Navy Closure Task Force

Draft

Tank Closure Plan, Supplement 3: Phase 1 Site Assessment Red Hill Bulk Fuel Storage Facility

JOINT BASE PEARL HARBOR HICKAM OAHU HI

June 2024

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June 2024

Prepared for Navy Closure Task Force by
AECOM Technical Services Inc
1001 Bishop Street Suite 1600
Honolulu HI 96813-3698

N62742-23-D-1802
CTO N6274223F0149

Worksheet #1: Title and Approval Page

Draft
Work Plan/Sampling and Analysis Plan
June 2024

Tank Closure Plan, Supplement 3: Phase 1 Site Assessment
Red Hill Bulk Fuel Storage Facility

Joint Base Pearl Harbor Hickam

Prepared for:

Department of the Navy
Navy Closure Task Force

Prepared for Navy Closure Task Force by
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Prepared under:
Comprehensive Long-Term Environmental Action Navy
Contract Number N62742-23-D-1802, CTO N6274223F0149

NOTE – Will be signed upon final submission

AECOM CTO Manager: ______________________________

(b) (6) Date

NOTE – Will be signed upon final submission

AECOM QA Program Manager: ______________________________

(b) (6) Date

NOTE – Will be signed upon final submission

Navy RPM: ______________________________

(b) (6) Date

EXECUTIVE SUMMARY

This Phase 1 Closure Site Assessment Work Plan (SAWP) presents the proposed sampling and analysis program for Phase 1 of a two-phase Site Assessment that will be conducted in connection with the permanent closure of the Red Hill Bulk Fuel Storage Facility ("Facility" or "Site") and associated infrastructure. (b) (3) [redacted] The objective of the two-phase Site Assessment is to satisfy the requirement in Hawaii Administrative Rules (HAR) Chapter 11-280.1, Subchapter 7 (specifically HAR §11-280.1-72 and HAR §11-280.1-73) to assess an underground storage tank (UST) system at closure.

In accordance with HAR §11- 280.1-72(a), the objective of the Closure Site Assessment is to "measure for the presence of a release where contamination is most likely to be present" at the UST site. The Closure Site Assessment contaminants of concern are petroleum hydrocarbons and additives that are part of the Comprehensive Environmental, Response, Compensation, and Liability Act (CERCLA) petroleum exemption. Non-petroleum contaminants will be addressed in a separate regulatory program under the applicable regulations.

Consistent with HAR §11-280.1-72(d), if the results of the Closure Site Assessment indicate that release response actions (site characterization and/or remediation) are required, such work will be performed in accordance with the HAR regulations for release response actions (HAR §11-280.1-60 through 11-280.1-67) under a separate work plan.

The Phase 1 Closure Site Assessment will address the "onsite" components of the Red Hill UST system, including components that were previously closed or abandoned. For the purposes of this SAWP, "onsite" includes the area within the Facility property boundaries, the Red Hill tunnel system, and the four Surge Tanks (b) (3) [redacted]

The Phase 2 Site Assessment will address the offsite portions of the JBPHH fuel system that are determined to be part of the Red Hill UST system. Prior to commencement of the Phase 2 Site Assessment, the Navy will evaluate the offsite components of the JBPHH fuel system (Figure 1), including components that were previously closed or abandoned or will be closed as part of Facility closure, to determine whether these components should be included in the Phase 2 investigation. The Navy will submit a separate Phase 2 SAWP to the Hawaii Department of Health (DOH) and the United States Environmental Protection Agency (EPA).

The Facility is a former military fuel storage facility (b) (3) [redacted] The Facility was used to store fuel for military purposes from the 1940s until defueling began in October 2023. Between October 2023 and March 29, 2024, the Navy removed over 104 million gallons of Jet Fuel Propellant (JP)-5, F-76 Marine Diesel, and F-24 Jet Fuel from the Facility. The remaining approximately 61,414 gallons of residual fuel and sludge will be removed during the cleaning of the USTs and the removal of the associated fuel transmission lines (USINDOPACOM 2024 [accessed on 21 May 2024]).

The portion of the Red Hill UST system that is situated within the Phase 1 Closure Site Assessment boundaries has been defueled and includes the following major components (Figure 2):

- The 20 field-constructed USTs located at the east end of the Red Hill tunnel system. Each tank is approximately 250 feet (ft) in height and 100 ft in diameter, with a capacity of approximately

12.5 million gallons. The 20 USTs are aligned in two parallel rows of ten tanks and are spaced approximately 200 ft on center.

- A [redacted]-inch steel pipeline (the F-76 line), an [redacted]-inch steel pipeline (the JP-5 line), and a [redacted]-inch pipeline (the F-24 line) that conveyed fuel from (b) (3)
- The Fuel Oil Reclaim (FOR) Pipeline, which ranges between [redacted] inches in diameter. The FOR Pipeline is connected to the 20 USTs and various tunnel sumps to collect condensate and oily wastewater and conveys those liquids to Tank 311, a 42,000-gallon aboveground storage tank (AST) located outside the entrance to Adit 3.
- The four underground Surge Tanks, which were built adjacent to the UGPH at JBPHH in the early 1940s as part of the original Facility construction. Surge Tanks ST1 through ST4 have respective capacities of 421,722; 422,100; 422,688; and 422,184 gallons.
- The section of the [redacted]-inch underground steel Abandoned Aviation Gasoline (AVGAS) Line (b) (3) will be assessed during the Phase 1 Closure Site Assessment. The Navy will evaluate the offsite section of the Abandoned AVGAS Line to determine whether it should be included in the Phase 2 investigation of the Site Assessment. The offsite section of the Abandoned AVGAS Line consists of a continuation of the [redacted]-inch underground steel, (b) (3) The Abandoned AVGAS Line carried AVGAS for several years during the 1960s and then was converted to JP-5 use until it was cleaned and abandoned in place in 2004.
- The Former Slop Tank, which was a steel 5,000-barrel AST that was constructed at the same time as the Former AVGAS Line to receive oily wastewater from USTs 17 through 20. The Former Slop Tank was demolished and removed from the Site in 2009.
- The Former Standby Power Plant, which is an underground spur of the Red Hill tunnel system (b) (3) During operation, the Standby Power Plant included five diesel-driven generators, their exhaust mufflers, fan equipment, and an overhead crane on rails. All equipment was removed at an unknown date prior to 2015.
- The Collection, Holding, and Transfer (CHT) Tank, which is an approximately 15 ft × 8 ft × 7 ft cement AST that sits (b) (3)
- The Former Holding Tank and connected Leach Tank, which were a pair of underground cylindrical cement tanks located outside Adit 3. The tanks were 8 ft in height and 7 ft in diameter and were located (b) (3). The two tanks were removed in 2022.

The Navy is currently responding to subsurface petroleum impacts associated with known and/or suspected fuel releases from the Red Hill UST system beneath the 20 USTs, the Former Oily Waste Disposal Facility, the Adit 3 tunnel area, the Former Holding Tank/Leach Tank area, and the CHT Tank under separate regulatory programs. The Navy will continue the response actions at these areas under their existing regulatory programs while the Phase 1 Site Assessment progresses.

The sampling and analysis program described in this Phase 1 Closure Site Assessment Work Plan is to assess other areas within the Phase 1 Site Assessment boundaries where there are no known impacts.

The scope of work proposed in this SAWP will verify the presence or absence of petroleum releases from the Red Hill UST system, as summarized below:

- In the Red Hill tunnels, the Navy will collect approximately 683 co-located soil vapor and soil samples from approximately 2 ft below the tunnel floor. The sample locations will be spaced at approximately 25-ft intervals, extending from Tank Farm USTs 19 and 20 to the UGPH at Adit 1 at JBPHH. The soil vapor samples will be analyzed for total petroleum hydrocarbons (TPH), volatile organic compounds (VOCs), and polynuclear aromatic hydrocarbons (PAHs) by EPA Method TO-17 and for methane, carbon dioxide, carbon monoxide, and oxygen by American Society of Testing Materials (ASTM) Method 1946D. The soil samples will be analyzed for TPH-diesel range organics (TPH-DRO) and TPH-lubricant range organics (TPH-LRO) by EPA Method 8015 (Figure 14, Figure 15, and Figure 17).
- Along the Abandoned AVGAS Line, the Navy will collect approximately 243 co-located soil vapor and soil samples at a depth that corresponds to the bottom of pipeline. Pending field verification, the bottom of the AVGAS Line is assumed to be approximately 4 ft below ground surface (bgs). The sampling locations will be spaced at approximately 25-ft intervals. The soil vapor samples will be analyzed for TPH, VOCs, and PAHs; and methane, carbon dioxide, and oxygen. The soil samples will be analyzed for tetraethyl lead by EPA Method 8270, and TPH-DRO and TPH-LRO (Figure 20).
- At the Former Slop Tank, the Navy will collect approximately 16 co-located soil vapor and soil samples spaced on a 25-ft grid around the footprint at approximately 5 ft bgs. The soil vapor and soil samples will be co-located. The soil vapor samples will be analyzed for TPH, VOCs, and PAHs; and methane, carbon dioxide, and oxygen. The soil samples will be analyzed for TPH-DRO and TPH-LRO (Figure 20).
- At Tank 311, the Navy will collect four co-located soil vapor and soil samples from around the perimeter and one soil vapor and soil sample from the outdoor section of the FOR line outside Adit 3 at approximately 2 ft bgs. The soil vapor samples will be analyzed for TPH, VOCs, and PAHs; and methane, carbon dioxide, and oxygen. The soil samples will be analyzed for TPH-DRO and TPH-LRO (Figure 16).
- At the Former Standby Power Plant, the Navy will collect approximately 11 co-located soil vapor and soil samples from approximately 2 ft below the tunnel floor. The soil vapor samples will be analyzed for TPH, VOCs, and PAHs; and methane, carbon dioxide, and oxygen. The soil samples will be analyzed for TPH-DRO and TPH-LRO (Figure 19).

  At the four Surge Tanks, the Navy will collect six soil vapor and twelve soil samples from borehole locations adjacent to the Surge Tanks. Six boreholes will be advanced to the depth that corresponds to the bottom of the Surge Tanks (pending field verification, the bottom of the Surge Tanks is anticipated to be approximately 30 ft bgs). One soil vapor sample and one soil sample will be collected from the bottom of each borehole. One soil sample will also be collected from each borehole at the depth interval exhibiting the highest photoionization detector (PID) reading. The soil vapor samples will be analyzed for TPH, VOCs, and PAHs; and methane, carbon dioxide, and oxygen. The soil samples will be analyzed for TPH-DRO, TPH-LRO, VOCs and PAHs (Figure 18).
- If groundwater is unexpectedly encountered at any of the above locations, groundwater samples will be collected in lieu of soil samples at those intervals and analyzed for the same COPCs as the soil samples.

Upon completion of field activities and sample analysis, the Navy will complete a Phase 1 Closure Site Assessment Report that documents the Phase 1 field investigation, integrates the Phase 1 analytical results with available environmental data from ongoing, separate release response actions at the Facility, and provide recommendations for further actions.

CONTENTS

APPENDIXES

FIGURES (INCLUDED IN APPENDIX A)

TABLES

ACRONYMS AND ABBREVIATIONS

µg/L	micrograms per liter
ACO	Administrative Consent Order
AFFF	aqueous film-forming foam
AOC	Administrative Order on Consent
AVGAS	aviation gasoline
bgs	below ground surface
BTEX	benzene, toluene, ethylene, and total xylenes
btf	below tunnel floor
BWS	Board of Water Supply, City and County of Honolulu
CAS	Chemical Abstracts Service
CERCLA	Comprehensive Environmental, Response, Compensation, and Liability Act
CF&T	contaminant fate and transport
CHT	Collection, Holding, and Transfer
CO_2	carbon dioxide
COC	chain of custody
COPC	chemical of potential concern
CSM	conceptual site model
CTO	contract task order
DL	detection limit
DLA	Defense Logistics Agency
DLNR CWRM	Department of Land and Natural Resources, State of Hawaii – Commission on Water Resource Management
DoD	Department of Defense
DOH	Department of Health, State of Hawaii
DQA	data quality assessment
DQO	data quality objective
EAL	Environmental Action Level
EDMS	Environmental Data Management System
EHE	Environmental Hazard Evaluation
ELAP	Environmental Laboratory Accreditation Program
EPA	Environmental Protection Agency, United States
EQuIS	Environmental Data Management Software
FOR	Fuel Oil Reclaim
ft	foot/feet
GAC	granular activated carbon
GPR	ground-penetrating radar
GPS	global positioning system
GWPP	Groundwater Protection Plan
HAR	Hawaii Administrative Rules
HDPE	high-density polyethylene
HEER	Hazard Evaluation and Emergency Response
JBPHH	Joint Base Pearl Harbor-Hickam
LAT	Lower Access Tunnel
LEL	lower explosive limit

LNAPL	light nonaqueous-phase liquid
LOD	limit of detection
LOQ	limit of quantitation
LTM	long-term monitoring
mg/kg	milligrams per kilogram
MPC	measurement performance criteria
MS/MSD	matrix spike/matrix spike duplicate
msl	mean sea level
NAS	Naval Air Station
NAVFAC	Naval Facilities Engineering Systems Command
ND	not detected
NFA	no further action
no.	number
NOI	Notice of Interest
NPDES	National Pollutant Discharge Elimination System
NSZD	natural source-zone depletion
OU	Operable Unit
OWDF	Oily Waste Disposal Facility
PAH	polynuclear aromatic hydrocarbon
PARCC	precision, accuracy, representativeness, comparability, and completeness
PCFA	Pearl City Fuel Annex
PID	photoionization detector
PQO	project quality objective
PSGS	passive soil gas sampler
PSL	project screening level
PSQ	principal study question
PSVP	passive soil vapor point
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
QSM	Quality Systems Manual
RHS	Red Hill Shaft
RI	remedial investigation
RPD	relative percent difference
SAP	sampling and analysis plan
SAWP	Site Assessment Work Plan
SL	screening level
SOP	standard operating procedure
SVMP	soil vapor monitoring point
TFH	total fuel hydrocarbons
TGM	Technical Guidance Manual
TPH	total petroleum hydrocarbons
TPH-DRO	total petroleum hydrocarbons – diesel range organics
TPH-GRO	total petroleum hydrocarbons – gasoline range organics
TPH-LRO	total petroleum hydrocarbons – lubricant range organics

UAT	Upper Access Tunnel
UFP-QAPP	Uniform Federal Policy for Quality Assurance Project Plans
UGPH	Underground Pumphouse
USGS	United States Geological Survey
UST	underground storage tank
VOC	volatile organic compound
WP	work plan

Worksheet #2: Work Plan/Sampling and Analysis Plan Identifying Information

Site Name/Number:	Red Hill Underground Storage Tank System
Operable Unit:	Not applicable
Contractor Name:	AECOM Technical Services, Inc.
Contract Number:	N62742-23-F-0149
Contract Title:	Comprehensive Long-Term Environmental Action Navy VI
Work Assignment Number (optional):	CTO 23F0149

1. This Phase 1 Closure Site Assessment Work Plan (SAWP) was prepared in accordance with the requirements of the *Uniform Federal Policy for Quality Assurance Project Plans* (DoD 2005) and United States Environmental Protection Agency *Guidance for Quality Assurance Project Plans, EPA QA/G-5* (EPA 2002).
2. Identify regulatory program:

Primary:	Hawaii Administrative Rules (HAR) 11-280.1-72 and 11-280.1-73
Secondary:	The defueling, closure, and Joint Base Pearl Harbor-Hickam (JBPHH) drinking water system administrative consent order (2023 Consent Order)

3. This SAWP is a project-specific SAWP.
4. List organizational partners (stakeholders) and identify the connection with lead organization:

Organization Partner/Stakeholder	Role
Navy Closure Task Force Red Hill	Lead Organization
State of Hawaii Department of Health	Lead Regulatory Agency
United States Environmental Protection Agency	Regulatory Agency

5. Lead organization: Navy Closure Task Force – Red Hill (NCTF-RH)
6. If any required SAWP elements and required information are not applicable to the project or are provided elsewhere, then note the omitted SAWP elements and provide an explanation for their exclusion below:

   All SAWP elements are applicable to the project, and no SAWP elements are provided elsewhere.

This document also includes the following appendixes:

- Appendix A: Figures
- Appendix B: Frame Foot Mark Spreadsheet
- Appendix C: Field Equipment Documentation
- Appendix D: Tunnel Sampling Locations
- Appendix E: NAVFAC Pacific Environmental Restoration Program Project Procedures and JBPHH Green Waste Policy
- Appendix F: EDMS Requirements
- Appendix G: References

Worksheet #3: Distribution List

The individuals listed below will receive electronic copies of the SAWP, subsequent SAWP revisions, SAWP addenda, and SAWP amendments.

Site Assessment Work Plan Recipient	Title	Organization	Telephone Number	E-mail Address
CDR Ben Dunn	Deputy for Environment & Remediation	NCTF-RH	[redacted]	(b) (6)
Milton Johnston	Environmental Director	NCTF-RH	[redacted]	[redacted]
(b) (6)	Navy Lead RPM	NCTF-RH	[redacted]	[redacted]
[redacted]	Red Hill SME Advisor	NAVFAC Pacific	[redacted]	[redacted]
[redacted]	Environmental Engineer	NAVFAC EXWC	[redacted]	[redacted]
[redacted]	DLA Environmental Lead	DLA	[redacted]	[redacted]
[redacted]	DLA Environmental Project Manager	DLA	[redacted]	[redacted]
Kelly Ann Lee	Regulator	DOH	808-586-4226	kellyann.lee@doh.hawaii.gov
Roxanne Kwan	Regulator	DOH	808-586-4226	roxanne.kwan@doh.hawaii.gov
Matt Cohen	Project Coordinator, Red Hill Project Team	EPA	415-972-3691	cohen.matthew@epa.gov
Lynn Brockway	Site Investigation and Remediation, Red Hill Project Team	EPA	808-539-0541	brockway.lynn@epa.gov
(b) (6)	CTO Manager	AECOM	[redacted]	(b) (6)
[redacted]	Deputy CTO Manager	AECOM	[redacted]	[redacted]
[redacted]	Field Manager	AECOM	[redacted]	[redacted]
[redacted]	QA Program Manager	AECOM	[redacted]	[redacted]

AECOM	AECOM Technical Services, Inc.
CDR	Commander
CLEAN	Comprehensive Long-Term Environmental Action Navy
CTO	Contract Task Order
DLA	Defense Logistics Agency
EXWC	Expeditionary Warfare Center
NAVFAC	Naval Facilities Engineering Systems Command
NCTF-RH	Navy Closure Task Force Red Hill
QA	quality assurance
RPM	Remedial Project Manager
SME	Subject Matter Expert

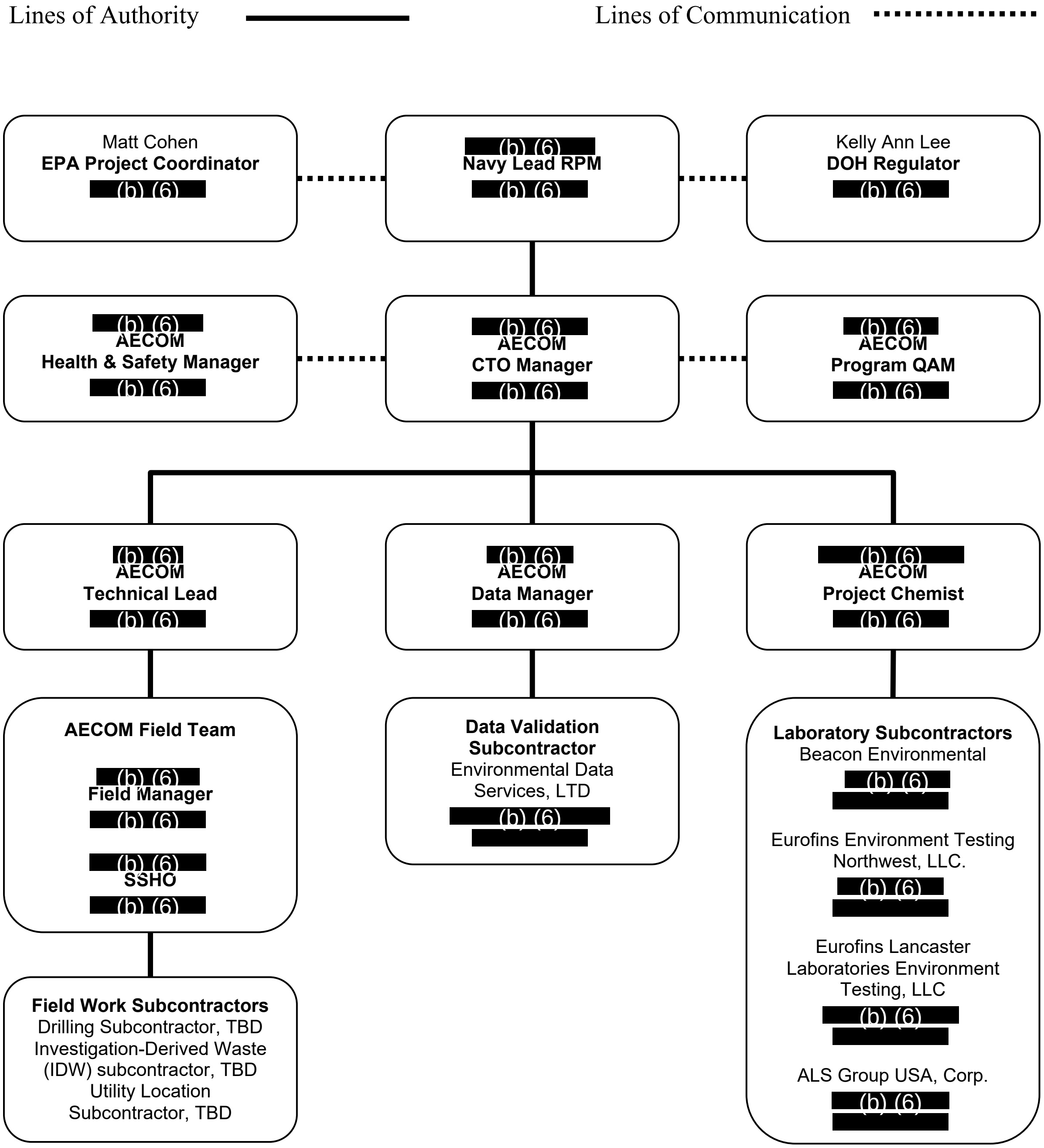
Worksheet #4: Project Personnel Sign-Off Sheet

Listed below are key personnel who are required to read and understand the SAWP prior to performing field activities. The contract task order (CTO) manager or designee will send an acknowledgement e-mail form with a link to the SAWP to the key personnel listed below. Upon completion of review of the SAWP, the personnel will acknowledge that they have read the SAWP by checking the acknowledgement box in the e-mail form and reply (send) to the originator of the e-mail. A record of the acknowledgement will be automatically documented. The acknowledgement document will be appended to project records. The SAWP will be reviewed verbally with the project personnel listed below in project kick-off meeting prior to field activities to verify the personnel understand the SAWP.

Project Personnel	Organization, Title
(b) (6) [redacted]	Navy, Lead RPM
[redacted]	AECOM, CTO Manager
[redacted]	AECOM, Deputy CTO Manager
[redacted]	AECOM, Field Manager
[redacted]	AECOM, SSHO
[redacted]	AECOM, Project Chemist
[redacted]	AECOM, Technical Lead
[redacted]	AECOM, Technical Quality Reviewer

Worksheet #5: Project Organizational Chart

The Project organizational chart is shown below.



Worksheet #6: Communication Pathways

The communication pathways for the SAWP are shown below.

Communication Driver	Responsible Entity	Name	Phone Number	Procedure
Regulatory Agency Interface	Navy Lead RPM	(b) (6) [redacted]	[redacted]	All project documentation will be forwarded by the Navy RPM. The Navy will be responsible for notifying EPA Region 9 and DOH when significant corrective actions or changes occur. Corrective actions will be communicated within 24 hours.
Project Management	AECOM CTO Manager	[redacted]	[redacted]	The AECOM CTO manager will direct and approve all communication to the Navy's RPM and provide monthly status reports to the Navy contracting officer. The AECOM CTO manager will notify the Navy RPM of field changes or modifications by close of business the following day.
QA/QC Management	AECOM QA Program Manager	[redacted]	[redacted]	The AECOM QA program manager will designate responsible project quality personnel to perform specified QA and QC activities and report to project and program management. Issues and non-conformances, and corrective actions will be reported to NAVFAC Pacific QA manager within 1 day of non-conformance issuance.
Field Progress Reports	AECOM Field Manager	[redacted]	[redacted]	The AECOM field manager will communicate relevant field information to the CTO manager and AECOM project chemist daily during field activities, by phone or e-mail.
Stop Work Due to Safety Issues	All Field Staff	[redacted]	[redacted]	All Field Staff have the authority to stop work by field subcontractors or field sampling personnel. Field work will then restart upon satisfactory implementation of the appropriate corrective actions.
SAWP Changes Prior to Field/Laboratory work	AECOM CTO Manager	[redacted]	[redacted]	Substantial changes to the planning documents will require the AECOM CTO manager prepare amended worksheets before the activities begin.
SAWP Changes in the Field	AECOM Field Manager	[redacted]	[redacted]	The AECOM field manager will notify the CTO manager of changes to the procedures specified in the SAWP during field activities. The AECOM CTO manager will determine the appropriate course of action and document these changes in the remedial investigation report.
Field Corrective Actions	AECOM Field Manager	[redacted]	[redacted]	The AECOM field manager will have the authority to stop work and issue corrective response actions to field sampling personnel. Modes of communications will be by telephone or e-mail within 24 hours.
Incident Reporting	AECOM SSHO	[redacted]	[redacted]	The AECOM safety and health officer will communicate site incidences to all relevant parties in an appropriate timeframe.
Daily COC Reports and Shipping Documentation	AECOM Field QC Coordinator	[redacted]	[redacted]	COCs and shipping records will be submitted via fax or e-mail to the AECOM project chemist at the end of each day that samples are collected.

Communication Driver	Responsible Entity	Name	Phone Number	Procedure
Sample Receipt Variances	Beacon Environmental Eurofins Environment Testing Northwest, LLC. Eurofins Lancaster Laboratories Environment Testing, LLC ALS Group USA, Corp.	(b) (6) [redacted]	[redacted]	All variances in sample receipt will be reported to the AECOM project chemist by the laboratory within 24 hours of variance. A signed copy of the COCs and a completed Sample Condition Report will be provided to the project chemist within 24 hours of sample receipt.
Reporting Laboratory Data Quality Issues	Beacon Environmental Eurofins Environment Testing Northwest, LLC. Eurofins Lancaster Laboratories Environment Testing, LLC ALS Group USA, Corp.	[redacted]	[redacted]	QA/QC issues that potentially affect data usability will be reported by the laboratory project manager to the project chemist by e-mail within 1 business day. If significant problems are identified from the laboratory that impacts the usability of the data, the project chemist will inform the Navy remedial project manager within 1 day of notification.
	Navy Lead RPM	[redacted]	[redacted]	If significant problems with the laboratory are identified, the Navy remedial project manager will inform the Navy Quality Assurance manager for evaluation to determine what corrective actions will be taken with respect to the accreditation process.
Reporting Lab Quality Variances	Beacon Environmental Eurofins Environment Testing Northwest, LLC. Eurofins Lancaster Laboratories Environment Testing, LLC ALS Group USA, Corp.	[redacted]	[redacted]	All laboratory QA/QC variance issues will be reported to AECOM project chemist by the laboratory within 1 day of variance. The variance(s) will be reported to the AECOM CTO manager the same business day and to the Navy within 2 business days.
Analytical Corrective Actions	AECOM Project Chemist	[redacted]	[redacted]	The AECOM project chemist will immediately notify the AECOM CTO manager and the laboratory project manager by e-mail of field or analytical procedures that were not performed in accordance with the planning documents. The AECOM project chemist will document the non-conformance and issue the corrective actions to be taken and will verify implementation of the corrective actions by the laboratory.
Reporting Data Validation Issues	AECOM Data Validation Task Manager	[redacted]	[redacted]	All data validation issues will be reported to the AECOM project chemist by the data validators by telephone or e-mail. The validators will generate memos to the laboratory in regards to incomplete deliverables or discrepancies. The issue(s) will also be reported to the AECOM CTO manager or the project chemist within 1 business day by telephone or e-mail.
Data Validation Corrective Actions	AECOM Analytical & Data Validation Advisor	[redacted]	[redacted]	The AECOM analytical and data validation advisor will have the authority to issue corrective response actions to laboratory and data validation firms. Corrective actions may be issued to the laboratory as a result of data validation results. Modes of communications will be by telephone or e-mail within 24 hours after audit.

AECOM	AECOM Technical Services, Inc.
COC	chain of custody
CTO	contract task order
DOH	Department of Health, State of Hawaii
EPA	Environmental Protection Agency, United States
NAVFAC	Naval Facilities Engineering Systems Command
QA	quality assurance
QC	quality control
RPM	remedial project manager
SSHO	site safety and health officer
TBD	to be determined
WP	work plan

Worksheet #7: Personnel Responsibilities Table

Project-specific responsibilities are provided in the following table.

Name	Title	Organizational Affiliation	Responsibilities
(b) (6)	Navy Lead RPM	NCTF-RH	Coordinates with Regulatory Agency/Agencies and other stakeholders. Contract technical administration and project oversight.
Kelly Ann Lee	Regulator	DOH	Provides regulatory oversight for the project.
Matt Cohen	Project Coordinator, Red Hill Project Team	EPA	Provides regulatory oversight for the project.
(b) (6)	CLEAN VI Program Manager	AECOM	Ensures compliance with contractual and technical procedures across the program.
	QA Program Manager	AECOM	Reviews all technical procedures. Oversees project QA and ensures that overall technical direction correlates with other Navy CLEAN sites.
	CTO Manager	AECOM	Coordinates with the Navy and provides overall technical direction and guidance for the project. Shares responsibility with the Navy RPM for distribution of project-related documents. Identifies project problems or non-conformance and initiates corrective action.
	SSHO (onsite)	AECOM	Implements the Site-Specific accident prevention plan; prepares, implements, oversees the AHAs; conducts daily tailgate health and safety meeting.
	Field QC Coordinator	AECOM	Maintains the QA/QC field logbook, ensures collection of QA/QC samples as proposed in the WP and documents collection. Provides QC review of field logbook maintained by the AECOM field manager.
	Safety and Health Manager	AECOM	Directs and oversees accident prevention plan and procedure.
	Field Manager	AECOM	Plans and oversees the implementation of field sampling, monitors adherence to activity-specific SOPs, and coordinates subcontractors in the field.
	Deputy CTO Manager	AECOM	Identifies sampling locations, directly oversees utility clearing, vegetation clearing, and intrusive activities (e.g., well installations). Describes soil and records the description in sampling logs and records well construction details.
	Project Chemist	AECOM	Provides specific technical assistance for the project including development of the project work and analytical plans and reporting document. Assists with analytical laboratory and data validation procurement, oversight/management, and coordination. Oversees all field sampling activities to ensure adherence to the WP. Coordinates with the analytical laboratory and data validation firms. Reviews and evaluates analytical data and summarizes data validation reports. Assists with sample collection, as needed.
	Analytical & Data Validation Advisor	AECOM	Assists with analytical and data validation, as well as data usability issues.
	Database Manager	AECOM	Manages and maintains the project database, provides data reports on an as-needed basis.
	Laboratory Manager	Beacon Environmental	Manages analytical data generation.
	Laboratory Manager	Eurofins Environmental Testing Northwest LLC	Manages analytical data generation.
	Laboratory Manager	ALS Group USA, Corp.	Manages analytical data generation.
	Laboratory Manager	Eurofins Lancaster Laboratories Environment Testing, LLC	Manages analytical data generation.
	Data Validation Task Manager	AECOM	Manages analytical data validation produced by the laboratory.

Name	Title	Organizational Affiliation	Responsibilities
[redacted] (b) (6)	Data Validation Subcontractor	Environmental Data Services, Ltd.	Provides analytical data validation support
TBD	Utility Location Subcontractor	TBD	Locates subsurface utilities, the Abandoned AVGAS Line, and the Surge Tanks
TBD	Drilling Subcontractor 1	TBD	Advances boreholes in the tunnel
TBD	Drilling Subcontractor 2	TBD	Advances boreholes outside the tunnel
TBD	IDW Subcontractor	TBD	Manages and disposes of IDW generated on this project.

AECOM	AECOM Technical Services, Inc.
AHA	activity hazard analysis
CLEAN	Comprehensive Long-Term Environmental Action Navy
CTO	Contract Task Order
IDW	investigation-derived waste
NAVFAC	Naval Facilities Engineering Systems Command
NCTF-RH	Navy Closure Task Force Red Hill
QA	quality assurance
QC	quality control
RPM	Remedial Project Manager
SI	site inspection
SME	Subject Matter Expert
SOP	standard operating procedure
SSHO	Site Safety and Health Officer
TBD	to be determined
WP	Work Plan

Worksheet #8: Special Personnel Training Requirements Table

The Phase 1 Closure Site Assessment will not require any specialized or non-routine training.

Project Function	Specialized Training By Title or Description of Course	Training Provider	Training Date	Personnel/Groups Receiving Training	Personnel Titles/Organizational Affiliation	Location of Training Records/Certificates
Not Applicable						

[a] If training records and/or certificates are on file elsewhere, document their location in this column. If training records and/or certificates do not exist or are not available, then this should be noted.

Worksheet #9: Project Scoping Session Participants Sheet

Project Name: Red Hill Site Assessment Planning and Tank Closure Support
Projected Date(s) of Sampling: January – June 2025
Contract Task Order Manager: (b) (6)
Date of Session: February 15, 2024 (Scoping Session No. 1)
Scoping Session Purpose: To discuss the Navy's initial proposed sampling and analysis plan for the Closure Site Assessment as well as the associated regulatory framework and objectives.

Site Name: Red Hill Bulk Fuel Storage Facility
Site Location: Joint Base Pearl Harbor- Hickam, Oahu, HI

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[redacted]	Project Chemist	AECOM	[redacted]	[redacted]

AECOM	AECOM Technical Services, Inc.
CTO	Contract Task Order
DLA	Defense Logistics Agency
DOH	Department of Health, State of Hawaii
EPA	Environmental Protection Agency, United States
E&R	Environment & Restoration
LCDR	Lieutenant Commander
NCTF-RH	Navy Closure Task Force Red Hill
RCRA	Resource Conservation and Recovery Act
RPM	Remedial Project Manager

Meeting Summary: The Navy presented 30 slides summarizing the Navy's proposed boundaries for the Phase I and Phase II Closure Site Assessments, the physical components of the Red Hill Underground Storage Tank (UST) system within the Phase I Closure Site Assessment Boundaries, the fuel storage history at the Facility, proposed target analytes and soil vapor screening levels, and the Navy's proposed sampling and analysis program for the Phase 1 Site Assessment. The meeting participants engaged in interactive discussions as the slides were presented.

Comments/Action Items:

- The Navy proposed that it would perform the Closure Site Assessment in two phases. Phase 1 will address the onsite portion of the Red Hill UST system, and Phase 2 will address the offsite portions of the JBPHH fuel system that are determined to be part of the Red Hill UST system. A map was presented showing the Phase 1 and potential Phase 2 Closure Site Assessment boundaries.
- The Navy proposed that the objective of the Phase 1 Closure Site Assessment will be to assess the onsite portions of the Red Hill UST system for the presence or absence of fuel-related compounds associated with known and unknown past releases from the Red Hill UST system in accordance with Hawaii Administrative Rule (HAR) 11.280.1-72 and 11.280.1-73 for performing a site assessment before UST closure is complete.
- The Navy confirmed that response actions for contamination identified during the Phase 1Site Assessment will be implemented in accordance with HAR 11-280.1 Subchapter 6 under separate DOH and EPA approved Work Plans.
- The Navy confirmed that the Phase 1 Closure Site Assessment will include sampling at the onsite section of the AVGAS Line, which was abandoned in place in 2004, and the former Slop Tank that was removed in 2009.
- The Navy confirmed that ongoing environmental investigations at the Former Oily Waste Disposal Facility (OWDF), Former Holding Tank and Leach Tank area, Collection, Holding, and Transfer (CHT) Tank, Adit 3, and beneath the 20 USTs would continue under their current regulatory programs, and that the data from these investigations will be integrated into the Phase 1 Site Assessment Report to inform a comprehensive assessment of the Red Hill UST system within the Phase 1 Closure Site Assessment boundaries.
- The Regulatory Agencies (RAs) requested that the Navy consider increasing the number of proposed sampling points and collecting passive carbon dioxide samples.
- The RAs referenced the December 19, 2023 letter from DOH to the Navy regarding "DOH Expectations for Site Assessment Required for Permanent Closure of the Red Hill Bulk Fuel Storage Facility, and noted that this letter describes content that DOH expects to be included in the Phase 1 SAWP.

Project Name: Red Hill Site Assessment Planning and Tank Closure Support
Projected Date(s) of Sampling: January – June 2025
Contract Task Order Manager: (b) (6)
Date of Session: March 11, 12, & 13, 2024 (Scoping Session No. 2)
Scoping Session Purpose: To discuss the Navy's proposed sampling and analysis plan for the Closure Site Assessment as well as the associated regulatory framework and objectives.

Site Name: Red Hill Bulk Fuel Storage Facility
Site Location: Joint Base Pearl Harbor- Hickam, Oahu, HI

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Project Name: Red Hill Site Assessment Planning and Tank Closure Support
Projected Date(s) of Sampling: January – June 2025
Contract Task Order Manager: (b) (6)
Date of Session: March 11, 12, & 13, 2024 (Scoping Session No. 2)
Scoping Session Purpose: To discuss the Navy's proposed sampling and analysis plan for the Closure Site Assessment as well as the associated regulatory framework and objectives.

Site Name: Red Hill Bulk Fuel Storage Facility
Site Location: Joint Base Pearl Harbor- Hickam, Oahu, HI

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[redacted]	CTO Manager	AECOM	[redacted]	[redacted]
[redacted]	Project Chemist	AECOM	[redacted]	[redacted]
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AECOM	AECOM Technical Services, Inc.
AOC/ACO	Administrative Order on Consent/Administrative Consent Order
CDR	Commander
CTO	Contract Task Order
DOH	Department of Health, State of Hawaii
DLA	Defense Logistics Agency
EPA	Environmental Protection Agency, United States
EV3	NAVFAC Pacific Environmental Restoration
MIDLANT	Atlantic
LCDR	Lieutenant Commander
NAVFAC	Naval Facilities Engineering Systems Command
NCTF-RH	Navy Closure Task Force Red Hill
PAC	Pacific
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RPM	Remedial Project Manager
TDY	Temporary Duty

[a] Only attended March 11 and March 12, 2024.
[b] Only attended March 12 and March 13, 2024.
[c] Only attended March 13, 2024.
[d] Only attended "VOC Sampler Presentation by Beacon Environmental" on March 13, 2024.
[e] Only attended sessions after lunch on March 13, 2024.

Meeting Summary: The Navy presented slides over the course of the three-day scoping session summarizing the Navy's plans for Phase I and Phase II of the Site Assessment, requirements and definitions of the Red Hill UST System, the study area and associated boundaries within the Phase I Closure Site Assessment, the historical data for the Red Hill Facility, the Navy's proposed Site Assessment, Investigation, and Remediation Schedule, and relevant information on the OWDF and per- and polyfluoroalkyl substances (PFAS), which were presented by the Environmental Restoration, Navy (ER,N) program. Additionally, Beacon Environmental provided a presentation on the VOC passive soil gas samplers. The meeting participants engaged in interactive discussions as the slides were presented.

Comments/Action Items:

- The representative from Beacon Environmental recommended that passive soil vapor samplers be spaced every 25 feet along the pipelines and that the samples be analyzed by EPA method.
- The Navy proposed collecting soil samples at each soil vapor sample location to analyze for TPH-o. Hydrocarbons in the TPH-o range are non-volatile, which are not captured in soil vapor samples.
- The EPA recommended that the Navy perform a pilot study to confirm the efficacy and appropriate spacing of passive soil vapor samples and compare to active soil vapor sample results.
- The Navy and EPA concurred that the Phase 1 Closure SAWP will be submitted to the RAs before the pilot study is performed and that if the pilot study indicates that the Phase 1 Closure SAWP should be modified, such modifications would be documented in an addendum to the Phase 1 Closure SAWP.
- EPA recommended to the group that EPA and DOH could provide conditional approval of the Phase 1 Closure SAWP while waiting for the pilot study results to help expedite the overall Phase 1 Closure Site Assessment process.

Project Name: Red Hill Site Assessment Planning and Tank Closure Support
Projected Date(s) of Sampling: January – June 2025
Contract Task Order Manager: (b) (6)
Date of Session: April 30, 2024 (Scoping Session No. 3)
Scoping Session Purpose: To discuss the Navy's initial proposed sampling and analysis plan for the Closure Site Assessment as well as the associated regulatory framework and objectives.

Site Name: Red Hill Bulk Fuel Storage Facility
Site Location: Joint Base Pearl Harbor- Hickam, Oahu, HI

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	Project Chemist	AECOM		

AECOM	AECOM Technical Services, Inc.
CDR	Commander
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DOH	Department of Health, State of Hawaii
EPA	Environmental Protection Agency, United States
MIDLANT	Atlantic
NAVFAC	Naval Facilities Engineering Systems Command
NCTF-RH	Navy Closure Task Force Red Hill
PAC	Pacific
PFAS	Per- and polyfluoroalkyl substances
RI	Remedial Investigation
RPM	Remedial Project Manager
SME	Subject Matter Expert
SSP&A	S. S. Papadopulos & Associates, Inc.
TDY	Temporary Duty

Meeting Summary: The Navy presented slides summarizing the Navy’s proposed boundaries for the Phase I and Phase II Closure Site Assessments, the Navy’s proposed sampling and analysis program for the Phase 1 Site Assessment, the proposed sampling pilot study, and the proposed list of target analytes and other potential analytes for the Site Assessment. The meeting participants engaged in interactive discussions as the slides were presented.

Comments/Action Items:

- The Navy will perform a sampling pilot study in the Adit 3 area beginning in approximately September 2024 after the shallow soil vapor extraction pilot study is completed (which is covered under a separate regulatory program). The pilot study will include the analysis of passive soil vapor samples by EPA Method TO-17, carbon dioxide using carbon traps, and active soil vapor samples by EPA Method TO-3, TO-15, ASTM D1946, and methane and carbon dioxide by field instrumentation.
- The group concurred that analysis for TPH-DRO with silica gel cleanup, 2-2-MME, and the natural attenuation parameters are not necessary to achieve the Site Assessment objective of identifying the presence or absence of releases from the Red Hill UST system. Moreover, it was agreed that silica gel cleanup, 2-2-MME, and natural attenuation parameters could be considered as target analytes in future investigations.
- The Navy agreed with a recommendation from the RAs to sample soil along the Abandoned AVGAS Line for tetraethyl lead rather than total lead.
- The RAs suggested increasing the number of samples that will be collected in the Former Slop Tank area and outside Adit 3. The Navy agreed to increase the number of samples that will be collected in the Former Slop Tank area. Due to the ongoing investigations at the CHT Tank area, Former OWDF, and Former Holding Tank and Leach Tank area, the Navy does not concur with increasing the number of soil samples outside Adit 3. Data from those ongoing investigations will be integrated into the summary report for the Phase 1 Closure Site Assessment.
- The Navy will submit the Phase 1 Site Assessment SAWP by June 28, 2024 and the Pilot Study Work Plan in July 2024.

