deviation
RT	retention time
SOP	standard operating procedure
TBD	to be determined

Table C-1: Location-Specific Sampling Methods/SOP Requirements

Sampling Location/ID Number [a]	Matrix	Depth (ft bgs)	Analytical Group	Number of Samples	Sampling SOP Reference
NMW24 (ZZ), NMW22 (MM), NMW25 (TT), RHMW18 (JJ), RHMW20 (BB), RHMW21 (II), NMW23 (XA), KK, PP, and QQ	Unconsolidated Material	Approx. 100–900	Chemical Analyses: VOCs, PAHs, TPH	1 primary per location [b,c] 1 duplicate per location [c] 1 MS/MSD pair per event [c] 1 trip blank per event [d]	Procedure I-B-1 *Soil Sampling*
NMW24 (ZZ), NMW22 (MM), NMW25 (TT), RHMW18 (JJ), RHMW20 (BB), RHMW21 (II), NMW23 (XA), KK, PP, and QQ	Unconsolidated Material, Potable Water	Approx. 100–900	Chemical Analyses: TPH with Silica Gel Cleanup	Contingent on non-Silica Gel Cleaned TPH-d and TPH-o detections [d]	Procedure I-B-1 *Soil Sampling* Procedure I-B-5 *Surface Water Sampling*
NMW24 (ZZ), NMW22 (MM), NMW25 (TT), RHMW18 (JJ), RHMW20 (BB), RHMW21 (II), NMW23 (XA), KK, PP, and QQ	Unconsolidated Material	Approx. 100–900	Geotechnical Analyses: Atterberg Limits, Effective Porosity, Permeability, Moisture Content and Density, Grain Size Distribution, Cation Exchange Capacity, pH, Total Organic Carbon	1 primary per location [b,c]	Procedure I-B-1 *Soil Sampling*
NMW24 (ZZ), NMW22 (MM), NMW25 (TT), RHMW18 (JJ), RHMW20 (BB), RHMW21 (II), NMW23 (XA), KK, PP, and QQ	Potable Water	Not applicable	Chemical Analyses: VOCs, PAHs, TPH	1 primary per event [f] 1 ambient blank per event [g]	Procedure I-B-5 *Surface Water Sampling*

Note: Procedures are from the *Project Procedures Manua*l (DON 2015).
ft ft or ft
[a] Wells are currently being identified with a temporary label (e.g., “XA”) reflected in this document; however, a permanent identifier (e.g., RHMW18) will be assigned when property access is received and permission to drill has been granted.
[b] Actual number of unconsolidated material samples will be dependent on field observations during coring. Unconsolidated material samples will only be collected if present at depths below 100 ft bgs or if contamination in the vadose zone is observed.
[c] Volumes for geotechnical, field duplicate, and MS/MSD samples will only be collected if sufficient unconsolidated material is present at each sampling interval. If limited volume is present, collecting volume for VOCs, PAHs, and TPH will take priority.
[c] One trip blank will be collected during each unconsolidated material sampling event.
[e] TPH with silica gel cleanup will only be analyzed for sample with detections of TPH-d and TPH-o from the non-silica gel cleaned extract.
[f] At minimum one primary potable water sample will be collected from each water pump outflow during drilling activities at each monitoring well location.
[g] At minimum one ambient blank will collected during each potable water sampling event to demonstrate field conditions.

Table C-2: Analyte List and Reference Limits

Matrix **Potable Water**

Analyte	CAS Number	Screening Criterion [a] (µg/L)	Project LOQ Goal (µg/L)	Project LOD Goal (µg/L)	Laboratory-Specific Limits (µg/L)		
					LOQ	LOD	DL
TPH							
TPH-g (C6–C10)	-3547	300	100	30	20	18	8.6
TPH-d (C10–C24)	-3527	400	134	40	40	25	13.07
TPH-o (C24–C40)	-35	500	167	50	40	40	5.54
VOCs							
Benzene	71-43-2	5.0	1.7	0.50	1.0	0.30	0.15
Ethylbenzene	100-41-4	30	10	3.0	1.0	0.50	0.23
Toluene	108-88-3	40	13	4.0	1.0	0.30	0.15
Total Xylenes	1330-20-7	20	6.7	2.0	2.0	0.30	0.15
PAHs							
1-Methylnaphthalene	90-12-0	10	3.3	1.0	0.20	0.10	0.040
2-Methylnaphthalene	91-57-6	10	3.3	1.0	0.20	0.10	0.040
Naphthalene	91-20-3	17	5.7	1.7	0.20	0.10	0.040

µg/L microgram per liter
CAS Chemical Abstracts Service
[a] DOH Tier 1 EALs (DOH 2017), Table D1-b Groundwater Action Levels, for groundwater is a current or potential drinking water resource and surface water body is not located within 150 meters of release site.

Matrix **Unconsolidated Material**

Analyte	CAS Number	Screening Criterion [a] (mg/kg)	Project LOQ Goal (mg/kg)	Project LOD Goal (mg/kg)	Laboratory-Specific Limits (mg/kg)		
					LOQ	LOD	DL
TPH							
TPH-g (C6–C10)	-3547	100	33	10	0.020	0.015	0.0061
TPH-d (C10–C24)	-3527	220	73	22	5.0	1.0	0.50
TPH-o (C24–C40)	-35	500	167	50	50	10	3.5
VOCs							
Benzene	71-43-2	0.30	0.10	0.030	0.005	0.002	0.0006
Ethylbenzene	100-41-4	3.7	1.2	0.37	0.005	0.002	0.001
Toluene	108-88-3	3.2	1.1	0.32	0.005	0.002	0.001
Total Xylenes	1330-20-7	2.1	0.70	0.21	0.01	0.005	0.0024
PAHs							
1-Methylnaphthalene	90-12-0	4.2	1.4	0.42	0.005	0.003	0.001
2-Methylnaphthalene	91-57-6	4.1	1.4	0.41	0.005	0.003	0.0009
Naphthalene	91-20-3	4.4	1.5	0.44	0.005	0.003	0.0009

mg/kg milligrams per kilogram
[a] DOH Tier 1 EALs (Summer 2016, updated January 2017), Table A-1 Groundwater Action Levels, for groundwater is a current or potential drinking water resource and surface water body is not located within 150 meters of release site.

Table C-3: Preparation and Analytical Requirements for Field and QC Samples

Matrix	Analytical Group	Preparation Reference/Method SOP Analytical Reference/Method SOP	Containers	Sample Volume	Preservation Requirement	Maximum Holding Time (preparation/analysis)
Unconsolidated Material	TPH-g, VOCs	Preparation Method: EPA 5035C Preparation SOP: TBD Analysis Method: EPA 8260C Analysis SOP: TBD	2 × 10mL water-preserved; 1 × 5mL methanol-preserved; Teflon-lined septum caps	40 mL	Cool to ≤6°C	7 days (water-preserved); 14 days (methanol-preserved).
	TPH-d, TPH-o	Preparation Method: EPA 3550C Preparation SOP: TBD Analysis Method: EPA 8015C Analysis SOP: TBD	1 × 8-oz glass jar, Teflon-lined lid	30 g	Cool to ≤6°C	Samples extracted within 14 days and analyzed within 40 days following extraction.
	TPH-d, TPH-o with Silica Gel Cleanup	Preparation Method: EPA 3550C/EPA 3630 Preparation SOP: TBD Analysis Method: EPA 8015C Analysis SOP: TBD		30 g	Cool to ≤6°C	Samples extracted within 14 days and analyzed within 40 days following extraction.
	PAHs	Preparation Method: EPA 3550C Preparation SOP: TBD Analysis Method: EPA 8270D SIM Analysis SOP: TBD		30 g	Cool to ≤6°C	Samples extracted within 14 days and analyzed within 40 days following extraction.
	Atterberg Limits	Preparation/Analysis Method: ASTM D4318 Preparation/Analysis SOP: ASTM D4318	1 × core section, or 4 × 8-oz glass jar, Teflon-lined lid	core	None	None.
	Effective Porosity	Preparation/Analysis Method: ASTM D6836M Preparation/Analysis SOP: ASTM D6836M				
	Permeability	Preparation/Analysis Method: ASTM D5084 Preparation/Analysis SOP: ASTM D5084				
	Moisture Content and Density	Preparation/Analysis Method: ASTM D2937 Preparation/Analysis SOP: ASTM D2937				
	Grain Size Distribution	Preparation/Analysis Method: ASTM D422 Preparation/Analysis SOP: ASTM D422				
	Cation Exchange Capacity	Preparation/Analysis Method: EPA 9081 Preparation/Analysis SOP: ANA9081				
	pH	Preparation/Analysis Method: EPA 9045 Preparation/Analysis SOP: ANA9045				
	Total Organic Carbon	Preparation/Analysis Method: Walkley Black Preparation/Analysis SOP: ANAWALKLEY				

Matrix	Analytical Group	Preparation Reference/Method SOP Analytical Reference/Method SOP	Containers	Sample Volume	Preservation Requirement	Maximum Holding Time (preparation/analysis)
Potable Water	TPH-g, VOCs	Preparation Method: EPA 5030B Preparation SOP: TBD Analysis Method: EPA 8260C Analysis SOP: TBD	5 × 40-mL vials, Teflon-lined septum caps	40 mL	No headspace, cool to ≤6°C and adjust to pH <2 with H_2SO_4, HCl, or solid $NaHSO_4$	Maximum holding time is 7 days if pH >2 or 14 days if pH <2.
	TPH-d, TPH-o	Preparation Method: EPA 3510C Preparation SOP: TBD Analysis Method: EPA 8015C Analysis SOP: TBD	2 × 1-L amber glass, Teflon-lined lid	1 L	Cool to ≤6°C	Samples extracted within 7 days and analyzed within 40 days following extraction.
	TPH-d, TPH-o with Silica Gel Cleanup	Preparation Method: EPA 3510C/EPA 3630 Preparation SOP: TBD Analysis Method: EPA 8015C Analysis SOP: TBD				
	PAHs	Preparation Method: EPA 3510C Preparation SOP: TBD Analysis Method: EPA 8270D SIM Analysis SOP: TBD	2 × 1-L amber glass, Teflon-lined lid	1 L	Cool to ≤6°C	Samples extracted within 7 days and analyzed within 40 days following extraction.
Product	Dynamic Viscosity	Preparation/Analysis Method: ASTM D445 Preparation/Analysis SOP: Kinematic Viscosity	4 × 40-mL vial, Teflon-lined lid	40 mL	None	None.
	Density	Preparation/Analysis Method: ASTM D971 Preparation/Analysis SOP: Density of Viscous Materials				
	Interfacial Tension	Preparation/Analysis Method: ASTM D1481 Preparation/Analysis SOP: Interfacial Tension				

g gram
H_2SO_4 sulfuric acid
HCl hydrogen chloride
L liter
mL milliliter
$NaHSO_4$ sodium bisulfate
oz ounce