Worksheet #10: Conceptual Site Model

10.1 OVERVIEW

This Site Assessment Work Plan (SAWP) presents the proposed sampling and analysis program for Phase 1 of a two-phase Site Assessment that will be conducted in connection with the permanent closure of the Red Hill Bulk Fuel Storage Facility ("Facility" or "Site") and associated infrastructure, Joint Base Pearl Harbor-Hickam (JBPHH), Oahu, Hawaii (Figure 1). The objective of the two-phase Site Assessment is to satisfy the requirement in Hawaii Administrative Rules (HAR) Chapter 11-280.1, Subchapter 7 (specifically HAR §11-280.1-72 and HAR §11-280.1-73) to assess an underground storage tank (UST) system at Closure. This document has been prepared by the United States Navy and Defense Logistics Agency (DLA) to address the tasks and requirements of Section 5.0 of the Statement of Work attached to the Administrative Consent Order for Defueling, Closure, and Drinking Water Protection for the Red Hill Bulk Fuel Storage Facility and the Joint Base Pearl Harbor-Hickam Water System (EPA Region 9 2023).

In accordance with HAR §11- 280.1-72(a), the objective of the Closure Site Assessment is to "measure for the presence of a release where contamination is most likely to be present" at the UST site. The Closure Site Assessment contaminants of concern are petroleum hydrocarbons and additives that are part of the Comprehensive Environmental, Response, Compensation, and Liability Act (CERCLA) petroleum exemption. Non-petroleum contaminants will be addressed in a separate regulatory program under the applicable regulations.

Consistent with HAR §11-280.1-72(d), if the results of the Site Assessment indicate that release response actions (site characterization and/or remediation) are required, such work will be performed in accordance with the HAR regulations for release response actions (HAR §11-280.1-60 through 11-280.1-67) under a separate work plan.

The Phase 1 Closure Site Assessment will address the "onsite" components of the Red Hill UST system, including components that were previously closed or abandoned. For the purposes of this SAWP, "onsite" includes the area within the Facility property boundaries, the Red Hill tunnel system, and the four Surge Tanks, located (b) (3) (Figure 2). Prior to commencement of the Phase 2 Site Assessment, the Navy will evaluate the offsite components of the JBPHH fuel system (Figure 1), including components that were previously closed or abandoned, to determine whether these components should be included in the Phase 2 investigation. The Phase 2 Site Assessment will address any offsite components of the fuel system that are determined to be included as part of permanent closure of the Red Hill UST system. The Navy will submit a separate Phase 2 SAWP to the Hawaii Department of Health (DOH) and the United States Environmental Protection Agency (EPA).

This Phase 1 SAWP was prepared using the Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP) 37-worksheet Tier I format (DoD 2005). Upon completion of field activities and sample analysis, the Navy will complete a Phase 1 Closure Site Assessment Report that documents the Phase 1 field investigation, integrates the Phase 1 analytical results with environmental data from release response actions that are already ongoing at the Facility, and provide recommendations for further actions.

This worksheet presents the conceptual site model (CSM) for the Site.

10.2 SITE DESCRIPTION, HISTORY, AND ENVIRONMENTAL SETTING

10.2.1 Site Description(s) and History

The Site is a former military fuel storage facility located in (b) (3) [redacted] (Figure 2). The following is a brief description of the Red Hill UST system infrastructure and history within the footprint of the Phase 1 Closure Site Assessment.

10.2.1.1 THE 20 USTS

The complex of 20 USTs (Tanks 1 through 20) ("Tank Farm") was constructed in place within the thick sequence of volcanic rocks that forms Red Hill between 1940 and 1943 (Figure 2). The Tank Farm begins at the makai (seaward) side of Tanks 1 and 2 and ends at the mauka (inland) side of Tanks 19 and 20 for a total length of approximately 1,900 feet (ft). Each UST is approximately 250 ft in height and 100 ft in diameter, with a capacity of approximately 12.5 million gallons. Each UST was constructed by excavating the volcanic rock formation of Red Hill to create a chamber for the tank, which was then lined with reinforced concrete and a ¼-inch-thick steel liner. The primary structure of each tank consists of an upper dome, barrel, and lower dome (Figure 3) (HAER 2015).

The 20 USTs are aligned in two parallel rows of ten tanks, spaced approximately 200 ft on center (Figure 2). Approximately 100 ft of volcanic rock separates the USTs from one another. The tops of the USTs are approximately 110–175 ft below ground surface (bgs), and the bottoms of the tanks are approximately 350–450 ft bgs and approximately 100–130 ft above the basal aquifer water table (DON 2016). The 10 tank "pairs" are installed at slightly increasing elevations moving upslope from JBPHH, i.e., the elevation of the bottoms of Tanks 1 and 2 is approximately 30 ft lower than that of Tanks 19 and 20.

Access to the USTs is provided by an Upper Access Tunnel (UAT) and a Lower Access Tunnel (LAT) that transit between the two parallel rows (Figure 2). Short access tunnels branch off from the LAT and terminate at a "face-wall" under each tank. Ancillary piping extends from each face-wall to connect to the three fuel transmission lines that were used to transfer fuel between the 20 USTs and the Underground Pumphouse (UGPH) located at Pearl Harbor. The three fuel transmission lines are located above the tunnel floors and are described in more detail in Section 10.2.1.2.

The subsurface beneath the 20 USTs has been the subject of several investigations, including an ongoing long-term groundwater monitoring program that began in 2005 and an ongoing soil vapor monitoring program that began in 2008. Data from these ongoing investigations indicate that the vadose zone and groundwater beneath the USTs are impacted with contamination related to past fuel releases from the USTs; therefore, no additional sampling is required in this SAWP to determine if contamination is present. Site characterization will continue to delineate existing contamination and evaluate the risk to human health and the environment. See Section 10.3 for additional information on the history of releases and release response actions in the Tank Farm.

The Phase 1 Site Assessment Sampling and Analysis Plan (Worksheet #17) includes sampling to supplement the existing soil vapor and groundwater data with shallow soil vapor and soil samples that will be collected from beneath the LAT floor to assess for the presence of impacts from releases that could have originated from piping or sumps within the Tank Farm.

10.2.1.2 FUEL TRANSMISSION LINES

The three fuel transmission lines that conveyed fuel from the 20 USTs to the UGPH include a [redacted]-inch steel pipeline (the F-76 line), an [redacted]-inch steel pipeline (the JP-5 line), and a [redacted]-inch pipeline (the F-24 line). The lines extend for approximately 17,000 ft (3.2 miles) from (b) (3) (CNRH 2020, Appendix F). (b) (3) (Figure 2). The three fuel transmission lines will be removed as part of Tank Closure activities.

(b) (3).

Although no actual or suspected releases from the three fuel transmission lines between the Tank Farm and the UGPH have been documented, no past environmental sampling has been conducted in this section of the tunnels to confirm the presence or absence of subsurface contamination associated with unknown releases from the fuel transmission lines. Therefore, the Phase 1 Site Assessment Sampling and Analysis Plan (Worksheet #17) includes sampling along the fuel transmission lines (the "LAT Study Area") to provide sufficient data to assess whether a release occurred.

10.2.1.3 FUEL OIL RECLAIM (FOR) SYSTEM

The FOR pipeline, which ranges between 4 and 6 inches in diameter, is connected to the 20 USTs and various tunnel sumps to collect condensate and oily wastewater and convey those liquids to Tank 311, a 42,000-gallon aboveground storage tank (AST) (b) (3) (Figure 2). (b) (3). The FOR System will remain in service after Tank Closure to manage condensate that is expected to drain from the 20 USTs over time (DON 2022e).

Although no actual or suspected releases from the FOR System have been documented, no past environmental sampling of the FOR System has been conducted to confirm the presence or absence of subsurface contamination associated with unknown releases from the FOR System. Therefore, the Phase 1 Site Assessment Sampling and Analysis Plan (Worksheet #17) includes sampling to provide sufficient data to assess whether such a release occurred.

10.2.1.4 FOUR UNDERGROUND SURGE TANKS

The four underground Surge Tanks were built (b) (3) in the early 1940s as part of the original Facility construction (Figure 2). Surge tanks ST1 through ST4 have respective capacities of 421,722; 422,100; 422,688; and 422,184 gallons (DON 2022e). Like the 20 Tank Farm USTs, each Surge Tank was constructed within an excavation of the surrounding volcanic rock formation. The interior dimensions for each Surge Tank are 60 ft in diameter by 21 ft in height. The outer construction adds approximately 7 ft to the tops of the Surge Tanks, rendering a total height of approximately 28 ft. Each Surge Tank is encased in a minimum 12-inch-thick reinforced concrete shell with a ¼-inch-thick interior steel liner plate. The Surge Tanks share one integral reinforced concrete roof slab (below ground surface) with a minimum slab thickness of 6 ft.

Although no actual or suspected releases from the Surge Tanks have been documented, no past environmental sampling has been conducted to confirm the presence or absence of subsurface contamination associated with unknown releases. Therefore, the Phase 1 Site Assessment Sampling and Analysis Plan (Worksheet #17) includes sampling to provide sufficient data to assess whether such a release occurred.

10.2.1.5 ABANDONED ADIT 6 AVGAS LINE

The Adit 6 Aviation Gasoline (AVGAS) Line was constructed between approximately 1960 and 1963 to transport AVGAS between (b) (3) (Figure 1). The Abandoned AVGAS Line consists of two underground sections: a 16-inch line that (b) (3), and an 8-inch line that (b) (3) Each section is approximately 6 miles in length. Tanks 19 and 20, as well as the 16-inch and 8-inch pipelines, were converted to JP-5 use in the mid-to-late 1960s (HAER 2015).The AVGAS Line was cleaned and abandoned in place in 2004 (Shaw 2005), but has not been previously investigated. See Section 10.3.8 for additional details.

Approximately 1 mile of the 16-inch pipeline is located underground (b) (3) (Figure 2).

Although no actual or suspected releases from the onsite section of the Abandoned AVGAS Line have been documented, no past environmental sampling along this pipeline has been conducted to confirm the presence or absence of subsurface contamination associated with unknown releases from the onsite section of the Abandoned AVGAS Line. Therefore, the Phase 1 Site Assessment Sampling and Analysis Plan (Worksheet #17) includes sampling along the onsite section of the Abandoned AVGAS Line designed to provide sufficient data to assess whether such a release occurred. The Navy will evaluate the offsite section of the Abandoned AVGAS Line to determine whether it should be included in the Phase 2 investigation of the Site Assessment.

10.2.1.6 FORMER SLOP TANK

The Former Slop Tank was a steel 5,000-barrel aboveground tank that was constructed at the same time as the Abandoned AVGAS Line to receive oily wastewater from Tanks 17 and 18 (which were converted JP-5 use at that time) and Tanks 19 and 20 (which were converted to AVGAS use at that time) and separate the fuel from the water. As such, the fuels separated by the Former Slop Tank included AVGAS and JP-5 from approximately 1963 to the mid to late 1960s and exclusively JP-5 thereafter (see Section 10.2.1.5 for additional details). The water emptied into South Halawa Stream, and the fuel was pumped to a loading stand, where it was loaded onto a truck via aboveground piping for offsite disposal (Earl and Wright 1962).

The Former Slop Tank was located approximately (b) (3) and received the oily wastewater from Tanks 17 through 20 via an underground -inch pipe (b) (3) (Figure 2). The 8-inch line connected to an aboveground 4-inch line (b) (3)

The Former Slop Tank and associated aboveground pipe were removed in 2009 (Shaw 2009). The 8-inch underground pipe that (b) (3) was plugged and left in place. Total petroleum hydrocarbons in the diesel range (TPH-DRO) were detected at concentrations below the DOH Environmental Action Level (EAL) in near-surface soil samples collected from the footprint of the Former Slop Tank after the tank was removed. Also, hydrocarbon odors were observed during the drilling of two nearby boreholes in 2013 and 2022. See Section 10.3.6 for additional details.

The Phase 1 Site Assessment Sampling and Analysis Plan (Worksheet #17) includes sampling in the vicinity of the Former Slop Tank and the abandoned 8-inch line (b) (3) The data collected during the Phase 1 Site Assessment will be integrated with the 2009 soil data and the 2015 and 2022 field observations to provide sufficient data to assess whether contamination associated with past releases from the Former Slop Tank or associated pipelines are present in this area.

10.2.1.7 FORMER STANDBY POWER PLANT

The Former Standby Power Plant was located in an (b) (3). Both access points have been locked and inaccessible for an unknown period of time (Figure 2). During operation, the Standby Power Plant included five diesel-driven generators, their exhaust mufflers, fan equipment, and an overhead crane on rails. All equipment was removed at an unknown date prior to 2015 (HAER 2015). The space previously occupied by the Former Standby Power Plant is currently vacant and has been inaccessible to date.

Base on a site reconnaissance of the outside entrance to the Former Standby Power Plant and a 1942 photo (Figure 4) of the Former Standby Power Plant when it was in operation, it is assumed that the Former Standby Power Plant is approximately 125 ft long and 25 ft wide. The actual dimensions will be verified in the field when the Former Standby Power Plant becomes accessible.

A diesel tank associated with the Former Standby Power Plant reportedly leaked in 1948 (Section 10.3.9). No past environmental sampling has been conducted at the Former Standby Power Plant. Therefore, the Phase 1 Site Assessment Sampling and Analysis Plan (Worksheet #17) includes sampling in the area formerly occupied by the Standby Power Plant to provide sufficient data to assess whether contamination from the 1948 release or other unknown releases in this area is present.

10.2.1.8 COLLECTION, HOLDING, AND TRANSFER (CHT) TANK

The CHT Tank is an approximately 15 ft × 8 ft × 7 ft aboveground cement tank that sits outside Adit 3 (Figure 2). The purpose of the CHT Tank is to receive sanitary waste from a sanitary septic tank inside Adit 3 and store the sanitary waste until it is transported off site. However, petroleum was inadvertently pumped into the CHT Tank during the November 20, 2021 JP-5 release. The CHT Tank then overflowed during rain events in December 2021 and January 2022, impacting the surrounding area with light nonaqueous-phase liquid (LNAPL) and petroleum-contaminated storm water. See Section 10.3.2 for additional details.

The Navy submitted a Site Characterization Plan Addendum under separate cover to EPA and DOH in March 2024 (DON 2024c) to assess the nature and lateral extent of petroleum hydrocarbons in near-surface soil around the CHT Tank. This Site Characterization Plan Addendum will be implemented as part of the Phase 1 Closure Site Assessment x).

10.2.1.9 FORMER HOLDING TANK AND LEACH TANK

The Former Holding Tank and connected Leach Tank were a pair of underground 8-ft-tall, 7-ft-diameter cylindrical cement tanks located [redacted] 250 ft northwest of the CHT Tank (Figure 2). The purpose of the Former Holding Tank and connected Former Leach Tank was to receive and discharge subsurface drainage, cooling water, and condensate collected from the sump located within the Adit 3 tunnel. During the November 20, 2021 JP-5 release, the Adit 3 sump filled with JP-5, activating the pump that transferred JP-5 into the Former Holding Tank and Leach Tank system.

A Phase 1 site investigation was conducted January 11–13, 2022 and consisted of subsurface soil sampling of 21 soil borings using a limited-access Geoprobe direct-push drilling rig collecting continuous samples in a step-out/step-in process from depths ranging from 4 to 24 ft bgs. During March 9–17, 2022, a Phase 2 investigation was conducted using a hollow-stem auger drilling rig to install eight additional borings and three temporary wells into the shallow perched water aquifer. The results of these investigations indicated that TPH and related chemical constituents were observed in soil and perched groundwater above DOH EALs (DON 2022f; 2023c).

The Navy followed up with two removal actions:

- Between May 13 and May 25, 2022, the Navy excavated and removed the Holding Tank, Leach Tank, adjacent piping, and contaminated soil.
- Between August 29 and October 3, 2022, the Navy excavated and disposed of an additional 1,300 cubic yards (approximate) of petroleum-contaminated soil to a maximum depth of approximately 30 ft bgs.
- The Navy has proposed an Environmental Hazard Evaluation (EHE) report and an Environmental Hazard Management Plan to manage COPCs remaining in place.

This release response action will continue concurrently with the Closure Site Assessment. Therefore, the Phase 1 Site Assessment Sampling and Analysis Plan (Worksheet #17) does not include any additional sampling related to the Former Holding Tank and Leach Tank area. Environmental data from the ongoing release response action will be integrated into the Phase 1 Closure Site Assessment Report.

10.2.1.10 FORMER OILY WASTE DISPOSAL FACILITY

The Former OWDF was constructed in the 1940s as a collection point for oily wastewater generated by the cleaning of the Red Hill Bulk Fuel Storage Facility's 20 large-capacity USTs, (b) (3) [redacted] (Figure 2). The Former OWDF was the site of a series of two reclamation and disposal pits, the first unlined and its later replacement lined, which were constructed in the same approximate location and used intermittently between 1943 and 1986. Each pit functioned similarly: as holding and settling ponds for bottom sludge and rinse water generated during periodic cleaning of the Red Hill Bulk Fuel Storage Facility USTs where recoverable oil was skimmed from the surface and collected in ASTs at the site for offsite use and processing. The remaining water either evaporated, infiltrated, or was otherwise disposed of. Operation of the disposal pits ceased in 1986.

In the 1990s and early 2000s, the Former OWDF was managed under CERCLA and as such, the Navy conducted a remedial investigation (RI) and removal action at the OWDF, which included investigating the nature and extent of contamination at the site, removing petroleum-impacted sludge and soil, and assessing the risk to human health and the environment. The RI concluded that the site did not pose a threat to human health or the environment (DON 2000). Based on the findings in the RI and the removal action, DOH and EPA agreed that the Former OWDF was impacted solely by petroleum hydrocarbons, and therefore would be regulated by DOH pursuant to the Hawaii Environmental Response Law (Chapter 128D, Hawaii Revised Statutes), rather than by EPA pursuant to CERCLA, despite the site being listed on the federal National Priorities List (DON 2001). DOH concurred with the findings and recommendations in the RI and in 2005 issued a no further action (NFA) determination for the site (DOH 2005).

After DOH issued its NFA determination in 2005, all the Former OWDF groundwater monitoring wells except one, now referred to as OWDFMW01, were abandoned, and OWDFMW01 was later incorporated into the groundwater long-term monitoring (LTM) program for the Red Hill tank farm, which is set forth in the Red Hill Groundwater Protection Plan (DON 2008a; 2014a). Subsequent laboratory analyses of some groundwater samples collected from OWDFMW01 between January 2010 and October 2015 reported the presence of TPH in the basal groundwater at concentrations that exceeded regulatory screening levels. These detections occurred both before and after a confirmed release of JP-8 from Red Hill Bulk Fuel Storage Facility UST Tank No. 5 in January 2014. The detection of elevated concentrations of TPH prompted the Navy to proactively conduct a site assessment at the Former OWDF to further investigate the nature and extent of potential impacts to the basal aquifer from the site and ascertain whether any response actions are warranted. DOH rescinded the NFA determination for the Former OWDF site on April 8, 2024, and the site assessment is ongoing.

The Former OWDF site assessment will continue concurrently with the Tank Closure Site Assessment. Therefore, the Phase 1 Site Assessment Sampling and Analysis Plan (Worksheet #17) does not include any additional sampling related to the Former OWDF site. Environmental data from the site assessment and any other upcoming evaluations at the Former OWDF site will be integrated into the Phase 1 Tank Closure Site Assessment Report

10.2.2 Environmental Setting

10.2.2.1 FUELS STORED AT THE FACILITY

The Facility was used to store fuel for military purposes from the 1940s until defueling in October 2023. Just prior to defueling, the 20 USTs and associated piping contained approximately 104 million gallons of JP-5, F-76 Marine Diesel, and F-24 Jet Fuel. Main defueling of the tanks was completed in March 2024; the remaining approximately 28,000 gallons of sludge will be removed during subsequent tank cleaning and pipe removal operations.[1]

The history of fuel storage from the 1940s until defueling is summarized as follows (HAER 2015):

- Diesel was stored at the Red Hill tank farm from inception in the early 1940s until the early 2000s.
- Navy Special Fuel Oil (NSFO) was stored at the Red Hill tank farm from inception until the early 1970s.
- AVGAS was stored in USTs 19 and 20 for approximately 2 years in the early to mid-1960s.
- JP-5 was stored at the Red Hill tank farm from the early 1960s until tank defueling in 2023.
- JP-8 was stored at the Red Hill tank farm from the late 1990s until the mid-2010s.
- F-24 jet fuel was stored at the Red Hill tank farm from the mid-2010s until tank defueling in 2023.

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[1] https://www.navyclosuretaskforce.navy.mil/News/Article-Display/Article/3724372/navy-assumes-r-esponsibility-of-red-hill-facility/accessed April 4, 2024.

- F-76 Marine Diesel Fuel was stored at the Red Hill tank farm from the early 2000s until tank defueling in 2023.

All these fuels are middle distillates except for AVGAS, which falls in the range of "gasolines" in accordance with the Hawaii DOH HEER Office *Technical Guidance Manual* (TGM) (DOH 2023).

AVGAS was stored at the Facility for an approximately 2- to 5-year period approximately 60 years ago (HAER 2015). AVGAS storage was limited to Tanks 19 and 20, with transport via the Abandoned AVGAS Pipeline (Section 10.2.1.5). AVGAS was never transported in Facility pipes located makai of (toward the shore from) Adit 6 or in any other Facility UST system infrastructure.

Past releases at the Facility are summarized in Section 10.3.

10.2.2.2 SURROUNDING AREA AND LAND USE

The Facility is zoned by the City and County of Honolulu as a mix of F1-Federal and Military and P-1 Restricted Preservation districts, (b) (3) [redacted] Navy personnel limit access to the site and area. Portions of the site are surrounded by chain-link fencing, and outside the immediate fenced area lie heavily wooded areas. JBPHH security personnel patrol nearby areas.

Between the Facility boundary and JBPHH, the Harbor Tunnel passes beneath a mix of public and residential lands.

10.2.2.3 CLIMATE

The subtropical climate of Oahu is warm, humid, and dominated by the prevailing northeast trade winds and ocean currents. Ocean temperatures are approximately 75–85 degrees Fahrenheit at Honolulu, and air temperatures in Oahu average 70–85 degrees Fahrenheit, with the warmest months being June through October. Northeasterly winds persist most of the year, and the northeastern (windward) sides of the island are commonly the wettest due to orographic lifting and cooling of marine air, which increases precipitation. There are generally two seasons for precipitation on the island: October to April is considered the wet season, and May to September is considered the dry season. On the Koʻolau Range's leeward slopes, precipitation generally increases up-valley as elevation increases, and decreases down-valley. Average annual precipitation in upper North Halawa Valley and upper Moanalua Valley, at approximately 1,000 ft mean sea level (msl) near the ridge line of the Koʻolau Range, is approximately 139 and 137 inches, respectively (i.e., 0.4 inch per day) (USGS 2017b; 2017a) In lower North Halawa Valley at approximately 180 ft msl near municipal water supply well Halawa Shaft, formerly active precipitation gauges (2005–2009) recorded an average annual precipitation of 35–41 inches (i.e., 0.1 inch per day) (USGS 2017c; 2017d).

10.2.3 Topography and Surface Water Drainage Patterns

Four major geomorphic provinces define the island of Oahu: two volcanic mountain ranges (Waianae and Koʻolau), the Schofield Plateau, and coastal plains that form the northwest and south island margins (Stearns and Vaksvik 1935). The Koʻolau Range is a shield (dome) volcano; the east (windward) half of which is “missing” because of collapse due to catastrophic mass wasting (Walker 1990). The pali (cliff line) on the windward side of the range defines the predominantly stream-eroded, back-collapsed scarp. In the south/central part of the range, where the Facility is located, the leeward flank of the shield volcano is eroded into a series of ridges and stream-carved valleys extending generally perpendicular from the Koʻolau crest, which trends northwest-southeast (DON 2019).

Surface water features in the general vicinity of the Facility include South Halawa Stream (an ephemeral stream approximately 600–800 ft north of the USTs), North Halawa Stream (approximately 4,000–4,500 ft northwest of the USTs), and Moanalua Stream (approximately 1,700–2,000 ft south of the USTs). Potential recharge (run-on and operational water use) from Halawa Quarry north of the Facility may also impact groundwater flow in this area. In Halawa Valley, streamflow may contribute water to perched groundwater within alluvial material (valley fill). Most precipitation percolates to the freshwater lens (i.e., basal aquifer) and does not maintain base flows in the streams (Izuka 1992). Groundwater that flows beneath the Facility does not intercept surface water inland of the ocean shoreline (DON 2007). Both South Halawa Stream and Moanalua Stream (to the north and south of the Red Hill ridge, respectively) are losing streams located approximately 170 ft or more above the basal aquifer water table in the vicinity of the Facility tanks.

(b) (3) [redacted]. South Halawa Stream merges with North Halawa Stream west of the Facility near the H-3 and H-201 Freeway interchange. Below the confluence of the two streams, Halawa Stream continues to meander to the west and then drains into the East Loch of Pearl Harbor north of the piers.

10.2.4 Geology and Soils

The Facility is located within the Koʻolau Volcanic series. The Koʻolau formation at Red Hill consists of basaltic lava flows that erupted from a fissure line approaching 30 miles in length and trending in a northwest rift zone (Wentworth and Macdonald 1953). Pāhoehoe and aʻā lava flows are present in the Koʻolau formation. The valleys on either side of the Red Hill ridge were formed as a result of fluvial erosion and are filled with sedimentary deposits (alluvium and colluvium), also known as valley fill, underlain by weathered basalt, also known as saprolite. Saprolite zones in Hawaii are typically around 75 ft thick but can be 300 ft thick or greater beneath the valley floors or in areas of high precipitation (Hunt Jr. 1996; Macdonald, Abbott, and Peterson 1983). The results of a seismic survey conducted in North and South Halawa Valleys, Red Hill, and Moanalua Valley (DON 2018a) found that valley fill and saprolite extend much deeper in the valleys surrounding Red Hill ridge, particularly in the center of the valleys and below the streambeds.

The Facility tanks are surrounded by rock in the vadose (i.e., unsaturated) zone, which consists primarily of basalt flows in complex, alternating layers. These heterogeneous layers vary from extremely high to extremely low permeability, with a correspondingly variable ability to transmit and hold LNAPL depending on the layer’s rock type and micro-pore structure (i.e., high ability in high-permeability aʻā and thin pāhoehoe flows; low ability in massive aʻā and massive pāhoehoe flows; limited transmissivity but high holding capacity in aʻā clinker zones).

Soils in the vicinity of the Facility are mapped as Helemano-Wahiawa association consisting of well-drained, moderately fine-textured and fine-textured soils (USDA SCS 1972). The surfaces of the basaltic flows have been weathered to form reddish-brown clayey silt, which is the basis for the local name “Red Hill.” These soils typically range from nearly level to moderately sloping and occur in broad areas dissected by very steep gulches. They formed in material weathered from basalt to a depth of approximately 10 ft bgs. Along the slopes, the basaltic bedrock is covered with approximately 10–

30 ft of Koʻolau residuum. These soils were derived from weathering of the underlying basalt bedrock or were deposited as alluvium/colluvium. The younger alluvium/colluvium deposits were derived from fractured basalts and tuff. Beneath the surficial soils, alternating layers of clay and basalts are encountered at depth. The northwestern slope of Red Hill is generally barren of soil and consists of outcropping basalt lava flows to the valley floor (DON 2019).

Lava Flows: The presence of nearly horizontal lava flows with variable strike and dip and alternately greater and lesser resistance to erosion at the site has been described in previous investigations and observed during site reconnaissance activities. Rapid erosion of the less-resistant beds, such as aʻā clinker, has resulted in undercutting of the more resistant massive aʻā and pāhoehoe layers. The flows vary from evenly bedded, relatively flat, and continuous to undulating and uneven. Aʻā clinker is composed of gravel- and cobble-size rubble that resembles a conglomerate. It is usually loosely held together unless it has been welded together by heat. Aʻā clinker is extremely permeable and is subject to more rapid chemical weathering processes. Vertical fractures present within individual lava flows of aʻā are also subject to rapid weathering. Similarly, the nearly horizontal contacts between pāhoehoe lava flows, which are absent of aʻā clinker, are susceptible to weathering. Rock layers with denser, more closely spaced intraflow fracturing appear more extensively weathered.

As described by Macdonald's (1941) report on the geology of the Red Hill and Waimalu Areas of Oahu, "*The lava flows form sheets 3 to 50 feet thick, with very irregular tops and bottoms, sloping gently southwestward. Many of them thin toward the southwest. The lavas moved down the slope toward the southwest as relatively narrow streams. Their continuity along the ridge at Red Hill is therefore greater than across the ridge.*"

Hunt Jr. (1996) describes that "*Wentworth and Macdonald (1953) listed measurements for 22 historical flows on Mauna Loa and Kilauea on the island of Hawaii, which presumably are typical of flows on Oahu as well. The flows on Hawaii average about 15 miles in length and about one-half mile in width.*" Given that the distance from the Northwest Rift Zone of Koʻolau volcano to Red Hill is approximately 6–7 miles, aʻā lava flow core widths could be significantly less than one-half mile wide, potentially hundreds of feet wide.

According to Macdonald (1941), many flows thicken or thin rapidly across the ridge, and some pinch out altogether at Red Hill. This implies the existence of relatively narrow flows. If clinker bridges are present, they would be pathways for lateral and vertical flow at the edges of a lava flow but would be limited in areal extent perpendicular to lava flow direction.

Hawaiian volcanic rocks vary in porosity and permeability depending on the emplacement process, lava type, genesis, flow thickness, flow rate, extent, cooling rate, and weathering. Permeability is typically highest in the relatively thick, unweathered rubbly aʻā clinker zones and intensely fractured zones or lava tubes of pahoehoe flows.

Caprock: West and southwest of the Facility, substantial thicknesses of heterogeneous sediments occur on the coastal plains in southern Oahu around Pearl Harbor. These terrestrial and marine sediments and reef limestone deposits form a wedge up to 1,000 ft thick, commonly referred to as caprock, and overlie the lava flows of the basaltic aquifer. Overall, the caprock has lower hydraulic conductivity than the basaltic rocks, and it confines the underlying basal aquifer in the Pearl Harbor and Honolulu areas. Rejuvenation stage volcanics, caprock deposits, deep-stream valley fill sediments, and saprolite all have the potential to impede groundwater flow.

Pyroclastic Deposits: Pyroclastic (airfall) deposits were encountered in rock cores at Red Hill. None have been observed in rock outcrops along Red Hill, but deposits were observed at Moanalua Golf Course and in the Honolulu Board of Water Supply (BWS) Moanalua Water Tunnel that runs south through the lower end of Red Hill from Halawa Valley to Moanalua Valley. These deposits are granular in nature and include ash, cinder, spatter, and larger blocks (i.e., tuff). Due to the highly weathered nature of pyroclastic deposits proximal to Red Hill, their porosity and permeability are similar to those of fine-grained consolidated granular sediments, with similar grain size and degree of sorting.

The southeastern third of Koʻolau volcano's remnant shield (which includes the site vicinity) experienced a rejuvenation stage of volcanism. Situated immediately to the south and southwest of Red Hill and extending to Pearl Harbor in the area of the Pearl Harbor tunnel, the Salt Lake Tuff consists of subaerial gray to brown tuff containing nodules of dunite (Stearns and Vaksvik 1935). It is as thick as 300 ft and passes beneath sea level. It overlies Aliamanu Tuff to its northwest, which is composed of water-laid gray to black or grayish-brown tuff, rounded gravel, and (in tunnels) large vesicular bombs and spatter (Stearns and Vaksvik 1935). It is separated from the overlying Salt Lake Tuff by red soil and typically overlies older alluvium. These tuffs are part of the Honolulu Volcanic Series (i.e., rejuvenation stage of volcanism). Pankiwskyj (1972) mapped the Salt Lake and Aliamanu tuff deposits and found that they are areally extensive and mantle a significant area of Pearl Harbor to the west and southwest of the Salt Lake and Aliamanu Crater areas. The tuff cone vents most likely have associated throat or root structures, based on academic research papers on other similar Honolulu Volcanic Series tuff cones (Wentworth 1938) as well as tuff cones outside of Hawaii (Sohn and Park 2005; White and Ross 2011).

Valley Fill: The deposits within and near the base of the valleys generally consist of fill of highly weathered and compact older alluvium that is mantled with more recent unconsolidated alluvium and colluvium (Oki 2005). The older alluvium consists of terrestrial sediments that vary in size from fine-grained particles to boulders, and is less permeable. The older alluvium has been weathered and compacted into a soft coherent mass (Wentworth 1951). The older alluvium may be hundreds of feet thick at lower altitudes, but at altitudes above approximately 400–600 ft, older alluvium may be nonexistent. These materials overlay highly weathered saprolite.

Saprolite: Based on previously collected rock samples and cores from borings, the horizon of soils and highly weathered basalt described as saprolite on the Red Hill ridge is approximately 15–25 ft thick. Saprolite is weathered rock material that retains textural features of the parent rock. Intense weathering of basaltic rocks can significantly reduce the permeability of the parent rock by transforming igneous minerals to clays and oxides (Hunt Jr. 1996). The saprolite zone beneath valley fill in stream valleys creates a barrier to groundwater flow because of the lower hydraulic conductivity of the clayey weathered basalt material. Saprolite most likely formed beneath a deeply incised paleo-valley that lies below the present-day South Halawa Stream. Geologic cross sections were prepared from available geologic logs of rock cores and from field mapping (see representative Figure 5 from the 2019 Red Hill CSM report [2019]). Geologic logs from the Red Hill groundwater monitoring network, from Macdonald (1941), and from Stearns (1943) were used to correlate the stratigraphy of the basalt flows at Red Hill.

10.2.5 Groundwater Hydrogeology

Groundwater flow and solute transport are controlled by hydraulic conditions (e.g., gradients) and physical properties of the hydrogeologic units, including hydraulic conductivity, effective porosity, specific yield, specific storage, anisotropy, and dispersivity.

Fresh groundwater inflow originates as deep infiltration of precipitation and seepage from surface water features (Figure 6). According to the United States Geological Survey (USGS), estimates of recharge for Oahu for recent conditions (2010 land cover and 1978–2007 rainfall) differ from predevelopment recharge values by only a few percent (Izuka et al. 2018). Spatial distribution of recharge mimics the orographic rainfall pattern—recharge is highest on windward slopes and mountain peaks below the top of the trade-wind inversion. Groundwater outflow includes withdrawals from wells and natural groundwater discharge to springs, streams, wetlands, and submarine seeps. Data collected by the USGS for groundwater levels, saltwater/freshwater interface, spring flow, and stream base-flow indicate an overall reduction in aquifer storage for most areas where groundwater has been extracted; this has caused groundwater levels to decline (Izuka et al. 2018).

Regional groundwater levels decrease from areas of recharge (mauka) to areas of discharge (makai). Locally, water level gradients are extremely low and are influenced by complex geologic conditions (e.g., heterogeneity) as well as by variability in local pumping stresses from water development shafts and wells.

Groundwater in Hawaii exists in two principal aquifer types: basal and caprock. Perched groundwater has also been observed beneath portions of the Facility. The basal aquifer exists as a lens of fresh water floating on and displacing seawater within the pore spaces, open fractures, and voids of the basalt that forms the underlying mass of each Hawaiian island. Near the shoreline and at lower elevations within the coastal plains, groundwater in the basal aquifer is typically confined by the overlying caprock and is under pressure. Waters that flow freely to the surface from wells that tap the basal aquifer are referred to as artesian. The landward edge of the caprock deposits terminates approximately 2,000 ft southwest of the Facility.

Shallow groundwater (at times identified as a perched zone) has been encountered at several locations in the site vicinity including.

- Shallow perched groundwater has been encountered during investigations at the Former OWDF site and release response actions at the Adit 3 and Former Holding Tank and Leach Tank, Halawa Correctional Facility, the City and County of Honolulu Halawa Bus Facility, and Tripler Hospital (DON 2019).
- Shallow perched water-bearing zones were also encountered during drilling of onsite monitoring wells RHMW04 at approximately 183–228 ft msl (DON 2007), and RHMW08 in two zones at approximately 214–217 and 193–198 ft msl.
- Shallow perched groundwater was observed at monitoring well RHMW11 on the South Halawa Valley floor at approximately 110–115 ft msl with continuous saturation within the saprolite (perched conditions not observed) (DON 2018b). The saprolite zone beneath valley fill creates a barrier to groundwater flow because of the lower hydraulic conductivity of the clayey weathered basalt material and higher groundwater levels.

The basal aquifer beneath the Facility is included in the Oahu Sole Source Aquifer (61 Fed. Reg. 47752 Section 1424[e]). The caprock aquifer consists of various kinds of sediments and sedimentary and volcanic rock containing groundwater under unconfined and semi-confined conditions. Commonly, the caprock consists of a thick sequence of nearly impermeable clays, coral, volcanic ash, and basalt that separates the caprock aquifer from the basal aquifer. The impermeable nature of these materials and the artesian nature of the basal aquifer severely restrict the downward migration of groundwater from the upper caprock aquifer (DON 2019).

Drinking Water Supply Wells: The location of regional water supply wells are shown on Figure 7. Additional detail on these wells is presented in the *Groundwater Model Evaluation Plan* (DON 2017a) and the *Conceptual Site Model, Investigation and Remediation, Revision 01* (DON 2019). The Halawa/Red Hill/Moanalua area provided approximately 25 percent of the drinking water for urban Honolulu prior to closure of wells following the November 2021 release. Drinking water supply wells Navy Red Hill Shaft (RHS), BWS Halawa Shaft, and BWS Moanalua Wells are of primary concern for the ongoing investigations at the Facility due to their proximity to the Facility and pumping capacities.

The following water supply wells ceased pumping following the November 2021 release and remain out of service as of the date of this SAWP:

- (b) (3) [redacted] RHS was physically disconnected from the drinking water system to make it unable to serve drinking water, and is currently connected to a water treatment system to support the capture and treatment of the groundwater potentially impacted by the November 2021 release. The treatment system currently discharges treated groundwater into South Halawa Stream rather than supplying drinking water. The discharged water is permitted under a National Pollutant Discharge Elimination System (NPDES) permit and is regularly tested and has met all discharge requirements. As such, untreated water from RHS no longer offers a complete pathway for human exposure.
- BWS Well 3-2354-001 (BWS Halawa Shaft), located approximately 4,600 ft north-northwest of the Facility boundary, provided municipal drinking water to the City and County of Honolulu until it ceased pumping in December 2021 in response to the November 20, 2021 JP-5 release from the Facility.
- (b) (3) [redacted], provided drinking water to JBPHH customers until it ceased pumping in December 2021 out of an abundance of caution in response to the November 20, 2021 JP-5 release from the Facility.

The following active water supply wells in the region continue to provide safe drinking water to the public:

- BWS Moanalua Wells 3-2153-010, -011, and -012 (Moanalua 1, 2, and 3), located approximately 1.3 miles south of the Facility boundary.
- (b) (3) [redacted].

Navy-Installed Groundwater Monitoring Wells: The groundwater monitoring network of approximately 40 existing monitoring wells is designed to monitor and protect the water supply wells by providing early warning of changing conditions that would be indicative of a past release migrating toward the water supply wells (Figure 8).

10.2.6 Vegetation and Wildlife

The ground surface above the Facility Subject to Closure is inhabited by non-native vegetation, including koa haole scrub, disturbed habitat, and landscaped areas. Koa haole grows throughout Oahu, primarily in areas that have been disturbed by grazing or human activities. The scrub community on Red Hill is dominated by koa haole (*Leucaena leucocephala*), guinea grass (*Panicum maximum*), and Chinese violet (*Asystasia gangetica*). The disturbed habitat is composed of weedy plant species that can withstand frequent disturbance by human activities or natural events. Although this vegetation does support some wildlife species, the habitat is considered very low quality and is primarily used by introduced, common urban species. The onsite habitat is not considered sensitive and is dominated by introduced plant and animal species that have replaced native species. No native or sensitive species were observed in a 1995 biological survey of the area (DON 1996b); while no subsequent threatened or endangered species surveys are known to have been conducted at the Facility, anticipated federal or state-listed threatened or endangered species are not known or expected to be present on site (DON 2005). The endangered Hawaiian hoary bat (ōpe‘ape‘a; *Lasiurus cinereus semotus*) could conceivably use the trees; therefore, requirements stipulated in the Categorical Exclusions are followed, and field personnel coordinate with the Navy's Natural and Cultural Resources personnel to obtain clearance prior to mobilizing for field work in areas containing trees. Woody plants greater than 15 ft tall will not be cleared between June 1 and September 15 due to the pupping season for the endangered Hawaiian hoary bat (DLNR 2015).

10.3 PAST RELEASES AT THE FACILITY

Documented fuel and other releases associated with the Facility are summarized below in descending chronological order.

10.3.1 AFFF Concentrate Release from Fire Suppression System at Adit 6, November 2022

Approximately 1,300 gallons of concentrated aqueous film-forming foam (AFFF) (which contains per- and polyfluoroalkyl substances [PFAS])was released at the entrance to Adit 6 during routine testing of the Facility's fire suppression system on November 29, 2022. Impacted areas include a 100-ft-long section of floor inside the tunnel entrance, crushed-rock apron, asphalt roadway, stormwater conveyance system that empties into South Halawa Stream, and underlying and adjacent soils outside the tunnel entrance. Remedial actions initiated the day of the spill include collection of released AFFF concentrate, over-excavation of the crushed-rock apron, removal of impacted stormwater conveyance structures and asphalt, over-excavation of underlying and adjacent soils, and containerization of all recovered material. Subsequent remedial actions to date include product and soil sample analysis and groundwater monitoring. Investigations and remedial actions associated with PFAS will continue under the CERCLA program (DON 2023e).

10.3.2 LAT Fire Suppression Drain Line JP-5 Release, November 2021

On November 20, 2021, JP-5 was released from an overhead 14-inch polyvinyl chloride (PVC) fire suppression drain line to the tunnel floor near Adit 3 (Figure 8). The release point, which is (b) (3) [redacted] is in proximity to the supply well's underlying water development tunnel that extends more than 1,200 ft east-southeast of the pumping station at an elevation of approximately 0–20 ft msl.

The Navy initially reported the release to DOH on November 21–22, 2021 while pursuing an investigation into the cause and extent of the release. On December 5, 2021, after additional investigation, the Navy submitted to DOH a Confirmed Release Notification Form reporting that a release of approximately 14,000 gallons of a mix of water and fuel from a fire suppression drain line in the tunnel downhill of the USTs (DOH 2021, Background).

Released fuel flowed westward along the Adit 3 Tunnel floor past the junction with the Pearl Harbor Tunnel and RHS. Fuel accumulated in two sumps (Adit 3 Sump and a sanitary sewer sump) approximately 750 ft west of the November 2021 release point (Figure 9). JP-5 fuel was recovered from the Adit 3 Sump, connected piping, the fire suppression recovery drain line, and the Holding Tank/Leach Tank area including subsurface soil. JP-5 fuel was also recovered from the sanitary sewer sump and the CHT Tank, which was fed by a pump in the sanitary sewer sump.

The November 2021 release released fuel to the environment via the following pathways:

- Natural and manmade penetrations through the concrete tunnel floor.
- Fuel that accumulated in the Adit 3 sanitary sewer sump was inadvertently pumped to the CHT Tank (see Section 10.2.1.9 for description). The fuel overflowed from the CHT Tank to the surrounding environment during heavy rains in December 2021 and January 2022.
- Fuel also likely back-flowed from the Adit 3 sump into a subfloor Hume pipe drainage system and associated utility corridor (Figure 9). The fuel may have then entered the environment through Hume pipe drainage system.
- Fuel that accumulated in the Adit 3 sump was inadvertently pumped to the Former Holding Tank and Leach Tank (see Section 10.2.1.8 for description), where it seeped into the subsurface leach field adjacent to the Leach Tank.

Fuel was also observed in the RHS water development tunnel. Upon confirmation that a fuel-like odor was present in drinking water in homes served by RHS, the supply well was shut off and isolated from the JBPHH Water Distribution System on November 28, 2021. The Navy initiated quarterly release response reports to DOH in March 2022 (DON 2022a).