Table C-4: Analytical Services

Matrix	Analytical Group	Sampling Locations/ ID Numbers	Analytical SOP	Data Package Turnaround Time	Laboratory/Organization (name and address)
Unconsolidated Material	VOCs (BTEX) TPH-g, TPH-d, TPH-o PAHs (1-methylnaphthalene, 2-methylnaphthalene, naphthalene)	NMW24 (ZZ), NMW22 (MM), NMW25 (TT), RHMW18 (JJ), RHMW20 (BB), RHMW21 (II), NMW23 (XA), KK, PP, and QQ	TBD	14 days after samples are received at laboratory	Eurofins TestAmerica Seattle [a] 5755 8th Street East Tacoma, WA 98424-1317
Unconsolidated Material	Atterberg Limits, Effective Porosity, Permeability, Moisture Content and Density, Grain Size Distribution, Cation Exchange Capacity, pH, Total Organic Carbon	NMW24 (ZZ), NMW22 (MM), NMW25 (TT), RHMW18 (JJ), RHMW20 (BB), RHMW21 (II), NMW23 (XA), KK, PP, and QQ	ASTM D4318, ASTM D6836M, ASTM D5084, ASTM D2937, ASTM D422, TBD	30 days after samples are received at laboratory	Eurofins TestAmerica Seattle [a] 5755 8th Street East Tacoma, WA 98424-1317 (subcontracted to TBD)
Potable Water	VOCs (BTEX) TPH-g, TPH-d, TPH-o PAHs (1-methylnaphthalene, 2-methylnaphthalene, naphthalene)	NMW24 (ZZ), NMW22 (MM), NMW25 (TT), RHMW18 (JJ), RHMW20 (BB), RHMW21 (II), NMW23 (XA), KK, PP, and QQ	TBD	14 days after samples are received at laboratory	Eurofins TestAmerica Seattle [a] 5755 8th Street East Tacoma, WA 98424-1317
Product	Dynamic viscosity, density, interfacial tension	JP-5 or similar kerosene-based jet fuel	ASTM D445, ASTM D971, ASTM D1481	30 days after samples are received at laboratory	Core Lab – Petroleum Services Division 3437 Landco Drive Bakersfield, CA 93308

BTEX benzene, toluene, ethylbenzene, and xylenes

[a] Laboratory meets DoD ELAP or American Association of State Highway and Transportation Officials accreditation requirements, as applicable, to support project needs.

Table C-5: Analytical SOP References

Laboratory: Eurofins TestAmerica Seattle
Point of Contact: TBD
Point of Contact Phone Number: TBD

Lab SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Variance to QSM (Yes/No)	Modified for Project Work? (Yes/No)
Preparatory Methods						
ANA8260	Analysis Of Water/Soil/Sludge By EPA Method 8260, Rev 22, 4/4/18	Definitive	VOCs, TPH-g (Unconsolidated Material, Water)	Preparation	No	No
SON001	Sonication Extraction of Soil, Sludge, and Solid (EPA Method 3550C), Rev 5, 0907/18	Definitive	TPH-d, TPH-o, PAHs (Unconsolidated Material)	Preparation	No	No
SEP11	Total Hydrocarbon (THC) Separatory Funnel Extraction of Water, Rev 8, 04/04/18	Definitive	TPH-d, TPH-o (Water)	Preparation	No	No
CLN004	3630C Silica Gel Cleanup, Rev 2, 12/22/16	Definitive	TPH-d, TPH-o Silica Gel Cleanup (Unconsolidated Material, Water)	Preparation	No	No
SEP004	625/8270 Separatory Funnel Extraction of Water (EPA Method 3510C), Rev 3, 01/24/18	Definitive	PAHs (Water)	Preparation	No	No
Analytical Methods						
ANA8260	Analysis Of Water/Soil/Sludge By EPA Method 8260, Rev 22, 4/4/18	Definitive	VOCs, TPH-g (Unconsolidated Material, Water)	GC-MS	No	No
ANA8015	Determination Of Total Extractable Petroleum Hydrocarbons (TPH) In Water, Sludges And Soils By GC-FID, Rev 11, 4/4/18	Definitive	TPH-d, TPH-o (Unconsolidated Material, Water)	GC-FID	No	No
ANA8270SIM	PAH By SIM By EPA Method 8270, Rev 8, 12/26/17	Definitive	PAHs (Unconsolidated Material, Water)	GC-MS	No	No
ANA9081	Cation-Exchange Capacity of Soils (Sodium Acetate), Rev 1, 10/15/18	Definitive	Cation Exchange Capacity (Unconsolidated Material)	ICP-AES	No	No
ANA9045	pH in Soil and Waste (EPA SW846 Method 9045D), Rev 5, 09/11/18	Definitive	pH (Unconsolidated Material)	pH Probe	No	No
ANAWALKLEY	Total Organic Carbon in Soil (Walkley-Black, modified), Rev 3, 10/15/18	Definitive	Total Organic Carbon (Unconsolidated Material)	Titration	No	No