It was later determined that the released JP-5 was inadvertently pumped into this overhead fire suppression drain pipeline during the May 2021 release (Section 10.3.3).

10.3.3 LAT Pipeline Breach JP-5 Release, May 2021

On May 6, 2021, Navy personnel responded to a reported release of fuel from a distribution pipeline inside the LAT in the vicinity of Tanks 17, 18, 19, and 20 (Figure 8). The Navy notified DOH of the release within 24 hours of the event and provided DOH preliminary findings of the ongoing investigation on October 1, 2021, indicating that JP-5 fuel was released during a fuel transfer and that there were no leaks from any fuel tanks. The Navy recovered JP-5 fuel from the tunnel drain system and then performed a complete wash down of the area with fresh water on May 7, 2021 (DON 2021c). It was later determined that some below-tank soil vapor monitoring point (SVMP) vaults on the tunnel floor near the May 2021 release affecting the utility of these SVMPs for identifying releases from their associated USTs. The Navy initiated quarterly release response reports to DOH in September 2021 (DON 2021a).[2]

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[2] Quarterly release response reports to DOH for the May and November 2021 Releases were merged starting with the July 7, 2022 quarterly report (DON 2022c).

10.3.4 Shallow Subsurface Soil Contamination at RHMW14, November 2018

Initial drilling of multilevel monitoring well RHMW14 at the Halawa Correctional Facility (Figure 8) was temporarily suspended in late November 2018 due to hydrocarbon odors noted in shallow soil at approximately 12 ft bgs (DON 2019). The landowner officially notified DOH on November 28, 2018. Suspected impacted soil appeared to be shallow and vertically localized (less than 20 ft bgs) based on follow-up analytical samples. A soil sample was collected from the drill cuttings at 12–19 ft bgs and analyzed for TPH and polynuclear aromatic hydrocarbons (PAHs); no results exceeded DOH Tier 1 EALs (internal email communication). Shallow soils were isolated via surface casing and drilling and installation of RHMW14 resumed on January 3, 2019 (DON 2019).

10.3.5 Tank 5 JP-8 Release, January 2014

During Tank 5 refilling operations in January 2014 following a routine 3-year tank inspection and refurbishment process, a release of approximately 27,000 gallons of JP-8 fuel was confirmed and reported to DOH on January 23, 2014 (Figure 8). During that month, a fuel hydrocarbon seep was observed on a tunnel wall below Tank 5, and SVMPs installed beneath Tank 5 exhibited a sharp increase in hydrocarbon vapor concentrations. Subsequent analyses indicated that the causes of the release were defective workmanship in welding by the tank refurbishment contractor, poor inspection, and ineffective quality control (QC). Pursuant to the 2015 AOC, the Navy conducted extensive site characterization investigations, groundwater flow and contaminant fate and transport modeling, and remedial alternative analyses (DON 2020; 2023a; 2023g), and initiated quarterly release response reports to DOH (DON 2014a). The release resulted in EPA, DOH, the Navy, and DLA agreeing to the Red Hill AOC in September 2015 (EPA Region 9 and DOH 2015). The Navy initiated quarterly release response reports to DOH in April 2014 (DON 2014b).[3]

10.3.6 Soil Contamination in Vicinity of Former Slop Tank, 2008–2022

During confirmation sampling following demolition of the Former Slop Tank located (b) (3) in 2008 (Section 10.2.1.6), TPH-DRO was detected in post-removal confirmation samples at concentrations up to 140 milligrams per kilogram (mg/kg) (Shaw 2009).

During a 2013 geotechnical investigation in the vicinity of the Former Slop Tank's location (PGE 2015), one of ten borings (B-5) drilled encountered a "strong hydrocarbon odor" in the weathered clinker and basalt from approximately 26 ft bgs to the total boring depth at 41.5 ft bgs. No samples were submitted for laboratory analysis of petroleum hydrocarbon contamination. The location and layout of the Former Slop Tank, adjacent Former Slop Tank pump, and boring B-5 are depicted on Figure 10.

During 2022 drilling of groundwater monitoring well RHMW17 approximately 200 ft northeast of the Former Slop Tank, soil and perched groundwater contamination was encountered. Notifications, data, and correspondence via email and meetings with DOH, EPA, and DLNR CWRM were provided regarding characterization of the shallow soil contamination and completion of RHMW17 (DON 2024b).

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[3] Quarterly release response reports to DOH for the 2014 Tank 5 Release and the May and November 2021 Releases were merged starting with the December 21, 2022 quarterly report (DON 2022d).

10.3.7 JP-5 Overhead Piping Spill in Tunnel, 2008

In March 2008, approximately 4 gallons of JP-5 fuel was released from overhead piping in the LAT (b) (3). The release landed on a pile of excavated soil covered with plastic sheeting, and migrated into an adjacent trench covered with plywood. Approximately 2 gallons were immediately removed from the ground surface using absorbent material, leaving an estimated 2 gallons to seep into the bedrock in the plywood-covered trench.

A limited removal action and site characterization investigation was conducted in June 2008. The trench was manually excavated to 5 ft below tunnel floor until observed pore-space fluid and staining was diminished; further excavation was halted due to stabilization issues. Although petroleum-impacted rock remains in the trench walls and floor, all potentially mobile fuel was removed. Parameters investigated were TPH, volatile organic compounds (VOCs), PAHs, and flashpoint. The Removal Action Report's Environmental Hazard Analysis determined that the release posed no further significant environmental hazards (DON 2008b).

10.3.8 Underwater Leak at Abandoned AVGAS/JP-5 Line, 2004

During cleaning and abandonment of a fuel pipeline that formerly connected (b) (3) (Section 10.2.1.5), a visible underwater leak was observed near valve chamber VC-4, (b) (3) (Figure 1). The leak was reported in the southernmost of two parallel 6-inch-diameter segments where the pipeline (b) (3) (Figure 1). The pipeline abandonment report (Shaw 2005) indicated that the leak prevented this segment of the line from being cleaned until it was repaired. No further information is available; the abandonment report does not indicate if the "leak" involved release of fuel from the line. There is no record of samples being collected from the subsurface along the former pipeline's approximately 12-mile length during cleaning and abandonment activities.

10.3.9 Release from Diesel UST Near RHS, 1948

In early 1948, the RHS water development tunnel was reportedly contaminated due to a diesel fuel spill, and the water pumping station was shut down from February 19 until April 27, 1948 (DON 1992, pg. 2-33). A Navy investigation concluded that the source of contamination was a 25,000-gallon diesel underground storage tank used to supply fuel for a Standby Power Plant then under construction (Section 10.2.1.7). The Former Standby Power Plant was located approximately 250 ft east-northeast of the pumping station (DON 1992, Figure 2-17). No other information is available.

10.3.10 Historical Tank Gallery Releases

10.3.10.1 1998–2002 SITE CHARACTERIZATION INVESTIGATION (DON 1999; 2002)

During the drilling of angle borings in bedrock under the 18 active fuel storage tanks to identify potential fuel product releases suspected at the Facility, petroleum contamination was encountered under several tanks.

An initial limited investigation conducted at Tanks 9 and 16 in 1998 drilled three borings extending under the width of each tank from inside the lower access tunnel at a downward (vertical) angle of 11 degrees, designed to avoid drilling into the tank's concrete base. Results confirmed the presence of a petroleum mixture within the underlying bedrock of Tank 16. Petroleum staining/saturation was observed on core segments from two of Tank 16's three borings, and free-phase petroleum product was encountered within a rock interval with an approximate thickness of 1.2 ft. Laboratory analysis of collected samples for TPH, VOCs, and PAHs indicated that the petroleum was an unknown mixture of hydrocarbons eluting in the diesel and motor oil range. The liquid sample exhibited TPH ("unknown hydrocarbon") at a concentration 8,100 µg/L. Different degrees of fuel weathering were exhibited in core samples from below Tank 16.

A second expanded investigation in 2000–2001 drilled one central (i.e., non-deflected) angle boring under each of the other 18 tanks at a vertical angle of 13–15 degrees. Samples were analyzed for TPH, VOCs, SVOCs, PAHs, metals, and fuel fingerprinting. Hydrocarbon impacts were noted beneath the floor and at depth in some of the angle borings advanced beneath the USTs. Six borings (under Tanks 1, 2, 3, 6, 13, and 20) exhibited hydrocarbon impacts (i.e., sheen on drill water, hydrocarbon odor, or elevated PID measurements) beneath the concrete floor. A hydrocarbon odor and elevated PID readings were observed at depth in angle borings under 15 of the 20 tanks (Tanks 1, 3, 4, 5, 6, 7, 11, 12, 13, 14, 16, 17, 18, 19, and 20). Fingerprinting analysis confirmed that the sample obtained for analysis contains petroleum hydrocarbons, which probably originated from the tank (DON 2002).

SVMPs were later installed in the central angle borings under the 18 active tanks to form the below-tank soil vapor monitoring network (Figure 11) prescribed in the 2008 Red Hill GWPP (DON 2008a), and the deflected angle borings under Tanks 9 and 16 were grouted shut.

10.3.10.2 2017 SVMP STUDY (DON 2019, APPENDIX B.3)

A 2017 soil vapor study (reported in the Red Hill CSM report) confirmed evidence of recent or historical fuel releases at Tank 5 and the presence of weathered LNAPL below the tank. Low levels of unweathered or lightly weathered petroleum vapors detected at the other tanks were considered likely associated with ongoing Facility operations combined with less volatile compounds likely associated with highly weathered historical releases. The low levels of unweathered petroleum vapors were consistent with minor vapor-phase emissions typical of any fuel storage operation. Although the presence of LNAPL was not reflected in quantitative analysis of soil vapor samples collected from tanks other than Tank 5 in October/November 2017, their chromatograms showed an unresolved hump of less-volatile compounds potentially consistent with the presence of highly weathered LNAPL.

The study's results suggested the presence of weathered LNAPL fuel below Tank 5 and the occurrence of significant ongoing natural source-zone depletion (NSZD) at that location. The results also suggested that the LNAPL observed below the tanks in the 1998–2012 borings has weathered to the point that most or all the volatile constituents have been depleted. The study also found that soil vapor monitoring could be used to track NSZD progress over time. (DON 2019, Appendix B.3).

10.3.10.3 TANK 16 FUEL LOSS FOLLOWING 1948 EARTHQUAKE

After an earth disturbance affecting Oahu on June 28, 1948, fuel gauging at Tank 16 during the period June 28–July 21 indicated a loss of 14 inches in the 100-ft-diameter tank. Tank 16 stored Navy Special Fuel Oil at the time. Further testing was conducted over the next 10 days before the tank was emptied and repaired. The total leakage indicated during the period of June 28–July 27, 1948 was estimated at 1,100 barrels (39,600 gallons) (Bechtel 1949, Section 6(c)). No further information is available.

10.3.10.4 RELEASES DOCUMENTED IN HISTORICAL OPERATIONAL RECORDS

Results of a detailed survey of Facility maintenance and repair records presented during a 2021 DOH contested case hearing for the Facility's UST permit application (DOH Case No. 19-UST-EA-01) tabulated 72 documented releases (Table 10-1).

Table 10-1: Tank Release Quantities Reported in Historical Maintenance and Repair Documentation

Year	Tank	Volume (gallons)
1947	1	5
1947	2	unknown
1948/49	16	11,009
1949	16	17,737
1949	3	4,260
1949	17	1,420
1952	6	unknown
1953	1	unknown
1954	2	0.375
1954	2	10
1958	9	1,500
1964	1	unknown
1964	1	[b]
1964	1	[b]
1964	5	1
1964	12	unknown
1964	19	unknown
1965	1	unknown
1965	1	unknown
1965	5	1
1966	1	unknown
1967	1	unknown
1969	17	1
1970	1	4,623
1971	1	16,830
1971	1	5,031
1972	1	4,810
1972	5	0.5
1973	7	unknown
1973	10	unknown
1973	12	unknown
1973	16	unknown
1975	1	10,671
1975	17	unknown
1976	10	unknown
1976	13	unknown
1977	1	999
1978	1	7,874
1978	1	13,221
1978	7	unknown
1978	9	[b]
1980	9	1,900
1980	10	3,123
1980	11	25,628
1980/81	7	6,505
1981	10	5,097
1981	12	4,280
1981	13	unknown
1981	15	unknown
1981	16	unknown
1981	16	unknown
1982	1	2,417
1982	1	871
1982	14	unknown
1983	1	2,229
1983	1	-1090[a]
1983	1	-1004[a]
1995	14	unknown
1996	9	unknown
1996	10	unknown
1998	7	unknown
1998	10	unknown
1998	16	1,469
1998	19	unknown
1999	1	unknown
2000	19	unknown
2002	6	unknown
2008	2	[b]
2008	2	[b]
2010	5	unknown
2012	unknown	6
2014	5	27,000

Source: Navy Memorandum Re History of Releases and Suspected Release Events at the Red Hill Bulk Fuel Storage Facility (DON 2021b)
[a] Negative volume reflects adjustment to previously reported release volume, based on observations during subsequent leak testing.
[b] Indicates duplicate reported releases or indeterminate information in the available documentation.

The reported release quantities in Table 10-1 total 178,435 gallons. Of the 72 events, 30 were attributed to the telltale leak detection system (which was removed from most tanks by 1983), six to weld flaws, two to corrosion or hole in the tank liner, one to contractor error, and the remainder to unknown causes. Twenty-six events are associated with Tank 1 (out of service since 1999) and Tank 19 (out of service since the mid-1980s).

10.3.11 Former OWDF Releases, 1943–1986

Oily waste residuum generated from routine cleaning and maintenance of the Facility's fuel storage tanks was released to the environment during the Former OWDF's years of operation. A two-phase RI investigated the impact of those releases.

Historical Operation: From the time of its 1943 construction until 1986, the Former OWDF was used as an outlet for sludge and oily wastewater generated from cleaning and maintenance of the Facility's fuel storage tanks. Initially, the Former OWDF contained an unlined oily waste pit (the "Old Pit") where oily wastes were routed, and recoverable oil was skimmed off the fluid surface for reuse. The remaining fluid was either left to evaporate or directed through piping to South Halawa Stream. One reportedly unsuccessful attempt was made to burn off sludge residue that remained in the bottom of the pit, and shortly thereafter in 1948 use of the Old Pit was discontinued and the underlying soil was excavated to a point below visible subsurface contamination (DON 1996a, Section 1.1.2.1).

In 1972, a lined Stilling Basin was constructed in the same approximate location as the Old Pit, for the same purpose of extracting recoverable oil from tank-cleaning wastewater. A former employee indicated that the original basin's asphalt lining began to crack shortly after construction, and it was reconstructed with a concrete liner. Piping to South Halawa Stream remained in place from the Old Pit installation and was reportedly used at least once to divert wastewater from the Stilling Basin to the stream. From 1980 to 1986, the relined Stilling Basin was used to separate reusable fuel and to evaporate water from tank bottom sludges before they were trucked to a fuel reclamation facility at Pearl Harbor for further processing. Use of the Stilling Basin was discontinued in 1986 after the initial subsurface investigation of the Former OWDF (DON 1996b, Section 1.1.2.2).

OWDF Phase I RI (DON 1996b): A 1996 Phase I RI investigated 11 environmental areas of concern and found that soil and perched shallow groundwater was impacted by petroleum hydrocarbons, mainly near the Stilling Basin (see Section 10.2.1.10 for current investigation status). Hydrocarbon contamination was detected in samples collected from disposal pit liquids and sludges, surface and subsurface soil, and the perched groundwater. Analytes with elevated concentrations included TPH and total fuel hydrocarbons (TFH). In addition, several VOCs, PAHs, and phenols were detected.

Contamination was not found in the Adit Number 3 Suspected Release Area, one of 11 environmental areas of concern investigated during the Phase I RI. The area was investigated (with trenching and soil sampling) based on a former employee's anecdotal report (published in the 1992 RI WP) of 1.3 million gallons of fuel spilling out of Adit 3 and into South Halawa Stream sometime during 1943–1945 (DON 1992, Section 2.2.1; 1996b, Section 1.1.2.6). The RI report's conclusions stated that "there is no documentation or evidence found to support this theory [of a massive release]" and that "evidence indicates that the suspected release associated with Adit Number 3 did not occur" (DON 1996b, Section 8.2.5).

Stilling Basin Removal Action (DON 1996a): In response to the Phase I RI interim findings, most of the Stilling Basin contamination was removed by excavation, backfilling, and capping in 1995. Detected concentrations of TPH in several confirmation soil samples collected at the base of the excavation after the removal action still exceeded the cleanup criterion; however, because the excavation was capped and petroleum hydrocarbons were not detected in groundwater samples after completion of the removal action, the removal and treatment of the disposal pit was deemed successful.

OWDF Phase II RI (DON 2000): Phase II conducted two 1998 groundwater sampling events at four shallow perched wells and three new deep basal aquifer monitoring wells; the results reported generally low levels of TPH in perched groundwater samples, and no TPH or PAHs in basal groundwater samples.

10.4 PRELIMINARY EXPOSURE ASSESSMENT

10.4.1 Contaminant Release Mechanisms

LNAPL entering the vadose zone from prior releases would have encountered a complex geology in the surrounding volcanic layers that varies significantly in their permeability and overall structure.

Geologic and water saturation characteristics in the rock could have potentially caused LNAPL to spread as it moves through the rock. As LNAPL moves through the larger pore spaces, some of it could be trapped in poorly connected fractures and blocked by nearby low-permeability regions or by surface tension and capillary forces of moisture, especially water held in the smaller pores. The potential presence of intact lava tubes may have served as preferential pathways and conduits for LNAPL.

Potentially contaminated media are tunnel air (vapor intrusion sub-slab contamination; unconsolidated materials, volcanic rock, and soil/rock vapor surrounding the tanks and tunnel; groundwater beneath the Facility, which has the potential to migrate offsite; and offsite surface water where groundwater may discharge. The tunnel and the fuel transmission lines pass beneath residential land (b) (3) [redacted] (see Figure 2). There is no evidence of a fuel transmission line release ever having occurred in this area. However, vapor intrusion into the indoor air at these residences and the school would be potentially contaminated media if a release occurred in this area.

All fuel has been removed from the onsite portion of the Red Hill UST system. Thus, the onsite portion of the Red Hill UST system is no longer a potential source of new releases.

10.4.2 Fate and Transport Considerations

An interim contaminant fate and transport (CF&T) model (DON 2023a) used the interim best available groundwater flow model (DON 2023d) and source terms developed in the interim best available vadose zone model (DON 2023h). The models simulated where groundwater containing dissolved fuel would go, how the fuel constituents would be naturally attenuated, which receptors may be affected (if any), and what the concentrations at the point of exposure would be. The final version of the CF&T model is being prepared for late 2024.

10.4.3 Exposure Pathways

Human receptors that may potentially contact onsite or offsite media impacted by past releases from the Facility Subject to Closure are occupational workers, construction workers, visitors, and offsite residents. Among the potentially complete exposure pathways identified, the primary pathway of concern is exposure to impacted drinking water via direct ingestion and dermal contact, and via inhalation while showering and bathing with drinking water. Animals and vegetation may also be exposed to drinking water as pets or from irrigation. Exposure by ecological receptors is considered incomplete or insignificant (DON 2019). For drinking water to be impacted, fuel constituents must migrate from the release point to offsite potable water supply wells and into the public water supply system. The current exposure pathway for drinking water from RHS is incomplete; it is physically disconnected from the distribution system.

10.4.4 Nature and Extent of Contamination

10.4.4.1 NATURE AND EXTENT OF CONTAMINATION IN THE VADOSE ZONE BENEATH THE 20 USTS

Vadose zone contamination beneath the 20 USTs has been monitored using SVMPs since 2008. The SVMP network under the fuel storage tanks in the tank farm consists of 47 probes installed during previous investigations in angle boreholes beneath each of the USTs that were active in 2008 (Tanks 2 through 18 and Tank 20). SVMPs were not installed beneath Tanks 19 and 20, which were permanently taken out of service since 1999 and the mid-1980s, respectively.

One angle boring is located under each tank, and two to three probes are installed in each boring. The three probe positions are referred to as shallow (near tank access), middle (near centerline of tank), and deep 13 (near outer opposite edge of the tank) of two to three monitoring points installed in angle borings under the formerly active storage tanks (Figure 11).

Historically, soil vapor monitoring beneath the Facility's fuel storage tanks has been conducted monthly at a minimum in accordance with the existing GWPP (DON 2008a; 2014a), the Red Hill AOC (EPA Region 9 and DOH 2015), and DOH Notices of Interest (NOIs) for the January 2014 Tank 5 release and the May 2021 Pipeline Release (DON 2014b). Since the 2021 releases, all SVMPs beneath the tanks have been sampled with a PID at least weekly except for SV15M, which is non-operational.

10.4.4.2 NATURE AND EXTENT OF CONTAMINATION IN THE BASAL AQUIFER

The extent of fuel-impacted basal groundwater as estimated in the Third Quarter 2023 Groundwater Monitoring Report (DON 2023b) is shown on Figure 12. Of the 33 monitoring wells sampled as part of release response efforts in 2023, fuel constituents were detected in nine monitoring wells and exceeded EALs only in RHMW02, for TPH-DRO. RHMW02 is located within the LAT adjacent to Tank 5.

Delineation wells continue to be installed to evaluate basal aquifer groundwater quality in the vicinity of the Facility. Perched groundwater has also been impacted in select locations. The purpose of groundwater sample collection from perched aquifers located beneath the Adit 3 and Pearl Harbor Tunnels is to evaluate impacts to shallow groundwater located above the basal aquifer. These data help to further characterize the occurrence, nature, and extent of fuel impacts and the potential for perched groundwater to serve as a source that could further impact the basal drinking water aquifer beneath it.

10.4.4.3 NATURE AND EXTENT OF CONTAMINATION AT ADIT 3

Investigation and sampling activities in response to the November 2021 release began on November 29, 2021. Characterization results for the shallow vadose zone (OU-1) are presented in a Draft Site Characterization Report (DON 2023g). Site characterization activities of the saturated/deep zone (OU-2) continue at Adit 3, and a site characterization report is forthcoming. Site characterization sampling locations as reported in the June 20, 2023 Quarterly Release Response Report (DON 2023f) are shown on Figure 13.

10.4.4.4 NATURE AND EXTENT OF CONTAMINATION AT THE FORMER HOLDING TANK AND LEACH TANK AREA

Characterization of the Former Holding Tank and Leach Tank area (Figure 9) occurred in two phases. Phase 1 of the characterization field work occurred from January 11–13, 2022 and consisted of sampling 21 soil borings in the vicinity of the Former Holding Tank and Leach Tank, where an unknown quantity of JP-5 was released to the environment during the November 20, 2021 release at Adit 3. Phase 1 activities and results were documented in a Draft Technical Memorandum in February 2022 (DON 2022f).

Following consultation with DOH and EPA, the Navy conducted Phase 2 field work from March 9–17, 2022 to vertically delineate the petroleum in subsurface soil and to characterize petroleum in the shallow perched water body located at approximately 30 ft bgs in the investigation area. Details and results of the Phase 2 field work were presented to the Regulatory Agencies in a *Final Technical Memorandum, Phase 2 Holding Tank and Leach Tank Characterization, November 2021 Pipeline Release* (DON 2023c).

After completion of the delineation field work, the Navy conducted a two-phase removal action. The first phase, completed in May 2022, included removal of the Holding Tank, Leach Tank, and petroleum-impacted soil immediately surrounding the tanks. The second phase, completed in September and October 2022, included removal of additional impacted soil to further mitigate the threat to human health and the environment.

Once the removal action confirmation sampling results have been evaluated by the Regulatory Agencies, the Navy will develop site-specific risk-based action levels following the DOH HEER Environmental Hazard Evaluation process and, if necessary, develop and implement an Environmental Hazard Management Plan in accordance with HEER guidelines.

10.4.4.5 NATURE AND EXTENT OF CONTAMINATION AT THE FORMER SLOP TANK

In 2008, following the removal of the Former Slop Tank, 13 soil samples were collected from the excavation area (Shaw 2009). Ten of these samples were analyzed for TPH as JP-5 (C10–C16) range, and two soil samples were analyzed for TPH as diesel (C10–C24). The reported concentrations were less than the contemporary and current DOH EALs. The sampling locations and analytical results are shown on Figure 10.

During two separate non-related investigations outside Adit 6 near the Former Slop Tank location and the Abandoned AVGAS Line in 2013 and 2022, investigators observed fuel odors during drilling activities. In 2013 while advancing Boring B-5 [redacted] (b) (3) during a geotechnical investigation (PGE 2015), "strong hydrocarbon odors" were reported in weathered clinker between approximately 32 and 40 ft bgs. In 2022 while drilling nearby monitoring well RHMW17, a hydrocarbon odor was reported in a soil sample collected from the borehole at approximately 38 ft bgs (DON 2022b). A chromatogram of the sample was consistent with undegraded JP-5. The locations of B-5 and RHMW17 are shown on Figure 10.

Worksheet #11: Project Quality Objectives/Systematic Planning Process Statements

This worksheet documents the project quality objectives (PQOs) developed for the Phase 1 Closure Site Assessment in accordance with Steps 1 through 7 of the EPA 7-Step Data Quality Objectives (DQOs) process, as defined in *Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4* (EPA 2006) and Naval Facilities Engineering Systems Command (NAVFAC) Pacific Project Procedure I-A-1, *Development of Project Quality Objectives* (DON 2015). The seven-step process is an evaluation tool used to identify the problems, goals of the study, and steps required to make appropriate decisions.

11.1 STEP 1: STATE THE PROBLEM

The Navy is in the process of permanently closing the Red Hill Bulk Fuel Storage Facility under an Emergency Order from DOH (DOH 2022) and an Administrative Consent Order (ACO) with EPA (EPA Region 9 2023). The ACO defines the Facility Subject to Closure as follows:

- The 20 USTs
- The three aboveground fuel transmission lines within the lower access tunnels that extend from the 20 USTs to the UGPH
- The four underground Surge Tanks located (b) (3)

The Emergency Order stipulates that "closure of the Facility must occur in accordance with chapter 11-280.1, HAR." The ACO has a similar requirement. The HAR §11-280.1 regulations regarding site assessments that are conducted in connection with a current permanent tank closure are provided in HAR §11-280.1-72:

> "**§11-280.1-72 Assessing the site at closure or change-in-service**. (a) Before permanent closure or a change-in-service is completed, owners and operators must measure for the presence of a release where contamination is most likely to be present at the UST site. In selecting sample types, sample locations and measurement methods, owners and operators must consider the method of closure, the nature of the stored substance, the types of backfill and surrounding soil, the depth and flow of groundwater, and other factors appropriate for identifying the presence of a release. The requirements of this section are satisfied if one of the external release detection methods allowed in section 11-280.1-43(5) and (6) is operating in accordance with the requirements in section 11-280.1-43 at the time of closure and indicates no release has occurred. (b) If contaminated soils, contaminated groundwater, or free product as a liquid or vapor is discovered under subsection (a), or by any other manner, owners and operators must begin release response action in accordance with subchapter 6."

HAR §11-280.1 also has regulations pertaining to the assessment of UST systems with field-constructed tanks or an airport hydrant fuel distribution system that were permanently closed before August 9, 2013. These regulations, which are potentially applicable to the Abandoned AVGAS Line, the Former Slop Tank and associated pipes, and the Former Standby Power Plant, are provided in HAR §11-280.1-73:

> "**§11-280.1-73** - Applicability to previously closed UST systems (a) When directed by the department, the owner and operator of an UST system permanently closed before December 22, 1988 must assess the excavation zone and close the UST system in accordance with this

> subchapter if releases from the UST may, in the judgment of the department, pose a current or potential threat to human health and the environment.(b) When directed by the department, the owner and operator of an UST system with field-constructed tanks or an airport hydrant fuel distribution system permanently closed before August 9, 2013 must assess the excavation zone and close the UST system in accordance with this subchapter if releases from the UST may, in the judgment of the department, pose a current or potential threat to human health and the environment."

As summarized in Worksheet #10, the Red Hill UST system operated for approximately 80 years from 1943 until defueling was completed in 2024. Multiple fuel releases at the Facility have been reported over the approximately 80-year operational life of the system, as summarized in Section 10.3. The presence of contamination from fuel releases at the Facility has been confirmed in the vadose zone beneath the USTs, beneath the Adit 3 floor, at the Former Holding Tank/Leach Tank area, near the Former Slop Tank, and at the Former OWDF.

Other areas of the Facility have not been assessed to determine the presence or absence of contamination from previous fuel releases. To fulfill the requirements of the Emergency Order and the ACO, the Navy will complete a Site Assessment. that will include passive soil vapor sampling, soil sampling, and active soil vapor sampling at the areas of the Facility that have not previously been assessed to determine the presence or absence of contamination from fuel releases from the Red Hill UST system. The new data will be integrated with the existing data to inform a comprehensive assessment of the Red Hill UST system at the Facility.

11.2 STEP 2: IDENTIFY THE STUDY GOALS

The second step of the PQO process involves identifying the key questions that the study attempts to address, the alternative outcomes that may result based on the answers to these key questions, and the development of decision statements. The principal study questions (PSQs) identified for this project are as follows:

- *PSQ #1:* Have sufficient data been collected to assess the presence or absence of releases at the areas within the Study Boundaries where contamination from the Red Hill UST system is most likely to be present?
- *PSQ #2:* Do sample results indicate the presence of previously unidentified fuel contamination from petroleum releases from the Red Hill UST system?

11.3 STEP 3: IDENTIFY THE INFORMATION INPUTS

The third step in the PQO process determines the following: (1) the types and sources of information needed to answer the PSQs and resolve the decision statement; (2) the quality of information needed; (3) whether the historical data are sufficient to make the decision or whether new data are required; and (4) the QC protocols.

Data collected from previous onsite investigations are insufficient to satisfy HAR §11-280.1 Subchapter 7 requirements for a Tank Closure Site Assessment. Therefore, a Site Assessment involving the collection of environmental samples at locations where previously unidentified petroleum contamination from a release from the Red Hill UST system may be present.

Primary decision inputs will include the following:

- *Past reported releases:* The Site Assessment Report will provide data for all areas associated with a past verified or unverified reported release (Section 10.3). The presence of contamination from reported fuel releases has already been determined at Adit 3, the Former Holding Tank and Leach Tank Area, the Former OWDF, the Former Slop Tank, and the Tank Farm beneath the 20 USTs (including Tank 5). Sampling has not been performed to determine the presence or absence of contamination from the reported 1948 diesel release at the Standby Generator Plant and the CHT Tank. Environmental samples will be collected from the Standby Generator Plant to assess current conditions in this area. In addition, samples will be collected from the CHT Tank area per the conditional approval of the Work Plan.
- *Potential release sources:* The Site Assessment Report will provide data for potential release sources. The potential release sources are the components (tanks, pipes, and appurtenances) that comprise the Red Hill UST system. As noted above fuel contamination has already been determined at Adit 6 (which includes a section of the FOR line), the CHT Tank, the Former Holding Tank and Leach Tank Area, the Former OWDF, the Former Slop Tank, and the Tank Farm beneath the 20 USTs. Sampling has not been performed to determine the presence or absence of petroleum contamination from releases from the fuel transmission lines, FOR line, Tank 311, the Surge Tanks, the section of the Abandoned AVGAS Line that is within the Facility boundaries, or the 8-inch Slop Tank supply that transits Adit 6. Environmental samples will be collected adjacent to these components of the Red Hill UST system to determine the presence or absence of contamination from past releases.
- *Age of available data:* The age of the existing available data have been evaluated to assess their applicability to the Phase 1 Closure Site Assessment. The soil data that was collected approximately 15 years ago from beneath the Slop Tank in 2009 (Section 10.3.6) is not considered to be representative of current site conditions. Environmental samples will be collected in the area of the Slop Tank during the Phase 1 Closure Site Assessment to assess current conditions.
- *Potential conduits to the subsurface:* Natural and manmade penetrations in the tunnel floor and sumps within the tunnel could have served as conduits facilitating the flow of fuel contamination into the subsurface if unreported releases from Red Hill UST system have occurred. Environmental samples will be collected from beneath the tunnel floor at locations near these potential conduits to confirm the presence or absence of contamination from past releases.
- *Nature of the stored substances:* Except for several years when AVGAS was stored in Tanks 19 and 20 and conveyed in the now-abandoned AVGAS Line, the Red Hill UST system stored middle distillates. Sampling at the Abandoned AVGAS Line will target gasoline, middle distillates, and degraded fuels. Sampling at all other locations will target middle distillates and degraded fuels.

11.4 STEP 4: DEFINE THE STUDY BOUNDARIES

The objective of PQO Step 4 is to define the spatial and temporal study boundaries of the populations covered by the decision statements to ensure that the data collected are representative of the population. Practical constraints that could interfere with sampling are also identified. The spatial boundaries represent both horizontal and vertical extents.

The horizontal boundaries for the Phase 1 Closure Site Assessment are the 144-acre Facility property boundaries; the approximately 3.2-mile-long LAT, Harbor Tunnel, and Makalapa Tunnel; and the Surge Tanks (Figure 2). The study boundaries will be divided into the following Study Areas, which are described in more detail in Worksheet #17:

- The Tank Farm Study Area extends from the easternmost wall in the tunnel to the east side of Tanks 1 and 2 (Figure 14). Environmental samples will be collected in the LAT Study Area to determine the presence or absence of contamination that could have been released from the fuel transmission lines or FOR line and entered the subsurface through the sumps, drains, and floor penetrations in this area.
- The LAT Study Area extends from the west boundary of the Tank Farm Study Area to the intersection of the Harbor Tunnel, Adit 3, and the LAT (Figure 15). Environmental samples will be collected in the LAT Study Area to determine the presence or absence of contamination that potentially could have been released from the fuel transmission lines or FOR line and entered the subsurface through the sumps, drains, and floor penetrations in this area.
- The Adit 3 Study Area extends from the Adit 3 entrance to the intersection of the Harbor Tunnel, Adit 3, and the LAT (Figure 13). Adit 3 is the location of the November 2021 release and the associated ongoing release response action. The existing environmental data from this release response action will be incorporated into the Site Assessment Report to address the November 2021 release and the section of the FOR line that transits Adit 3.
- The Former OWDF Study Area includes the area within the Former OWDF boundaries that are shown on Figure 16. The existing environmental data from past and ongoing Former OWDF investigations will be incorporated into the Phase 1 Closure Site Assessment Report. Environmental samples will not be collected from this area as part of the Phase 1 Closure Site Assessment.
- The CHT Tank Study Area includes the CHT Tank and the immediate surrounding area (Figure 16). The CHT Tank will be sampled in accordance with the Site Characterization Plan Addendum (DON 2024c), and the associated results will be incorporated into the Phase I Site Assessment.
- The Tank 311 Study Area includes Tank 311 and the outdoor section of the FOR line that extends from the Adit 3 entrance to Former Tank 311 (Figure 16). Environmental samples will be collected in the Tank 311 Study Area to determine the presence or absence of contamination that potentially could have been released from Tank 311 and the FOR line.
- The Former Holding Tank and Leach Tank Study Area includes the Former Holding Tank and Leach Tank excavation area (Figure 16). The existing environmental data from the ongoing Holding Tank/Leach Tank release response action will be incorporated into the Phase 1 Closure Site Assessment Report. Environmental samples will not be collected from this area as part of the Phase 1 Closure Site Assessment.
- The Harbor Tunnel Study Area extends from the (b) (3) (Figure 17). Environmental samples will be collected in the Harbor Tunnel Study Area to determine the presence or absence of contamination that potentially could have been released from the fuel transmission lines and entered the subsurface through the sumps, drains, and floor penetrations in this area.
- The Surge Tanks Study Area includes the four underground Surge Tanks that are (b) (3) (Figure 18). Environmental samples will be collected in the Surge Tanks Study

Area to determine the presence or absence of contamination that potentially could have been released from the Surge Tanks.

- The Former Standby Power Plant Study Area includes the Former Standby Power Plant (Figure 19). Environmental samples will be collected in this area to assess the presence or absence of contamination from the reported 1948 release or other unreported releases.
- The Abandoned AVGAS Line Study Area extends the length of the AVGAS Line from the Adit 6/Tank Farm intersection to the Facility Boundary (Figure 20). Environmental samples will be collected in this area to assess the presence or absence of contamination that potentially could have been released from the Abandoned AVGAS Line. An approximately 100-ft section of the Adit 6 tunnel floor has been sealed as part of the response action to the November 2022 AFFF release. To protect the seal, this approximately 100-ft section of the Adit 6 tunnel floor will not be sampled.

Given that the objective of the Phase 1 Closure Site Assessment is to "measure for the presence of a release where contamination is most likely to be present," sampling will focus on shallow subsurface environmental media beneath aboveground pipes, aboveground storage tanks, and buried pipes. The bottoms of the buried Abandoned AVGAS Line, abandoned 8-inch slop, and underground section of the FOR line are unlikely to be deeper than approximately 4 ft bgs (the actual depth will be determined in the field). Thus, the vertical boundaries are approximately 5 ft bgs. The Navy will notify DOH and EPA if it becomes necessary to adjust the horizontal or vertical boundaries.

The temporal boundary for the Phase 1 Closure Site Assessment is limited to the time necessary to complete the field activities and data evaluation.

11.5 STEP 5: DEVELOP THE ANALYTIC APPROACH AND DECISION RULES

Step 5 in the PQO process develops decision rules that will guide the analytical approach used to draw conclusions from the data. The following decision rules have been developed for the project:

- *PSQ #1:* Have sufficient data been collected to determine the presence or absence of releases at the areas within the Study Boundaries where contamination from the Red Hill UST system is most likely to be present?
  - Outcome 1 (Yes): Recommend that the onsite UST system has met the HAR §11-280.1 Subchapter 7 Site Assessment requirements.
  - Outcome 2 (No): Recommend that additional onsite sampling should be conducted to meet the HAR §11-280.1 Subchapter 7 Site Assessment requirements.
- *PSQ #2:* Do sample results suggest the presence of previously unidentified fuel contamination from petroleum releases from the Red Hill UST system?
  - Outcome 1 (Yes): Evaluate the entire body of data from the Red Hill UST system and work with DOH and EPA to determine the appropriate response action.
  - Outcome 2 (No): Continue to implement and assess the existing response actions under their existing regulatory programs to determine if No Further Action is required for the other areas of the Red Hill UST system within the Study Boundaries.

11.6 STEP 6: SPECIFY PERFORMANCE OR ACCEPTANCE CRITERIA

Step 6 identifies the criteria that will be used to determine whether the data are of sufficient quality to make the decisions outlined above. This subsection identifies the potential sources of study error and describes how those errors will be minimized throughout the investigation.

11.6.1 Sources of Error

Sources of error in an investigation can be divided into two main categories: sampling error and measurement error. A sampling error (field or laboratory) occurs as a result of a sampling design that does not allow for an equal probability of including any given part of the population of interest in the sample. A measurement error occurs as a result of performance variance from laboratory instrumentation, analytical methods, and operator error. EPA identifies the combination of all these errors as the “total study error” (EPA 2006). One objective of the investigation is to reduce the total study error so that decision makers can be confident that the data collected accurately represent the chemical characteristics of the site.

11.6.2 Managing Decision Error

The investigation will use techniques to minimize total study error with sampling design, sampling methodologies, and laboratory measurement of COPCs. The following methods will be used during the field investigation to minimize possible total study errors:

- Evaluate all available historical data to identify COPCs, select appropriate sampling locations, and define site characteristics.
- Apply standardized field sampling methodologies as discussed in Worksheets #17 and #18.
- Use applicable standard analytical methods as discussed in Worksheets #23, #24, and #25 for sample analysis by an analytical laboratory accredited by the United States Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP), to reduce measurement error.
- Validate the analytical data to identify and control potential laboratory error and sampling error using spikes, blanks, and field duplicates as discussed in Worksheets #34 through #36.

Decision errors associated with judgmental sampling are based on sampling design and measurement errors. Assuming that the best possible professional judgment was used to develop the judgmental sampling plan (i.e., position sampling locations), the most important total study errors will be associated with field and laboratory techniques involved in the collection and analysis of the data.

11.6.3 Identifying and Managing Measurement Error

Possible decision errors generated by sampling errors will be minimized during the field investigation by applying standardized field sampling methodologies as discussed in Worksheet #17 and applicable standardized field sampling methodologies as discussed in Worksheets #18, #20, #21, and #22.

Potential decision errors will be minimized by controlling laboratory measurement error to the extent practicable. Laboratory sampling error may be introduced during preparation and analysis of samples. Laboratory measurement errors will be controlled by following standard analytical procedures and methods; evaluating quality assurance (QA)/QC data; and calibrating, maintaining, testing, and inspecting laboratory equipment (see Worksheets #23, #24, and #25). An analytical laboratory accredited by DoD ELAP will analyze samples using appropriate analytical methods (discussed in

Worksheets #23, #24, and #25), and qualified laboratory technicians will operate laboratory instruments to reduce measurement errors. The laboratory operates under the baseline requirements as outlined in the DoD/Department of Energy Quality Systems Manual, Version 6.0 (DoD and DOE 2023).

11.7 STEP 7: OPTIMIZE THE DESIGN

The objective of Step 7 in the PQO process is to use the acceptance criteria generated in Steps 1–6 to develop a resource-effective design for collecting and measuring environmental data. The principal objective of the sampling and analysis program is to assess whether unknown onsite releases have occurred in areas that have not been previously investigated. The sampling design for this Closure Site Assessment has been developed to collect and measure environmental data in a manner that is efficient in terms of meeting regulatory requirements, cost, and project schedule; and to generate data to satisfy the DQOs.

For this sampling design, the principal objective is to evaluate whether the analytical results indicate the presence or absence of petroleum contamination associated with a release from the Red Hill UST system. In summary, the Phase 1 Closure Site Assessment objectives will be achieved as follows:

- Identify areas that are known to be impacted with petroleum from releases from the Red Hill UST system and are currently under investigation (Worksheet #10).
- Identify the areas of the Facility that have not been previously assessed for the presence or absence of petroleum-related contamination and would likely have been impacted by any known or suspected releases that may have occurred (Worksheet #10).
- Identify target analytes and sampling methods that will provide comprehensive assessment of the presence or absence of volatile, semivolatile, and non-volatile fuel constituents and additives at each sampling location (Worksheet #15).
- Implement the Sampling and Analysis program that is described in Worksheet #17 to identify areas in which petroleum-related contamination associated with releases from the Red Hill UST system is present and those areas in which such contamination is absent.
- Integrate the findings of the Phase 1 Closure Site Assessment sampling and analysis program and the other Red Hill investigations to develop a Facility-wide understanding of the presence and absence of petroleum-related contamination associated with releases from the Red Hill UST system. The integrated findings will provide the basis for recommending next steps and answering the decision rules described in Section 11.5 (Step 5: Develop the Analytic Approach and Decision Rules).]

It is believed that an adequate number of sampling locations are planned to satisfy the data needs, achieve the project objectives, and enable informed management decisions. The quality of data collected during the investigation should support recommendations for further action or no further evaluation.

Worksheet #12: Field Quality Control Samples

Measurement Performance Criteria Table – Field QC Samples

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 ≤50% water [d] RPD ≤100% soil (judgmental) [d]
Field blank	All	Once per source of decontamination water per sampling event	Adequacy of the decontamination water quality	≤1/2 of LOQ
Equipment rinsate	All	5% of primary samples collected per matrix per analytical method	Adequacy of the decontamination process	≤1/2 of LOQ
Trip blank	VOCs, TPH-GRO (soil, water, soil gas)	One per cooler	Contamination during sample transport	≤1/2 of LOQ

%	percent
DQI	data quality indicator
GRO	gasoline range organics
LOQ	limit of quantitation
QC	quality control
RPD	relative percent difference
RSD	relative standard deviation
TPH	total petroleum hydrocarbons
VOC	volatile organic compound

[a] Refer to Worksheets #11 and #15 for a list of all analytical groups.
[b] Per Procedure III-B, *Field* QC Samples (DON 2015); refer to Worksheet #20 for a summary of QC samples by project location, matrix, and analytical group.
[c] Per Section 10.6.1.2, *Technical Guidance Manual* (DOH 2017b).
[d] Per Section II, *Data Validation Procedures* (DON 2015).