Note: The laboratory SOPs listed in the table are the most current revisions at the time of publication of this MWIWP. The Navy consultant will review the laboratory SOPs immediately prior to sample submittal to ensure that the laboratory uses SOPs that are in compliance with the DoD QSM annual review requirement.
GC-FID gas chromatography-flame ionization detector
GC-MS gas chromatography-mass spectrometry
ICP-AES inductively coupled plasma-atomic emission spectroscopy

Laboratory: Eurofins TestAmerica Seattle (subcontracted to TBD)
Point of Contact: TBD
Point of Contact Phone Number: TBD

Lab SOP Number	Title	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Modified for Project Work? (Yes/No)
Preparatory/Analytical Methods					
ASTM D4318	Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils, ASTM D4318	Definitive	Atterberg Limits (Unconsolidated Material)	Liquid limit device	No
ASTM D5084	Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter, ASTM D5084	Definitive	Permeability (Unconsolidated Material)	Hydraulic system	No
API RP40	Recommended Practices for Core Analysis, Recommended Practice 40, API RP40	Definitive	Total Porosity (Unconsolidated Material)	Porosimeter	No
ASTM D2937	Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method, ASTM D2937	Definitive	Moisture Content and Density (Unconsolidated Material)	Drive cylinder	No
ASTM D422	Standard Test Method for Particle-Size Analysis of Soils, ASTM D422	Definitive	Particle Size Distribution (Unconsolidated Material)	Hydrometer and sieve	No

Note: The laboratory SOPs listed in the table are the most current revisions at the time of publication of this MWIWP. The Navy consultant will review the laboratory SOPs immediately prior to sample submittal to ensure that the laboratory uses SOPs that are in compliance with the American Association of State Highway and Transportation Officials review requirement.

Table C-6: Laboratory QC Samples for Chemistry Analyses

Matrix	**Unconsolidated Material, Potable Water**
Analytical Group	**VOCs, TPH-g**
Analytical Method/SOP Reference	Analytical Method: SW-846 8260C Preparation Method: EPA 5035A, EPA 5030B Laboratory SOPs: TBD
Analytical Organization	Eurofins TestAmerica Seattle

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
LOD determination and verification	At initial set-up and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each.	The apparent signal to noise ratio must be at least 3 and the results must meet all method requirements for analyte identification.	If the LOD verification fails, the laboratory must: 1) Repeat the detection limit determination and LOD verification at a higher concentration; or 2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration.	Analyst Lab QA Officer Project Chemist	Bias/ Representativeness	QC acceptance criteria as specified by Lab SOP TBD.
LOQ establishment and verification	At initial setup: 1) Verify LOQ; and 2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each.	1) The LOQ and associated precision and bias must meet client requirements and must be reported; or 2) In the absence of client requirements, must meet control limits of the LCS. 3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Volume 1, Module 4, Section 1.5.2 of the DoD (DoD and DOE 2021).	If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	QC acceptance criteria as specified by Lab SOP TBD and at least as stringent as specified by DoD QSM 5.4 (DoD and DOE 2021).
Tune check	Prior to the ICAL and prior to each 12-hour period of sample analysis.	Specific ion abundance criteria of BFB or DFTPP from method.	Retune instrument and verify.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	No samples may be analyzed without a passing tune.
CCV	Before sample analysis, after every 10 field samples, after every 12 hours of analysis time, and at the end of the analysis sequence.	All reported analytes and surrogates within established RT windows. All reported analytes and surrogates within ±20% of true value. All reported analytes and surrogates within ±50% for the end of the analytical batch CCV.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision	Results may not be reported without a valid CCV. If reanalysis cannot be performed, data must be qualified and explained in the case narrative. If the specific version of a method requires additional evaluation (e.g., average response factors) these additional requirements must also be met.