Worksheet #13: Secondary Data Criteria and Limitations Table

Secondary Data Criteria and Limitations Table

Secondary Data	Data Source	Data Generator	How Data Will Be Used	Limitations on Data Use
Tank Farm SVMPs Data	EDMS and historical reports	DON	Provide a comprehensive Site Assessment of the Red Hill UST System within the Phase 1 boundaries.	No Limitations
Former OWDF data	NIRIS and historical reports	DON	Provide a comprehensive Site Assessment of the Red Hill UST System within the Phase 1 boundaries.	No Limitations
RHMW21 soil data	EDMS and historical reports	DON	Provide a comprehensive Site Assessment of the Red Hill UST System within the Phase 1 boundaries.	No Limitations
Former Slop Tank data	Historical reports and field observations from RHMW17 and B-5	DON	Provide a comprehensive Site Assessment of the Red Hill UST System within the Phase 1 boundaries.	No Limitations
Adit 3 investigations data	EDMS and historical reports	DON	Provide a comprehensive Site Assessment of the Red Hill UST System within the Phase 1 boundaries.	No Limitations
CHT investigations data	EDMS and historical reports	DON	Provide a comprehensive Site Assessment of the Red Hill UST System within the Phase 1 boundaries.	No Limitations
HT/LT investigations data	EDMS and historical reports	DON	Provide a comprehensive Site Assessment of the Red Hill UST System within the Phase 1 boundaries.	No Limitations
Reported releases	Historical records	DON	Provide a comprehensive Site Assessment of the Red Hill UST System within the Phase 1 boundaries.	No Limitations
HT/LT investigations data	EDMS and historical reports	DON	Provide a comprehensive Site Assessment of the Red Hill UST System within the Phase 1 boundaries.	No Limitations

CHT	Collection, Holding, and Transfer Tank
HT/LT	Holding Tank and Leach Tank
OWDF	Oily Waste Disposal Facility
SVMP	Soil Vapor Monitoring Probes
UST	underground storage tank

Worksheet #14: Summary of Project Tasks

This worksheet provides a brief overview of project activities. The DON (2015) procedures cited in this worksheet are from the *Project Procedures Manual, U.S. Navy Environmental Restoration Program, NAVFAC Pacific* (DON 2015) and are presented in Appendix E. Details of sampling design and rationale are presented in Worksheet #17.

14.1 SITE PREPARATION

The activities presented in the following sections will be completed prior to drilling and sampling activities.

14.1.1 Dig Permit Procurement

Navy dig permits will be prepared for subsurface sampling. Permit procurement will be divided into the follow designations based on specific sampling areas as listed below:

- Tunnel (Tank Farm, Lower Access Tunnel, Harbor Tunnel, Former Standby Power Plant)
- Tank 311
- Former Slop Tank
- Abandoned AVGAS Line
- Surge Tanks

14.1.2 Site Reconnaissance

A site reconnaissance will be performed in preparation for drilling and sampling activities. Field team personnel will identify potential boring locations and any obstructions that could hinder site activities, determine layout for equipment and staging materials, evaluate site conditions, and visually inspect the site for potential health and safety hazards. Site reconnaissance specific to tunnel locations and the Surge Tank locations are described in detail below.

14.1.2.1 TUNNEL (TANK FARM, LOWER ACCESS TUNNEL, HARBOR TUNNEL, FORMER STANDBY POWER PLANT)

Due to limitations that can arise from performing work inside the Facility tunnel, in addition to what was stated above, the following will be determined during site reconnaissance:

- The closest 110-volt electrical outlet to proposed sampling location and confirmation that the outlet is operating properly.
- The nearest entrance and exit for proposed sampling locations based on distance and accessibility.
- Suitable locations for staging equipment within the tunnel that are near proposed sampling locations but out of the way of other concurrent activities in the tunnel, including train movement and other tank closure activities.
- The most efficient mode of transportation throughout the tunnel for personnel and equipment, such as a standard bicycle with trailer or hand cart, considering stairwells and other limitations depending on which entrance and exit points the field team personnel will use.

- Whether any light bulbs need to be replaced to provide adequate lighting or whether additional lighting is deemed necessary and how power will be supplied to the additional light source (e.g., battery, outlet).
- Whether standing water is present due to water seeping through walls that need to be removed or diverted so as not to compromise sample integrity.
- Access into the Former Standby Power Plant, to be coordinated with the Navy RPM.
- The need for deconfliction between different concurrent closure efforts within the tunnel, such as pipeline removal and tank cleaning, to be coordinated by the Navy RPM and may include the issuance for daily work permits for deconfliction/emergency notification purposes.

14.1.2.2 SURGE TANKS

The Surge Tanks are most easily accessed through JBPHH and are not located within the confines of the RHBFSF gates. During site reconnaissance, the field team will make note of any obstructions that could hinder site access during drilling such as locked gates and storage items such as shipping containers, vehicles, and dumpsters. and coordinate with the Navy RPM to ensure that sampling teams will have adequate access to proposed drilling and sampling areas.

14.1.3 Vegetation Clearance

Vegetation clearance including the removal of small trees, scrub, and grasses will be performed by a qualified subcontractor to provide access for sampling activities, where necessary. Woody plants greater than 15 ft tall will not be cleared between June 1 and September 15 due to the pupping season for the endangered Hawaiian hoary bat (ōpeʻapeʻa; *Lasiurus cinereus semotus*) that may be present in the area (DLNR 2015).

Green waste will be placed in approved containers and disposed of in accordance with the JBPHH Green Waste Policy dated March 22, 2022 (Appendix E) to prevent the spread of the invasive coconut rhinoceros beetle. Vegetation clearance activities specific to Tank 311 and the Abandoned AVGAS Line are described in detail below.

14.1.3.1 TANK 311

The proposed location of sample T3110004 on the southeast side of Tank 311 is in a heavily vegetated area. A transect of at least 5 ft by approximately 25 ft will need to be cleared for access to the proposed sampling location prior to the geophysical survey.

14.1.3.2 ABANDONED AVGAS LINE

According to Navy geographic information system (GIS) files, the Abandoned AVGAS Line appears to cross behind a fence line through a vegetated area [redacted] (b) (3) (Figure 16). Because the exact location of the line will not be known until the geophysical survey is conducted (Section 14.2.2), it is recommended that special attention is provided to ensure sufficient geophysical and potholing activities are completed prior to vegetation clearance to ensure vegetation is cleared in the appropriate location.

Once the geophysical survey (Section 14.2.1) and potholing (Section 14.2.2) activities have been completed, the vegetation clearance activities will be conducted. It is assumed that two separate transects will be cleared for adequate drilling and sampling access to the Abandoned AVGAS Line.

The first transect will be approximately 5 ft × 215 ft between the section of vegetated area between (b) (3) The second transect will be approximately 5 ft × 900 ft between the approximate location of the Former Holding Tank and Leach Tank toward the southwest to where the Abandoned AVGAS Line (b) (3). Transect locations and widths are subject to change pending the results of determining the location of the Abandoned AVGAS Line.

14.1.4 Traffic Control

Field teams will set up sufficient cones, barricades, or delineators in sampling areas where they are deemed necessary.

Abandoned AVGAS Line. Traffic control will be necessary to manage traffic patterns on (b) (3) during geophysical clearance and sample collection. It is assumed that the Abandoned AVGAS Line runs underneath (b) (3) a span of approximately 4,700 ft (Figure 20). A traffic control plan will be designed prior to geophysical locating and may be amended pending results of the geophysical survey.

14.1.5 Access Gate Construction

An access gate may be required to provide adequate access to the Abandoned AVGAS Line (b) (3) (Figure 16). The area is currently accessible through an approximately 3-ft-wide gate; however, a section of fence may require removal to accommodate drilling equipment. This will be determined after the geophysical survey (Section 14.2.1) is performed to identify the exact location of the Abandoned AVGAS Line. If any fencing needs to be removed, the Navy RPM will coordinate with Security on requirements.

14.2 LOCATING ABANDONED AVGAS LINE AND SURGE TANKS

Historical plans, figures, photographs, and as-builts were reviewed to help best identify the exact below-ground location of the Surge Tanks and Abandoned AVGAS Line. Their approximate locations are plotted on Figure 18 and Figure 20, respectively. Prior to any ground-disturbing activities, the exact location of the Abandoned AVGAS Line and Surge Tanks will be determined with a geophysical survey and confirmed with a potholing technique as described in the following subsections.

14.2.1 Geophysical Survey to Locate AVGAS Line and Surge Tanks

A geophysical survey will be performed by a qualified subcontractor to locate and delineate the Abandoned AVGAS Line and Surge Tanks. Geophysical techniques that may include magnetic, electromagnetic, and/or ground-penetrating radar will be used in accordance with Procedure I-B-2, *Geophysical Testing* and Procedure I-A-5, *Utility Clearance* (DON 2015).

14.2.2 Potholing to Determine Depth of the Abandoned AVGAS Line

After the location of the Abandoned AVGAS Line and the Surge Tanks are determined through geophysical surveying, a qualified subcontractor will confirm their locations using utility potholing. A series of small test holes will be created through either vacuum excavation or hand digging to confirm the horizontal position and depth of these features. These will occur at approximately 500-ft intervals along the proposed location of the Abandoned AVGAS Line.

14.2.3 Land Survey

The Abandoned AVGAS Line, at all locations where a change in direction occurs, and the Surge Tanks will be clearly marked with paint, whiskers, or stakes with colored marking tape within a reasonable timeframe after completion of the geophysical survey and potholing.

A licensed land surveyor will survey these markings to determine the horizontal coordinates of the Abandoned AVGAS Line and Surge Tanks in accordance with Procedure I-I, *Land Surveying* (DON 2015). All land survey activities will meet requirements specified in Precise Digital Level to National Geodetic Survey Standards for land surveying and will use Second Order, Class I procedures as referenced in the *Technical Memorandum, Topographic Survey* (DON 2017b). The field manager will be responsible for maintaining the markings between the land survey and drilling activities.

14.3 GEOPHYSICAL SURVEY FOR SUBSURFACE UTILITY CLEARANCE

Prior to intrusive activities, magnetic, electromagnetic, and/or ground penetrating radar geophysical surveys will be conducted by the geophysical subcontractor at the proposed drilling locations. These activities will evaluate the location of underground utilities in accordance with Procedure I-B-2, *Geophysical Testing* (DON 2015) and Procedure I-A-5, *Utility Clearance* (DON 2015). Ultrasonic detection may be necessary to locate non-metallic (e.g., asbestos-cement, high-density polyethylene, or PVC) utility lines that may not have tracer wire provisions. The purpose of the survey is to prevent damage to utilities during soil boring advancement. Additionally, field personnel will coordinate with the Navy RPM to obtain site utility maps to help locate underground appurtenances. Subsurface utilities will be marked with flagging tape, stakes, or biodegradable spray paint.

A public utility location request will also be made through Hawaii One Call Center to locate subsurface utilities (e.g., electric power, water, phone lines, underground fuel pipelines).

Tunnel Locations. Passive soil vapor point (PSVP) locations will be identified using ground-penetrating radar to identify the thickness of the concrete and avoid utilities and rebar. Locations in the tunnel will be preferentially located between the rails of the railroad track or in the center of the tunnel. If for some reason locations cannot be sited in the center of the tunnel, the field teams will use their judgment to determine the best location based on obstacles. All relocated PSVPs will be sited within 5 ft of their original proposed location in the tunnel floor and at least 1 ft away from the tunnel wall or any tunnel wall obstacle. All locations will be sited within the cleared area marked by the utility clearance method as “cleared of utilities.”

14.4 BOREHOLE ADVANCEMENT AND PASSIVE SOIL VAPOR POINT INSTALLATION

Prior to any drilling, a hand auger or other hand tool will be used where feasible to manually advance the borehole to a maximum 5 ft bgs, or until refusal is encountered or the installation target total depth is achieved, to ensure the location is cleared of utilities. The total depth of some proposed locations is less than 5 ft bgs; if target total depth is reached with the hand auger, then a drill rig will not be used at that location. Proposed boreholes will be advanced using a handheld hammer drill or a drilling rig equipped with hollow-stem augers or direct-push technology in accordance with Procedure I-C-1, *Monitoring Well Installation and Abandonment* (DON 2015).

14.4.1 Hammer Drilling

PSVPs will be installed using hammer drilling techniques at the following Study Areas:

Location	Number of Proposed PSVP Boreholes	Total Depth of Advancement (ft btf or bgs)
Tank Gallery	75	2–3
Lower Access Tunnel	120	
Former Standby Power Plant	11	
Harbor Tunnel	488	
Abandoned AVGAS Line (Adit 6)	12	3–5
Tank 311	4	3
Tank 311 (FOR Line)	1	3

Note: Refer to Worksheet #18 for sample names, Worksheet #19 for proposed analytical methods, and Appendix D Figures 1 through 46 for proposed sampling locations.
btf below tunnel floor

Concrete drilling through the tunnel floor or adjacent to Tank 311 will be conducted using a concrete hammer drill with up to a 36-inch extension using 1- and 1.5-inch-diameter drill bits. Power will be supplied using a standard alternating-current 120-volt power source (or appropriate direct current and voltage if battery-powered drills are to be used) that will be identified during the tunnel site reconnaissance. Alternatively, a portable generator may be used at Tank 311. The drill hole will be moistened with small amounts of water to mitigate sparking and dust generation and will be continuously removed with a high-powered vacuum during drilling. Drill holes will pass through the tunnel floor (expected to be between 8 and 16 inches thick) to between 1–2 ft btf or through the soil to approximately 3 ft bgs at Tank 311. Drill holes will be sealed following their completion to prevent fluids from passing through. Inside the tunnel, the drilling area will be monitored using a lower explosive limit (LEL) meter to ensure that conditions never exceed the LEL during drilling. A PID will also be used to monitor ambient VOCs during all drilling activities. Drill holes will be monitored during drilling to ensure the integrity of the concrete slab. Any cracks in the slab will be repaired to Navy specifications. A dust meter will be used to monitor dust levels inside the tunnel.

Subsurface material will be sampled from cuttings in accordance with Procedure I-B-1, *Soil Sampling* (DON 2015). The cuttings will be inspected and logged to characterize the lithology and evaluate potential preferential pathways for contaminant migration. The presence of contamination may be indicated by staining on cuttings and recovered rock cores or by elevated PID readings. This information will be recorded in the project field logbook. In general, each log for unconsolidated material will note the following: group name, color, grain size and percentage of coarse fraction, plasticity, toughness, moisture, consistency; and for consolidated material: rock-quality designation; color; texture; strength; degree and orientation of fracturing; shape, size, and volume of voids; weathering; and secondary staining or mineralization. High-resolution photographs of the materials will be taken and detailed photo logs will be prepared. Munsell color chips will be used for color characterization. Tunnel thickness, lithologic descriptions, PID screening results, and other relevant observations will be recorded in the geologic logs.

Any drill holes that are not used for any reason will be abandoned. All abandoned drill holes will be filled with Portland cement concrete and finished flush to the initial tunnel floor surface. Final drill hole abandonments will be completed so that no liquid will pass through them into the native environment.

14.4.2 Direct-Push Drilling

Direct-push technology drilling techniques will be used at the following locations:

Location	Number of Proposed PSVP Boreholes	Total Depth of Advancement (ft bgs)
Abandoned AVGAS Line	231	3–5
Former Slop Tank	165	5

Note: Refer to Worksheet #18 for sample names, Worksheet #19 for proposed analytical methods, and Figure 20 for proposed sampling locations.

A direct-push drilling rig will be used to advance boreholes and collect discrete subsurface soil samples in accordance with Procedure I-H, *Direct Push Sampling Techniques* (DON 2015) at the proposed locations illustrated on Figure 20. The drill rig will be equipped with minimum 1.5-inch-diameter drive rods and an acetate sleeve. Discrete subsurface soil collection will be conducted in accordance with Procedure I-B-1, *Soil Sampling* (DON 2015).The field geologist will identify the types of soil collected using Procedure I-E, *Soil and Rock Classification* (DON 2015). Each sample core will be screened for soil vapor at 1-ft intervals using a PID. If compacted or bedrock material is encountered and the borehole is unable to be advanced using direct-push, the borehole will be relocated nearby.

14.4.3 Hollow-Stem Auger Drilling

Hollow-stem auger drilling techniques will be used at the following location:

Location	Number of Proposed PSVP Boreholes	Total Depth of Advancement (ft bgs)
Surge Tanks	6	35

Note: Refer to Worksheet #18 for sample names, Worksheet #19 for proposed analytical methods, and Figure 18 for proposed sampling locations.

A hollow-stem auger drill rig equipped with a minimum 4¼-inch-inner-diameter auger will be used to advance boreholes and collect soil samples from the surface to at least 35 ft bgs or until groundwater is encountered at up to six locations around the perimeter of the Surge Tanks. If refusal is encountered shallower than the desired target depth (e.g., due to an encountered boulder), drillers will be prepared to advance an additional borehole within 10 ft of the borehole where refusal was encountered. The proposed borehole locations are shown on Figure 18. Starting at 5 feet bgs, soil will be collected at 5-ft intervals using a 1.5-ft-long, 2-inch-diameter California split-spoon sampler fitted with precleaned stainless steel or brass sleeves. Soil from the split spoons will be evaluated in the field for lithology and screened for organic vapor using a PID in accordance with Procedure I-B-1, *Soil Sampling* (DON 2015). It is anticipated that groundwater will be encountered at approximately 20 ft bgs in the Surge Tank Study Area.

14.4.4 Borehole Abandonment

Boreholes will be abandoned after sampling activities have been completed. Abandonment will be performed in accordance with Procedure I-C-1, *Monitoring Well Installation and Abandonment* (DON 2015), which involves sealing the borehole with cement-bentonite grout. The grout will be placed with a tremie pipe in one operation from the bottom of the boring to within a minimum of 2 ft bgs for borings deeper than 10 ft bgs. For borings shallower than 10 ft bgs, cement-bentonite will be free-poured down the hole. Additional grout may need to be placed if settling occurs. The surface will be completed to match the surrounding area.

14.5 SAMPLE COLLECTION

The Site Assessment includes the collection and laboratory analysis of soil, vapor, and potentially groundwater samples to determine if contamination is present. Sample collection and laboratory analytical methods for samples, as well as the rationale for selecting sampling locations and criteria to be used for selection of specific depth intervals for analysis, are presented in Worksheet #17. Refer to Worksheets #18 and #20 for further detailed location-specific methods and the complete sampling schedule. The following subsections describe the methodology for collecting the samples.

14.5.1 Vapor Sampling

14.5.1.1 ACTIVE SOIL VAPOR POINT SAMPLING

Upon completion of passive soil vapor monitoring in boreholes in which active soil vapor samples are proposed, hand-held field instruments including a PID, Multi-RAE (or equivalent meter), and landfill gas meter will be used to screen the location for VOCs, oxygen, and carbon dioxide (CO_2). The hand-held meters will be placed in the open borehole and parameters will be recorded on the respective boring logs. In deeper borings advanced to greater than 5 ft bgs, a temporary probe will be placed inside the casing.

14.5.1.2 PASSIVE SOIL VAPOR POINT INSTALLATION

After boreholes are advanced to their target depths as described in Section 14.4, passive soil gas samplers (PSGSs) manufactured by Beacon Environmental will be deployed in accordance with "Instructions for PSG Sampler Deployment, Retrieval and Return to Beacon Environmental" (Appendix C). For shallow borings advanced to 5 ft bgs or less in soil or vegetation covered areas, a PSGS will be deployed into the open borehole. The PSGS will be hung by a wire from a piece of tightly crumpled aluminum foil. The aluminum foil plug will seal the hole approximately ¼ inch below grade, and surrounding soil will be collapsed above the plug, leaving the retrieval wire coiled flat on the ground surface.

For shallow borings advanced to 5 ft bgs or less in the tunnel, a minimum 1-inch-diameter metal pipe will be used to case the first 1 ft of a minimum 2-ft borehole. If the 1-inch-diameter, 12-inch-long metal pipe supplied by Beacon Environmental is not compatible with the borehole, then a similar 1-inch-diameter, thin-walled pipe will be used. The PSGS will be deployed to the bottom of the casing and the retrieval wire will be secured to the exterior of the casing. The borehole will be sealed with an aluminum foil plug and covered to grade with a ¼ inch thick concrete patch made of pre-mixed dry concrete mortar mix. For shallow borings that are advanced using direct-push and for the deeper borings, which include any boring advanced to 5 ft bgs or more, the minimum 1.5-inch-diameter borehole will be cased with minimum 1-inch-diameter, pre-cleaned Schedule 40 PVC blank pipe with at least 1ft of 0.020-inch slotted screen. The annular space around the slotted screen will be backfilled with a course #3 Monterey sand to at least 1 ft above the slotted screen. The remainder of the casing will be backfilled and finished with a bentonite seal to prevent gasses from escaping and preserve the equilibrium. Once the boreholes are cased as necessary, a Beacon PSGS will be lowered with the open end down to the top of the screened interval and the retrieval wire will be secured to the well cap.

The field sample ID, date and time of emplacement to the nearest minute, borehole depth, type of surfacing, and other relevant information will be recorded on the sampling log and referenced in the field logbook.

Field staff will minimize potential contamination of PSGSs by wearing nitrile gloves while handling all Beacon PSGS and associated equipment. PSGSs will be stored in sealed containers and transported in Beacon's provided sample kit until they are ready to be deployed to minimize potential airborne contamination.

14.5.1.3 PASSIVE SOIL VAPOR POINT REMOVAL

PSGSs will be retrieved within 14 calendar days of installation following the conclusion of the exposure period. PSGSs will be removed from the hole by gently pulling the retrieval wire.

- In soil or vegetation covered areas, the soil will be cleared, and a small screwdriver will be used to remove the aluminum foil plug, if necessary.
- In concrete or asphalt covered areas, the concrete seal will first need to be removed with a hammer or chisel before removing the aluminum foil plug.

Once retrieved, the black sampling cap used to allow gas migration will be removed from the PSGS. The exterior of the Beacon PSGS will be cleaned with a shop towel or similar disposable towel, all retrieval wire will be removed using wire cutters, and the vial threads will be cleaned with a gauze cloth provided in the Beacon sampling kit. Transport vials made of glass and marked with green labels are available for use only if a PSGS is broken during retrieval. If this occurs, all contents from the broken PSGS will be transferred to the transport vial. The solid-white shipping cap will be screwed onto the vial and marked with the sample ID using a ballpoint pen. A Sharpie pen will not be used to mark the caps.

Each sealed and labeled PSGS will be placed into a 3-inch × 4-inch individual sampler bag with an airtight seal. The individual sampler bag will be labeled with the sample ID on the white block on the bag using a ballpoint pen before being placed into a larger bag prelabeled as "Return Shipment Bag." The provided chain of custody (COC) form and the field logbook will be updated with the sample ID, date and time of retrieval (to the nearest minute), and any other relevant information. Prior to sealing the Return Shipment Bag, field teams will verify that all samples are properly stored in the bag alongside an adsorbent pack and a labeled trip blank.

Following the verification of all contents, the Return Shipment Bag will be sealed and placed in the upper tray of the field kit. Used equipment including sampling caps, casing pipe, and wire will be disposed of as municipal trash. A custody seal will be affixed on the field kit and labeled with the unique COC ID number. The kit will be placed in its original cardboard shipping box along with the completed and signed COC. The samples will be shipped via FedEx overnight express delivery to Beacon Environmental located in Bel Air, Maryland. No ice or preservatives are required for this shipment. Each PSGS has a hold time of 30 days.

After removal, all boreholes will be abandoned in accordance with Procedure I-C-1, *Monitoring Well Installation and Abandonment* (DON 2015).

14.5.2 Soil Samples

The collection of subsurface soil samples will be conducted in accordance with Procedure I-B-1, *Soil Sampling* (DON 2015). The samples will be inspected for evidence of contamination (visual, olfactory, or elevated PID readings) to evaluate the potential migration of LNAPL and associated constituents. The depth of the sample and a physical description of the soil according to the Unified Soil Classification System will be recorded in the soil sample log along with other pertinent information as outlined in Procedure I-E, *Soil and Rock Classification* (DON 2015).

All sample containers will be labeled with the sampling location, date and time of collection, and unique sample identifier as discussed in Worksheet #27, and recorded in the field logbook. In addition to the primary samples, duplicates, and matrix spike/matrix spike duplicate (MS/MSD) samples will be collected along with other blank samples, as indicated in Worksheet #12. The samples will be placed in an insulated cooler with ice, pending shipment to the designated analytical laboratory as indicated in Worksheet #17 for analyses as summarized below:

- VOCs, TPH-DRO, TPH-LRO and PAHs at the Surge Tank
- TPH-DRO TPH-LRO, PAHs, tetraethyl lead at the Abandoned AVGAS Line
- TPH-DRO, TPH-LRO at all Study Areas

14.5.2.1 SUBSLAB SOIL/ROCK DRILL CUTTING SAMPLES

Discrete subslab soil samples will be from the hammer drill auger from beneath the tunnel floor. Minimal amounts of material will be available for collection in the areas of the tunnel floor subsurface that consists of bedrock basalt. Cuttings will be very fine in massive a‘ā, and the drilling method will not be conducive to capturing VOCs or SVOCs, due to the heat generated by the drilling method. Due to the limited material anticipated and the hardness of the rock matrix in many locations in the Facility’s tunnels, where solid sampling material is not generated in sufficient volume, sampling will be limited to non-VOCs and VOCs will be evaluated using soil vapor methods.

To account for the poor media for sampling solids, all subslab sampling locations will also be sampled using PSVPs and active soil vapor monitoring points. Borings will be collected for laboratory analysis of COPCs to provide additional data on the level of contamination present in the area (if any). Subsurface soil will be collected from soil cuttings at the following depths:

- The deepest depth the borehole is advanced
- Areas where field observations suggest the potential for contamination

14.5.2.2 SUBSURFACE SOIL SAMPLES

Discrete subsurface soil samples may be collected using direct-push sampling techniques, split-spoon sampling methods, or a soil recovery hand auger depending on the method used to advance the boring. All samples will be collected in accordance with Procedure I-B-1, *Soil Sampling* (DON 2015) and Procedure I-H, *Direct Push Sampling Techniques* (DON 2015), as applicable.

One discrete subsurface soil sample will be collected from the bottom of each proposed borehole. For the Abandoned AVGAS Line, the proposed sampling interval will extend 1 ft below the base of the pipeline, which will be determined after the pipeline depth is identified during potholing activities described in Section 14.2.2. Sampling locations and depths will be recorded on the boring log. If VOCs are suspected based on field observations including elevated PID readings, staining or odors, one additional sample will be collected from the interval where the maximum PID concentration was observed.

14.5.3 Groundwater Samples

If groundwater is encountered before a boring reaches its target depth, bailer grab samples will be collected using a disposable Teflon bailer with a bottom-discharging device. The bailer will be deployed in a way that minimizes the disturbance and aeration of the water column. Groundwater physical parameters of pH, conductivity, dissolved oxygen, oxidation-reduction potential, and turbidity will be measured from the first bail. All water quality parameters will be measured with a water quality meter that is calibrated according to manufacturer-specific recommendations.

Groundwater samples will be collected using PFAS-free materials (tubing, bailers, pumps) and in accordance with Procedure I-C-3, *Monitoring Well Sampling* (DON 2015). The groundwater samples will be inspected for evidence of contamination (visual, olfactory, or elevated PID readings) to evaluate the potential migration of LNAPL and associated constituents. Groundwater samples will be collected directly into laboratory-supplied high-density polyethylene (HDPE) sample bottles with HDPE screwcaps. The sample bottles which will be labeled with the sampling location, date and time of collection, and unique sample identifier as discussed in Worksheet #27 and recorded in the field logbook. In addition to the primary samples, duplicates and MS/MSD samples will be collected along with other blank samples, as indicated in Worksheet #12.

The sample bottles will be sealed, labeled, and placed in an insulated chest with double-bagged wet ice, and shipped to the designated analytical laboratory according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody Procedures* (DON 2015) for analysis for TPH-GRO, TPH-DRO, VOCs, and PAHs. The shipping labels, coolers, and ice will be PFAS-free.

14.5.4 LNAPL Samples and Free Phase Product Characterization

If LNAPL is encountered during any ground intrusive activities, LNAPL samples will be collected to characterize the LNAPL and the concentration of COPCs in the LNAPL. Samples will be collected using a bailer and analyzed for fuel type and other COPCs. Free-phase petroleum product samples will be submitted for fuel fingerprint analysis and aging to determine the extent of these differences and characterize the free product encountered in the monitoring wells. Collection of LNAPL will be done in accordance with Procedure I-C-3, *Monitoring Well Sampling*, Section 5.3.5 (DON 2015).

14.5.4.1 SHEEN SAMPLING

If LNAPL layers are present or if sheens are observed, sheen samplers capable of sorbing LNAPL will be deployed in the monitoring wells. Vendor-supplied sheen samplers connected to a decontaminated water level tape (or similar) will be lowered to the groundwater surface in monitoring wells that have evidence of LNAPL or sheens. Once in the water, the sheen sampler's paper wrap will disintegrate to open the sampler. The sampler will be "bobbed" on the groundwater surface to open the sampler "skirt" and expose the sorbent material to the water for a minimum of 5 minutes. Using the water level tape, the sampler will be retrieved and placed in a laboratory-supplied glass jar for analysis. The sampling duration and water level will be recorded.

14.5.5 Quality Control Samples

Field QC samples will be collected to evaluate field variability and sampling error in accordance with Procedure III-B, Field QC Samples (DON 2015). Refer to Worksheets #12 and #20 for a summary of the field QC samples that will be collected on this project. The laboratory will also prepare and analyze QC samples. These may include blanks, surrogates, laboratory duplicates, MSs/MSDs, laboratory control samples, and any other applicable QC criteria defined in Procedure III-A, Laboratory QC Samples (DON 2015). Worksheet #28 presents a list of the laboratory QC samples for this project. No field and equipment blanks will be collected for potential sheen samplers and free product fuel samples.

14.6 SAMPLE MANAGEMENT

To ensure sample quality and representativeness, all samples will be appropriately managed from the time of collection through the time of relinquishment to the certified analytical laboratory. Each sample will be assigned a descriptive sample ID number to identify the sampling location, type, sequence, matrix, and depth of each sample. Sample information including the descriptive sample ID number, date and time of collection, sample analyses, number and type of containers, sample type, sample location, and types of preservative will be recorded in the QA/QC logbook and in accordance with Procedure III-D, *Logbooks* (DON 2015).

A label will be affixed to each sample container to identify the sample, the date and time of collection, site name, the laboratory analyses, preservative, sample type, and the field personnel who collected the sample. Custody seals will also be affixed to each sample container to ensure that the samples have not been tampered with prior to laboratory analysis. Samples will be placed on ice immediately after collection. COC forms and samples will be packed in coolers and shipped via FedEx or equivalent to the DoD ELAP-accredited laboratory.

Samples will be identified in accordance with Procedure I-A-8, *Sample Naming* (DON 2015) and as described in Worksheet #27. Samples will be managed and shipped in accordance with Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*, and Procedure III-F, *Sampling Handling, Storage, and Shipping* (DON 2015).

14.7 LAND SURVEY

A licensed land surveyor will locate, mark, and determine the coordinates of sampling locations outside the tunnel in accordance with Procedure I-I, *Land Surveying* (DON 2015). It is anticipated that the land surveying activities will be conducted after drilling and sampling have been completed to determine the horizontal and vertical (elevation) coordinates of each location. The land survey will meet Second Order, Class I Survey requirements to measure precise elevation and location coordinates for the ground surface of the 258 anticipated outside-tunnel sampling locations. All land survey activities will meet requirements specified in Precise Digital Level to National Geodetic Survey Standards for land surveying.

14.8 EQUIPMENT DECONTAMINATION

All equipment decontamination will be performed using water that is certified PFAS-free by a laboratory and in accordance with Procedure I-F, *Equipment Decontamination* (DON 2015). Decontamination of non-disposable soil and groundwater sampling equipment (e.g., drilling rods, sample liners, water level meter) is necessary to prevent cross-contamination and to maintain the highest integrity possible in collected samples. Decontamination of non-disposable equipment will be conducted before each use and upon completion of sampling activities.

The decontamination of drilling and heavy equipment (i.e., rods, augers, and tremie pipes) will be completed by high-pressure steam cleaning, followed by rinsing with potable water. The decontamination procedure for reusable sampling equipment (e.g., split spoons, bladder pump) will consist of the following:

1. Wash with a non-phosphate detergent (Alconox, Liquinox, or other suitable detergent) and potable water solution.
2. Rinse in a bath with water that is certified PFAS-free by a laboratory.
3. Spray with laboratory-grade isopropyl alcohol.
4. Rinse in a bath with deionized or distilled water that is certified PFAS-free by a laboratory.

5. Spray with deionized or distilled water that is certified PFAS-free by a laboratory.

14.9 INVESTIGATION-DERIVED WASTE MANAGEMENT AND DISPOSAL

It is anticipated that the following types of investigation-derived waste (IDW) will be generated during the field investigation:

- Soil cuttings from soil boring activities
- Purge water from groundwater sampling activities
- Fluids generated during decontamination of non-consumable sampling equipment (e.g., oil/water interface probe, drill rig, augers)
- Miscellaneous IDW, anticipated to be composed primarily of spent disposable personal protective equipment

IDW will be marshaled and stored on site, and will be handled, stored, and labeled in accordance with Procedure I-A-6, *IDW Management* (DON 2015). Unless otherwise indicated, IDW will be stored temporarily in 55-gallon drums, to be located on wooden pallets (solid IDW) or spill containment (liquid IDW) pallets in a Navy-approved equipment staging area. The drums will be segregated according to source and matrix, and at least one composite IDW sample will be collected from each grouping for waste characterization in accordance with Procedure I-D-1, *Drum Sampling* (DON 2015).

IDW will be disposed of within 90 calendar days after the IDW is generated. The IDW inventory and analytical data obtained during the investigation will be evaluated to select appropriate disposal methods. The evaluation will include review of Resource Conservation and Recovery Act and Toxic Substances Control Act regulations, and discussion with facilities authorized to receive wastes.

14.10 DATA EVALUATION (TIER 1)

For the Site Assessment, analytical results will be evaluated in comparison with the project screening levels (PSLs), which are defined as the limits specific to Beacon PSGSs that are exposed to subsurface soil vapor for approximately 14 days, EPA Contract Laboratory Program Statement of Work For Superfund Analytical Methods SFAM01.0 (November 2020), and DOH Evaluation of Environmental Hazards at Sites with Contamination Soil and Groundwater Volume 1: User's Guide Fall 2017 (DOH 2017a):

- Soil vapor screening levels presented are based on limits specific to Beacon PSGSs that are exposed to subsurface soil gas for approximately 14 days (as summarized in Worksheet #15).
- Soil screening levels for VOCs are based on EPA Contract Laboratory Program Statement of Work for Superfund Analytical Methods SFAM01.0 (November 2020) Table 1 Contract Required Quantitation Limits for Medium Soil/Sediment/Waste.
- Soil screening levels for PAHs are based on EPA Contract Laboratory Program Statement of Work for Superfund Analytical Methods SFAM01.0 (November 2020) Table 2 Contract Required Quantitation Limits for Low Soil/Sediment/Waste.

If groundwater is encountered:

- Groundwater screening levels for VOCs are based on EPA Contract Laboratory Program Statement of Work for Superfund Analytical Methods SFAM01.0 (November 2020) Table 1 Contract Required Quantitation Limits for Trace Water.

- Groundwater and soil screening levels for TPH are based on known laboratory quantitation limits as recommended in the DOH Evaluation of Environmental Hazards at Sites with Contamination Soil and Groundwater Volume 1: User's Guide Fall 2017 Section 2.8 Laboratory Reporting Limit and Ambient Background (DOH 2017a).
- Groundwater screening levels for PAHs are based on EPA Contract Laboratory Program Statement of Work for Superfund Analytical Methods SFAM01.0 (November 2020) Table 2 Contract Required Quantitation Limits for Low Water by SIM.

14.11 DATA

Data generated during this investigation will include the following:

- VOC, TPH-GRO, TPH-DRO, PAH, methane, CO_2, and O_2 concentrations reported for soil vapor.
- VOC, TPH-GRO, TPH-DRO, TPH-LRO, and PAH concentrations reported for groundwater samples (if encountered).
- VOC, TPH-GRO, TPH-DRO, TPH-LRO, PAH, and tetraethyl lead concentrations reported for soil samples.
- Physical characteristics of soils and rock core recorded on bore logs, including: Unified Soil/Rock Classification System; color (Munsell Soil Color Chart); soil grain size classification by percent; moisture content; structure, particle shape, angularity, and maximum size; plasticity of fines; odor and staining; and rock fracture.
- Survey data of sample locations.
- Survey data of Abandoned AVGAS Link and Surge Tank locations.
- Product or sheen characterization results (if encountered), including fuel fingerprint analysis.

The selected laboratories are currently DoD ELAP-accredited for all preparation and analytical methods associated with analysis of the COPCs identified in this document.

14.11.1 Data Management Tasks

All analytical data, field notes, data sheets, and other data necessary to support the project will be maintained in JBPHH Red Hill Bulk Fuel Storage Facility Environmental Data Management System (EDMS) All hard copies of analytical data, field notes, data sheets, and other data necessary to support the project will be maintained in the AECOM Honolulu office, as detailed in Worksheet #29.

14.11.2 Documentation and Records

All field observations and measurements will be recorded in a field notebook and project-specific field data sheets. All samples will have global positioning system (GPS) locations. COC forms, air bills, and sample logs will be prepared and retained for each sample. See Worksheet #21 for a list of documentation standard operating procedures (SOPs). All data will be included in the investigation report.

14.11.3 Assessment/Audit Tasks

The project chemist, QA program manager, and field manager will be responsible for assessment and audit tasks (Worksheet #7). The CTO manager will be responsible for coordinating the field audit.

14.11.4 Data Reporting

The analytical laboratory will verify, reduce, and report data as specified in their DoD ELAP-evaluated laboratory QA plan. Analytical data will be uploaded into the JBPHH Environmental Data Management System (EDMS) by the laboratories as laboratory reports in pdf consistent with *Section 4.2 Laboratory Data Deliverables* of the *Department of Defense (DoD) General Data Validation Guidelines* [DVG] (DoD 2019), and electronic data deliverables (EDDs) as specified in Appendix F.

The analytical data will be reviewed before it is validated to address time-critical issues such as re-extraction, matrix interference, and holding times. The data usage and the appropriate QA/QC level will be evaluated.

14.11.5 Data Review Tasks

All analytical laboratory data results will be validated by a third-party data validation firm in accordance with protocols primarily outlined in the DVG and the applicable DVG Modules. Third-party data validation will consist of Stage 2B validation (90 percent) and Stage 4 validation (10 percent) reviews. The first 10 percent of project field data (COPCs) generated by the laboratory will be validated at Stage 4 validation to establish a baseline, ensuring the laboratory has complied with the requirements outlined in both the analytical methods and the current DoD QSM Version. In addition, data quality checks (i.e., evaluating the precision and accuracy) will be performed once the analytical data are received from the laboratory. AECOM will verify the data against the specified limits of quantitation (LOQs) and limits of detection (LODs) in Worksheet #15.

All project analytical data will be validated by a third-party data validation firm in accordance with the *Department of Defense General Data Validation Guidelines September 2019 Revision 1* (DoD 2019) and the following Modules*:*

- Data Validation Guidelines Module 1: *Data Validation Procedure for Organic Analysis by GC/MS* (DoD 5/11/2020)
- Data Validation Guidelines Module 4: *Data Validation Procedure for Organic Analysis by GC* (DoD 3/09/2021)
- Data Validation Guidelines Modules 1, 2, 3, 4 and 6: *Revised Table for Sample Qualification in the Presence of Blank Contamination (DoD 10/4/2023)*

Where the DoD Validation Guideline documents do not apply, the third-party validation firm will use the NAVFAC Pacific Data Validation Procedures outlined in the appropriate methodology listed below.

- Procedure II-A, *Data Validation*
- Procedure II-B, *Level C and Level D Data Validation for GC/MS Volatile Organics by SW-846 8260*
- Procedure II-C, *Level C and Level D Data Validation for GC/MS Semivolatile Organics by SW-846 (Full Scan and SIM)*
- Procedure II-H, *Level C and Level D Data Validation for Total Petroleum Hydrocarbons by SW-846 8015*
- Procedure II-R, *Level C and Level D Data Validation for Wet Chemistry Analyses*

- Procedure II-S, *Data Quality Assessment Report*
- Procedure II-W, *Level C and Level D Data Validation for GC/FID/ECD Volatile Organics and Fixed Gases in Soil Gas/Vapor by EPA Method TO-03 and ASTM D1946*
- Procedure II-X, *Level C and Level D Data Validation for GC/MS Volatile Organics and Fixed Gases in Soil Gas/Vapor by EPA Methods TO-14, TO-15, and TO-17*

The third-party validation firm will download laboratory reports from EDMS and validate analytical data in accordance with procedures above. Subsequently, the validation firm will upload the completed data validation reports into EDMS and add qualification flags in accordance with procedures detailed in the above referenced documents.

All documents produced for the project will be maintained in EDMS library. Upon closure of the project, laboratory documents will be archived to a NAVFAC Pacific approved administration record facility.

Worksheet #15: Reference Limits and Evaluation Tables

This worksheet presents the list of soil vapor, soil, and groundwater analytes and associated laboratory-defined detection limits (DLs), limit of detections (LODs) and limit of quantitation (LOQs) that will be evaluated during the Phase I Closure Site Assessment to support the determination of presence or absence of subsurface contamination related to petroleum releases from the Red Hill UST system within the Study Boundaries. This list includes those fuel-related target analytes that are recommended in the DOH TGM (DOH 2023) as well as other analytes that were specifically requested by DOH and EPA during the Scoping Sessions held on February 15, March 6, March 11–13, and April 30, 2024 (as summarized in Worksheet #9) with Navy, EPA, and DOH. The Phase 1 Site Assessment laboratory analytical results, field measurements, and visual and olfactory observations,, will be documented in a Site Assessment Report that will be submitted to EPA and DOH for review and approval. The Site Assessment Report will also present proposed response actions and associated analyte-specific project screening levels (SLs) for soil vapor, soil, and groundwater.

As applicable, collected samples will be sent to and analyzed by DoD Environmental Laboratory Accreditation Program (DoD-accredited laboratories), and the samples analysis will be done following the baseline requirements of the *Department of Defense (DoD) Quality System Manual (QSM)* (DoD and DOE 2023).