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
MB	Each time analytical batch.	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common lab contaminants, no analytes detected >LOQ.	Correct problem. If required, re-prep and reanalyze MB and all samples processed with the contaminated blank.	Analyst Lab QA Officer Project Chemist	Bias	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ.
LCS	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	Per DoD QSM Appendix C Limits, Method SW-846 8260C and Lab SOP TBD.	Correct problem. If required, re-prep and reanalyze the LCS and all samples processed in the associated preparatory batch for the failed analytes. Results may not be reported without a valid LCS.	Analyst Lab QA Officer Project Chemist	Accuracy	QC acceptance criteria at least as stringent as specified by DoD QSM 5.4 (DoD and DOE 2021).
MS/MSD pair	One per analytical method for each batch of at most 20 samples.	Per DoD QSM Appendix C Limits, Method SW-846 8260C and Lab SOP TBD. MSD or Matrix Duplicate: RPD of all analytes ≤20%.	Examine the PQOs. Notify Lab QA officer and project chemist about additional measures to be taken.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision	For matrix evaluation, use QC acceptance criteria at least as stringent as specified by DoD QSM 5.4 (DoD and DOE 2021).
Internal standards verification	Every field sample, standard, and QC sample.	Retention time ±10 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard.	Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision/ Representativeness	Laboratory in-house method manual to be followed for acceptance criteria.
Surrogate spike	All field and QC samples.	Per DoD QSM Appendix C Limits, Method SW-846 8260C and Lab SOP TBD.	For QC and field samples, correct problem then re-prep and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision/ Representativeness	QC acceptance criteria at least as stringent as specified by DoD QSM 5.4 (DoD and DOE 2021).
Trip blank	1 per cooler.	Target analytes ≤1/2 LOQ.	Reanalyze for confirmation through a second analysis of the trip blank. Examine the PQOs.	Analyst Lab QA Officer Project Chemist	Accuracy/Bias, Representativeness/ Contamination	Target analytes ≤1/2 LOQ.

Matrix	**Unconsolidated Material, Potable Water**
Analytical Group	**TPH-d, TPH-o with and without Silica Gel Cleanup**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8015C Preparation Method: EPA 3550C/3630C, EPA 3510C/3630C Laboratory SOPs: TBD
Analytical Organization	Eurofins TestAmerica Seattle

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
LOD determination and verification	At initial set-up and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each.	The apparent signal to noise ratio must be at least 3 and the results must meet all method requirements for analyte identification.	If the LOD verification fails, the laboratory must: 1) Repeat the detection limit determination and LOD verification at a higher concentration; or 2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration.	Analyst Lab QA Officer Project Chemist	Bias/ Representativeness	QC acceptance criteria as specified by Lab SOP TBD.
LOQ establishment and verification	At initial setup: 1) Verify LOQ; and 2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each.	1) The LOQ and associated precision and bias must meet client requirements and must be reported; or 2) In the absence of client requirements, must meet control limits of the LCS. 3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Volume 1, Module 4, Section 1.5.2 of the DoD QSM 5.4 (DoD and DOE 2021).	If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	QC acceptance criteria as specified by Lab SOP TBD, and at least as stringent as specified by DoD QSM 5.4 (DoD and DOE 2021).
CCV	Before sample analysis, after every 10 field samples, and at the end of the analysis sequence.	All reported analytes and surrogates within established RT windows. All reported analytes and surrogates within ±20% of true value.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision	Results may not be reported without a valid CCV. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.
MB	Each time samples are extracted and one per matrix per analytical method for each batch of at most 20 samples.	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common lab contaminants, no analytes detected >LOQ.	Correct problem. If required, re-prep and reanalyze MB and all samples processed with the contaminated blank.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ.

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
LCS	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	Per DoD QSM Appendix C Limits, Method 8015C and Lab SOP TBD.	Correct problem. If required, re-prep and reanalyze the LCS and all samples processed in the associated preparatory batch for the failed analytes.	Analyst Lab QA Officer Project Chemist	Accuracy	QC acceptance criteria at least as stringent as specified by DoD QSM 5.4 (DoD and DOE 2021).
Internal standards verification	Every field sample, standard, and QC sample.	Retention time ±30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard.	Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision/ Representativeness	Laboratory in-house method manual to be followed for acceptance criteria.
Surrogate spike	All field and QC samples.	Per DoD QSM Appendix C Limits, Method 8015C and Lab TBD.	For QC and field samples, correct problem then re-prep and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision/ Representativeness	QC acceptance criteria at least as stringent as specified by DoD QSM 5.4 (DoD and DOE 2021).
Surrogate spike for silica gel cleanup procedure	All field and QC samples.	Acceptable recovery range of 0 to 1% of spiked amount of polar hydrocarbon surrogate.	For QC and field samples, if sufficient sample extract is available, re-run extracts through silica gel cleanup procedure and reanalyze all failed samples for failed surrogates in the associated preparatory batch. Otherwise, re-extract samples and re-run silica gel cleanup on re-extract prior to re-analysis, if sufficient sample material is available.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision/ Representativeness	Polar hydrocarbon surrogate recovered at ≤1% of sp ked amount.
MS/MSD pair	One per analytical method for each batch of at most 20 samples.	Per DoD QSM Appendix C Limits, Method 8015C and Lab SOP TBD. MSD or Matrix Duplicate: RPD of all analytes ≤30%.	Examine the PQOs. Notify Lab QA officer and project chemist about additional measures to be taken.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision	For matrix evaluation, use QC acceptance criteria at least as stringent as specified by DoD QSM 5.4 (DoD and DOE 2021).

Matrix	**Unconsolidated Material, Potable Water**
Analytical Group	**PAHs**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8270D SIM Preparation Method: EPA 3550C, EPA 3510C Laboratory SOPs: TBD
Analytical Organization	Eurofins TestAmerica Seattle

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
LOD determination and verification	At initial set-up and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each.	The apparent signal to noise ratio must be at least 3 and the results must meet all method requirements for analyte identification.	If the LOD verification fails, the laboratory must: 1) Repeat the detection limit determination and LOD verification at a higher concentration; or 2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration.	Analyst Lab QA Officer Project Chemist	Bias/ Representativeness	QC acceptance criteria as specified by Lab SOP TBD.
LOQ establishment and verification	At initial setup: 1) Verify LOQ; and 2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each.	1) The LOQ and associated precision and bias must meet client requirements and must be reported; or 2) In the absence of client requirements, must meet control limits of the LCS. 3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Volume 1, Module 4, Section 1.5.2 of the DoD QSM 5.4 (DoD and DOE 2021).	If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	QC acceptance criteria as specified by Lab SOP TBD, and at least as stringent as specified by DoD QSM 5.4 (DoD and DOE 2021).
Performance check	Before ICAL and sample analysis, and at the beginning of each 12-hour shift.	Degradation of DDT must be ≤20%. Benzidine and pentachlorophenol will be present at their normal responses, and will not exceed a tailing factor of 2.	Correct problem, then repeat performance checks.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	Degradation of DDT must be ≤20%; and benzidine and pentachlorophenol must be present at normal responses and tailing factor is ≤2. No samples must be analyzed until performance check is within criteria.
Tune Check	Prior to the ICAL and prior to each 12-hour period of sample analysis.	Specific ion abundance criteria of BFB or DFTPP from method.	Retune instrument and verify.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	No samples may be analyzed without a passing tune.

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
CCV	Before sample analysis, after every 10 field samples, after every 12 hours of analysis time, and at the end of the analysis sequence.	All reported analytes and surrogates within established RT windows. All reported analytes and surrogates within ±20% of true value.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision	Results may not be reported without a valid CCV. If reanalysis cannot be performed, data must be qualified and explained in the case narrative.
MB	Each time samples are extracted and one per matrix per analytical method for each batch of at most 20 samples.	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common lab contaminants, no analytes detected >LOQ.	Correct problem. If required, re-prep and reanalyze MB and all samples processed with the contaminated blank.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ.
LCS	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	Per DoD QSM Appendix C Limits, Method 8270D SIM and Lab SOP TBD.	Correct problem. If required, re-prep and reanalyze the LCS and all samples processed in the associated preparatory batch for the failed analytes.	Analyst Lab QA Officer Project Chemist	Accuracy	QC acceptance criteria at least as stringent as specified by DoD QSM 5.4 (DoD and DOE 2021).
Internal standards verification	Every field sample, standard, and QC sample.	Retention time ±10 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard.	Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision/ Representativeness	Laboratory in-house method manual to be followed for acceptance criteria.
Surrogate spike	All field and QC samples.	Per DoD QSM Appendix C Limits, Method 8270D SIM and Lab SOP TBD.	For QC and field samples, correct problem then re-prep and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision/ Representativeness	QC acceptance criteria at least as stringent as specified by DoD QSM 5.4 (DoD and DOE 2021).
MS/MSD pair	One per analytical method for each batch of at most 20 samples.	Per DoD QSM Appendix C Limits, Method 8270D SIM and Lab SOP TBD. MSD or Matrix Duplicate: RPD of all analytes ≤20%.	Examine the PQOs. Notify Lab QA Officer and project chemist about additional measures to be taken.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision	For matrix evaluation, use QC acceptance criteria at least as stringent as specified by DoD QSM 5.4 (DoD and DOE 2021).

Matrix	**Unconsolidated Material, Potable Water**
Analytical Group	**pH, TOC, CEC**
Analytical Method/SOP Reference	Analytical Method: EPA 9045, Walkley Black, EPA 9081 Preparation Method: EPA 9045, Wa kley Black, EPA 9081 Laboratory SOPs: TBD
Analytical Organization	Eurofins TestAmerica Seattle

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
LOD determination and verification	At initial set-up and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each.	The apparent signal to noise ratio must be at least 3 and the results must meet all method requirements for analyte identification.	If the LOD verification fails, the laboratory must: 1) Repeat the detection limit determination and LOD verification at a higher concentration; or 2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration.	Analyst Lab QA Officer Project Chemist	Bias/ Representativeness	QC acceptance criteria as specified by Lab SOP TBD.
LOQ establishment and verification	At initial setup: 1) Verify LOQ; and 2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each.	1) The LOQ and associated precision and bias must meet client requirements and must be reported; or 2) In the absence of client requirements, must meet control limits of the LCS. 3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Volume 1, Module 4, Section 1.5.2 of the DoD QSM 5.4 (DoD and DOE 2021).	If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	QC acceptance criteria as specified by Lab SOP TBD, and at least as stringent as specified by DoD QSM 5.4 (DoD and DOE 2021).
MB	Each time samples are extracted and one per matrix per analytical method for each batch of at most 20 samples.	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common lab contaminants, no analytes detected >LOQ.	Correct problem. If required, re-prep and reanalyze MB and all samples processed with the contaminated blank.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ.
LCS	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	Per DoD QSM Appendix C Limits, Method TBD and Lab SOP TBD.	Correct problem. If required, re-prep and reanalyze the LCS and all samples processed in the associated preparatory batch for the failed analytes.	Analyst Lab QA Officer Project Chemist	Accuracy	QC acceptance criteria at least as stringent as specified by DoD QSM 5.4 (DoD and DOE 2021).