Matrix: **Soil Gas**

Analytical Group: **VOCs, TPH, PAHs**

		Project				
Analyte	CAS#	LOQ Goal	LOD Goal	LOQ	LOD	DL
Benzene	71-43-2	4.68	2.34	4.68	2.34	0.94
Ethylbenzene	100-41-4	2.92	1.46	2.92	1.46	0.58
Toluene	108-88-3	6.2	3.1	6.2	3.1	1.24
o-Xylene	95-47-6	2.82	1.41	2.82	1.41	0.56
p & m-Xylene	108-38-3	2.82	1.41	2.82	1.41	0.56
Naphthalene	91-20-3	3.1	1.55	3.1	1.55	0.62
1,2,4-Trimethylbenzene	95-63-6	3	1.5	3	1.5	0.6
1,3,5-Trimethylbenzene	108-67-8	3	1.5	3	1.5	0.6
Cyclohexane	110-82-7	4.86	2.43	4.86	2.43	0.97
Isopropylbenzene	98-82-8	3	1.5	3	1.5	0.6
n-Butylbenzene	104-51-8	3.17	1.58	3.17	1.58	0.63
n-Heptane	142-82-5	5.3	2.65	5.3	2.65	1.06
n-Hexane	110-54-3	4.92	2.46	4.92	2.46	0.98
n-Propylbenzene	103-65-1	3	1.5	3	1.5	0.6
p-Isopropyl toluene	99-87-6	3.17	1.58	3.17	1.58	0.63
sec-Butylbenzene	135-98-8	3.17	1.58	3.17	1.58	0.63
tert-Butylbenzene	98-06-6	3.17	1.58	3.17	1.58	0.63
TPH C5-C18	C5-C18TPH	775	388	775	388	194
C5-C8 Aliphatics	E1790666	4.59	2.3	4.59	2.3	0.92
C9-C10 Aromatics	E1790674	3.1	1.55	3.1	1.55	0.62
C9-C12 Aliphatics	E1790668	3.31	1.65	3.31	1.65	0.66
1-Methylnaphthalene	90-12-0	3.26	1.63	3.26	1.63	0.65
2-Methylnaphthalene	91-57-6	3.26	1.63	3.26	1.63	0.65
Acenaphthene	83-32-9	3.4	1.7	3.4	1.7	0.68
Acenaphthylene	208-96-8	3.35	1.68	3.35	1.68	0.67
Fluorene	86-73-7	3.54	1.77	3.54	1.77	0.71
Styrene	100-42-5	2.79	1.39	2.79	1.39	0.56

Note: Units are in microgram per cubic meters (µg/m^3).

—	not available
CAS	Chemical Abstracts Service
DL	detection limit
LOD	limit of detection
LOQ	limit of quantitation
no.	number
SL	screening level

[a] Screening level is based on Laboratory-Specified Limits are based on Passive Sampler collection period of 14 days

Matrix: **Soil Gas**
Matrix: **Soil Gas**
Analytical Group: **Biogenic Gases**

		Project		Instrument-Specific Limits [a]		
Analyte	CAS No.	LOQ Goal	LOD Goal	LOQ	LOD	DL
Methane	74-82-8	—	—	0.3	—	—
Carbon dioxide	124-38-9	—	—	0.3	—	—
Oxygen	7782-44-7	—	—	1	—	—

Note: Units are in percent volume.
— not applicable
[a] Instrument-Specified Limits reflect the lowest possible measurement accounting plus bias.

Matrix: **Soil Gas**
Analytical Group: **Biogenic Gases**

		Project		Laboratory-Specific Limits [a]		
Analyte	CAS No.	LOQ Goal	LOD Goal	LOQ	LOD	DL
Methane	74-82-8	—	—	1,000	—	—
Carbon dioxide	124-38-9	—	—	1,000	—	—
Oxygen	7782-44-7	—	—	1,000	—	—

Note: Units are in percent volume.
— not applicable
[a] Laboratory-Specified Limits reflect the lowest possible measurement accounting plus bias

Matrix: **Groundwater**

Analytical Group: **VOCs**

		Project		Laboratory-Specific Limits		
Analyte	CAS No.	LOQ Goal	LOD Goal	LOQ	LOD	DL
Benzene	71-43-2	5.00E-01	1.67E-01	0.2	0.07	0.03
Toluene	108-88-3	5.00E-01	1.67E-01	0.2	0.15	0.05
Ethylbenzene	100-41-4	5.00E-01	1.67E-01	0.2	0.07	0.03
Xylenes	1330-20-7	5.00E-01	1.67E-01	0.5	0.35	0.147
Naphthalene	91-20-3	5.00E-01	1.67E-01	0.5	0.4	0.163
1,3,5-Trimethylbenzene	108-67-8	5.00E-01	1.67E-01	0.5	0.35	0.152
1,2,4-Trimethylbenzene	95-63-6	5.00E-01	1.67E-01	0.5	0.35	0.203

Note: Units are in microgram per liter (µg/L).
— to be determined

Matrix: **Groundwater**

Analytical Group: **TPH**

		Project		Laboratory-Specific Limits		
Analyte	CAS No.	LOQ Goal	LOD Goal	LOQ	LOD	DL
TPH-GRO [C5 - C12]	Gas	5.00E+01	5.00E+01	100	80	31
TPH-DRO [C12-C24]	Diesel	2.00E+02	1.00E+02	110	100	82
TPH-LRO [C24 - C48]	Oil	2.00E+02	1.00E+02	350	300	180

Note: Units are in microgram per liter (µg/L).
— to be determined

Matrix: **Groundwater**

Analytical Group: **PAHs**

Analyte	CAS No.	Project		Laboratory-Specific Limits		
		LOQ Goal	LOD Goal	LOQ	LOD	DL
Acenaphthene	83-32-9	1.00E-01	3.33E-02	0.1	0.032	0.014
Acenaphthylene	208-96-8	1.00E-01	3.33E-02	0.05	0.032	0.009
Anthracene	120-12-7	1.00E-01	3.33E-02	0.1	0.08	0.022
benzo(a)anthracene	56-55-3	1.00E-01	3.33E-02	0.05	0.032	0.014
benzo(b)fluoranthene	205-99-2	1.00E-01	3.33E-02	0.1	0.08	0.022
benzo(g,h,i)perylene	191-24-2	1.00E-01	3.33E-02	0.05	0.032	0.012
benzo(a)pyrene	50-32-8	1.00E-01	3.33E-02	0.1	0.08	0.022
benzo(k)fluoranthene	207-08-9	1.00E-01	3.33E-02	0.05	0.032	0.012
chrysene	218-01-9	1.00E-01	3.33E-02	0.1	0.08	0.037
dibenzo(a,h)anthracene	53-70-3	1.00E-01	3.33E-02	0.1	0.032	0.015
fluoranthene	206-44-0	1.00E-01	3.33E-02	0.2	0.18	0.054
fluorene	86-73-7	1.00E-01	3.33E-02	0.1	0.032	0.017
indeno(1,2,3-cd)pyrene	193-39-5	1.00E-01	3.33E-02	0.05	0.032	0.014
methylnaphthalene, 1-	90-12-0	1.00E-01	3.33E-02	0.1	0.08	0.033
methylnaphthalene, 2-	91-57-6	1.00E-01	3.33E-02	0.2	0.08	0.039
phenanthrene	85-01-8	1.00E-01	3.33E-02	0.1	0.08	0.031
pyrene	129-00-0	1.00E-01	3.33E-02	0.1	0.08	0.033

Note: Units are in microgram per liter (µg/L).
— to be determined

Matrix: **Aqueous**

Analytical Group: **Organic Lead – Tetraethyl Lead**

Analyte	CAS No.	Project		Laboratory-Specific Limits		
		LOQ Goal	LOD Goal	LOQ	LOD	DL
Tetraethyl Lead	78-00-2	5.00E+00	2.50E+00	5.0	2.5	0.9

Note: Units are in microgram per liter (µg/L).
— to be determined

Matrix: **Soil**

Analytical Group: **VOCs**

		Project		Laboratory-Specific Limits		
Analyte	CAS No.	LOQ Goal	LOD Goal	LOQ	LOD	DL
Benzene	71-43-2	2.50E-01	8.33E-02	0.02	0.015	0.0038
Toluene	108-88-3	2.50E-01	8.33E-02	0.06	0.03	0.0135
Ethylbenzene	100-41-4	2.50E-01	8.33E-02	0.04	0.03	0.0091
Xylenes	1330-20-7	2.50E-01	8.33E-02	0.04	0.015	0.0071
Naphthalene	91-20-3	2.50E-01	8.33E-02	0.005	0.004	0.00162
1,3,5-Trimethylbenzene	108-67-8	2.50E-01	8.33E-02	0.04	0.03	0.0076
1,2,4-Trimethylbenzene	95-63-6	2.50E-01	8.33E-02	0.04	0.03	0.0135
1,2,3-Trimethylbenzene	526-73-8	NA	NA	0.04	0.03	0.0084

Note: Units are in milligrams per kilogram (mg/kg).
— to be determined

Matrix: **Soil**

Analytical Group: **TPH**

		Project		Laboratory-Specific Limits		
Analyte	CAS No.	LOQ Goal	LOD Goal	LOQ	LOD	DL
TPH-GRO [C5 - C12]	Gas	4.00E+00	3.00E+00	4	3	1.3
TPH-DRO [C12-C24]	Diesel	5.00E+01	3.00E+01	50	30	12.4
TPH-LRO [C24 - C40]	Oil	5.00E+01	3.00E+01	50	30	20

Note: Units are in milligrams per kilogram (mg/kg).
— to be determined

Matrix: **Soil**

Analytical Group: **PAHs**

		Project		Laboratory-Specific Limits		
Analyte	CAS No.	LOQ Goal	LOD Goal	LOQ	LOD	DL
Acenaphthene	83-32-9	1.70E-01	5.67E-02	0.005	0.0015	0.0006
Acenaphthylene	208-96-8	1.70E-01	5.67E-02	0.005	0.0015	0.0005
Anthracene	120-12-7	1.70E-01	5.67E-02	0.005	0.0015	0.0006
Benzo(a)anthracene	56-55-3	1.70E-01	5.67E-02	0.005	0.004	0.00178
Benzo(b)fluoranthene	205-99-2	1.70E-01	5.67E-02	0.005	0.003	0.00116
Benzo(g,h,i)perylene	191-24-2	1.70E-01	5.67E-02	0.005	0.0015	0.0005
benzo(a)pyrene	50-32-8	1.70E-01	5.67E-02	0.005	0.003	0.00084
Benzo(k)fluoranthene	207-08-9	1.70E-01	5.67E-02	0.005	0.0015	0.0006
Chrysene	218-01-9	1.70E-01	5.67E-02	0.005	0.003	0.0015
Dibenzo(a,h)anthracene	53-70-3	1.70E-01	5.67E-02	0.005	0.0015	0.00072
Fluoranthene	206-44-0	1.70E-01	5.67E-02	0.005	0.003	0.0014
Fluorene	86-73-7	1.70E-01	5.67E-02	0.005	0.0015	0.0005
Indeno(1,2,3-cd)pyrene	193-39-5	1.70E-01	5.67E-02	0.005	0.0015	0.0006
Methylnaphthalene, 1-	90-12-0	1.70E-01	5.67E-02	0.005	0.0015	0.00063
Methylnaphthalene, 2-	91-57-6	1.70E-01	5.67E-02	0.005	0.003	0.00205
Phenanthrene	85-01-8	1.70E-01	5.67E-02	0.005	0.004	0.00163
Pyrene	129-00-0	1.70E-01	5.67E-02	0.005	0.003	0.00097

Note: Units are in milligrams per kilogram (mg/kg).
— to be determined

Matrix: **Soil**

Analytical Group: **Organic Lead – Tetraethyl Lead**

		Project		Laboratory-Specific Limits [a]		
Analyte	CAS No.	LOQ Goal	LOD Goal	LOQ	LOD	DL
Tetraethyl Lead	78-00-2	5.00E-01	1.67E-01	0.167	0.100	0.0367

Note: Units are in milligrams per kilogram (mg/kg).
— to be determined

Worksheet #16: Project Schedule/Timeline Table

The DOH Hazard Evaluation & Emergency Response Office (HEER) Office Technical Guidance Manual (TGM) (DOH 2023) provides guidance implementing the Hawaii State Contingency Plan (SCP). The SCP defines two response action processes: the removal action process and the remedial action process. The removal action process, which is used for most responses to historical releases, has fewer administrative requirements than the remedial action process. Thus the removal action process allows for prompter action than the remedial action process (due to the urgency of the threats posed and the need for prompt action, emergency responses are typically conducted under the removal action process). In a smaller number of cases, where the HEER Office determines that a more intensive level of review and scrutiny is needed or removal actions may be impractical, the remedial action process is used.

Following completion of the Phase 1 and Phase 2 Closure Site Assessments field work, the Navy will submit Site Assessment Reports that summarize the Site Assessment results, identify the areas of the Red Hill System in which petroleum contamination is present, and provide recommendations for further actions in those areas in which petroleum contamination is present. Given the large footprint of the Red Hill UST system, it is possible that petroleum contamination may be identified in multiple non-contiguous areas with each area requiring its own response action. At this stage of the process, there is not enough information or data available to forecast where response actions will be required, what the appropriate response actions will be, or how long these response actions and intermediate steps will take.

The schedule/timeline presented below presents the sequence of steps for a single Remedial Action. Given the current level of uncertainty, this is a preliminary schedule/timeline that will be updated as work progresses, and site conditions are better understood.

16.1 PHASE 1 CLOSURE SITE ASSESSMENT TIMELINE

Activities	Organization	Anticipated Date of Initiation	Anticipated Date of Completion	Deliverable	Deliverable Due Date
Prepare and submit In-Progress Draft Phase 1 SAWP	AECOM	4-Mar-24	10-May-24	In Progress Draft Phase 1 SAWP	15-May-24
Review and comment In-Progress Draft Phase 1 SAWP	Navy	13-May-24	21-Jun-24	In Progress Draft Phase 1 SAWP	21-Jun-24
Prepare and submit Draft Phase 1 SAWP	AECOM	24-Jun-24	28-Jun-24	Draft Phase 1 SAWP	28-Jun-24
RAs review and comment on Draft Phase 1 SAWP	RAs	1-Jul-24	30-Aug-24	N/A	30-Aug-24
Prepare and submit Pre-Final Phase 1 SAWP	AECOM	2-Sep-24	27-Sep-24	Pre-Final Phase 1 SAWP	27-Sep-24
Review and comment Pre-Final Phase 1 SAWP	Navy	30-Sep-24	29-Nov-24	Pre-Final Phase 1 SAWP	29-Nov-24
Prepare and Submit Final Phase 1 SAWP	AECOM	2-Dec-24	6-Dec-24	Final Phase 1 SAWP	6-Dec-24
Prepare and submit In-Progress Draft Pilot Study WP	AECOM	3-Jun-24	28-Jun-24	In-Progress Draft Pilot Study WP	28-Jun-24
Review In-Progress Draft Pilot Study WP	Navy	1-Jul-24	5-Jul-24	In-Progress Draft Pilot Study WP	5-Jul-24
Prepare and submit Draft Pilot Study WP	AECOM	8-Jul-24	12-Jul-24	Draft Pilot Study WP	12-Jul-24
RAs review/comment on Draft Pilot Study WP	RAs	15-Jul-24	26-Jul-24	N/A	26-Jul-24
Pilot Study Scoping Meeting	Navy/RAs	19-Jul-24	19-Jul-24	N/A	N/A
Prepare and submit Pre-Final Pilot Study WP	AECOM	29-Jul-24	2-Aug-24	Pre-Final Pilot Study WP	2-Aug-24
Review and comment Pre-Final Pilot Study WP	Navy	5-Aug-24	9-Aug-24	Pre-Final Pilot Study WP	9-Aug-24
Prepare and submit Final Pilot Study WP	AECOM	12-Aug-24	16-Aug-24	Final Pilot Study WP	16-Aug-24

Activities	Organization	Anticipated Date of Initiation	Anticipated Date of Completion	Deliverable	Deliverable Due Date
Adit 3 SVE Pilot Study Ends	Navy	30-Aug-24	30-Aug-24	N/A	N/A
Two-week Adit 3 subsurface stabilization period	Navy	31-Aug-24	15-Sep-24	N/A	N/A
Pilot Study Field Work	Navy	16-Sep-24	18-Oct-24	N/A	N/A
Pilot Study Laboratory Sample Analyses	Laboratory	7-Oct-24	25-Oct-24	N/A	N/A
Pilot Study Data Validation	AECOM	21-Oct-24	29-Nov-24	N/A	N/A
Prepare and submit In-Progress Draft Pilot Study Report	AECOM	21-Oct-24	20-Dec-24	In-Progress Draft Pilot Study Report	20-Dec-24
Review and comment In-Progress Draft Pilot Study Report	Navy	23-Dec-24	3-Jan-25	In-Progress Draft Pilot Study Report	3-Jan-25
Prepare and submit Draft Pilot Study Report	AECOM	6-Jan-25	10-Jan-25	Draft Pilot Study Report	10-Jan-25
Review and comment on Draft Pilot Study Report	RAs	13-Jan-24	24-Jan-25	N/A	N/A
Prepare and submit Pre-Final Pilot Study Report	AECOM	27-Jan-25	31-Jan-25	Pre-Final Pilot Study Report	31-Jan-25
RAs review and comment on Pre-Final Pilot Study Report	Navy	3-Feb-25	7-Feb-25	Pre-Final Pilot Study Report	7-Feb-25
Prepare and submit Final Pilot Study Report	AECOM	10-Feb-25	14-Feb-25	Final Pilot Study Report	14-Feb-25
Phase 1 Site Assessment Field Work	NCTF-RH	24-Feb-25	29-Aug-25	N/A	N/A
Phase 1 Site Assessment Laboratory Sample Analyses	Laboratory	17-Mar-25	12-Sep-25	N/A	N/A
Phase 1 Site Assessment Data Validation	Data Validation Subcontractor	31-Mar-25	26-Sep-25	N/A	N/A
Prepare In-Progress Draft Phase 1 Site Assessment Report	AECOM	5-May-25	24-Oct-25	Draft Phase 1 Site Assessment Report	24-Oct-25
Review and Comment on In-Progress Draft Phase 1 Site Assessment Report	Navy	27-Oct-25	21-Nov-25	In-Progress Draft Phase 1 Site Assessment Report	21-Nov-25
Prepare and submit Draft Phase 1 Site Assessment Report	AECOM	24-Nov-25	28-Nov-25	Draft Phase 1 Site Assessment Report	28-Nov-25
RAs review and comment on Draft Phase 1 Site Assessment Report	RAs	1-Dec-25	30-Jan-26	N/A	N/A
Prepare and submit Pre-Final Phase 1 Site Assessment Report	AECOM	2-Feb-26	20-Feb-26	Pre-Final Phase 1 Site Assessment Report	20-Feb-26
Review and comment on Pre-Final Phase 1 Site Assessment Report	Navy	23-Feb-26	27-Mar-26	Pre-Final Phase 1 Site Assessment Report	27-Mar-26
Prepare and submit Final Phase 1 Site Assessment Report	AECOM	30-Mar-26	3-Apr-26	Final Phase 1 Site Assessment Report	3-Apr-26

AECOM	AECOM Technical Services, Inc.
APP	accident prevention plan
DASN	Deputy Assistant Secretary of the Navy
FS	feasibility study
IDW	investigation-derived waste
N/A	not applicable
NAVFAC	Naval Facilities Engineering Systems Command
NCTF-RH	Navy Closure Task Force-Red Hill
RAs	Regulatory Agencies (United States Environmental Protection Agency and Hawaii Department of Health)
RI	remedial investigation
TBD	to be determined
TM	technical memorandum
WP	work plan

16.2 PHASE 2 CLOSURE SITE ASSESSMENT TIMELINE

Activities	Organization	Anticipated Date of Initiation	Anticipated Date of Completion	Deliverable	Deliverable Due Date
Phase 2 SAWP Scoping Meeting 1	RAs, Navy	12-Feb-25	12-Feb-25	NA	NA
Phase 2 SAWP Scoping Meeting 2	RAs, Navy	12-Mar-25	12-Mar-25	NA	NA
Phase 2 SAWP Scoping Meeting 3	RAs, Navy	16-Apr-25	16-Apr-25	NA	NA
Prepare and submit In-Progress Draft Phase 2 SAWP	AECOM	10-Mar-25	9-May-25	In Progress Draft Phase 2 SAWP	14-Mar-25
Review and comment In-Progress Draft Phase 2 SAWP	Navy	12-May-25	20-Jun-25	In Progress Draft Phase 2 SAWP	20-Jun-25
Prepare and submit Draft Phase 2 SAWP	AECOM	23-Jun-25	27-Jun-25	Draft Phase 2 SAWP	27-Jun-25
RAs review and comment on Draft Phase 2 SAWP	RAs	30-Jun-25	29-Aug-25	N/A	29-Aug-25
Prepare and submit Pre-Final Phase 2 SAWP	AECOM	1-Sep-25	26-Sep-25	Pre-Final Phase 2 SAWP	26-Sep-25
Review and comment Pre-Final Phase 2 SAWP	Navy	29-Sep-25	28-Nov-25	Pre-Final Phase 2 SAWP	28-Nov-25
Prepare and Submit Final Phase 2 SAWP	AECOM	1-Dec-25	5-Dec-25	Final Phase 2 SAWP	5-Dec-25
Phase 2 Site Assessment Field Work	NCTF-RH	2-Mar-26	4-Sep-26	N/A	N/A
Phase 2 Site Assessment Laboratory Sample Analyses	Laboratory	23-Mar-26	18-Sep-26	N/A	N/A
Phase 2 Site Assessment Data Validation	Data Validation Subcontractor	6-Apr-26	2-Oct-26	N/A	N/A
Prepare In-Progress Draft Phase 2 Site Assessment Report	AECOM	4-May-26	23-Oct-26	Draft Phase 2 Site Assessment Report	23-Oct-26
Review and Comment on In-Progress Draft Phase 2 Site Assessment Report	Navy	26-Oct-26	20-Nov-26	In-Progress Draft Phase 2 Site Assessment Report	20-Nov-26
Prepare and submit Draft Phase 2 Site Assessment Report	AECOM	23-Nov-26	27-Nov-26	Draft Phase 2 Site Assessment Report	27-Nov-26
RAs review and comment on Draft Phase 2 Site Assessment Report	RAs	30-Nov-26	29-Jan-27	N/A	N/A
Prepare and submit Pre-Final Phase 2 Site Assessment Report	AECOM	1-Feb-27	19-Feb-27	Pre-Final Phase 2 Site Assessment Report	19-Feb-27
Review and comment on Pre-Final Phase 2 Site Assessment Report	Navy	22-Feb-27	26-Mar-27	Pre-Final Phase 2 Site Assessment Report	26-Mar-27
Prepare and submit Final Phase 2 Site Assessment Report	AECOM	29-Mar-27	2-Apr-27	Final Phase 2 Site Assessment Report	2-Apr-27

16.3 REMEDIAL INVESTIGATION TIMELINE

Activities	Organization	Anticipated Date of Initiation	Anticipated Date of Completion	Deliverable	Deliverable Due Date
Prepare and submit In-Progress Draft Remedial Investigation WP	AECOM			In Progress Draft Remedial Investigation WP	
Review and comment In-Progress Draft Remedial Investigation WP	Navy			In Progress Draft Remedial Investigation WP	
Prepare and submit Draft Remedial Investigation WP	AECOM			Draft Remedial Investigation WP	
RAs review and comment on Draft Remedial Investigation WP	RAs			N/A	
Prepare and submit Pre-Final Remedial Investigation WP	AECOM			Pre-Final Remedial Investigation WP	
Review and comment Pre-Final Remedial Investigation WP	Navy			Pre-Final Remedial Investigation WP	
Prepare and Submit Final Remedial Investigation WP	AECOM			Final Remedial Investigation WP	
Remedial Investigation Field Work	NCTF-RH			N/A	
Remedial Investigation Laboratory Sample Analyses	Laboratory			N/A	
Remedial Investigation Data Validation	Data Validation Subcontractor			N/A	
Prepare In-Progress Draft Remedial Investigation Report	AECOM			Draft Remedial Investigation Report	
Review and Comment on In-Progress Draft Remedial Investigation Report	Navy			In-Progress Draft Remedial Investigation Report	
Prepare and submit Draft Remedial Investigation Report	AECOM			Draft Remedial Investigation Report	
RAs review and comment on Draft Remedial Investigation Report	RAs			N/A	
Prepare and submit Pre-Final Remedial Investigation Report	AECOM			Pre-Final Remedial Investigation Report	
Review and comment on Pre-Final Remedial Investigation Report	Navy			Pre-Final Remedial Investigation Report	
Prepare and submit Final Remedial Investigation Report	AECOM			Final Remedial Investigation Report	

16.4 ENVIRONMENTAL HAZARD EVALUATION TIMELINE

Activities	Organization	Anticipated Date of Initiation	Anticipated Date of Completion	Deliverable	Deliverable Due Date
Prepare and submit In-Progress Draft EHE	AECOM			In Progress Draft EHE	
Review and comment In-Progress Draft EHE	Navy			In Progress Draft EHE	
Prepare and submit Draft EHE	AECOM			Draft EHE	
RAs review and comment on Draft EHE	RAs			N/A	
Prepare and submit Pre-Final EHE	AECOM			Pre-Final EHE	
Review and comment Pre-Final EHE	Navy			Pre-Final EHE	
Prepare and Submit Final EHE	AECOM			Final EHE	

EHE Environmental Hazard Evaluation

16.5 REMEDIAL ALTERNATIVES ANALYSIS TIMELINE

Activities	Organization	Anticipated Date of Initiation	Anticipated Date of Completion	Deliverable	Deliverable Due Date
Prepare and submit In-Progress Draft RAA Report	AECOM			In Progress Draft RAA Report	
Review and comment In-Progress Draft RAA Report	Navy			In Progress Draft RAA Report	
Prepare and submit Draft RAA Report	AECOM			Draft RAA Report	
RAs review and comment on Draft RAA Report	RAs			N/A	
Prepare and submit In-Progress Draft RAA Report	AECOM			In Progress Draft RAA Report	
Review and comment In-Progress Draft RAA Report	Navy			In Progress Draft RAA Report	
Prepare and submit Pre-Final RAA Report	AECOM			Pre-Final RAA Report	
Review and comment Pre-Final RAA Report	Navy			Pre-Final RAA Report	
Prepare and Submit Final RAA Report	AECOM			Final RAA Report	
Prepare and submit In-Progress Preliminary Draft RAM Report	AECOM			In Progress Preliminary Draft RAM Report	
Review and comment In-Progress Preliminary Draft RAM Report	Navy			In-Progress Preliminary Draft RAM Report	
Prepare and submit Preliminary Draft RAM Report	AECOM			Preliminary Draft RAM Report	
RAs review and comment on Preliminary Draft RAM	RAs			N/A	
RAs Prepare Draft RAM	RAs			N/A	

Activities	Organization	Anticipated Date of Initiation	Anticipated Date of Completion	Deliverable	Deliverable Due Date
Public Comment Period	RAs			N/A	
Remedy Selection and Final RAM	RAs			Final RAM	
VRP or Consent Order	RAs			N/A	
Prepare and submit In-Progress Draft RAWP	AECOM			In Progress Draft RAWP	
Review and comment In-Progress Draft RAWP	Navy			In Progress Draft RAWP	
Prepare and submit Draft RAWP	AECOM			Draft RAWP	

RAA	Remedial Alternatives Analysis
RAM	Response Action Memorandum
RAWP	Remedial Action Work Plan

Worksheet #17: Sampling Design and Rationale

This worksheet describes the sampling design and rationale for the Phase 1 Closure Site Assessment at the Facility. The principal objective of the Phase 1 Closure Site Assessment is to satisfy the Site Assessment requirements of HAR §11-280.1 Subchapter 7 by measuring "for the presence of a release where contamination is most likely to be present at the UST site." As noted in Worksheet #10, existing response actions are ongoing under different regulatory programs at certain areas of the Facility where previous releases have occurred, and contamination is known to be present. These response actions will continue under their existing regulatory programs while the Phase I Closure Site Assessment sampling is performed at the areas where the presence or absence of impacts from a release has not been confirmed.

Following completion of the Phase 1 Site Assessment sampling, the Phase 1 Closure Site Assessment data will be integrated with the available data from the existing response actions to provide a comprehensive assessment of presence and absence of impacts of petroleum releases within the Phase 1 Site Assessment boundaries. Instead, the existing data will be integrated with the new data to be collected to provide a complete Onsite Closure Site Assessment.

The sampling strategy will use a judgmental approach relying on a thorough evaluation of existing data, historical documentation, and site reconnaissance observations to identify appropriate analytes and sampling locations. Factors that were considered while designing the sampling program include:

- *Method of Closure:* There are no plans at this time to excavate the 20 USTs, the four Surge Tanks, or the previously abandoned underground pipelines.
- *Depth to groundwater:* The depth to the basal aquifer is over 100 ft bgs in the vicinity of the 20 USTs and gradually decreases towards the coast. Perched groundwater has been encountered in certain areas within the Facility boundaries including in the Adit 3 area. If groundwater is present in any of the sampling locations, groundwater samples will be collected at those locations.
- *Groundwater flow direction:* The groundwater flow direction should not affect the number, type, or location of samples.
- *Nature of the stored substance:* Except for several years when AVGAS was stored in Tanks 19 and 20 and conveyed in the now-abandoned AVGAS Line, the Red Hill UST system stored middle distillates. Sampling at the Abandoned AVGAS Line will target gasoline, middle distillates, and degraded fuels. Sampling at all other locations will target middle distillates and degraded fuels.
- *Other factors:* The typical dimensions of the LAT and Harbor Tunnel are 12 ft 8 inches wide with a height that ranges between 10 ft 5 inches and 12 ft. The width increases to 24 ft 4 inches in certain sections; however, the vast majority of the tunnel is 12 ft 8 inches. Pipes up to 32 inches in diameter line both sidewalls, further reducing the available workspace. These space constraints will be taken into consideration when selecting drilling methods.

17.1 PILOT STUDY

The Navy is proposing a multimedia sampling approach consisting of passive soil vapor sampling, active soil vapor sampling, soil sampling, and potentially groundwater sampling. Groundwater samples will be collected in lieu of soil samples at any locations where groundwater is unexpectedly encountered at planned soil sampling intervals. This multimedia sampling approach is designed to use the sampling techniques that will be most effective at detecting the presence or absence of each of the COPCs that are listed in Worksheet #15.

Based on extensive research and field experience, the Navy concludes that the proposed PSVPs, which will be placed in the ground for 2 weeks and use sorbent materials to collect volatile COPCs over the entire 2-week period, will detect volatile COPCs at lower concentrations and from greater lateral and vertical distances than traditional soil samples or active soil vapor sampling techniques. Soil samples will be collected to assess for the presence or absence of non-volatile COPCs that are not effectively captured by other sampling techniques. Active soil vapor sampling will be used to assess for the presence or absence of gaseous COPCs that are not effectively captured on sorbent materials.

Out of an abundance of caution, the Navy will conduct a pilot study to confirm the effectiveness of these proposed sampling techniques as well as the optimal spacing between sampling locations. The pilot study will consist of collecting passive soil vapor samples, active soil vapor samples, and soil samples from areas of known contamination and areas where contamination is unlikely to be present because there have been no documented or suspected releases in these areas. A Pilot Study Work Plan will be submitted to EPA and DOH for review and comment prior to commencing the Pilot Study. To expedite Pilot Study implementation, the associated Work Plan will be prepared as a technical memorandum rather than in UFP-QAPP format. A Pilot Study Report with conclusions and recommendations will be submitted to EPA and DOH for review and comment after the Pilot Study is completed.

If the Pilot Study results indicate that any changes to the sampling strategy presented below are warranted, the Navy will submit a SAWP addendum to EPA and DOH documenting the changes. Such potential changes could include but are not limited to changes in sample spacing and sample techniques.

17.2 STUDY AREAS

The following subsections present the sampling plan and sampling locations for each Study Area

17.2.1 Tank Farm Study Area

The Tank Farm Study Area (Figure 14) includes the Tank Farm portion of the LAT, (b) (3) The potential release sources that are in the Tank Farm Study Area include the 20 USTs, the overhead fuel transmission lines, and the FOR line. In addition, there is a manhole, five AFFF sumps, and the FOR sump within the Tank Farm Study Area, which are potential conduits to the subsurface. The Tank Farm Study Area sampling program is designed to assess for the presence or absence of petroleum from these potential release sources and conduits.

Although ongoing characterization under the Tank Farm USTs is currently being conducted via horizontal angle boring SVMPs, conditions directly below the tunnel floor and associated sumps have not been evaluated sufficiently to determine presence or absence of fuel-related constituents. Figure 14 indicates approximately 77 locations will be sampled for:

- Volatile and semivolatile petroleum constituents using PSVPs
- TPH from soil samples
- Methane and oxygen using active soil vapor sampling methods
- CO_2 using carbon trap or active soil vapor sampling methods in selected locations

Sampling locations consist of shallow soil borings (total depth of approximately 2 ft below tunnel floor [btf]) will be spaced approximately 25 ft apart, based on the optimum radius of influence expected from the PSVPs. Some sampling locations may be adjusted to place the borings adjacent to natural and manmade penetrations and drains located within the tunnel floor that were potential conduits for released fuel to flow from the surface to the subsurface. In addition to the proposed Phase 1 Site Assessment data, existing data from the Tank Farm Study Area will be integrated into the Closure Site Assessment report.

17.2.2 LAT Study Area

The LAT Study Area (Figure 15) [redacted] (b) (3) (from Tanks 1 and 2 to the November 20, 2021 JP-5 release response action area). The potential release sources that are in the Tank Farm Study Area include the fuel transmission lines, and the FOR line. The LAT Study Area sampling program is designed to assess for the presence or absence of petroleum from these two potential release sources.

There have not been any known releases in the LAT Study Area. Conditions directly below the tunnel floor and associated sumps have not been evaluated sufficiently to determine the presence or absence of fuel-related constituents. Figure 15 indicates approximately 89 locations will be sampled for:

- Volatile and semivolatile petroleum constituents using PSVPs
- TPH from soil samples
- Methane and oxygen using active soil vapor sampling methods
- CO_2 using carbon trap or active soil vapor sampling methods in selected locations

Sampling locations consist of shallow soil borings (total depth of approximately 2 ft btf) that will be spaced approximately 25 ft apart, based on the optimum radius of influence expected from the PSVPs. Some sampling locations may be adjusted to place the borings adjacent to natural and manmade penetrations and drains located within the tunnel floor that were potential conduits for released fuel to flow from the surface to the subsurface.

17.2.3 Tank 311 Study Area

Tank 311 and the associated FOR pipeline are located in the Tank 311 Study Area shown on the Study Areas Outside Adit 3 (Figure 16). Although there have not been any known releases outside the Tank 311 secondary containment area, this Study Area has not previously been assessed for petroleum impacts. Therefore, four shallow soil borings will be installed around Tank 311, and a fifth shallow boring will be installed at the midway point of the FOR pipeline, which extends from the Adit 3 portal to Tank 311 to confirm the presence or absence of petroleum impacts from Tank 311 and the outdoor section of the FOR line. The five borings will be sampled for:

- Volatile and semivolatile petroleum constituents using PSVPs
- TPH from soil samples
- Methane and oxygen using active soil vapor sampling methods
- CO_2 using carbon trap or active soil vapor sampling methods in selected locations

Shallow borings will be drilled with a hammer drill to approximately 2.5 ft bgs in locations biased toward staining and areas of stunted vegetation, if they are observed.

17.2.4 CHT Tank Study Area

The subsurface beneath the CHT Tank Study Area (Figure 16) is known to have been impacted with petroleum that overflowed from the CHT Tank in December 2022 and January 2023. The Navy has submitted a CHT Site Characterization Plan Addendum (DON 2024c) to the RAs for review to address this release. Data collected from the CHT Tank Study Area in accordance with CHT Site Characterization Plan Addendum will be integrated into the Closure Site Assessment Report.

17.2.5 Former Holding Tank and Leach Tank Study Area

The Former Holding Tank and Leach Tank Study Area (Figure 16) is known to have been impacted with petroleum that overflowed from the Former Holding Tank and Leach Tank in December 2022 and January 2023. Therefore, this Study Areas is the subject of an ongoing investigation and removal action. Additional samples will not be collected from the Former Holding Tank and Leach Tank Study Area during the Phase 1 Closure Site Assessment. The existing data from the Former Holding Tank and Leach Tank Study Area will be integrated into the Closure Site Assessment report.

17.2.6 Former OWDF Study Area

The Former OWDF Study Area (Figure 16) is the subject of an ongoing investigation. Additional samples will not be collected from the Former OWDF Study Area during the Phase 1 Closure Site Assessment. The existing data from the Former OWDF Study Area will be integrated into the Closure Site Assessment report.

17.2.7 Adit 3 Study Area

The Adit 3 Study Area is the subject of an ongoing investigation (Figure 16). Additional samples will not be collected from the Adit 3 Study Area during the Phase 1 Closure Site Assessment. The existing data from the Adit 3 Study Area will be integrated into the Closure Site Assessment report.

17.2.8 Harbor Tunnel Study Area

[redacted] (b) (3) Although there have not been any known releases in the Harbor Tunnel Study Area, conditions directly below the tunnel floor in this area have not been evaluated sufficiently to determine presence or absence of fuel-related constituents. The potential release sources in the Harbor Tunnel Study Area are the three fuel transmission lines. Approximately 488 locations will be sampled as follows to assess for the presence or absence of petroleum release in the Harbor Tunnel Study Area:

- Volatile and semivolatile petroleum constituents using PSVPs
- TPH from soil samples
- Methane and oxygen using active soil vapor sampling methods
- CO_2 using carbon trap or active soil vapor sampling methods in selected locations

Sampling locations consist of shallow soil borings (total depth of approximately 2 ft btf) that will be spaced approximately 25 ft apart, based on the optimum radius of influence expected from the PSVPs. Some sampling locations may be adjusted to place the borings adjacent to natural and manmade penetrations and drains located within the tunnel floor that were potential conduits for released fuel to flow from the surface to the subsurface.

17.2.9 Surge Tank Study Area

Although there have not been any known releases from the Surge Tanks, the Surge Tank Study Area (Figure 18) has not previously been assessed for petroleum impacts. Six soil borings will be installed to a depth equivalent to the bottom of the Surge Tanks around the perimeter of the tanks using hollow-stem auger or direct push techniques, with one subsurface soil sample analyzed at the maximum PID concentration, and one subsurface soil sample collected at the bottom of each borehole to indicate the presence or absence of petroleum constituents. Samples from the six soil borings will be sampled and analyzed as follows:

- Volatile and semivolatile petroleum constituents using PSVPs.
- Sample cores from each of the six soil borings will be screened with a PID at 1-ft intervals.
- Two soil samples (one soil sample from the base of each Surge Tank and one soil sample from the core section with the highest PID reading) will be collected from each of the six soil borings (total of 12 subsurface soil samples) and analyzed for TPH-GRO, TPH-DRO, TPH-LRO, PAHs, and VOCs.

If groundwater is encountered at any of the planned soil sampling intervals, groundwater samples will be collected in lieu of the soil sample.

17.2.10 Former Standby Power Plant Study Area

The Former Standby Power Plant Study Area (Figure 19) (b) (3) Base on a site reconnaissance of the outside entrance to the Former Standby Power Plant and a 1942 photo (Figure 4) of the Former Standby Power Plant when it was in operation, it is assumed that the Former Standy Power Plant is approximately 275 ft long and 25 ft wide. The actual dimensions and sampling locations will be verified in the field when the Former Standby Power Plant becomes accessible.

A petroleum release reportedly occurred in the Former Standby Power Plant Study Area in 1943. However, this area has not previously been assessed for petroleum impacts. As shown on Figure 19, 11 shallow borings spaced approximately 25 feet apart will be installed with a hammer drill in a grid pattern through the concrete floor of the Study Area and will be sampled for:

- Volatile and semivolatile petroleum constituents using PSVPs
- TPH from soil samples
- Methane and oxygen using active soil vapor sampling methods
- CO_2 using carbon trap or active soil vapor sampling methods in selected locations

Sampling locations within in the Former Standby Power Plant Study Area are expected to consist of shallow soil borings (total depth of approximately 2 ft btf) that will be spaced approximately 25 ft apart, based on the optimum radius of influence expected from the PSVPs, to approximately 2.5 ft depth for efficiency and best coverage of the area. The sampling locations may be adjusted based on field observations when the Former Standby Power Plant becomes accessible.

17.2.11 Former Slop Tank Study Area

Soil samples indicating the presence of low-level petroleum hydrocarbons (less than DOH EALs) in shallow soil were collected from the Former Slop Tank Study Area (Figure 20) after the tank was demolished and removed from the site in 2009. "Strong hydrocarbon odors" were later detected between 30 and 40 ft bgs during subsequent nearby drilling activities not related to the Former Slop Tank (PGE 2013; DON 2022a). These samples are deemed insufficient to close this Study Area without additional Site Assessment evidence of presence or absence of fuel-related contamination. Therefore, 16 soil borings will be installed in 25-foot grids around the Building 313, and a another soil boring will be installed adjacent to the abandoned 8-inch slop line (b) (3) [redacted] using direct-push techniques to estimated depths of approximately 2-3 ft bgs to assess for the presence or absence of petroleum releases from the Slop Tank and abandoned 8-inch slop line. These boreholes will be sampled and analyzed as follows:

- Volatile and semivolatile petroleum constituents using PSVPs
- TPH from soil samples
- Methane and oxygen using active soil vapor sampling methods
- CO_2 using carbon trap or active soil vapor sampling methods in selected locations

17.2.12 Abandoned AVGAS Line Study Area

(b) (3) [redacted]. Although there have not been any known releases from the Abandoned AVGAS Line, this area has not previously been assessed for petroleum impacts. As shown on Figure 20, passive soil vapor, active soil vapor, and soil samples will be collected from approximately 230 locations along the section of the Abandoned AVGAS Line (b) (3) [redacted]

The objective of the samples that will be collected inside Adit 6 will be to assess for potential releases from the Abandoned AVGAS Line as well as the parallel abandoned 8-inch Slop Tank line that also transits Adit 6. (b) (3) [redacted] Sample borings will be advanced along the Adit 6 west wall and each will be sampled for:

- Volatile and semivolatile petroleum constituents using PSVPs
- TPH and tetraethyl lead from soil samples
- Methane and oxygen using active soil vapor sampling methods
- CO_2 using carbon trap or active soil vapor sampling methods in selected locations

Samples will not be collected from the approximately northernmost 100-ft section of the Adit 6 tunnel due to a special tunnel floor seal in that area of the Adit 6 tunnel. In-tunnel sampling locations will be spaced approximately 25 ft apart to a depth of approximately 2 ft btf.

Samples along the external portion of the Abandoned AVGAS Line will be collected using direct push technology. Samples will be collected adjacent to and directly beneath the 18-inch AVGAS Line at an estimated depth of 3–5 ft bgs. Actual sampling locations and depths will be determined in the field to meet these objectives.

17.3 SAMPLING AND FIELD PROCEDURES

The field activities will be conducted in general accordance with the NAVFAC Pacific Environmental Restoration Program Project Procedures Manual (DON 2015) and the Red Hill Accident Prevention Plan (DON 2024a), as well as manufacturer specific sampling protocols. Detailed descriptions of the project tasks, procedures, and methodologies are presented in Worksheet #14.

Field quality control (QC) samples will be collected at each study area to meet the study area data quality objectives. A summary of the environmental sampling locations, sample media, analytical methods for all samples to be collected is tabulated in Worksheet #18. Specific details of the types and numbers of the Field QC samples are provided in Worksheet #20.