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

Table C-7: Analytical Instrument and Equipment Maintenance, Testing, and Inspection

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference [a]
GC-FID and GC-MS	Change gas purifier.	N/A.	Visually inspect if traps are changing color.	Every 6–12 months	No moisture	Replace indicating traps.	Analyst or certified instrument technician	TBD
	Change syringes/syringe needles.	N/A.	Visually inspect for wear or damage.	Every 3 months	N/A	Replace syringe if dirt is noticeable in the syringe.	Analyst or certified instrument technician	
	Change inlet liner, liner O-rings, and inlet septum.	N/A.	Visually inspect for dirt or deterioration.	Weekly for liner Monthly for O-rings Daily for septum	N/A	Replace and check often.	Analyst or certified instrument technician	
	Change front-end column.	N/A.	Check peak tailing, decreased sensitivity, retention time changes, etc.	Weekly, monthly, or when needed	N/A	Remove 1/2 to 1 meter from the front of the column when experiencing problems.	Analyst or certified instrument technician	
	Clean injector ports.	N/A.	N/A.	As needed	N/A	N/A.	Analyst	
	Replace trap on purge-and-trap systems.	N/A.	N/A.	Bi-monthly or as needed	N/A	N/A.	Analyst	
	Replace columns.	N/A.	N/A.	If chromatograms indicate poss ble contamination	N/A	N/A.	Analyst	
GC-FID	Replace detector jets.	N/A.	N/A.	As needed	N/A	N/A.	Analyst	TBD
	Replace hydrocarbon traps and oxygen traps on helium and hydrogen gas lines.	N/A.	N/A.	Every 4–6 months	N/A	N/A.	Analyst	
	Replace chemical trap.	N/A.	N/A.	Yearly or as needed	N/A	N/A.	Analyst	
	Replace converter tube in gas purifier system.	N/A.	N/A.	Yearly or as needed	N/A	N/A.	Analyst	

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference [a]
GC-MS	Change tune MSD, check the calibration vial, and replace the foreline pump oil.	N/A.	Visually inspect and monitor the fluid becoming discolored.	As needed or every 6 months	In accordance with manufacturer’s recommendation or lab SOP	Keep plenty of PFTBA; refill the vial and check the fluid; change when the fluid becomes discolored.	Analyst or certified instrument technician	TBD
	Run tuning program to determine if source is functioning properly.	N/A.	N/A.	Daily	N/A	Cool system, vent, disassemble, and clean.	Analyst	TBD
	N/A	Tune instrument.	N/A.	Daily or every 12 hours	Per method	Liner and septa are replaced; tune file used is manually adjusted.	Analyst	
	Vacuum rough pump oil level is checked.	N/A.	N/A.	Every 4–6 weeks	N/A	Add oil if needed.	Analyst	
	Replace/refill carrier gas line oxygen and moisture traps.	N/A.	N/A.	Yearly or as needed	N/A	N/A.	Analyst	
Water Bath (Precision Microprocessor controlled)	Check instrument connections, water level, and thermometer.	Measure water temperature against a calibrated thermometer.	Visually inspect for wear or damage and indicator from computer controls.	Daily and annual maintenance from manufacturer	Refer to manufacturer’s recommendation	Return to manufacturer for recalibration or call for maintenance service.	Analyst or certified instrument technician	INS001
Drying Oven	Thermometer indicator.	Measure oven temperature against a calibrated thermometer.	Visually inspect for wear or damage and indicator from computer controls.	Daily and annual maintenance from manufacturer	Refer to manufacturer’s recommendation	Return to manufacturer for recalibration or call for maintenance service.	Analyst or certified instrument technician	INO003
Analytical Balance	Check digital LCD display and ensure a flat base for the Instrument.	Calibrate against verified (NIST) mass.	Visually inspect for wear or damage and indicator from computer controls.	Daily and annual maintenance from manufacturer	Refer to manufacturer’s recommendation	Return to manufacturer for recalibration or call for maintenance service.	Analyst or certified instrument technician	INO011
pH Meter	Check LCD display and pH probe.	3 point calibration using known standards.	Visually inspect for wear or damage and indicator from computer controls.	Daily and annual maintenance from manufacturer	±0.05 units	Return to manufacturer for recalibration or call for maintenance service.	Analyst or certified manufacture instrument technician	INO038

Note: No instrument and equipment maintenance, testing, and inspection criteria for geotechnical analyses.
N/A not applicable
NIST National Institute of Standards and Technology
PFTBA perfluorotributylamine
[a] See Analytical SOP References table (Table C-5).

Table C-8: Analytical Instrument Calibration

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

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference [a]
GC-FID EPA Method 8015C	Minimum 5-point ICAL for linear calibration Minimum 6-point ICAL for quadratic calibration	Prior to sample analysis	RSD for each analyte ≤20% or least square regression ≥0.995. Non-linear least squares regression (quadratic) for each analyte ≤0.995.	Correct problem then repeat ICAL.	Lab Manager/Analyst or certified instrument technician	ANA8015
	Second source calibration verification	Once after each ICAL	Analytes within ±20% of expected value (initial source), and within established RT windows.	Correct problem and verify second source standard. Rerun second source verification. If fails, correct problem and repeat ICAL.	Lab Manager/Analyst or certified instrument technician	
	RT window width	At method set-up and after major maintenance	RT width is ±3 times standard deviation for each analyte RT from 72-hour study. For TPH-d: calculate RT based on C12 and C25 alkanes.	N/A.	Lab Manager/Analyst or certified instrument technician	
	Establishment and verification of the RT window for each analyte and surrogate	Once per ICAL and at the beginning of the analytical shift for establishment of RT; and with each CCV for verification of RT	Using the midpoint standard or the CCV at the beginning of the analytical shift for RT establishment; and analyte must fall within established window during RT verification.	N/A.	Lab Manager/Analyst or certified instrument technician	
	Run second source cal bration verification (ICV)	ICV: Daily, before sample analysis, unless ICAL performed same day	All analytes within ±20% of expected value (%D).	Correct problem and rerun ICV. If fails, repeat ICAL.	Lab Manager/Analyst or certified instrument technician	
	CCV	Daily, before sample analysis, unless ICAL performed same day and after every 10 samples and at the end of the analysis sequence	All analytes within ±20% of expected value (%D).	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-cal brate; then reanalyze all affected samples since the last acceptable CCV.	Lab Manager/Analyst or certified instrument technician	
Water Bath	Measure water temperature against a calibrated thermometer	Annually	In accordance with unit model and manufacturer’s recommendation or laboratory SOP.	Terminate analysis, recalibrate, and verify before sample analysis.	Lab Manager/Analyst or certified instrument technician	INS001
Drying Oven	Measure oven temperature against a calibrated thermometer	Annually	In accordance with unit model and manufacturer’s recommendation or laboratory SOP.	Terminate analysis, recalibrate, and verify before sample analysis.	Lab Manager/Analyst or certified instrument technician	INO003

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference [a]
Analytical Balance	Calibrate against verified (NIST) mass	Daily or prior to analyzing samples	In accordance with unit model and manufacturer's recommendation or laboratory SOP.	Terminate analysis, recalibrate, and verify before sample analysis.	Lab Manager/Analyst or certified instrument technician	INO011
pH Meter	Run a minimum 3-point calibration; run CCV	Daily or prior to analyzing samples; one CCV for every 10 samples	±0.05 unit.	Terminate analysis, recalibrate, and verify before sample analysis.	Lab Manager/Analyst or certified instrument technician	INO038

Note: No instrument cal bration procedures for geotechnical analyses.

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

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

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

Data Review Input	Description	Responsible for Verification (name, organization)	Step I/IIa/IIb [a]	Internal/External
Laboratory system audits	Determine whether the laboratory holds a current DoD ELAP certification for all analyses to be performed for the project.	Project Chemist (Navy consultant)	Step I	Internal
Field procedures	Determine whether field procedures are performed in accordance with this SAP and prescr bed procedures.	QA Program Manager (Navy consultant)	Step I	Internal
Field logbook and notes	Review the field logbook and any field notes on a weekly basis and place them in the project file. Copies of the field logbook and field notes will be provided to the Navy consultant CTO manager and included in the Field Audit Report.	Field Manager (Navy consultant)	Step I	Internal
Instrument calibration sheets	Determine whether instruments are calibrated and used in accordance with manufacturer's' requirements.	Project Chemist (Navy consultant) & Data Validator (LDC)	Step I	Internal & External
CoC forms	Review CoC completed forms and verify them against the corresponding packed sample coolers. A copy of each CoC will be placed in the project file. The original CoC will be taped inside the cooler for shipment to the analytical laboratory.	Project Chemist (Navy consultant)	Step I	Internal
Sampling analytical data package	Verify all analytical data packages for completeness prior to submittal of the data to the data validator.	Laboratory Project Manager (Eurofins TestAmerica Seattle)	Step I	External
Analytes	Determine whether all analytes specified in Table C-2 were analyzed and reported on by the laboratory.	Project Chemist (Navy consultant)	Step IIa	Internal
CoC and field QC logbook	Examine data traceability from sample collection to project data generation.	Project Chemist (Navy consultant)	Step IIa	Internal
Laboratory data and SAP requirements	Assess and document the performance of the analytical process. A summary of all QC samples and results will be verified for measurement performance criteria and completeness. Full Validation will be performed on 10% of the data and Standard Validation will be performed on 90% of the data. A report will be prepared within 21 days of receipt.	Data Validator (LDC) & Project Chemist (Navy consultant)	Steps IIa & IIb	Internal & External
VOCs	Complete Procedure II-B, *Level C and Level D Data Validation Procedure for GC/MS Volatile Organics by SW-846 8260B* (DON 2015).	Data Validator (LDC)	Step IIa	External
PAHs and SVOCs	Complete Procedure II-C, *Level C and Level D data Validation Procedure for GC/MS Semivolatile Organics by SW-846 8270C* (Full Scan and SIM) (DON 2015).	Data Validator (LDC)	Step IIa	External

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

MPC measurement performance criteria
[a] IIa Compliance with methods, procedures, and contracts. See Table 10, page 117, UFP-QAPP manual, V.1 (DoD 2005).
IIb Comparison with measurement performance criteria in the SAP. See Table 11, page 118, UFP-QAPP manual, V.1 (DoD 2005).