Worksheet #18: Location-Specific Sampling Methods/SOP Requirements Tables

18.1 TANK FARM STUDY AREA

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
TNKF0000-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0000-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0000-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0025-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0025-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0025-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0050-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0050-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0050-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0075-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0075-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0075-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0100-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0100-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0100-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0125-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0125-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0125-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0150-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0150-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0150-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0175-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0175-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0175-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0200-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0200-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0200-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0225-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0225-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0225-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
TNKF0250-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0250-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0250-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0275-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0275-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0275-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0300-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0300-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0300-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0325-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0325-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0325-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0350-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0350-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0350-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0375-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0375-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0375-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0400-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0400-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0400-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0425-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0425-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0425-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0450-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0450-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0450-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0475-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0475-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0475-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0500-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0500-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0500-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
TNKF0525-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0525-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0525-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0550-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0550-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0550-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0575-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0575-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0575-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0600-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0600-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0600-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0625-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0625-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0625-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0650-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0650-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0650-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0675-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0675-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0675-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0700-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0700-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0700-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0725-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0725-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0725-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0750-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0750-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0750-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0775-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0775-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0775-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
TNKF0800-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0800-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0800-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0825-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0825-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0825-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0850-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0850-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0850-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0875-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0875-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0875-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0900-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0900-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0900-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0925-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0925-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0925-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0950-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0950-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0950-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF0975-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF0975-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF0975-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1000-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1000-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1000-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1025-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1025-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1025-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1050-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1050-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1050-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
TNKF1075-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1075-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1075-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1100-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1100-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1100-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1125-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1125-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1125-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1150-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1150-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1150-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1175-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1175-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1175-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1200-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1200-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1200-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1225-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1225-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1225-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1250-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1250-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1250-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1275-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1275-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1275-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1300-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1300-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1300-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1325-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1325-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1325-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
TNKF1350-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1350-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1350-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1375-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1375-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1375-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1400-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1400-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1400-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1425-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1425-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1425-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1450-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1450-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1450-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1475-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1475-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1475-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1500-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1500-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1500-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1525-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1525-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1525-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1550-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1550-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1550-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1575-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1575-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1575-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1600-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1600-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1600-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
TNKF1625-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1625-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1625-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1650-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1650-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1650-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1675-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1675-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1675-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1700-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1700-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1700-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1725-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1725-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1725-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1750-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1750-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1750-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1775-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1775-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1775-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1800-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1800-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1800-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1825-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1825-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1825-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1850-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1850-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1850-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1875-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1875-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1875-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
TNKF1900-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1900-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1900-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
TNKF1925-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
TNKF1925-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
TNKF1925-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14

ID	identification
SOP	standard operating procedure

[a] SOP or worksheet that describes the sample collection procedures.

18.2 LOWER ACCESS TUNNEL STUDY AREA

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
LATS0000-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0000-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0000-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0025-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0025-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0025-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0050-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0050-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0050-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0075-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0075-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0075-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0100-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0100-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0100-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0125-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0125-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0125-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0150-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0150-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0150-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
LATS0175-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0175-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0175-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0200-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0200-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0200-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0225-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0225-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0225-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0250-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0250-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0250-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0275-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0275-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0275-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0300-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0300-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0300-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0325-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0325-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0325-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0350-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0350-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0350-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0375-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0375-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0375-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0400-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0400-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0400-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0425-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0425-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0425-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
LATS0450-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0450-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0450-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0475-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0475-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0475-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0500-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0500-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0500-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0525-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0525-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0525-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0550-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0550-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0550-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0575-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0575-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0575-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0600-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0600-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0600-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0625-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0625-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0625-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0650-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0650-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0650-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0675-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0675-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0675-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0700-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0700-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0700-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
LATS0725-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0725-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0725-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0750-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0750-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0750-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0775-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0775-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0775-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0800-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0800-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0800-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0825-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0825-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0825-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0850-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0850-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0850-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0875-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0875-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0875-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0900-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0900-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0900-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0925-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0925-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0925-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0950-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0950-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0950-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS0975-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS0975-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS0975-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
LATS1000-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1000-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1000-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1025-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1025-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1025-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1050-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1050-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1050-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1075-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1075-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1075-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1100-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1100-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1100-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1125-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1125-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1125-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1150-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1150-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1150-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1175-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1175-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1175-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1200-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1200-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1200-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1225-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1225-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1225-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1250-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1250-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1250-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
LATS1275-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1275-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1275-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1300-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1300-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1300-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1325-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1325-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1325-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1350-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1350-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1350-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1375-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1375-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1375-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1400-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1400-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1400-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1425-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1425-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1425-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1450-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1450-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1450-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1475-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1475-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1475-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1500-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1500-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1500-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1525-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1525-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1525-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
LATS1550-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1550-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1550-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1575-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1575-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1575-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1600-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1600-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1600-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1625-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1625-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1625-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1650-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1650-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1650-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1675-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1675-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1675-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1700-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1700-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1700-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1725-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1725-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1725-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1750-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1750-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1750-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1775-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1775-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1775-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1800-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1800-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1800-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
LATS1825-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1825-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1825-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1850-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1850-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1850-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1875-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1875-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1875-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1900-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1900-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1900-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1925-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1925-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1925-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1950-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1950-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1950-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS1975-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS1975-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS1975-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS2000-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS2000-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS2000-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS2025-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS2025-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS2025-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS2050-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS2050-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS2050-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS2075-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS2075-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS2075-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
LATS2100-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS2100-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS2100-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS2125-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS2125-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS2125-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS2150-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS2150-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS2150-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS2175-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS2175-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS2175-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS2200-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS2200-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS2200-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
LATS2225-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
LATS2225-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
LATS2225-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14

18.3 HARBOR TUNNEL STUDY AREA

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT0000-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0000-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0000-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0025-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0025-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0025-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0050-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0050-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0050-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0075-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0075-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT0075-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0100-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0100-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0100-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0125-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0125-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0125-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0150-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0150-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0150-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0175-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0175-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0175-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0200-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0200-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0200-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0225-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0225-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0225-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0250-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0250-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0250-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0275-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0275-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0275-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0300-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0300-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0300-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0325-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0325-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0325-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0350-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0350-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT0350-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0375-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0375-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0375-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0400-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0400-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0400-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0425-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0425-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0425-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0450-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0450-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0450-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0475-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0475-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0475-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0500-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0500-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0500-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0525-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0525-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0525-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0550-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0550-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0550-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0575-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0575-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0575-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0600-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0600-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0600-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0625-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0625-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT0625-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0650-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0650-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0650-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0675-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0675-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0675-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0700-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0700-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0700-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0725-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0725-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0725-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0750-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0750-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0750-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0775-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0775-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0775-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0800-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0800-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0800-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0825-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0825-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0825-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0850-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0850-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0850-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0875-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0875-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0875-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0900-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0900-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT0900-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0925-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0925-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0925-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0950-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0950-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0950-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT0975-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT0975-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT0975-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1000-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1000-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1000-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1025-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1025-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1025-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1050-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1050-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1050-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1075-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1075-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1075-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1100-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1100-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1100-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1125-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1125-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1125-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1150-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1150-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1150-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1175-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1175-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT1175-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1200-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1200-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1200-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1225-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1225-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1225-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1250-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1250-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1250-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1275-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1275-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1275-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1300-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1300-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1300-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1325-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1325-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1325-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1350-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1350-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1350-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1375-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1375-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1375-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1400-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1400-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1400-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1425-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1425-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1425-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1450-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1450-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT1450-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1475-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1475-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1475-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1500-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1500-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1500-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1525-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1525-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1525-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1550-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1550-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1550-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1575-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1575-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1575-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1600-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1600-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1600-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1625-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1625-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1625-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1650-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1650-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1650-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1675-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1675-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1675-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1700-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1700-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1700-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1725-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1725-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT1725-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1750-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1750-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1750-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1775-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1775-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1775-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1800-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1800-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1800-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1825-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1825-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1825-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1850-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1850-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1850-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1875-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1875-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1875-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1900-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1900-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1900-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1925-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1925-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1925-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1950-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1950-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1950-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT1975-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT1975-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT1975-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2000-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2000-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT2000-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2025-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2025-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2025-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2050-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2050-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2050-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2075-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2075-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2075-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2100-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2100-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2100-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2125-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2125-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2125-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2150-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2150-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2150-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2175-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2175-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2175-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2200-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2200-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2200-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2225-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2225-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2225-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2250-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2250-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2250-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2275-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2275-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT2275-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2300-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2300-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2300-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2325-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2325-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2325-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2350-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2350-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2350-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2375-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2375-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2375-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2400-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2400-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2400-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2425-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2425-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2425-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2450-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2450-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2450-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2475-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2475-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2475-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2500-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2500-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2500-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2525-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2525-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2525-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2550-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2550-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT2550-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2575-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2575-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2575-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2600-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2600-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2600-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2625-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2625-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2625-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2650-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2650-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2650-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2675-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2675-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2675-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2700-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2700-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2700-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2725-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2725-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2725-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2750-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2750-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2750-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2775-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2775-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2775-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2800-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2800-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2800-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2825-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2825-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT2825-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2850-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2850-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2850-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2875-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2875-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2875-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2900-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2900-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2900-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2925-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2925-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2925-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2950-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2950-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2950-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT2975-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT2975-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT2975-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3000-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3000-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3000-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3025-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3025-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3025-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3050-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3050-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3050-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3075-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3075-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3075-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3100-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3100-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT3100-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3125-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3125-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3125-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3150-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3150-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3150-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3175-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3175-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3175-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3200-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3200-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3200-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3225-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3225-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3225-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3250-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3250-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3250-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3275-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3275-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3275-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3300-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3300-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3300-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3325-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3325-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3325-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3350-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3350-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3350-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3375-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3375-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT3375-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3400-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3400-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3400-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3425-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3425-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3425-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3450-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3450-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3450-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3475-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3475-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3475-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3500-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3500-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3500-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3525-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3525-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3525-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3550-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3550-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3550-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3575-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3575-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3575-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3600-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3600-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3600-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3625-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3625-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3625-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3650-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3650-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT3650-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3675-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3675-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3675-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3700-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3700-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3700-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3725-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3725-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3725-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3750-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3750-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3750-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3775-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3775-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3775-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3800-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3800-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3800-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3825-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3825-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3825-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3850-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3850-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3850-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3875-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3875-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3875-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3900-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3900-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3900-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3925-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3925-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT3925-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3950-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3950-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3950-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT3975-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT3975-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT3975-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4000-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4000-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4000-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4025-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4025-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4025-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4050-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4050-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4050-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4075-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4075-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4075-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4100-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4100-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4100-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4125-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4125-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4125-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4150-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4150-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4150-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4175-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4175-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4175-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4200-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4200-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT4200-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4225-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4225-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4225-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4250-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4250-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4250-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4275-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4275-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4275-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4300-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4300-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4300-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4325-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4325-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4325-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4350-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4350-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4350-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4375-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4375-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4375-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4400-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4400-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4400-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4425-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4425-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4425-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4450-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4450-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4450-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4475-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4475-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT4475-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4500-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4500-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4500-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4525-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4525-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4525-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4550-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4550-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4550-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4575-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4575-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4575-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4600-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4600-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4600-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4625-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4625-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4625-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4650-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4650-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4650-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4675-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4675-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4675-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4700-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4700-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4700-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4725-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4725-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4725-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4750-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4750-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT4750-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4775-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4775-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4775-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4800-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4800-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4800-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4825-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4825-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4825-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4850-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4850-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4850-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4875-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4875-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4875-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4900-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4900-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4900-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4925-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4925-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4925-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4950-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4950-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4950-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT4975-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT4975-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT4975-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5000-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5000-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5000-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5025-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5025-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT5025-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5050-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5050-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5050-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5075-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5075-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5075-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5100-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5100-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5100-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5125-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5125-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5125-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5150-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5150-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5150-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5175-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5175-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5175-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5200-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5200-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5200-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5225-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5225-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5225-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5250-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5250-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5250-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5275-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5275-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5275-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5300-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5300-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT5300-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5325-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5325-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5325-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5350-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5350-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5350-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5375-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5375-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5375-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5400-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5400-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5400-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5425-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5425-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5425-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5450-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5450-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5450-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5475-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5475-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5475-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5500-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5500-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5500-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5525-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5525-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5525-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5550-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5550-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5550-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5575-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5575-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT5575-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5600-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5600-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5600-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5625-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5625-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5625-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5650-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5650-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5650-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5675-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5675-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5675-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5700-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5700-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5700-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5725-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5725-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5725-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5750-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5750-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5750-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5775-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5775-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5775-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5800-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5800-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5800-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5825-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5825-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5825-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5850-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5850-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT5850-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5875-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5875-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5875-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5900-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5900-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5900-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5925-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5925-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5925-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5950-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5950-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5950-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT5975-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT5975-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT5975-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6000-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6000-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6000-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6025-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6025-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6025-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6050-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6050-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6050-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6075-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6075-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6075-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6100-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6100-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6100-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6125-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6125-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT6125-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6150-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6150-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6150-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6175-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6175-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6175-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6200-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6200-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6200-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6225-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6225-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6225-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6250-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6250-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6250-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6275-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6275-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6275-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6300-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6300-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6300-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6325-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6325-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6325-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6350-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6350-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6350-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6375-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6375-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6375-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6400-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6400-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT6400-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6425-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6425-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6425-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6450-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6450-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6450-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6475-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6475-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6475-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6500-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6500-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6500-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6525-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6525-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6525-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6550-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6550-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6550-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6575-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6575-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6575-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6600-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6600-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6600-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6625-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6625-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6625-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6650-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6650-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6650-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6675-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6675-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT6675-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6700-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6700-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6700-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6725-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6725-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6725-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6750-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6750-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6750-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6775-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6775-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6775-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6800-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6800-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6800-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6825-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6825-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6825-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6850-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6850-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6850-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6875-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6875-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6875-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6900-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6900-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6900-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6925-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6925-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6925-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6950-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6950-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT6950-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT6975-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT6975-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT6975-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7000-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7000-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7000-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7025-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7025-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7025-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7050-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7050-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7050-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7075-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7075-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7075-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7100-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7100-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7100-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7125-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7125-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7125-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7150-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7150-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7150-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7175-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7175-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7175-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7200-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7200-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7200-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7225-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7225-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT7225-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7250-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7250-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7250-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7275-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7275-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7275-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7300-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7300-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7300-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7325-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7325-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7325-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7350-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7350-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7350-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7375-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7375-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7375-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7400-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7400-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7400-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7425-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7425-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7425-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7450-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7450-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7450-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7475-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7475-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7475-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7500-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7500-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT7500-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7525-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7525-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7525-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7550-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7550-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7550-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7575-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7575-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7575-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7600-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7600-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7600-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7625-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7625-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7625-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7650-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7650-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7650-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7675-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7675-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7675-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7700-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7700-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7700-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7725-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7725-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7725-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7750-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7750-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7750-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7775-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7775-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT7775-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7800-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7800-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7800-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7825-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7825-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7825-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7850-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7850-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7850-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7875-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7875-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7875-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7900-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7900-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7900-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7925-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7925-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7925-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7950-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7950-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7950-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT7975-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT7975-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT7975-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8000-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8000-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8000-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8025-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8025-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8025-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8050-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8050-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT8050-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8075-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8075-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8075-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8100-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8100-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8100-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8125-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8125-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8125-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8150-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8150-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8150-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8175-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8175-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8175-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8200-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8200-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8200-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8225-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8225-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8225-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8250-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8250-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8250-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8275-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8275-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8275-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8300-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8300-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8300-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8325-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8325-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT8325-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8350-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8350-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8350-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8375-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8375-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8375-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8400-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8400-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8400-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8425-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8425-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8425-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8450-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8450-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8450-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8475-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8475-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8475-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8500-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8500-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8500-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8525-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8525-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8525-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8550-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8550-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8550-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8575-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8575-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8575-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8600-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8600-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT8600-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8625-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8625-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8625-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8650-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8650-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8650-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8675-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8675-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8675-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8700-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8700-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8700-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8725-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8725-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8725-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8750-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8750-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8750-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8775-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8775-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8775-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8800-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8800-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8800-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8825-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8825-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8825-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8850-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8850-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8850-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8875-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8875-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT8875-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8900-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8900-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8900-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8925-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8925-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8925-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8950-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8950-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8950-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT8975-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT8975-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT8975-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9000-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9000-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9000-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9025-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9025-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9025-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9050-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9050-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9050-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9075-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9075-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9075-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9100-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9100-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9100-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9125-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9125-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9125-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9150-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9150-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT9150-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9175-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9175-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9175-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9200-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9200-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9200-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9225-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9225-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9225-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9250-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9250-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9250-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9275-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9275-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9275-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9300-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9300-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9300-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9325-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9325-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9325-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9350-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9350-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9350-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9375-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9375-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9375-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9400-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9400-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9400-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9425-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9425-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT9425-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9450-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9450-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9450-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9475-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9475-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9475-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9500-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9500-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9500-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9525-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9525-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9525-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9550-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9550-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9550-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9575-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9575-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9575-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9600-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9600-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9600-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9625-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9625-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9625-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9650-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9650-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9650-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9675-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9675-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9675-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9700-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9700-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT9700-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9725-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9725-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9725-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9750-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9750-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9750-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9775-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9775-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9775-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9800-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9800-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9800-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9825-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9825-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9825-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9850-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9850-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9850-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9875-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9875-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9875-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9900-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9900-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9900-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9925-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9925-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9925-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9950-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9950-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT9950-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT9975-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT9975-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT9975-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10000-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10000-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10000-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10025-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10025-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10025-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10050-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10050-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10050-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10075-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10075-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10075-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10100-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10100-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10100-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10125-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10125-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10125-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10150-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10150-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10150-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10175-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10175-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10175-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10200-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10200-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10200-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10225-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10225-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10225-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10250-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10250-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT10250-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10275-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10275-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10275-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10300-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10300-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10300-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10325-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10325-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10325-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10350-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10350-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10350-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10375-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10375-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10375-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10400-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10400-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10400-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10425-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10425-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10425-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10450-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10450-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10450-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10475-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10475-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10475-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10500-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10500-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10500-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10525-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10525-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT10525-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10550-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10550-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10550-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10575-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10575-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10575-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10600-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10600-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10600-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10625-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10625-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10625-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10650-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10650-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10650-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10675-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10675-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10675-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10700-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10700-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10700-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10725-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10725-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10725-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10750-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10750-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10750-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10775-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10775-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10775-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10800-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10800-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT10800-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10825-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10825-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10825-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10850-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10850-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10850-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10875-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10875-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10875-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10900-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10900-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10900-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10925-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10925-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10925-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10950-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10950-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10950-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT10975-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT10975-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT10975-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11000-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11000-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11000-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11025-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11025-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11025-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11050-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11050-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11050-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11075-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11075-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT11075-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11100-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11100-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11100-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11125-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11125-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11125-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11150-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11150-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11150-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11175-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11175-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11175-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11200-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11200-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11200-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11225-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11225-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11225-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11250-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11250-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11250-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11275-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11275-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11275-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11300-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11300-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11300-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11325-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11325-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11325-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11350-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11350-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT11350-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11375-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11375-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11375-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11400-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11400-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11400-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11425-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11425-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11425-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11450-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11450-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11450-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11475-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11475-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11475-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11500-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11500-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11500-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11525-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11525-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11525-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11550-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11550-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11550-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11575-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11575-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11575-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11600-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11600-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11600-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11625-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11625-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT11625-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11650-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11650-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11650-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11675-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11675-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11675-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11700-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11700-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11700-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11725-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11725-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11725-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11750-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11750-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11750-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11775-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11775-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11775-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11800-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11800-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11800-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11825-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11825-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11825-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11850-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11850-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11850-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11875-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11875-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11875-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11900-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11900-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT11900-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11925-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11925-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11925-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11950-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11950-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11950-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT11975-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT11975-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT11975-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT12000-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT12000-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT12000-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT12025-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT12025-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT12025-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT12050-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT12050-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT12050-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT12075-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT12075-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT12075-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT12100-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT12100-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT12100-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT12125-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT12125-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT12125-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT12150-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT12150-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT12150-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT12175-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT12175-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
HRBT12175-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14
HRBT12200-PVN01-D2.0	Soil Vapor	2.0	VOCs, TPH, PAHs	1	Worksheet #14
HRBT12200-AVN01-D2.0	Soil Vapor	2.0	Biogenic Gases	1	Worksheet #14
HRBT12200-BSN01-D2.0	Soil	2.0	TPH-DRO/LRO	1	Worksheet #14

18.4 ABANDONED AVGAS PIPELINE STUDY AREA

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
AVGL0000-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0000-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0000-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0025-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0025-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0025-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0050-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0050-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0050-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0075-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0075-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0075-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0100-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0100-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0100-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0125-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0125-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0125-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0150-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0150-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0150-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0175-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0175-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0175-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0200-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
AVGL0200-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0200-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0225-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0225-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0225-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0250-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0250-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0250-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0275-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0275-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0275-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0300-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0300-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0300-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0325-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0325-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0325-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0350-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0350-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0350-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0375-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0375-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0375-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0400-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0400-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0400-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0425-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0425-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0425-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0450-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0450-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0450-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0475-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
AVGL0475-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0475-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0500-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0500-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0500-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0525-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0525-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0525-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0550-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0550-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0550-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0575-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0575-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0575-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0600-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0600-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0600-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0625-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0625-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0625-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0650-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0650-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0650-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0675-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0675-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0675-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0700-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0700-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0700-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0725-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0725-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0725-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0750-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
AVGL0750-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0750-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0775-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0775-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0775-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0800-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0800-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0800-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0825-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0825-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0825-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0850-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0850-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0850-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0875-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0875-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0875-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0900-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0900-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0900-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0925-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0925-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0925-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0950-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0950-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0950-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL0975-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL0975-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL0975-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1000-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1000-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1000-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1025-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
AVGL1025-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1025-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1050-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1050-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1050-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1075-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1075-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1075-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1100-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1100-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1100-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1125-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1125-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1125-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1150-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1150-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1150-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1175-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1175-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1175-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1200-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1200-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1200-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1225-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1225-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1225-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1250-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1250-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1250-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1275-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1275-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1275-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1300-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
AVGL1300-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1300-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1325-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1325-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1325-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1350-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1350-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1350-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1375-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1375-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1375-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1400-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1400-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1400-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1425-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1425-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1425-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1450-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1450-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1450-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1475-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1475-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1475-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1500-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1500-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1500-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1525-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1525-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1525-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1550-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1550-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1550-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1575-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
AVGL1575-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1575-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1600-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1600-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1600-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1625-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1625-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1625-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1650-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1650-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1650-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1675-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1675-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1675-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1700-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1700-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1700-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1725-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1725-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1725-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1750-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1750-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1750-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1775-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1775-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1775-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1800-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1800-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1800-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1825-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1825-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1825-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1850-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
AVGL1850-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1850-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1875-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1875-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1875-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1900-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1900-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1900-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1925-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1925-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1925-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1950-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1950-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1950-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL1975-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL1975-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL1975-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2000-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2000-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2000-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2025-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2025-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2025-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2050-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2050-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2050-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2075-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2075-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2075-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2100-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2100-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2100-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2125-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
AVGL2125-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2125-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2150-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2150-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2150-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2175-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2175-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2175-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2200-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2200-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2200-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2225-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2225-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2225-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2250-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2250-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2250-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2275-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2275-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2275-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2300-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2300-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2300-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2325-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2325-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2325-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2350-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2350-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2350-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2375-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2375-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2375-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2400-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
AVGL2400-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2400-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2425-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2425-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2425-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2450-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2450-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2450-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2475-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2475-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2475-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2500-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2500-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2500-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2525-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2525-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2525-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2550-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2550-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2550-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2575-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2575-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2575-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2600-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2600-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2600-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2625-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2625-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2625-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2650-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2650-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2650-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2675-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
AVGL2675-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2675-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2700-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2700-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2700-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2725-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2725-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2725-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2750-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2750-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2750-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2775-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2775-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2775-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2800-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2800-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2800-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2825-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2825-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2825-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2850-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2850-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2850-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2875-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2875-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2875-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2900-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2900-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2900-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2925-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2925-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2925-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2950-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
AVGL2950-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2950-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL2975-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL2975-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL2975-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3000-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3000-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3000-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3025-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3025-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3025-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3050-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3050-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3050-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3075-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3075-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3075-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3100-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3100-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3100-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3125-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3125-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3125-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3150-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3150-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3150-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3175-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3175-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3175-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3200-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3200-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3200-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3225-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
AVGL3225-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3225-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3250-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3250-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3250-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3275-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3275-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3275-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3300-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3300-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3300-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3325-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3325-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3325-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3350-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3350-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3350-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3375-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3375-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3375-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3400-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3400-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3400-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3425-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3425-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3425-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3450-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3450-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3450-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3475-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3475-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3475-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3500-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
AVGL3500-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3500-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3525-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3525-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3525-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3550-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3550-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3550-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3575-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3575-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3575-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3600-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3600-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3600-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3625-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3625-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3625-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3650-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3650-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3650-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3675-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3675-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3675-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3700-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3700-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3700-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3725-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3725-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3725-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3750-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3750-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3750-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3775-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
AVGL3775-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3775-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3800-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3800-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3800-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3825-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3825-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3825-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3850-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3850-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3850-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3875-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3875-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3875-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3900-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3900-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3900-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3925-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3925-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3925-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3950-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3950-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3950-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL3975-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL3975-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL3975-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4000-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4000-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4000-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4025-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4025-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4025-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4050-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
AVGL4050-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4050-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4075-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4075-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4075-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4100-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4100-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4100-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4125-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4125-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4125-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4150-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4150-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4150-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4175-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4175-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4175-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4200-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4200-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4200-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4225-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4225-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4225-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4250-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4250-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4250-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4275-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4275-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4275-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4300-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4300-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4300-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4325-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
AVGL4325-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4325-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4350-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4350-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4350-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4375-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4375-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4375-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4400-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4400-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4400-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4425-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4425-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4425-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4450-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4450-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4450-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4475-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4475-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4475-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4500-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4500-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4500-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4525-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4525-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4525-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4550-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4550-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4550-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4575-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4575-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4575-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4600-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
AVGL4600-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4600-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4625-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4625-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4625-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4650-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4650-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4650-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4675-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4675-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4675-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4700-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4700-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4700-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4725-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4725-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4725-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4750-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4750-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4750-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4775-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4775-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4775-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4800-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4800-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4800-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4825-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4825-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4825-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4850-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4850-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4850-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4875-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
AVGL4875-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4875-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4900-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4900-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4900-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4925-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4925-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4925-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4950-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4950-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4950-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL4975-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL4975-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL4975-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5000-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5000-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5000-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5025-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5025-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5025-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5050-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5050-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5050-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5075-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5075-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5075-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5100-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5100-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5100-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5125-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5125-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5125-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5150-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
AVGL5150-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5150-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5175-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5175-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5175-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5200-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5200-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5200-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5225-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5225-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5225-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5250-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5250-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5250-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5275-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5275-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5275-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5300-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5300-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5300-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5325-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5325-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5325-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5350-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5350-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5350-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5375-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5375-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5375-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5400-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5400-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5400-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5425-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
AVGL5425-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5425-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5450-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5450-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5450-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5475-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5475-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5475-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5500-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5500-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5500-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5525-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5525-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5525-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5550-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5550-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5550-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5575-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5575-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5575-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5600-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5600-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5600-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5625-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5625-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5625-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5650-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5650-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5650-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5675-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5675-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5675-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5700-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
AVGL5700-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5700-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5725-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5725-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5725-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14
AVGL5750-PVN01-D3.5	Soil Vapor	3.5	VOCs, TPH, PAHs	1	Worksheet #14
AVGL5750-AVN01-D3.5	Soil Vapor	3.5	Biogenic Gases	1	Worksheet #14
AVGL5750-BSN01-D3.5	Soil	3.5	TPH-DRO/LRO, TEL	1	Worksheet #14

18.5 SURGE TANK STUDY AREA

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
SRGT0001-PVN01-D35.0	Soil Vapor	35.0	VOCs, TPH, PAHs	1	Worksheet #14
SRGT0001-AVN01-D35.0	Soil Vapor	35.0	Biogenic Gases	1	Worksheet #14
SRGT0001-BSN01-D15.0	Soil	15.0	TPH-DRO/LRO, VOCs, PAHs	1	Worksheet #14
SRGT0001-BSN02-D35.0	Soil	35.0	TPH-DRO/LRO, VOCs, PAHs	1	Worksheet #14
SRGT0002-PVN01-D35.0	Soil Vapor	35.0	VOCs, TPH, PAHs	1	Worksheet #14
SRGT0002-AVN01-D35.0	Soil Vapor	35.0	Biogenic Gases	1	Worksheet #14
SRGT0002-BSN01-D15.0	Soil	15.0	TPH-DRO/LRO, VOCs, PAHs	1	Worksheet #14
SRGT0002-BSN02-D35.0	Soil	35.0	TPH-DRO/LRO, VOCs, PAHs	1	Worksheet #14
SRGT0003-PVN01-D35.0	Soil Vapor	35.0	VOCs, TPH, PAHs	1	Worksheet #14
SRGT0003-AVN01-D35.0	Soil Vapor	35.0	Biogenic Gases	1	Worksheet #14
SRGT0003-BSN01-D15.0	Soil	15.0	TPH-DRO/LRO, VOCs, PAHs	1	Worksheet #14
SRGT0003-BSN02-D35.0	Soil	35.0	TPH-DRO/LRO, VOCs, PAHs	1	Worksheet #14
SRGT0004-PVN01-D35.0	Soil Vapor	35.0	VOCs, TPH, PAHs	1	Worksheet #14
SRGT0004-AVN01-D35.0	Soil Vapor	35.0	Biogenic Gases	1	Worksheet #14
SRGT0004-BSN01-D15.0	Soil	15.0	TPH-DRO/LRO, VOCs, PAHs	1	Worksheet #14
SRGT0004-BSN02-D35.0	Soil	35.0	TPH-DRO/LRO, VOCs, PAHs	1	Worksheet #14
SRGT0005-PVN01-D35.0	Soil Vapor	35.0	VOCs, TPH, PAHs	1	Worksheet #14
SRGT0005-AVN01-D35.0	Soil Vapor	35.0	Biogenic Gases	1	Worksheet #14
SRGT0005-BSN01-D15.0	Soil	15.0	TPH-DRO/LRO, VOCs, PAHs	1	Worksheet #14
SRGT0005-BSN02-D35.0	Soil	35.0	TPH-DRO/LRO, VOCs, PAHs	1	Worksheet #14
SRGT0006-PVN01-D35.0	Soil Vapor	35.0	VOCs, TPH, PAHs	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
SRGT0006-AVN01-D35.0	Soil Vapor	35.0	Biogenic Gases	1	Worksheet #14
SRGT0006-BSN01-D15.0	Soil	15.0	TPH-DRO/LRO, VOCs, PAHs	1	Worksheet #14
SRGT0006-BSN02-D35.0	Soil	35.0	TPH-DRO/LRO, VOCs, PAHs	1	Worksheet #14

18.6 FORMER STANDBY POWER PLANT STUDY AREA

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
FSPP0001-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSPP0001-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
FSPP0001-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO	1	Worksheet #14
FSPP0002-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSPP0002-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
FSPP0002-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO	1	Worksheet #14
FSPP0003-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSPP0003-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
FSPP0003-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO	1	Worksheet #14
FSPP0004-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSPP0004-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
FSPP0004-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO	1	Worksheet #14
FSPP0005-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSPP0005-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
FSPP0005-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO	1	Worksheet #14
FSPP0006-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSPP0006-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
FSPP0006-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO	1	Worksheet #14
FSPP0007-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSPP0007-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
FSPP0007-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO	1	Worksheet #14
FSPP0008-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSPP0008-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
FSPP0008-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO	1	Worksheet #14
FSPP0009-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSPP0009-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
FSPP0009-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO	1	Worksheet #14
FSPP0010-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSPP0010-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
FSPP0010-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO	1	Worksheet #14
FSPP0011-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSPP0011-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
FSPP0011-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO	1	Worksheet #14

18.7 TANK 311 STUDY AREA

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
T3110001-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
T3110001-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
T3110001-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO	1	Worksheet #14
T3110002-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
T3110002-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
T3110002-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO	1	Worksheet #14
T3110003-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
T3110003-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
T3110003-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO	1	Worksheet #14
T3110004-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
T3110004-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
T3110004-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO	1	Worksheet #14
T3110005-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
T3110005-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
T3110005-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO	1	Worksheet #14

18.8 FORMER SLOP TANK STUDY AREA

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
FSLT0001-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSLT0001-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
FSLT0001-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO, VOCs, TPH-GRO, PAHs	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
FSLT0002-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSLT0002-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
FSLT0002-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO, VOCs, TPH-GRO, PAHs	1	Worksheet #14
FSLT0003-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSLT0003-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
FSLT0003-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO, VOCs, TPH-GRO, PAHs	1	Worksheet #14
FSLT0004-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSLT0004-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
FSLT0004-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO, VOCs, TPH-GRO, PAHs	1	Worksheet #14
FSLT0005-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSLT0005-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
FSLT0005-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO, VOCs, TPH-GRO, PAHs	1	Worksheet #14
FSLT0006-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSLT0006-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
FSLT0006-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO, VOCs, TPH-GRO, PAHs	1	Worksheet #14
FSLT0007-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSLT0007-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
FSLT0007-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO, VOCs, TPH-GRO, PAHs	1	Worksheet #14
FSLT0008-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSLT0008-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
FSLT0008-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO, VOCs, TPH-GRO, PAHs	1	Worksheet #14
FSLT0009-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSLT0009-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
FSLT0009-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO, VOCs, TPH-GRO, PAHs	1	Worksheet #14
FSLT0010-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSLT0010-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
FSLT0010-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO, VOCs, TPH-GRO, PAHs	1	Worksheet #14
FSLT0011-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSLT0011-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
FSLT0011-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO, VOCs, TPH-GRO, PAHs	1	Worksheet #14
FSLT0012-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSLT0012-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
FSLT0012-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO, VOCs, TPH-GRO, PAHs	1	Worksheet #14

Sampling Location/ID Number	Matrix	Depth (feet bgs)	Analytical Group	Number of Samples	Sampling SOP Reference [a]
FSLT0013-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSLT0013-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
FSLT0013-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO, VOCs, TPH-GRO, PAHs	1	Worksheet #14
FSLT0014-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSLT0014-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
FSLT0014-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO, VOCs, TPH-GRO, PAHs	1	Worksheet #14
FSLT0015-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSLT0015-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
FSLT0015-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO, VOCs, TPH-GRO, PAHs	1	Worksheet #14
FSLT0016-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSLT0016-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
FSLT0016-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO, VOCs, TPH-GRO, PAHs	1	Worksheet #14
FSLT0017-PVN01-D2.5	Soil Vapor	2.5	VOCs, TPH, PAHs	1	Worksheet #14
FSLT0017-AVN01-D2.5	Soil Vapor	2.5	Biogenic Gases	1	Worksheet #14
FSLT0017-BSN01-D2.5	Soil	2.5	TPH-DRO/LRO, VOCs, TPH-GRO, PAHs	1	Worksheet #14

Worksheet #19: Field Sampling Requirements Table

Matrix	Analytical Group	Preparation Reference/Method SOP Analytical Reference/Method SOP	Containers	Sample Volume	Preservation Requirement	Maximum Holding Time (preparation/analysis)
Soil (Subsurface) Field Sampling (discrete)						
Subsurface Soil [a]	Percent Moisture	Preparation Method: ASTM D2216 Prep SOPs: TA-WC-0160/EFAFS-T-AFS-SOP5133 Analysis Method: ASTM D2216 Analysis SOP: TA-WC-0160/EFAFS-T-AFS-SOP5133	1 × 16 oz wide-mouth glass, Teflon-lined lid	50 g	Cool to ≤6°C	No maximum holding time.
Subsurface Soil [a, b]	VOCs	Preparation Method: EPA 5035A Preparation SOP: EFGS-T-VOA-SOP41085 Analysis Method: EPA 8260D Analysis SOP: EFGS-T-VOA-SOP41085	1 – 4 oz jar [c] with Teflon-lined septum cap with 25 mL methanol	25 g per 4 oz jar [c]	Methanol and Surrogate Cool to ≤6°C	14 days when shipped to laboratory within 48 hours at <6°C.
Subsurface Soil [a, b]	TPH-GRO	Preparation Method: EPA 5035A Preparation SOP: EFGS-T-VOA-SOP41119 Analysis Method: EPA 8260 GRO Analysis SOP: EFGS-T-VOA-SOP41119	1 - 4 oz jar [c] with Teflon-lined septum cap with 25 mL methanol	25 g per 4 oz jar [c]	Methanol and Surrogate Cool to ≤6°C	14 days when shipped to laboratory within 48 hours at <6°.
Subsurface Soil [a]	TPH-DRO/LRO	Preparation Method: EPA 3546 Prep SOPs: EFGS-T-OP-SOP41432 Analysis Method: EPA 8015D Analysis SOP: EFGS-T-GCS-SOP40900	1 × 16 oz wide-mouth glass, Teflon-lined lid	50 g	Cool to ≤6°C	Samples extracted within 14 days and analyzed within 40 days following extraction.
Subsurface Soil [a]	PAHs	Preparation Method: EPA 3546 Prep SOPs: EFGS-T-OP-SOP41432 Analysis Method: EPA 8270E SIM Analysis SOP: EFGS-T-MSS-SOP41389	1 × 16 oz wide-mouth glass, Teflon-lined lid	30 g	Cool to ≤6°C	Samples extracted within 14 days and analyzed within 40 days following extraction.
Subsurface Soil [a]	Tetraethyl Lead	Preparation Method: EPA 3550C Prep SOPs: WI10928 Analysis Method: EPA 8270D SIM Analysis SOP: WI9587	1 × 16 oz wide-mouth glass, Teflon-lined lid	100 g	Cool to ≤6°C	Samples extracted within 14 days and analyzed within 40 days following extraction.
Water (Groundwater, Aqueous)						
Water	VOCs	Preparation Method: EPA 5035A Preparation SOP: EFGS-T-VOA-SOP41085 Analysis Method: EPA 8260D Analysis SOP: EFGS-T-VOA-SOP41085	3 × 40-mL vials, Teflon-lined septum caps	40 mL	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.
Water	TPH-GRO	Preparation Method: EPA 5035A Preparation SOP: EFGS-T-VOA-SOP41119 Analysis Method: EPA 8260 GRO Analysis SOP: EFGS-T-VOA-SOP41119	3 × 40-mL vials, Teflon-lined septum caps	40 mL	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.
Water	TPH-DRO/LRO	Preparation Method: EPA 3546 Prep SOPs: EFGS-T-OP-SOP41411 Analysis Method: EPA 8015D Analysis SOP: EFGS-T-GCS-SOP40900	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.

Matrix	Analytical Group	Preparation Reference/Method SOP Analytical Reference/Method SOP	Containers	Sample Volume	Preservation Requirement	Maximum Holding Time (preparation/analysis)
Water	PAHs	Preparation Method: EPA 3546 Prep SOPs: EFGS-T-OP-SOP41411 Analysis Method: EPA 8270E SIM Analysis SOP: EFGS-T-MSS-SOP41389	2 x1-L amber glass, Teflon-lined lid	1 L	Cool to ≤6°C	Samples extracted within 7 days and analyzed within 40 days following extraction.
Water	Tetraethyl Lead	Preparation Method: EPA 3510C Preparation SOP: WI10928 Analysis Method: EPA 8270D Analysis SOP: WI9587	2 x1-L amber glass, Teflon-lined lid	1 L	Cool to ≤6°C	Samples extracted within 7 days and analyzed within 40 days following extraction.
Soil Gas						
Soil Gas	VOCs, TPH, PAHs	Analysis Method: EPA TO-17 Analysis SOP: SOP 7	Custom Made Beacon PSG sampler sorbent	N/A	Sealed in a Ziploc	Maximum holding time is 30 days.
Soil Gas	Biogenic Gases CH_4, CO_2, O_2	Analysis Method: ASTM D1946 Analysis SOP: VOA-EPA3C	1 L Summa	N/A	N/A	Maximum holding time is 30 days.
Soil Gas	Helium	Analysis Method: EPA 3C Analysis SOP: VOA-HHE	1 L Summa	N/A	N/A	Maximum holding time is 30 days.

°C	degree Celsius
ASTM	ASTM International
DRO	diesel range organics
EPA	Environmental Protection Agency, United States
g	gram
GRO	gasoline range organics
H_2SO_4	sulfuric acid
HCl	hydrogen chloride
ISM	incremental sampling methodology
kg	kilogram
L	liter
LRO	lube oil range organics
mL	milliliter
N/A	not applicable
$NaHSO_4$	sodium bisulfate
NOAA	National Oceanic and Atmospheric Administration
oz	ounce
PAH	polynuclear aromatic hydrocarbon
PSG	passive soil gas
SIM	selective ion monitoring
SOP	standard operating procedure
TGM	Technical Guidance Manual
TPH	total petroleum hydrocarbons
VOA	volatile organic analyte
VOC	volatile organic compound

[a] Sample results will be reported on a dry weight basis.

[b] Volatiles (VOCs, TPH-GRO) are not typically sampled for surface soils using ISM; refer to TGM Section 4.2.7 (DOH 2017b).

[c] Pre-tared 4 oz jar.

[d] This corresponds to requirements for semivolatile organic compound analysis; however, holding times for prepared PCB samples may be as high as a year.

[f] ASTM D2216 is for moisture content only.

Worksheet #20: Field Quality Control Sample Summary Tables

20.1 TANK FARM STUDY AREA

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates	No. of MS/MSD Pairs	No. of Field Blanks	No. of Equipment Blanks	No. of VOA Trip Blanks	No. of PT Samples
Soil Gas	VOCs, TPH, PAHs	77	8	0	0	0	3	0
Soil Gas	Biogenic Gases	77	0	0	0	0	0	0
Soil	TPH-DRO/LRO	77	8	4	1	1	3	0

20.2 LOWER ACCESS TUNNEL STUDY AREA

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates	No. of MS/MSD Pairs	No. of Field Blanks	No. of Equipment Blanks	No. of VOA Trip Blanks	No. of PT Samples
Soil Gas	VOCs, TPH, PAHs	92	10	0	0	0	4	0
Soil Gas	Biogenic Gases	92	0	0	0	0	0	0
Soil	TPH-DRO/LRO	92	10	5	1	1	4	0

20.3 HARBOR TUNNEL STUDY AREA

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates	No. of MS/MSD Pairs	No. of Field Blanks	No. of Equipment Blanks	No. of VOA Trip Blanks	No. of PT Samples
Soil Gas	VOCs, TPH, PAHs	484	50	0	0	0	18	0
Soil Gas	Biogenic Gases	484	0	0	0	0	0	0
Soil	TPH-DRO/LRO	484	50	5	1	1	18	0

20.4 AVGAS STUDY AREA

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates	No. of MS/MSD Pairs	No. of Field Blanks	No. of Equipment Blanks	No. of VOA Trip Blanks	No. of PT Samples
Soil Gas	VOCs, TPH, PAHs	230	23	0	0	0	9	0
Soil Gas	Biogenic Gases	230	0	0	0	0	0	0
Soil	TPH-DRO/LRO	230	23	12	1	2	9	0

20.5 SURGE TANK STUDY AREA

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates	No. of MS/MSD Pairs	No. of Field Blanks	No. of Equipment Blanks	No. of VOA Trip Blanks	No. of PT Samples
Soil Gas	VOCs, TPH, PAHs	6	1	0	0	0	1	0
Soil Gas	Biogenic Gases	6	0	0	0	0	0	0
Soil	VOCs, TPH-GRO, PAHs	6	1	1	1	1	1	0
Soil	TPH-DRO/LRO	6	1	1	1	1	1	0

20.6 FORMER STANDBY POWER PLANT STUDY AREA

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates	No. of MS/MSD Pairs	No. of Field Blanks	No. of Equipment Blanks	No. of VOA Trip Blanks	No. of PT Samples
Soil Gas	VOCs, TPH, PAHs	11	2	0	0	0	1	0
Soil Gas	Biogenic Gases	11	0	0	0	0	0	0
Soil	TPH-DRO/LRO	11	2	1	1	1	1	0

20.7 TANK 311 STUDY AREA

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates	No. of MS/MSD Pairs	No. of Field Blanks	No. of Equipment Blanks	No. of VOA Trip Blanks	No. of PT Samples
Soil Gas	VOCs, TPH, PAHs	5	1	0	0	0	1	0
Soil Gas	Biogenic Gases	5	0	0	0	0	0	0
Soil	VOCs, TPH-GRO, PAHs	5	1	1	1	1	1	0
Soil	TPH-DRO/LRO	5	1	1	1	1	1	0

20.8 FORMER SLOP TANK STUDY AREA

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates	No. of MS/MSD Pairs	No. of Field Blanks	No. of Equipment Blanks	No. of VOA Trip Blanks	No. of PT Samples
Soil Gas	VOCs, TPH, PAHs	17	2	0	0	0	1	0
Soil Gas	Biogenic Gases	17	0	0	0	0	0	0
Soil	VOCs, TPH-GRO, PAHs	17	1	1	1	1	1	0
Soil	TPH-DRO/LRO	17	2	1	1	1	1	0

Worksheet #21: Project Sampling SOP References scope

Reference Number	Title, Revision Date and/or Number [a]	Originating Organization of Sampling SOP	Equipment Type	Comments
N/A	TGM, Section 4.2 Multi Increment Sample Collection (DOH 2017b)	DOH	Disposable plastic scoops for surface samples	No
I-A-6	IDW Management (DON 2015)	NAVFAC Pacific	N/A	No
I-A-8	Sample Naming (DON 2015)	NAVFAC Pacific	N/A	Yes [b]
I-B-1	Soil Sampling (DON 2015)	NAVFAC Pacific	Split-spoon sampler and liners with hollow-stem or solid-stem auger	No
I-B-1	Soil Sampling (DON 2015)	NAVFAC Pacific	Disposable plastic scoops for surface samples and liners for subsurface soil samples	Yes [c]
I-B-2	Geophysical Testing Procedure (DON 2015)	NAVFAC Pacific	Low frequency electromagnetic induction and ground penetrating radar	No
I-B-3	Active Soil Gas Survey (DON 2015)	NAVFAC Pacific	Portable Gas Chromatograph (ECD or FID)	No
I-B-3	Passive Soil Gas Survey (DON 2015)	NAVFAC Pacific	Adsorption samplers for GC/MS	No
I-D-1	Drum Sampling (DON 2015)	NAVFAC Pacific	COLIWASA or glass thieving tubes	No
I-E	Soil and Rock Classification (DON 2015)	NAVFAC Pacific	N/A	No
I-F	Equipment Decontamination (DON 2015)	NAVFAC Pacific	N/A	No
I-H	Direct Push Sampling Techniques (DON 2015)	NAVFAC Pacific	N/A	No
I-I	Land Surveying (DON 2015)	NAVFAC Pacific	GPS	No
III-A	Laboratory QC Samples (Water, Soil) (DON 2015)	NAVFAC Pacific	N/A	No
III-B	Field QC Samples (Water, Soil) (DON 2015)	NAVFAC Pacific	N/A	No
III-D	Logbooks (DON 2015)	NAVFAC Pacific	N/A	No
III-E	Record Keeping, Sample Labeling, and Chain of Custody Procedures (DON 2015)	NAVFAC Pacific	N/A	No
III-F	Sample Handling, Storage and Shipping (DON 2015)	NAVFAC Pacific	N/A	No

DOH	Department of Health, State of Hawaii
ECD	electron capture detector
FID	flame ionization detector
GC/MS	gas chromatography/mass spectrometry
GPS	global positioning system
IDW	investigation-derived waste
N/A	not applicable
NAVFAC	Naval Facilities Engineering Systems Command
QC	quality control
SOP	standard operating procedure.
TGM	Technical Guidance Manual

[a] Applicable procedures from the Project Procedures Manual (DON 2015) and TGM (DOH 2017b).
[b] Modified to remove COC Sample Number format abccc.
[c] Modified for incremental sampling only.

Worksheet #22: Field Equipment Calibration, Maintenance, Testing, and Inspection Table

Field Equipment	Calibration Activity	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference [a]
PID Meter	Calibrate with ambient air and a calibration span gas (100 ppm isobutylene).	Keep batteries charged.	Calibrate with calibration gas.	Visually inspect meter for wear or damage before calibration.	Daily	Stable and acceptable readings achieved per manufacturer's instructions	If readings do not stabilize, do not use device.	Field Manager	Manufacturer's specifications for all inspection, testing, maintenance, and calibrations.
Vacuum Pump	N/A	N/A	Determine if pumps are working correctly.	Test pump.	Daily	Pump is working correctly and air can be pumped	Check manufacturer's specifications and fix or obtain a new pump.	Field Manager	Manufacturer's specifications for all inspection, testing, maintenance, and calibrations.
Passive samplers	N/A	N/A	N/A	Visually inspect for damage and fit correctly to wells.	Daily	Passive sampler is placed correctly in the well and will not be tampered with	Determine depth to screen and groundwater levels at high and low tide for proper placement.	Field Manager	Manufacturer's specifications for all inspection, testing, maintenance, and calibrations.
Summa Canisters	N/A	N/A	N/A	Visually inspect for any damage to canisters.	Daily	N/A	N/A	Field Manager	Manufacturer's specifications for all inspection, testing, maintenance, and calibrations.
Dust Monitor	Calibrate per manufacturer's instructions.	Keep batteries charged.	Activities per manufacturer's instructions.	Visually inspect meter for wear or damage before calibration.	Daily	Stable and acceptable readings achieved per manufacturer's instructions	If readings do not stabilize, do not use device.	Field Manager	Manufacturer's specifications for all inspection, testing, maintenance, and calibrations.
Trimble dGPS	Prior to survey, verify vs. previously surveyed location (e.g., benchmark).	Visual inspection.	Check daily vs. position established during field sampling or previously surveyed location.	Check daily.	Daily	≤1.0 meter	Return to manufacturer for recalibration.	Field Manager	No SOP.
Noise Dosimeter	Prior to work on the project site, calibrate against QC-10 calibrator.	Visual inspection.	Check daily and calibrate against QC-10 calibrator.	Visually inspect for wear of damage and daily check.	Every 8 hours	70–143 dB	Return to manufacturer for recalibration.	Field Manager	No SOP. Maintenance and inspection in accordance with manufacturer's recommendation.

Field Equipment	Calibration Activity	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference [a]
Landfill Gas Monitor	Zero with ambient air and calibrate with a low and high mixture of methane, carbon dioxide and oxygen.	Keep batteries charged.	Calibrate with calibration gas.	Visually inspect meter for wear or damage before calibration.	Zero daily Calibrate weekly	Stable and acceptable readings achieved per manufacturer's instructions	If readings do not stabilize, do not use device.	Field Manager	Manufacturer's specifications for all inspection, testing, maintenance, and calibrations.

%	percent
dB	decibel
dGPS	dead reckoning Global Positioning System
mL	milliliter
N/A	not applicable
PID	photoionization detector
ppm	part per million
SOP	standard operating procedure

[a] Specify the appropriate reference letter or number from the Project Sampling SOP References table (Worksheet #21).

Worksheet #23: Analytical SOP References Table

Multiple laboratories will contribute to the Site Assessment Tank Closure Plan Phase 1 analytical effort. Each laboratory and their SOPs are listed below.

Passive Soil Gas:
Beacon Environmental
526 Underwood Laine, Bel Air, MD 21014
(b) (6)
[redacted]

Soil and Water:
Eurofins Environment Testing Northwest, LLC
5755 8th Street East Tacoma, WA 98424
(b) (6)
[redacted]

Active Soil Gas:
ALS Group USA, Corp.
2655 Park Center Drive, Suite A, Simi Valley, CA 93065
(b) (6)
[redacted]

Tetraethyl Lead Lab:
Eurofins Lancaster Laboratories Environment Testing, LLC
2425 New Holland Pike, Lancaster, PA 17601
(b) (6)
[redacted]

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)
Passive Soil Gas						
SOP 7 (Beacon)	GC/MS Sample Analysis for Packed Tubes and Beacon Passive Air Samplers by EPA Methods TO-17 and TO-15, Rev 17, 6/6/2023	Definitive	VOC, TPH, PAHs (Soil Gas)	TD-GC-MS	No	No
Active Soil Gas						
VOA-EPA3C	ASTM D1946 – Determination of Hydrogen, Carbon Monoxide, Carbon Dioxide, Nitrogen, Methane, and Oxygen using Gas Chromatography with Thermal Conductivity Detection (TCD) in Accordance with EPA Method 3C or ASTM D 1946; Rev.18; 04/5/2024	Definitive	Biogenic Gases (Soil Gas) CH_4, O_2, CO_2	GC-TCD	No	No
VOA-HHE	EPA 3C - Analysis of Hydrogen and Helium Using Gas Chromatography with Thermal Conductivity (TCD); Rev.9.0; 12/8/2023	Definitive	Helium	GC-TCD	No	No
Soil and/or Water						
EFGS-T-VOA-SOP41085	EPA Method 8260D Determination of Volatile Organic Compounds by GC/MS 12/21/2023 V4	Definitive	VOCs (Soil/Water)	Preparation/GC-MS	No	No
EFGS-T-VOA-SOP41119	Methods 8260B LUFT, AK101, NWTPH-Gx Gasoline Range Organics Analysis by Mass Spectrometry 3/8/2023 V3	Definitive	TPH (Soil/Water)	Preparation/GC-MS	No	No
EFGS-T-GCS-SOP40900	EPA Method 8015D Extractable Petroleum Fuel Hydrocarbons 2/14/2023 V 1.1	Definitive	TPH–DRO/LRO (Soil/Water)	GC-FID	No	No
EFGS-T-MSS-SOP41389	Method 8270E Semivolatile Organic Compound (Base/Neutrals and Acids) Analysis by GC/MS 11/17/2022 V 1.1	Definitive	PAHs (Soil/Water)	GC-MS	No	No
TA-WC-0160/ EFAFS-T-AFS-SOP5133	Percent Moisture in Soil V1 2/14/2021	Definitive	Percent Moisture (Soil)	Preparation	No	No
EFGS-T-OP-SOP41411	EPA Method 3510C Separatory Funnel Extraction of Water V 2.1, 10/3/2022	Definitive	TPH-DRO/LRO and PAHs (Water)	Preparation	No	No
EFGS-T-OP-SOP41432	EPA Method 3546 Microwave Extraction V 2 2/14/2021	Definitive	TPH-DRO/LRO and PAHs (Soil)	Preparation	No	No
WI10928	Microwave Extraction by Method 3546 for Semivolatiles, Version 14, 04/15/2022	Definitive	Tetraethyl Lead (Soil)	Preparation	No	No

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)
WI9587	Tetraethyl Lead (TEL) in Water and Solids by 8270D/E by GC/MS, Version 10, effective 07/27/2020	Definitive	Tetraethyl Lead (Soil)	GC-MS	No	No
SOP11892	Determining Method Detection Limits and Limits of Quantitation, Version 16, effective 2/1/2023	N/A	N/A	N/A	No	No
WI9598	GC/MS Preventative and Corrective Maintenance, Version 6, 9/26/2019	N/A	Maintenance	N/A	No	No

Note: The laboratory SOPs listed in Worksheet #23 are the most current revisions at the time of publication of this WP. AECOM will review the laboratory SOPs immediately prior to sample submittal to ensure that the laboratory uses SOPs that are in compliance with the DoD QSM annual review requirement.

ASTM	ASTM International
DoD	Department of Defense
DRO	diesel range organics
EPA	Environmental Protection Agency, United States
GC-FID	gas chromatography-flame ionization detector
GC-MS	gas chromatography-mass spectrometry
GRO	gasoline range organics
LRO	lube oil range organics
MIS	multi-increment sampling
N/A	not applicable
no.	number
PAH	polynuclear aromatic hydrocarbon
QSM	Quality Systems Manual
SIM	selective ion monitoring
SOP	standard operating procedure
SVOC	semivolatile organic compound
TCD	Thermal Conductivity Detector
TD	Thermal Desorption
TPH	total petroleum hydrocarbons
VOC	volatile organic compound

Worksheet #24: Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference [a]
GC-MS EPA Methods 8260D, 8260 GRO, 8270D/E, 8720D SIM, TO-17	Tuning	Prior to ICAL and at the beginning of each 12-hour period	Refer to method for specific ion criteria.	Retune instrument and verify. Rerun affected samples.	Lab Manager/Analyst or certified instrument technician	EFGS-T-VOA-SOP41085, EFGS-T-VOA-SOP41119, WI9587, EFGS-T-MSS-SOP41389, SOP 7 (Beacon)
	Minimum 5-point ICAL for linear calibration Minimum 6-point ICAL for quadratic calibration For WI9587, Minimum 6-point ICAL	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. % RSD ≤15%, if >15% then linear fit r2≥0.99	Correct problem then repeat ICAL.	Lab Manager/Analyst or certified instrument technician	EFGS-T-VOA-SOP41085, EFGS-T-VOA-SOP41119, WI9587, EFGS-T-MSS-SOP41389, SOP 7 (Beacon)
	Second source calibration verification	After ICAL	All analytes within ±20% of expected value. For WI9587, Tetraethyl Lead ≤30% Drift	Correct problem and verify second source standard; rerun second source verification. If fails, correct problem and repeat initial calibration.	Lab Manager/Analyst or certified instrument technician	EFGS-T-VOA-SOP41085, EFGS-T-VOA-SOP41119, WI9587, EFGS-T-MSS-SOP41389, SOP 7 (Beacon)
	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	EFGS-T-VOA-SOP41085, EFGS-T-VOA-SOP41119, WI9587, EFGS-T-MSS-SOP41389, SOP 7 (Beacon)
	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	EFGS-T-VOA-SOP41085, EFGS-T-VOA-SOP41119, WI9587, EFGS-T-MSS-SOP41389, SOP 7 (Beacon)
	CCV	Daily, before sample analysis, unless ICAL performed same day and after every 10 samples and at the end of the analysis sequence. For WI9587, every 12 hours.	All analytes within ±20% of expected value (%D). All reported analytes and surrogates within ± 50% for end of analytical batch CCV.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Lab Manager/Analyst or certified instrument technician	EFGS-T-VOA-SOP41085, EFGS-T-VOA-SOP41119, WI9587, EFGS-T-MSS-SOP41389, SOP 7 (Beacon)
	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	EFGS-T-VOA-SOP41085, EFGS-T-VOA-SOP41119, WI9587, EFGS-T-MSS-SOP41389, SOP 7 (Beacon)

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference [a]
GC-FID EPA Method 8015D	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 initial calibration.	Lab Manager/Analyst or certified instrument technician	EFGS-T-GCS-SOP40900
	Second source calibration verification	Once after each initial calibration	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 initial calibration.	Lab Manager/Analyst or certified instrument technician	EFGS-T-GCS-SOP40900
	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-DRO: calculate RT based on C12 and C25 alkanes.	N/A	Lab Manager/Analyst or certified instrument technician	EFGS-T-GCS-SOP40900
	Establishment and verification of the RT window for each analyte and surrogate	Once per ICAL and at the beginning of the analytical shift for establishment of RT; and with each CCV for verification of RT	Using the midpoint standard or the CCV at the beginning of the analytical shift for RT establishment; and analyte must fall within established window during RT verification.	N/A	Lab Manager/Analyst or certified instrument technician	EFGS-T-GCS-SOP40900
	Run second source calibration 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 initial calibration.	Lab Manager/Analyst or certified instrument technician	EFGS-T-GCS-SOP40900
	CCV	Daily, before sample analysis, unless ICAL performed same day and after every 10 samples and at the end of the analysis sequence	All analytes within ±20% of expected value (%D).	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Lab Manager/Analyst or certified instrument technician	EFGS-T-GCS-SOP40900

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference [a]
GC-TCD ASTM D1946, EPA 3C	Initial Calibration (ICAL) – minimum of five levels	Initially and if continuing calibration no longer meets criteria	Analytes calibrated using average RF, RSD ≤15% (VOA-EPC3C); RSD ≤20% (VOA-HHE);	1) May repeat one point (if analyzing 5 levels) or two points (if analyzing 6 levels) 2) Inspect the system for problems and perform required maintenance 3) Repeat initial calibration Problem must be corrected. Samples may not be analyzed until there is a valid ICAL.	Lab Manager/Analyst or certified instrument technician	VOA-EPA3C, VOA-HHE
	Initial Calibration Verification (ICV)	Following every ICAL	Percent recovery for each analyte 85-115% (VOA-EPA3C); Percent recovery for each analyte 80-120% (VOA-HHE)	Correct problem and verify second source standard. Rerun second source verification. If that fails, correct problem and repeat initial calibration. Problem must be corrected. Samples may not be analyzed until there is a valid ICV.	Lab Manager/Analyst or certified instrument technician	VOA-EPA3C, VOA-HHE
	Continuing Calibration Verification (CCV)	Initial run of batch, every 10 samples, and end of batch (all samples must be bracketed by two CCVs) or whichever is more frequent	1) Percent difference of ≤10% (VOA-EPA3C); Percent difference of ≤20% (VOA-HHE) 2) Retention time (RT) for each analyte in the standard within 0.33 min. from mean RT from the ICAL.	1) Reanalyze CCV [Analyze 2 additional CCVs] 2) Identify and correct problem; re-analyze or where appropriate qualify the data. 3) Repeat initial calibration if CCV corrective action is unsuccessful.	Lab Manager/Analyst or certified instrument technician	VOA-EPA3C, VOA-HHE
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	Manufacturer SOP
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	Manufacturer SOP

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference [a]
Analytical Balance	Calibrate against verified (National Institute of Standards and Technology) 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	Manufacturer SOP
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	Manufacturer SOP

%	percent
%D	percent difference
amu	atomic mass unit
CA	corrective action
CCV	continued calibration verification
CFR	Code of Federal Regulations
CRDL	contract-required detection limit
D	difference
DRO	diesel range organics
EPA	Environmental Protection Agency, United States
GC-FID	gas chromatography-flame ionization detector
GC-MS	gas chromatography-mass spectrometry
IC	initial calibration
ICAL	initial calibration
ICV	initial calibration verification
IS	internal standard
LOD	limit of detection
LOQ	limit of quantitation
m/z	mass-to-charge ration
MDL	method detection limit
N/A	not applicable
RF	response factor
RRT	relative retention time
RSD	relative standard deviation
RT	retention time
S/N	signal-to-noise ratio
SIM	selected ion monitoring
SOP	standard operating procedure
TCD	thermal conductivity detector
TPH	total petroleum hydrocarbons

[a] Specify the appropriate reference letter or number from the Analytical SOP References table (Worksheet #23).

Worksheet #25: Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference [a]
GC-FID GC-MS GC-TCD	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	EFGS-T-VOA-SOP41085, EFGS-T-VOA-SOP41119, WI9598, EFGS-T-MSS-SOP41389, SOP 7 (Beacon), VOA-EPA3C, VOA-HHE
	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	EFGS-T-VOA-SOP41085, EFGS-T-VOA-SOP41119, WI9598, EFGS-T-MSS-SOP41389, SOP 7 (Beacon), VOA-EPA3C, VOA-HHE
	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	EFGS-T-VOA-SOP41085, EFGS-T-VOA-SOP41119, WI9598, EFGS-T-MSS-SOP41389, SOP 7 (Beacon), VOA-EPA3C, VOA-HHE
	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	EFGS-T-VOA-SOP41085, EFGS-T-VOA-SOP41119, WI9598, EFGS-T-MSS-SOP41389, SOP 7 (Beacon), VOA-EPA3C, VOA-HHE
GC-FID	Clean injector ports.	N/A	N/A	As needed	N/A	N/A	Analyst	EFGS-T-GCS-SOP40900
	Replace trap on purge-and-trap systems.	N/A	N/A	Bi-monthly or as needed	N/A	N/A	Analyst	EFGS-T-GCS-SOP40900
	Replace detector jets.	N/A	N/A	As needed	N/A	N/A	Analyst	EFGS-T-GCS-SOP40900
	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	EFGS-T-GCS-SOP40900
	Replace chemical trap.	N/A	N/A	Yearly or as needed	N/A	N/A	Analyst	EFGS-T-GCS-SOP40900
	Replace converter tube in gas purifier system.	N/A	N/A	Yearly or as needed	N/A	N/A	Analyst	EFGS-T-GCS-SOP40900

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	EFGS-T-VOA-SOP41085, EFGS-T-VOA-SOP41119, WI9598, EFGS-T-MSS-SOP41389, SOP 7 (Beacon)
	Run tuning program to determine if source is functioning properly.	N/A	N/A	Daily	N/A	Cool system, vent, disassemble and clean.	Analyst	EFGS-T-VOA-SOP41085, EFGS-T-VOA-SOP41119, WI9598, EFGS-T-MSS-SOP41389, SOP 7 (Beacon)
	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	EFGS-T-VOA-SOP41085, EFGS-T-VOA-SOP41119, WI9598, EFGS-T-MSS-SOP41389, SOP 7 (Beacon)
	Replace columns.	N/A	N/A	If chromatograms indicate possible contamination	N/A	N/A	Analyst	EFGS-T-VOA-SOP41085, EFGS-T-VOA-SOP41119, WI9598, EFGS-T-MSS-SOP41389, SOP 7 (Beacon)
	Vacuum rough pump oil level is checked.	N/A	N/A	Every 4-6 weeks	N/A	Add oil if needed.	Analyst	EFGS-T-VOA-SOP41085, EFGS-T-VOA-SOP41119, WI9598, EFGS-T-MSS-SOP41389, SOP 7 (Beacon)
	Replace/refill carrier gas line oxygen and moisture traps.	N/A	N/A	Yearly or as needed	N/A	N/A	Analyst	EFGS-T-VOA-SOP41085, EFGS-T-VOA-SOP41119, WI9598, EFGS-T-MSS-SOP41389, SOP 7 (Beacon)

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference [a]
GC-MS (TO-17 only)	Concentrator Trap	ICAL/CCV	ICAL/CCV	As needed indicated by calibration and QC difficulties	Clean blank, sufficient sensitivity, and ICAL meets linearity criteria	Routine maintenance includes periodic solvent cleaning of Silco steel lines in the valve oven if contamination is suspected. Also, periodic replacement of multi-sorbent or partial replacement of the trap if analyte specific deterioration is detected.	Analyst	SOP 7 (Beacon)
GC-TCD (ASTM D1946 EPA 3C)	Detector	ICAL/CCV	ICAL/CCV	As needed indicated by calibration and QC difficulties	Clean blank, sufficient sensitivity, and ICAL meets linearity criteria	Replace Filament Assembly	Analyst	VOA-EPA3C, VOA-HHE
	Injection Lines	ICAL/CCV	ICAL/CCV	As needed indicated by calibration and QC difficulties	Clean blank, sufficient sensitivity, and ICAL meets linearity criteria	Purge with nitrogen to ensure line is not blocked	Analyst	VOA-EPA3C, VOA-HHE
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	Manufacturer SOP
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	Manufacturer SOP
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	Manufacturer SOP
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	Manufacturer SOP

GC-FID	gas chromatography-flame ionization detector
GC-MS	gas chromatography-mass spectrometry
LCD	liquid crystal display
MSD	matrix spike duplicate
N/A	not applicable
NIST	National Institute of Standards and Technology
SOP	standard operating procedure

[a] Specify the appropriate reference letter or number from the Analytical SOP References table (Worksheet #23).

Worksheet #26: Sample Handling System

Item	Personnel/Organization/Time Limit
Sample Collection, Packaging, and Shipment	
Sample Collection	Field manager, field QC coordinator, field geologist/AECOM
Sample Packaging	Field manager, field QC coordinator, field geologist/AECOM
Coordination of Shipment	Field QC coordinator, field geologist/AECOM
Type of Shipment/Carrier	Insulated cooler/FedEx Corporation
Sample Receipt and Analysis	
Sample Receipt	Sample custodian/Designated analytical laboratories [a]
Sample Custody and Storage	Sample custodian/Designated analytical laboratories [a]
Sample Preparation	Laboratory analyst/Designated analytical laboratories [a]
Sample Determinative Analysis	Laboratory analyst/Designated analytical laboratories [a]
Sample Archiving	
Field Sample Storage	90 days from sample receipt
Sample Extract/Digestate Storage	90 days from extraction/digestion
Sample Disposal	
Personnel/Organization	Sample custodian/Designated analytical laboratories [a]
Number of Days from Analysis	90 days

AECOM	AECOM Technical Services, Inc.
no.	number
QC	quality control

[a] Designated analytical laboratories include: Beacon Environmental, Eurofins Environment Testing Northwest, LLC, Eurofins Lancaster Laboratories Environment Testing, LLC, and ALS Group LLC.

Worksheet #27: 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).

27.1 DESCRIPTIVE IDENTIFICATION NUMBER

A descriptive ID number 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:

AAAAbbbb-CCdee-Dff.f

Where:

AAAA = Study area (Table 27-1)

bbbb = Sample location number. For Study Areas LATS, LATS, HRBT, and AVGAS this number will represent the distance in feet from the origin of the Study Area (e.g., 0025, 0050). For the remainder of the Study Areas this number will represent the sample number (e.g., 0001, 0002).

CC = Matrix and sample type (Table 27-2)

d = Field QC sample type (Table 27-3)

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 feet below ground surface (bgs) (measured to the tenth of a foot). For field blanks, trip blanks and equipment blanks, the depth field will contain the month and date of collection.

For example, the sample number TNKF0025-PVN02-D2.0 would indicate that the sample for passive soil vapor was collected 25 ft from the origin of the Tank Farm Study Area, sample 02, at 2 f bgs. The duplicate sample would be designated as TNKF0025-PVFD02-D2.0. These characters will establish a unique descriptive identifier that will be used during data evaluation.

Table 27-1: Area Identifiers

Identifier	Study Area	Study Area Boundaries
TNKF	Tank Farm Study Area	(b) (3)
LATS	Lower Access Tunnel Study Area	
HRBT	Harbor Tunnel Study Area	
SRGT	Surge Tank Study Area	
FSPP	Former Standby Power Plant Study Area	
T311	Tank 311 Study Area	

Identifier	Study Area	Study Area Boundaries
AVGL	Abandoned AVGAS Line Study Area	(b) (3) [redacted]
FSLT	Former Slop Tank Study Area	[redacted]
CHTT	CHT Tank Study Area	The perimeter of the ongoing investigation at the CHT
HTLT	Former Holding Tank and Leach Tank Study Area	The perimeter of the ongoing investigation at the Holding Tank/Leach Tank ar
OWDF	Former OWDF Study Area	Perimeter of the OWDF
ADI3	Adit 3 Study Area	Adit 3

Table 27-2: Sample Type and Matrix Identifiers (Examples)

Identifier	Sample Type	Matrix
PV	Passive Soil Vapor	Soil Vapor
AV	Active Soil Vapor	Soil Vapor
BS	Subsurface soil	Soil
GW	Groundwater	Water
WQ	Water Quality Sample	Water

Table 27-3: Field QC Sample Type Identifiers (Keep for Consistency)

Identifier	Field or QC Sample Type	Description
N	Primary Sample	All field samples except QC samples
FD	Duplicate	Co-located for soil (adjacent liners)/replicate for water
E	Equipment Blank	Water
B	Field Blank	Water
T	Trip Blank	Water

27.2 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 Procedures* (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 Module 2 "Quality Systems General Requirements" of the *Department of Defense (DoD) and Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories*, Version 6.0 (DoD and DOE 2023).

Worksheet #28: Laboratory QC Samples Table

Matrix	**Soil Gas**
Analytical Group	**VOCs, TPH, PAHs**
Analytical Method/SOP Reference	**Analytical Method: EPA TO-17** **Preparation Method: EPA TO-17** **Laboratory SOPs:** SOP 7 (Beacon)
Analytical Organization	**Beacon Environmental**

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 SOP 7 (Beacon).
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 Module 4 of the DoD QSM 6.0 (DoD and DOE 2023).	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 SOP 7 (Beacon).
Tune Check	Prior to the initial calibration and prior to each 24-hour period of sample analysis.	Specific ion abundance criteria of BFB from method.	Retune instrument and verify.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	No samples may be analyzed without a passing tune.

Matrix	**Soil Gas**
Analytical Group	**VOCs, TPH, PAHs**
Analytical Method/SOP Reference	**Analytical Method: EPA TO-17** **Preparation Method: EPA TO-17** **Laboratory SOPs:** SOP 7 (Beacon)
Analytical Organization	**Beacon Environmental**

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
CCV	Before sample analysis and at the end of the analysis sequence.	All reported analytes and surrogates within established RT windows. All reported analytes within +/- 20% of true value. Note: If CCV is biased high and analyte is ND (not detected) results are acceptable. It will be noted in case narrative. All reported analytes and surrogates withing +/-50% for end of analytical batch Closing CCV.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision	Results may not be reported without a valid CCV. If reanalysis cannot be performed, data must be qualified and explained in the case narrative. If the specific version of a method requires additional evaluation (e.g., average response factors) these additional requirements must also be met.
MB	Each time 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.	All reported analytes and surrogates within established RT windows. All reported analytes within +/- 20% of true value. Method TO-17 and SOP 7 (Beacon).	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 as specified by SOP 7 (Beacon).
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.

Matrix	**Soil Gas**
Analytical Group	**VOCs, TPH, PAHs**
Analytical Method/SOP Reference	**Analytical Method: EPA TO-17** **Preparation Method: EPA TO-17** **Laboratory SOPs:** SOP 7 (Beacon)
Analytical Organization	**Beacon Environmental**

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
Surrogate spike	All field and QC samples.	Per Method TO-17 and SOP 7 (Beacon).	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 as specified by SOP 7 (Beacon).
Trip blank	One 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	**Soil Gas**
Analytical Group	**Biogenic Gases and Helium**
Analytical Method/SOP Reference	**Analytical Method: ASTM D1946 and EPA 3C** **Preparation Method: ASTM D1946 and EPA 3C** **Laboratory SOPs:** VOA-EPA3C and VOA-HHE
Analytical Organization	**ALS Group USA, Corp.**

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
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 Module 4 of the DoD QSM 6.0 (DoD and DOE 2023).	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 VOA-EPA3C.
CCV	Before sample analysis and at the end of the analysis sequence.	All reported analytes within established RT windows. All reported analytes percent difference of ≤10% (VOA-EPA3C); percent difference of ≤20% (VOA-HHE)	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision	Results may not be reported without a valid CCV. If reanalysis cannot be performed, data must be qualified and explained in the case narrative. If the specific version of a method requires additional evaluation (e.g., average response factors) these additional requirements must also be met.
MB	Each time samples are extracted and one per matrix per analytical method for each batch of at most 20 samples.	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 >LOQ.
LCS	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	All reported analytes within established RT windows. All reported analytes within laboratory in-house limits. Methods VOA-EPA3C and VOA-HHE.	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 as specified by VOA-EPA3C and VOA-HHE.

Matrix	**Soil Gas**
Analytical Group	**Biogenic Gases and Helium**
Analytical Method/SOP Reference	**Analytical Method: ASTM D1946 and EPA 3C** **Preparation Method: ASTM D1946 and EPA 3C** **Laboratory SOPs:** VOA-EPA3C and VOA-HHE
Analytical Organization	**ALS Group USA, Corp.**

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
Laboratory Duplicates (LD)	Once every analytical batch of 20 or fewer samples	Relative Percent Difference (RPD) within laboratory in-house limits. Methods VOA-EPA3C and VOA-HHE.	Reanalyze LD. Flag data if third aliquot is unacceptable.	Analyst Lab QA Officer Project Chemist	Precision	QC acceptance criteria as specified by VOA-EPA3C and VOA-HHE.

Matrix	**Subsurface Soil**
Analytical Group	**VOCs**
Analytical Method/SOP Reference	Analytical Method: SW-846 8260D Preparation Method: EPA 5035A Laboratory SOPs: EFGS-T-VOA-SOP41085
Analytical Organization	Eurofins Environment Testing Northwest, LLC

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 EFGS-T-VOA-SOP41085.
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 Module 4 of the DoD QSM 6.0 (DoD and DOE 2023).	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 EFGS-T-VOA-SOP41085, and at least as stringent as specified by DoD QSM 6.0 (DoD and DOE 2023).
Tune Check	Prior to the initial calibration 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.

Matrix	**Subsurface Soil**
Analytical Group	**VOCs**
Analytical Method/SOP Reference	Analytical Method: SW-846 8260D Preparation Method: EPA 5035A Laboratory SOPs: EFGS-T-VOA-SOP41085
Analytical Organization	Eurofins Environment Testing Northwest, LLC

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
MB	Each time samples are extracted and one per matrix per analytical method for each batch of at most 20 samples.	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common lab contaminants, no analytes detected >LOQ.	Correct problem. If required, re-prep and reanalyze MB and all samples processed with the contaminated blank.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ.
LCS	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	Per DoD QSM Appendix C Limits, Method SW-846 8260C and Lab SOP EFGS-T-VOA-SOP41085.	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 6.0 (DoD and DOE 2023).
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 EFGS-T-VOA-SOP41085. 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 6.0 (DoD and DOE 2023) for LCS.
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 (DoD and DOE 2023), Method SW-846 8260C and Lab SOP EFGS-T-VOA-SOP41085.	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 6.0 (DoD and DOE 2023).

Matrix	**Subsurface Soil**
Analytical Group	**VOCs**
Analytical Method/SOP Reference	Analytical Method: SW-846 8260D Preparation Method: EPA 5035A Laboratory SOPs: EFGS-T-VOA-SOP41085
Analytical Organization	Eurofins Environment Testing Northwest, LLC

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
Trip blank	One 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.

%	percent
BFB	4-bromofluorobenzene
CCV	continuing calibration verification
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
GC	gas chromatography
ICAL	initial calibration
LCS	laboratory control sample
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
MS	matrix spike
MSD	matrix spike duplicate
QA	quality assurance
QC	quality control
QSM	Quality Systems Manual
RPD	relative percent difference
RT	retention time
SOP	standard operating procedure
TBD	to be determined
VOC	volatile organic compound

Matrix	**Subsurface Soil**
Analytical Group	**TPH-GRO**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8260 GRO Preparation Method: EPA 5035A Laboratory SOPs: EFGS-T-VOA-SOP41119
Analytical Organization	Eurofins Environment Testing Northwest, LLC

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 EFGS-T-VOA-SOP41119.
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. See Module 4 of the DoD QSM 6.0 (DoD and DOE 2023).	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 Module 4 of the DoD QSM 6.0 (DoD and DOE 2023).	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 EFGS-T-VOA-SOP41119 and at least as stringent as specified by DoD QSM 6.0 (DoD and DOE 2023).
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.

Matrix	**Subsurface Soil**
Analytical Group	**TPH-GRO**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8260 GRO Preparation Method: EPA 5035A Laboratory SOPs: EFGS-T-VOA-SOP41119
Analytical Organization	Eurofins Environment Testing Northwest, LLC

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
MB	Each time samples are extracted and one per matrix per analytical method for each batch of at most 20 samples.	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common lab contaminants, no analytes detected >LOQ.	Correct problem. If required, re-prep and reanalyze MB and all samples processed with the contaminated blank.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ.
LCS	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	Per DoD QSM Appendix C Limits, Method 8015C and lab SOP EFGS-T-VOA-SOP41119.	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 6.0 (DoD and DOE 2023).
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 EFGS-T-VOA-SOP41119. 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 6.0 (DoD and DOE 2023).
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 (DoD and DOE 2023), Method 8015C and lab SOP EFGS-T-VOA-SOP41119.	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 6.0 (DoD and DOE 2023).

Matrix	**Subsurface Soil**
Analytical Group	**TPH-GRO**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8260 GRO Preparation Method: EPA 5035A Laboratory SOPs: EFGS-T-VOA-SOP41119
Analytical Organization	Eurofins Environment Testing Northwest, LLC

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
Trip blank	One 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.

%	percent
CCV	continuing calibration verification
DoD	Department of Defense
DQI	data quality indicator
DQO	data quality objective
EICP	extracted ion current profile
EPA	Environmental Protection Agency, United States
GC	gas chromatography
GRO	gasoline range organics
ICAL	initial calibration
LCS	laboratory control sample
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
MS	matrix spike
MSD	matrix spike duplicate
QA	quality assurance
QC	quality control
QSM	Quality Systems Manual
RPD	relative percent difference
RT	retention time
SOP	standard operating procedure
TBD	to be determined
TPH	total petroleum hydrocarbons

Matrix	**Subsurface Soil**
Analytical Group	**TPH-DRO/LRO**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8015C Preparation Method: EPA 3546 Laboratory SOPs: EFGS-T-GCS-SOP40900 / EFGS-T-OP-SOP41432 (respectively)
Analytical Organization	Eurofins Environment Testing Northwest, LLC

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 EFGS-T-GCS-SOP40900.
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 Module 4 of the DoD QSM 6.0 (DoD and DOE 2023).	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 EFGS-T-GCS-SOP40900 and at least as stringent as specified by DoD QSM 6.0 (DoD and DOE 2023).
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.

Matrix	**Subsurface Soil**
Analytical Group	**TPH-DRO/LRO**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8015C Preparation Method: EPA 3546 Laboratory SOPs: EFGS-T-GCS-SOP40900 / EFGS-T-OP-SOP41432 (respectively)
Analytical Organization	Eurofins Environment Testing Northwest, LLC

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 EFGS-T-GCS-SOP40900.	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 6.0 (DoD and DOE 2023).
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 EFGS-T-GCS-SOP40900. 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 6.0 (DoD and DOE 2023).
Surrogate spike	All field and QC samples.	Per DoD QSM Appendix C Limits, Method 8015C and lab SOP EFGS-T-GCS-SOP40900.	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 6.0 (DoD and DOE 2023).

CCV	continuing calibration verification
DoD	Department of Defense
DQI	data quality indicator
DQO	data quality objective
DRO	diesel range organics
EPA	Environmental Protection Agency, United States
LCS	laboratory control sample
LOD	limit of detection
LOQ	limit of quantitation
LRO	lube oil range organics
TPH	total petroleum hydrocarbons
MB	method blank
MS	matrix spike
MSD	matrix spike duplicate
QA	quality assurance
QC	quality control
QSM	Quality Systems Manual
RPD	relative percent difference
RT	retention time
SOP	standard operating procedure
TBD	to be determined

Matrix	**Subsurface Soil**
Analytical Group	**Organic Lead – Tetraethyl Lead**
Analytical Method/SOP Reference	Analytical Method: SW-846 8270D/E Preparation Method: EPA 3546 Laboratory SOPs: WI9587 / WI10928
Analytical Organization	Eurofins Lancaster Laboratories Environment Testing, LLC

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 SOP11892.
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 Module 4 of the DoD QSM 6.0 (DoD and DOE 2023).	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 SOP11892 and at least as stringent as specified by DoD QSM 6.0 (DoD and DOE 2023).
Performance check	Before initial calibration 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 ≤3 and ≤5 respectively.	Correct problem, then repeat performance checks.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	Degradation of DDT must be ≤20%. Benzidine and pentachlorophenol will be present at their normal responses and will not exceed a tailing factor of ≤3 and ≤5 respectively.
Tune Check	Prior to the initial calibration and prior to each 12-hour period of sample analysis.	Specific ion abundance criteria of DFTPP.	Retune instrument and verify.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	No sample will be analyzed without a passing tune.

Matrix	**Subsurface Soil**
Analytical Group	**Organic Lead – Tetraethyl Lead**
Analytical Method/SOP Reference	Analytical Method: SW-846 8270D/E Preparation Method: EPA 3546 Laboratory SOPs: WI9587 / WI10928
Analytical Organization	Eurofins Lancaster Laboratories Environment Testing, LLC

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 12 hours, 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 > LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher.	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 > LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher.
LCS	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	Reported analyte within laboratory in-house limits per Lab SOP WI9587.	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	Reported analyte within laboratory in-house limits per Lab SOP WI9587.
Internal standards verification	Every field sample, standard, and QC sample.	RT change ≤30 sec. of associated reference standard; 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.	Reported analyte within laboratory in-house limits per Lab SOP WI9587.	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	Reported analyte within laboratory in-house limits per Lab SOP WI9587.

Matrix	**Subsurface Soil**
Analytical Group	**Organic Lead – Tetraethyl Lead**
Analytical Method/SOP Reference	Analytical Method: SW-846 8270D/E Preparation Method: EPA 3546 Laboratory SOPs: WI9587 / WI10928
Analytical Organization	Eurofins Lancaster Laboratories Environment Testing, LLC

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
MS/MSD pair	One per matrix per analytical method for each batch of at most 20 samples.	Reported analyte within laboratory in-house limits per Lab SOP WI9587. RPD ≤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	Reported analyte within laboratory in-house limits per Lab SOP WI9587. RPD ≤20%.

%	percent
CCV	continuing calibration verification
DDT	dichlorodiphenyltrichloroethane
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
GC	gas chromatography
ICAL	initial calibration
LCS	laboratory control sample
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
MS	matrix spike
MSD	matrix spike duplicate
QA	quality assurance
QC	quality control
QSM	Quality Systems Manual
RPD	relative percent difference
RT	retention time
SOP	standard operating procedure
TBD	to be determined

Matrix	**Subsurface Soil**
Analytical Group	**PAHs**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8270DSIM Preparation Method: EPA 3550C Laboratory SOPs: EFGS-T-MSS-SOP41389
Analytical Organization	Eurofins Testing Environment Northwest, LLC

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 EFGS-T-MSS-SOP41389.
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 Module 4 of the DoD QSM 6.0 (DoD and DOE 2023).	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 EFGS-T-MSS-SOP41389 and at least as stringent as specified by DoD QSM 6.0 (DoD and DOE 2023).
Tune Check	Prior to the initial calibration and prior to each 12-hour period of sample analysis.	Specific ion abundance criteria of DFTPP or BFB from method.	Retune instrument and verify	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	No samples may be analyzed without a passing tune.
Performance check	Before initial calibration 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.

Matrix	**Subsurface Soil**
Analytical Group	**PAHs**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8270DSIM Preparation Method: EPA 3550C Laboratory SOPs: EFGS-T-MSS-SOP41389
Analytical Organization	Eurofins Testing Environment Northwest, LLC

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, 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 8270DSIM and Lab SOP EFGS-T-MSS-SOP41389.	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 6.0 (DoD and DOE 2023).
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 8270DSIM and Lab SOP EFGS-T-MSS-SOP41389.	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 6.0 (DoD and DOE 2023).

Matrix	**Subsurface Soil**
Analytical Group	**PAHs**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8270DSIM Preparation Method: EPA 3550C Laboratory SOPs: EFGS-T-MSS-SOP41389
Analytical Organization	Eurofins Testing Environment Northwest, LLC

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
MS/MSD pair	One per analytical method for each batch of at most 20 samples.	Per DoD QSM Appendix C Limits, Method 8270DSIM and Lab SOP EFGS-T-MSS-SOP41389. 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 6.0 (DoD and DOE 2023).

%	percent
BFB	4-bromofluorobenzene
CCV	continuing calibration verification
DDT	dichlorodiphenyltrichloroethane
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
GC	gas chromatography
ICAL	initial calibration
LCS	laboratory control sample
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
MS	matrix spike
MSD	matrix spike duplicate
PAH	polynuclear aromatic hydrocarbon
QA	quality assurance
QC	quality control
QSM	Quality Systems Manual
RPD	relative percent difference
RT	retention time
SIM	selected ion monitoring
SOP	standard operating procedure
TBD	to be determined

Matrix	**Groundwater**
Analytical Group	**VOCs**
Analytical Method/SOP Reference	Analytical Method: SW-846 8260C Preparation Method: EPA 5030B Laboratory SOPs: EFGS-T-VOA-SOP41085
Analytical Organization	Eurofins Testing Environment Northwest, LLC

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 EFGS-T-VOA-SOP41085.
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 Module 4 of the DoD QSM 6.0 (DoD and DOE 2023).	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 EFGS-T-VOA-SOP41085 and at least as stringent as specified by DoD QSM 6.0 (DoD and DOE 2023).
Tune check	Prior to the initial calibration 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.

Matrix	**Groundwater**
Analytical Group	**VOCs**
Analytical Method/SOP Reference	Analytical Method: SW-846 8260C Preparation Method: EPA 5030B Laboratory SOPs: EFGS-T-VOA-SOP41085
Analytical Organization	Eurofins Testing Environment Northwest, LLC

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 ANA8260C.	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 6.0 (DoD and DOE 2023).
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 EFGS-T-VOA-SOP41085. 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 6.0 (DoD and DOE 2023).
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 EFGS-T-VOA-SOP41085.	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 6.0 (DoD and DOE 2023).

Matrix	**Groundwater**
Analytical Group	**VOCs**
Analytical Method/SOP Reference	Analytical Method: SW-846 8260C Preparation Method: EPA 5030B Laboratory SOPs: EFGS-T-VOA-SOP41085
Analytical Organization	Eurofins Testing Environment Northwest, LLC

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
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.

%	percent
BFB	4-bromofluorobenzene
CCV	continuing calibration verification
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
GC	gas chromatography
ICAL	initial calibration
LCS	laboratory control sample
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
MS	matrix spike
MSD	matrix spike duplicate
QA	quality assurance
QC	quality control
QSM	Quality Systems Manual
RPD	relative percent difference
RT	retention time
SOP	standard operating procedure
TBD	to be determined
VOC	volatile organic compound

Matrix	**Groundwater**
Analytical Group	**TPH-GRO**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8015C Preparation Method: EPA 5030B Laboratory SOPs: EFGS-T-VOA-SOP41119
Analytical Organization	Eurofins Testing Environment Northwest, LLC

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 EFGS-T-VOA-SOP41119.
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 Module 4 of the DoD QSM 6.0 (DoD and DOE 2023).	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 EFGS-T-VOA-SOP41119 and at least as stringent as specified by DoD QSM 6.0 (DoD and DOE 2023).
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.

Matrix	**Groundwater**
Analytical Group	**TPH-GRO**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8015C Preparation Method: EPA 5030B Laboratory SOPs: EFGS-T-VOA-SOP41119
Analytical Organization	Eurofins Testing Environment Northwest, LLC

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
MB	Each time samples are extracted and one per matrix per analytical method for each batch of at most 20 samples.	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common lab contaminants, no analytes detected >LOQ.	Correct problem. If required, re-prep and reanalyze MB and all samples processed with the contaminated blank.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ.
LCS	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	Per DoD QSM Appendix C Limits, Method 8015C and Lab SOP EFGS-T-VOA-SOP41119.	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 6.0 (DoD and DOE 2023).
Internal standards verification	Every field sample, standard, and QC sample.	Retention time ± 30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard.	Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision/ Representativeness	Laboratory in-house method manual to be followed for acceptance criteria.
Surrogate spike	All field and QC samples.	Per DoD QSM Appendix C Limits, Method 8015C and Lab SOP EFGS-T-VOA-SOP41119.	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 6.0 (DoD and DOE 2023).
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 EFGS-T-VOA-SOP41119. 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 6.0 (DoD and DOE 2023).

Matrix	**Groundwater**
Analytical Group	**TPH-GRO**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8015C Preparation Method: EPA 5030B Laboratory SOPs: EFGS-T-VOA-SOP41119
Analytical Organization	Eurofins Testing Environment Northwest, LLC

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
Trip blank	One 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.

%	percent
CCV	continuing calibration verification
DoD	Department of Defense
DQI	data quality indicator
DQO	data quality objective
EICP	extracted ion current profile
EPA	Environmental Protection Agency, United States
GC	gas chromatography
GRO	gasoline range organics
ICAL	initial calibration
LCS	laboratory control sample
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
MS	matrix spike
MSD	matrix spike duplicate
QA	quality assurance
QC	quality control
QSM	Quality Systems Manual
RPD	relative percent difference
RT	retention time
SOP	standard operating procedure
TBD	to be determined
TPH	total petroleum hydrocarbons

Matrix	**Groundwater**
Analytical Group	**TPH-DRO/LRO**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8015C Preparation Method: EPA 3510C Laboratory SOPs: EFGS-T-GCS-SOP40900
Analytical Organization	Eurofins Testing Environment Northwest, LLC

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 EFGS-T-GCS-SOP40900.
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 Module 4 of the DoD QSM 6.0 (DoD and DOE 2023).	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 EFGS-T-GCS-SOP40900, and at least as stringent as specified by DoD QSM 6.0 (DoD and DOE 2023).
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.

Matrix	**Groundwater**
Analytical Group	**TPH-DRO/LRO**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8015C Preparation Method: EPA 3510C Laboratory SOPs: EFGS-T-GCS-SOP40900
Analytical Organization	Eurofins Testing Environment Northwest, LLC

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
MB	Each time samples are extracted and one per matrix per analytical method for each batch of at most 20 samples.	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common lab contaminants, no analytes detected >LOQ.	Correct problem. If required, re-prep and reanalyze MB and all samples processed with the contaminated blank.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ.
LCS	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	Per DoD QSM Appendix C Limits, Method 8015C and Lab SOP EFGS-T-GCS-SOP40900.	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 6.0 (DoD and DOE 2023).
Internal standards verification	Every field sample, standard, and QC sample.	Retention time ±30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard.	Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision/ Representativeness	Laboratory in-house method manual to be followed for acceptance criteria.
Surrogate spike	All field and QC samples.	Per DoD QSM Appendix C Limits, Method 8015C and Lab SOP EFGS-T-GCS-SOP40900.	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 6.0 (DoD and DOE 2023).

Matrix	**Groundwater**
Analytical Group	**TPH-DRO/LRO**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8015C Preparation Method: EPA 3510C Laboratory SOPs: EFGS-T-GCS-SOP40900
Analytical Organization	Eurofins Testing Environment Northwest, LLC

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
MS/MSD pair	One per analytical method for each batch of at most 20 samples.	Per DoD QSM Appendix C Limits, Method 8015C and Lab SOP EFGS-T-GCS-SOP40900. 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 6.0 (DoD and DOE 2023).

%	percent
CCV	continuing calibration verification
DoD	Department of Defense
DQI	data quality indicator
DQO	data quality objective
DRO	diesel range organics
EICP	extracted ion current profile
EPA	Environmental Protection Agency, United States
ICAL	initial calibration
LCS	laboratory control sample
LOD	limit of detection
LOQ	limit of quantitation
LRO	lube oil range organics
MB	method blank
MS	matrix spike
MSD	matrix spike duplicate
QA	quality assurance
QC	quality control
QC	quality control
QSM	Quality Systems Manual
RPD	relative percent difference
RT	retention time
SOP	standard operating procedure
TBD	to be determined
TPH	total petroleum hydrocarbons

Matrix	**Aqueous**
Analytical Group	**Organic Lead – Tetraethyl Lead**
Analytical Method/SOP Reference	Analytical Method: SW-846 8270D/E Preparation Method: EPA 3510C Laboratory SOPs: WI9587 / WI10928 (respectively)
Analytical Organization	Eurofins Lancaster Laboratories Environment Testing, LLC

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 SOP11892.
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 Module 4 of the DoD QSM 6.0 (DoD and DOE 2023).	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 SOP11892, and at least as stringent as specified by DoD QSM 6.0 (DoD and DOE 2023).
Performance check	Before initial calibration 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 ≤3 and ≤5 respectively.	Correct problem, then repeat performance checks.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	Degradation of DDT must be ≤20%. Benzidine and pentachlorophenol will be present at their normal responses and will not exceed a tailing factor of ≤3 and ≤5 respectively.
Tune Check	Prior to the initial calibration and prior to each 12-hour period of sample analysis.	Specific ion abundance criteria of DFTPP.	Retune instrument and verify.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	No samples may be analyzed without a passing tune.

Matrix	**Aqueous**
Analytical Group	**Organic Lead – Tetraethyl Lead**
Analytical Method/SOP Reference	Analytical Method: SW-846 8270D/E Preparation Method: EPA 3510C Laboratory SOPs: WI9587 / WI10928 (respectively)
Analytical Organization	Eurofins Lancaster Laboratories Environment Testing, LLC

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 12 hours, 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 > LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher.	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 > LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher.
LCS	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	Reported analyte within laboratory in-house limits per Lab SOP WI9587.	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	Reported analyte within laboratory in-house limits per Lab SOP WI9587.
Internal standards verification	Every field sample, standard, and QC sample.	RT change ≤30 sec. of associated reference standard; 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.	Reported analyte within laboratory in-house limits per Lab SOP WI9587.	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	Reported analyte within laboratory in-house limits per Lab SOP WI9587.

Matrix	**Aqueous**
Analytical Group	**Organic Lead – Tetraethyl Lead**
Analytical Method/SOP Reference	Analytical Method: SW-846 8270D/E Preparation Method: EPA 3510C Laboratory SOPs: WI9587 / WI10928 (respectively)
Analytical Organization	Eurofins Lancaster Laboratories Environment Testing, LLC

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
MS/MSD pair	One per analytical method for each batch of at most 20 samples.	Reported analyte within laboratory in-house limits per Lab SOP WI9587. RPD ≤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	Reported analyte within laboratory in-house limits per Lab SOP WI9587. RPD ≤20%.

%	percent
BFB	4-bromofluorobenzene
CCV	continuing calibration verification
DDT	dichlorodiphenyltrichloroethane
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
GC	gas chromatography
ICAL	initial calibration
LCS	laboratory control sample
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
MS	matrix spike
MSD	matrix spike duplicate
QA	quality assurance
QC	quality control
QSM	Quality Systems Manual
RPD	relative percent difference
RT	retention time
SOP	standard operating procedure
SVOC	semivolatile organic compound
TBD	to be determined

Matrix	**Groundwater**
Analytical Group	**PAHs**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8270D SIM Preparation Method: EPA 3510C Laboratory SOPs: EFGS-T-MSS-SOP41389
Analytical Organization	Eurofins Testing Environment Northwest, LLC

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 EFGS-T-MSS-SOP41389.
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 Module 4 of the DoD QSM 6.0 (DoD and DOE 2023).	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 EFGS-T-MSS-SOP41389, and at least as stringent as specified by DoD QSM 6.0 (DoD and DOE 2023).
Performance check	Before initial calibration 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 initial calibration 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.

Matrix	**Groundwater**
Analytical Group	**PAHs**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8270D SIM Preparation Method: EPA 3510C Laboratory SOPs: EFGS-T-MSS-SOP41389
Analytical Organization	Eurofins Testing Environment Northwest, LLC

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 EFGS-T-MSS-SOP41389.	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 6.0 (DoD and DOE 2023).
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 EFGS-T-MSS-SOP41389.	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 6.0 (DoD and DOE 2023).

Matrix	**Groundwater**
Analytical Group	**PAHs**
Analytical Method/SOP Reference	Analytical Method: EPA Method 8270D SIM Preparation Method: EPA 3510C Laboratory SOPs: EFGS-T-MSS-SOP41389
Analytical Organization	Eurofins Testing Environment Northwest, LLC

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
MS/MSD pair	One per analytical method for each batch of at most 20 samples.	Per DoD QSM Appendix C Limits, Method 8270D SIM and Lab SOP EFGS-T-MSS-SOP41389. 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 6.0 (DoD and DOE 2023).

%	percent
BFB	4-bromofluorobenzene
CCV	continuing calibration verification
DDT	dichlorodiphenyltrichloroethane
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
GC	gas chromatography
ICAL	initial calibration
LCS	laboratory control sample
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
MS	matrix spike
MSD	matrix spike duplicate
PAH	polynuclear aromatic hydrocarbon
QA	quality assurance
QC	quality control
QSM	Quality Systems Manual
RPD	relative percent difference
RT	retention time
SIM	selected ion monitoring
SOP	standard operating procedure
TBD	to be determined

Worksheet #29: Project Documents and Records Table

Document [a]	Storage/Archive Location
Sample Collection Documents and Records	Storage: AECOM Technical Services, Inc. 1001 Bishop Street Suite 1600 Honolulu, HI 96813 Phone: 808-523-8874 Laboratory documents shall be shipped to: Iron Mountain 2456 Lugonia Ave Redlands, CA 92374 Phone: 800-899-4766
Field logbook (and sampling notes)	
Field sample forms (e.g., boring logs, sample log sheets, drilling logs)	
Chain of custody records	
Air Bills	
Photographs	
Field task modification forms	
Field sampling SOPs	
Laboratory documents and records	
Sample collection logs	
Health and safety sign in sheets	
Accident Prevention Plan acknowledgement	
Communication logs	
Documentation of deviation from methods	
Excavation permits	
Corrective action forms/documentation of the audits	
Documentation of internal QA review	
Identification of QC samples	
Sampling instrument calibration logs	
Sampling location and sampling plan	
Sampling report	
Analytical Records	
Chain of custody records	
Sample receipt forms and sample tracking forms	
Preparation and analysis forms and/or logbooks	
Tabulated data summary forms and raw data for field samples, standards, QC checks, and QC samples	
Case narrative	
Sample chronology (time of receipt, extraction, and analysis)	
Identification of QC samples	
Communication logs	
Corrective action reports	
Definitions of laboratory qualifiers	
Documentation of corrective action results	
Documentation of laboratory method deviations	
Electronic data deliverables	
Instrument calibration reports	
Laboratory sample identification numbers	
Reporting forms, completed with actual results	

Document [a]	Storage/Archive Location
Signatures for laboratory sign-off (e.g., laboratory QA manager)	Storage: AECOM Technical Services, Inc. 1001 Bishop Street Suite 1600 Honolulu, HI 96813 Phone: 808-523-8874 Laboratory documents shall be shipped to: Iron Mountain 2456 Lugonia Ave Redlands, CA 92374 Phone: 800-899-4766
Standards traceability records	
Project Data Assessment Records	
Field sampling audit checklists	
Analytical audit checklists	
Data review reports	
Telephone logs	
Corrective action reports	
Laboratory assessment	
Laboratory QA plan	
LOD study information	
DoD ELAP accreditation	
Offsite Analysis Documents and Records	
Chain of custody documents	
Laboratory Data Reports	
Third-Party Data Validation Reports	

DoD	Department of Defense
ELAP	Environmental Laboratory Accreditation Program
LOD	limit of detection
QA	quality assurance
QC	quality control
SOP	standard operating procedure

[a] All documents produced for the project will be kept in a secured facility for the life of the project. Upon project closure, laboratory data will be archived at the Iron Mountain facility, as directed by the Navy. AECOM Technical Services, Inc. will retain copies of the project documentation for 10 years.

Worksheet #30: Analytical Services Table

Matrix	Analytical Group	Sampling Locations/ ID Numbers	Analytical SOP	Data Package Turnaround Time	Laboratory/Organization [a] (name and address, contact person and telephone number)	Backup Laboratory/Organization (name and address, contact person and telephone number)
Soil Gas	VOC, TPH, PAHs	Refer to WS 18	TO-17	21 calendar days after samples are received at the laboratory	Beacon Environmental 526 Underwood Laine Bel Air, MD 21014 (b) (6) [redacted]	None
Soil Gas	Biogenic Gases	Refer to WS 18	ASTM D1946	21 calendar days after samples are received at the laboratory	ALS Group USA, Corp 2655 Park Center Drive, Suite A Simi Valley, CA 93065 (b) (6) [redacted]	None
Soil Gas	Helium	Refer to WS 18	EPA 3C Modified	21 calendar days after samples are received at the laboratory	ALS Group USA, Corp 2655 Park Center Drive, Suite A Simi Valley, CA 93065 (b) (6) [redacted]	None
Soil	VOCs, TPH-GRO	Refer to WS18	8260D, 8260 GRO	21 calendar days after samples are received at the laboratory	Eurofins Environment Testing Northwest, LLC 5755 8th Street East Tacoma, WA 98424 (b) (6) [redacted]	None
Soil	TPH-DRO/LRO	Refer to WS18	8015D	21 calendar days after samples are received at the laboratory	Eurofins Environment Testing Northwest, LLC 5755 8th Street East Tacoma, WA 98424 (b) (6) [redacted]	None
Soil	PAHs	Refer to WS18	8270DSIM	21 calendar days after samples are received at the laboratory	Eurofins Environment Testing Northwest, LLC 5755 8th Street East Tacoma, WA 98424 (b) (6) [redacted]	None

Matrix	Analytical Group	Sampling Locations/ ID Numbers	Analytical SOP	Data Package Turnaround Time	Laboratory/Organization [a] (name and address, contact person and telephone number)	Backup Laboratory/Organization (name and address, contact person and telephone number)
Soil	TEL	Refer to WS18	8270D/E	21 calendar days after samples are received at the laboratory	Eurofins Lancaster Laboratories Environment Testing, LLC 2425 New Holland Pike Lancaster, PA 17601 (b) (6) [redacted]	None

ASTM	ASTM International
DRO	diesel range organics
GRO	gasoline range organics
LRO	lubricant range organics
PAH	polynuclear aromatic hydrocarbons
TEL	tetraethyl lead
TPH	total petroleum hydrocarbons
ID	identification
SOP	standard operating procedure
WS	worksheet

[a] Laboratory meets accreditation requirements to support project needs.

Data packages will be prepared according to NAVFAC Pacific Environmental Restoration Program Procedure I-A-7, *Analytical Data Validation Planning and Coordination* (DON 2015). Data packages must include, at a minimum, the following sections:

1. Cover sheet
2. Table of contents
3. Case narrative
4. Analytical results
5. Sample management records
6. Quality assurance/quality control information
7. Information for third-party review

For complete details of hard copy and electronic data deliverable data package requirements, see Appendix F.

Worksheet #31: Planned Project Assessments Table

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment	Person(s) Responsible for Responding to Assessment Findings	Person(s) Responsible for Identifying and Implementing Corrective Action	Person(s) Responsible for Monitoring Effectiveness of Corrective Action
Review of field procedures	Daily	Internal	AECOM	Field Manager	Field Team Members	Field Manager	CTO Manager
Review of field notes/logbook	Weekly	Internal	AECOM	Field Manager/Field QC Coordinator	Field Team Members	Field Manager	CTO Manager
Review of field instrument calibration sheets	Daily	Internal	AECOM	Field Manager	Field Team Members	Field Manager	CTO Manager
Review of COC forms	Daily	Internal	AECOM	Project Chemist	Field QC Coordinator	Field Manager/Field QC Coordinator	CTO Manager
Field audit	Once	Internal	AECOM	Quality Assurance Manager	CTO Manager/ Field Manager	Field Manager	CTO Manager/Field Manager
Laboratory data assessment	Once per SDG	External/Internal	EDS/AECOM	Third-Party Data Validator/Project Chemist	Laboratory Project Manager	Laboratory Project Manager	Third-Party Data Validator/Project Chemist

AECOM	AECOM Technical Services, Inc.
EDS	Environmental Data Services, LTD
COC	chain of custody
CTO	contract task order
QC	quality control
SDG	sample delivery group

Worksheet #32: Assessment Findings and Corrective Action Responses

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings	Timeframe of Notification	Nature of Corrective Action Response Documentation	Individual(s) Receiving Corrective Action Response [a]	Timeframe for Response
Review of field procedures	Verbal communication/logbook record	CTO Manager	Immediate	Logbook entry	CTO Manager	24 hours after notification
Review of field notes/logbook	Logbook record	CTO Manager	Immediate	Logbook entry	CTO Manager	24 hours after notification
Review of field instrument calibration sheets	Logbook record	CTO Manager	Immediate	Logbook entry	CTO Manager	24 hours after notification
Review of COC forms	Logbook record	Field Manager	Immediate	E-mail	QC Coordinator/ Field Manager, AECOM	24 hours after notification
Field audit	Written audit report	CTO Manager/ Field Manager	72 hours after audit	Letter	Quality Assurance Manager	24 hours after notification
Laboratory data assessment	Verbal communication or e-mail	CTO Manager/Laboratory Project Manager	24 hours after notification	Letter or e-mail	Third-Party Data Validator/Project Chemist	24 hours after notification

AECOM	AECOM Technical Services, Inc.
COC	chain of custody
CTO	contract task order
QC	quality control

[a] Copies of all assessment findings and corrective action responses will be provided to the Naval Facilities Engineering Systems Command, remedial project manager.

Worksheet #33: Quality Assurance Management Reports Table

Type of Report	Frequency	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation	Report Recipient(s)
Third-Party Data Validation Report	Once, after submission of each sampling delivery group from the analytical laboratory	March 2025 – November 2025	Data Validator, Environmental Data Services	CTO Manager (AECOM) and RPM (Navy)
Third-Party DQAR	Once, after all data are generated	November 2025 – January 2026	Data Validator, Environmental Data Services	CTO Manager (AECOM) and RPM (Navy)
Field Audit Report	Once, during the initial three weeks of the field work	February 2025 – August 2025	Quality Assurance Manager, AECOM	CTO Manager (AECOM), CTO Field Manager (AECOM), and QA Manager (Navy)

AECOM	AECOM Technical Services, Inc.
CTO	contract task order
DQAR	data quality assessment report
NAVFAC	Naval Facilities Engineering Systems Command
QA	quality assurance
RPM	remedial project manager
TBD	to be determined

Worksheets #34-36: Data Verification and Validation (Steps I and IIa/IIb) Process Table

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 ((b) (6), AECOM)	Step I	Internal
Field procedures	Determine whether field procedures are performed in accordance with this WP/SAP and prescribed procedures.	QA Program Manager ((b) (6) AECOM)	Step I	Internal
Field logbook and notes	Review the field logbook and any field notes on a weekly basis and place them in the project file. Copies of the field logbook and field notes will be provided to the CTO manager and included in the Field Audit Report.	Field Manager ((b) (6), AECOM)	Step I	Internal
Instrument calibration sheets	Determine whether instruments are calibrated and used in accordance with manufacturer's' requirements.	Project Chemist ((b) (6), AECOM) & Data Validator ((b) (6), EDS)	Step I	Internal & External
COC forms	Review COC completed forms and verify them against the corresponding packed sample coolers. A copy of each COC will be placed in the project file. The original COC will be taped inside the cooler for shipment to the analytical laboratory.	Project Chemist ((b) (6), AECOM)	Step I	Internal
Sampling analytical data package	Verify all analytical data packages for completeness prior to submittal of the data to the data validator.	Project Manager (b) (6), Beacon Environmental)	Step I	External
Analytes	Determine whether all analytes specified in Worksheet #15 were analyzed and reported on by the laboratory.	Project Chemist ((b) (6), AECOM)	Step IIa	Internal
COC and field QC logbook	Examine data traceability from sample collection to project data generation.	Project Chemist (b) (6), AECOM)	Step IIa	Internal
Laboratory data and WP/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 (b) (6), EDS) & Project Chemist (b) (6), AECOM)	Steps IIa & IIb	Internal & External
VOCs	Data Validation Guidelines Module 1: Data Validation Procedure for Organic Analysis by GC/MS (DoD 2020); and Complete Procedure II-B, *Level C and Level D Data Validation for GC/MS Volatile Organics by SW-846 8260* (DON 2015).	Data Validator (b) (6), EDS)	Step IIa	External
Organic Lead and PAHs	Data Validation Guidelines Module 1: Data Validation Procedure for Organic Analysis by GC/MS (DoD 2020); and Complete Procedure II-C, *Level C and Level D Data Validation for GC/MS Semivolatile Organics by SW-846 8270 (Full Scan and SIM)* (DON 2015).	Data Validator (b) (6), EDS)	Step IIa	External
TPH	Data Validation Guidelines Module 4: Data Validation Procedure for Organic Analysis by GC (DoD 2021); and Complete Procedure II-H, *Level C and Level D Data Validation for Total Petroleum Hydrocarbons by SW-846 8015* (DON 2015).	Data Validator (b) (6) EDS)	Step IIa	External

Data Review Input	Description	Responsible for Verification (name, organization)	Step I/IIa/IIb [a]	Internal/ External
Wet Chemistry	Complete Procedure II-R, *Level C and Level D Data Validation for Wet Chemistry Analyses* (DON 2015).	Data Validator (b) (6), EDS)	Step IIa	External
Sampling plan	Determine whether the number and type of soil and groundwater samples specified in Worksheet #20 were collected and analyzed.	Project Chemist (b) (6), AECOM) & Field Manager (b) (6), AECOM)	Step IIb	Internal
Field QC samples	Establish that the number of QC samples specified in Worksheet #20 were collected and analyzed.	Project Chemist (b) (6), AECOM)	Step IIb	Internal
Project quantitation limits and data qualifiers	Establish that sample results met the project quantitation limits and qualify the data in accordance with Procedure II-A, *Data Validation Procedure* (DON 2015).	Data Validator (b) (6), EDS) & Project Chemist (b) (6), AECOM)	Step IIb	Internal & External
Validation report	Summarize outcome of data comparison to MPC in the WP/SAP. Include qualified data and an explanation of all data qualifiers.	Data Validator (b) (6), EDS)	Step IIa	External

%	percent
AECOM	AECOM Technical Services, Inc.
COC	chain of custody
CTO	contract task order
DoD	Department of Defense
ELAP	Environmental Laboratory Accreditation Program
GC/MS	gas chromatography/mass spectrometry
MPC	measurement performance criteria
PAH	polynuclear aromatic hydrocarbon
QA	quality assurance
QC	quality control
SAP	sampling and analysis plan
SIM	selective ion monitoring
SVOC	semivolatile organic compound
TPH	total petroleum hydrocarbons
VOC	volatile organic compound
WP	work plan

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

Worksheet #37: Usability Assessment

37.1 SUMMARY OF THE DATA USABILITY ASSESSMENT PROCESS

A systematic data quality assessment (DQA) process involving data verification steps and third-party data validation, as specified in Worksheets #34-36 will be implemented to assess the usability of environmental sample data generated for this Site Assessment. The evaluation will consider any deviations from proposed field activities or sampling and handling procedures. Field quality control samples and laboratory control samples will be evaluated against measurement performance criteria (MPC) presented in Worksheets #12 and #28 to determine whether the project quality objectives in presented in Worksheet #11 were met. Upon completion of the verification and validation processes the data quality indicators will be evaluated for each analytical group in terms of meeting MPC goals as expressed by the precision, accuracy, representativeness, comparability, and completeness (PARCC) criteria. Variances in QC parameters will be assessed in relation to the potential impacts upon the usability of the affected data and interpretation of field sampling results. The Site Assessment report will include discussions of any limitations on the use of project data from this assessment as well as potential impacts on the project decision statement process.

37.2 FIELD ACTIVITY AND DATA VERIFICATION SUMMARY

The AECOM field manager will be responsible for periodic internal reviews to verify that field sampling procedures, instrument calibrations, and other relevant activities are performed in accordance with the work plan / sampling and analysis plan (WP/SAP). A bound field logbook will be used to document deviations in the proposed field activities, changes in sampling locations, sample types, and other relevant issues.

The data verification process will include onsite data review against the WP/SAP requirements for completeness and accuracy per Worksheet #22 (SOP requirements for calibration, maintenance, and testing). In addition, the review process will verify that SOPs for field sampling and analysis were followed.

The COC records and field QC logbook will be examined for traceability of data from sample collection to the planned and requested analyses for environmental field and field QC samples (as specified in Worksheets #18, #19, and #20).

Upon receipt from the designated analytical laboratory, electronic data will be assessed for proper reporting format with respect to data fields and content.

37.3 DATA VALIDATION AND DATA QUALITY ASSESSMENT PROCESS

A third-party data validation firm will validate all analytical laboratory data results to assess method compliance, calibration frequency and acceptability, QC frequency and acceptability, and data usability. A minimum of 10 percent of the analytical data will validated by a Stage 4 Validation (Electronic and Manual, following *Department of Defense General Data Validation Guidelines September 2019 Revision 1* (DoD 2019). At a minimum, the remaining 90 percent of the analytical data will be validated according to 2B Validation (Electronic and Manual [S3VEM]) as outlined in the DoD General Data Validation Guidelines and supporting Module procedures.

The analytical data will be evaluated for QA and QC based on the Department of Defense General Data Validation Guidelines and supporting Modules (DoD 2019), the *Department of Defense (DoD) and Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental*

Laboratories, Version 6.0 (DoD and DOE 2023), and when applicable the *Project Procedures Manual, U.S. Navy Environmental Restoration Program, Data Validation Procedures NAVFAC Pacific* (DON 2015).

Sample data that do not meet the *DoD Validation Guidance Procedures* (DoD 2019) (or supporting NAVFAC PAC ER Program Procedures [DON 2015]) and DoD QSM 6.0 (DoD and DOE 2023) acceptance criteria will be qualified with an abbreviation, or flag, to indicate a deficiency with the data. These qualifier flags are listed in Table 37-1 and further description of data qualifier flags and qualification codes are presented in the *DoD Validation Guidance Procedures* (DoD 2019).

Table 37-1: List of Data Qualifiers and Definitions

Qualifier	Definition
U	The analyte was not detected and was reported as less than the LOD or as defined by the customer. The LOD has been adjusted for any dilution or concentration of the sample.
J	The reported result was an estimated value with an unknown bias.
J+	The result was an estimated quantity, but the result may be biased high.
J-	The result was an estimated quantity, but the result may be biased low.
N	The analysis indicates the presence of an analyte for which there was presumptive evidence to make a “tentative identification.”
NJ	The analyte has been “tentatively identified” or “presumptively” as present and the associated numerical value was the estimated concentration in the sample.
UJ	The analyte was not detected and was reported as less than the LOD or as defined by the customer. However, the associated numerical value is approximate.
X	The sample results (including non-detects) were affected by serious deficiencies in the ability to analyze the sample and to meet published method and project quality control criteria. The presence or absence of the analyte cannot be substantiated by the data provided. Acceptance or rejection of the data should be decided by the project team (which will include a project chemist), but exclusion of the data is recommended.

LOD limit of detection

Once the data are reviewed and qualified according to the DoD Validation Guidance Procedure Modules (DoD 2019) and DoD QSM (DoD and DOE 2023), a DQA process will summarize the QA/QC evaluation of the data according to the PARCC criteria relative to the MPCs or project quality objectives in accordance with Naval Facilities Engineering Systems Command, Pacific Environmental Restoration Program Procedure II-S, *Data Quality Assessment Report Procedure* (DON 2015).

- Precision is a measure of the agreement between or reproducibility of analytical results under a given set of conditions. Precision is expressed as the relative percent difference (RPD) or percent relative standard deviation. Precision is primarily assessed by calculating an RPD from the reported concentrations of the spiked compounds for each sample in the matrix spike/matrix spike duplicate pair and laboratory duplicate or laboratory control sample/laboratory control sample duplicate pairs. Laboratory and field sampling precision are further evaluated by calculating RPDs for duplicate pairs.
- Accuracy in the analytical sense is defined by the agreement between a determined concentration and the true value of the parameter and is used to identify bias in each measurement system. Accuracy is assessed through the analysis of matrix spike, matrix spike duplicate, laboratory control sample, and other samples containing surrogate spikes**.** Surrogate spikes are either isotopically labeled compounds or compounds that are not typically detected

in the samples. Percent recovery is calculated and Recoveries outside acceptable QC limits may be caused by factors such as instrumentation, analyst error, or matrix interference.

- Representativeness is a qualitative expression of the degree to which the sample data are characteristic of a population. and is evaluated by reviewing the QC results of blank samples and holding times.
- Comparability is a qualitative measure of the equivalence between analytical data sets that is influenced by factors such as sample collection and handling techniques, matrix type, and analytical method.
- Completeness is defined as the percentage of acceptable sample results compared to the total number of sample results. Completeness is evaluated to determine if an acceptable amount of usable data were obtained so that a valid scientific site assessment can be completed.
- Sensitivity is the ability of an analytical method or instrument to discriminate between measurement responses representing different concentrations. Prior to and after sample analysis the detection limits, limits of detection, and limits of quantitation are verified for the target analytes presented in Worksheet #15 to ensure they are detected at concentrations necessary to support the data quality objectives.

A quantitative and qualitative assessment of the data will identify potential sources of error, uncertainty, and bias that may affect the overall usability. The PARCC criteria are then evaluated for each analytical fraction in relation to specific QC deviations and their effects on both individual data points and the analyses as a whole.

Appendix A: Figures

(b) (3)

[redacted]

(b) (3)

[redacted]

Legend

━ Phase 1 Site Assessment Footprint (on-site)

━ Phase 2 Site Assessment Footprint (off-site)

▭ Site 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. Pipeline locations are approximate.
4. Abbreviation:
   VC - valve chamber

N

0 2,250 4,500 9,000
Feet

Figure 1
Vicinity Map
Tank Closure Plan, Supplement 3
Red Hill Bulk Storage Facility
JBPHH, O'ahu, Hawai'i

(b) (3)

[redacted]

(b) (3)

[redacted]

Legend

—	Phase 1 Site Assessment
—	Underground Injection Control Line (UIC Line)
▭	Site Boundary
—	Stream

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. **Acronyms:**
   CHT = Collection, Holding, and Transfer
   OWDF = Oily Waste Disposal Facility
   UIC = Underground Injection Control

N

0 750 1,500 3,000 Feet

Figure 2
Phase 1 Site Plan
Tank Closure Plan, Supplement 3
Red Hill Bulk Storage Facility
JBPHH, O'ahu, Hawai'i

Portion of original drawing dated December 30, 1941 showing the general design and construction of typical underground fuel tank. (Drawing # 294305, NFP Plan Files)

(b) (3)

[redacted]

Figure 3
UST Design Drawing
Tank Closure Plan, Supplement 3
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, Hawai‘i

16009 NOy-4173-261 11/3/42 4729-42
FOURTEENTH NAVAL DISTRICT, PEARL HARBOR, T.H.
UNDERGROUND FUEL STORAGE, RED HILL.
UNDERGROUND STANDBY DIESEL POWER PLANT WITH 5 UNITS IN OPERATION.

Source: HAER (2015)

(National Archives II #71-CA-180B-05)

(b) (3)

[redacted]

Legend

🟫	Alluvium	🟨	Volcanic Tuff
🟧	Saprolite	▤	Marine Limestone
🟦	Massive A'ā Basalt		
▨	A'ā Clinker		
🟩	Pāhoehoe		
▽	Groundwater Surface (Approximate)		

Notes

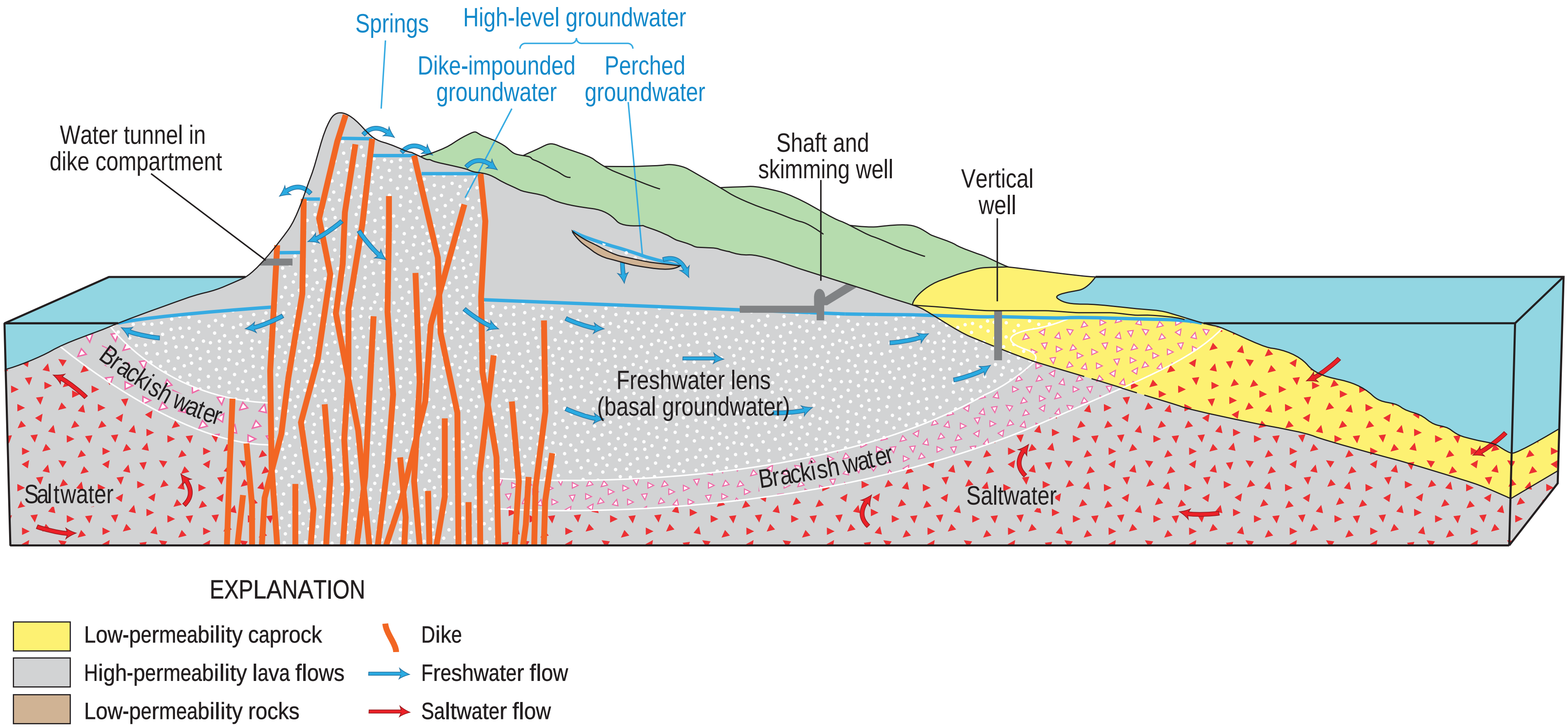
1. B-01, -02, -03, -04, -05, -06, -07, -8, -9, and -10: DON 2012
2. Hālawa No.1, -2B, -3, and -4: Macdonald 1941

(b) (3)

[redacted]

C:\Users\OSTERM~1\AppData\Local\Temp\AcPublish_8056\Fig5-8_CrossSecA-A'_Extend.dwg 08/21/24 10:53 AM Ostermank

Figure 5
Cross Section A-A' Extended
Tank Closure Plan, Supplement 3
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i



Source: Izuka et al. (2016 [2018]), Figure 21; as modified from Oki et al. (1999)

Figure 6
Conceptual Cross Section View of Oahu Hydrogeology
Tank Closure Plan, Supplement 3
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

(b) (3) [redacted]

(b) (3) [redacted]

Legend

Supply Well

- ○ Agriculture
- 🟢 Domestic
- 🟣 Industrial
- 🔵 Irrigation
- 🟠 Military
- 🟡 Municipal
- — Stream
- — Phase 1 Site Assessment Footprint
- ▨ Site Boundary and Fuel Storage Tanks

Notes

1. Map projection: NAD 1983 Hawaii State Plane Zone 3 ft.
2. Base Map: DigitalGlobe, Inc. (DG) and NRCS.
   Publication_Date: 2015

N

0 3,000 6,000 12,000
Feet

Figure 7
Regional Water Supply Wells
Tank Closure Plan, Supplement 3
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

(b) (3)

[redacted]

(b) (3)

[redacted]

⊕ Water Supply Well

▭ Site Boundary

— Tunnel or Adit

— Stream

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

N

0 600 1,200 2,400 Feet

Figure 8
Red Hill Groundwater Monitoring Network
and Location of Recent Releases
Tank Closure Plan, Supplement 3
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

(b) (3)

[redacted]

Figure 9: Adit 3 and Lower Access (Pearl Harbor) Tunnel

(b) (3)

[redacted]

(b) (3)

[redacted]

Legend

⊕ Boring Location

◕ Red Hill Monitoring Well

▭ Site Boundary

— Stream

Notes

1. Map projection: NAD_1983_StatePlane_Hawaii_3_FIPS_5103_Feet
2. Base Map: Google earth, © 2017 Google
3. Location of Former Slop Tank features are estimated from U.S. Naval Supply Center Pearl Harbor, Yards & Docks Drawing No. 890473 -Conversion of POL Storage Facilities, Red Hill Storage 5000 BBL Slop Tank Plan, dated 6/28/60. Location of Boring B-5 from PGE (2015).

Figure 10
Location of Former
Slop Tank S-355 and Slop Pump
Tank Closure Plan, Supplement 3
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

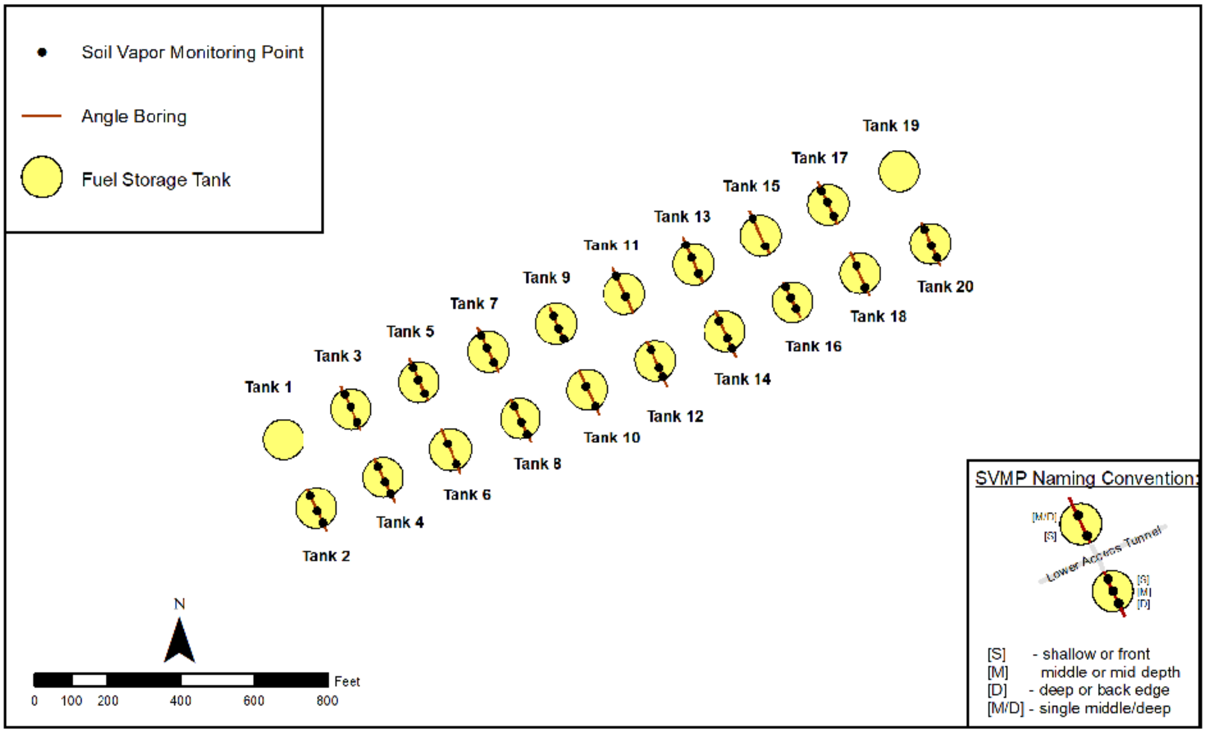


Figure 11: Soil Vapor Monitoring Network Below the Red Hill Fuel Storage Tanks

(b) (3)

(b) (3)

Notes

1. Map projection:
   NAD_1983_StatePlane_Hawaii_3_FIPS_5103_Feet
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. Results are in micrograms per liter (µg/L)
4. Acronyms:
   COPC - chemical of potential concern

   J - estimated
   U - Not detected above the LOD

Analyte	Screening Criterion
TPH-d (C10-C24)	400
TPH-d (C10-C24) with SGC	—
TPH-o (C24-C40)	500
TPH-o (C24-C40) with SGC	—
Ethylbenzene	30
Toluene	40
Xylenes	20
1-Methylnapthalene	10
Naphthalene	17

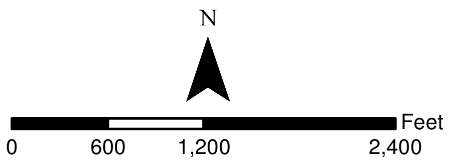


Figure 12
Third Quarter 2023 COPC Detections
Tank Closure Plan, Supplement 3
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

(b) (3)

[redacted]

(b) (3)

[redacted]

Legend

━	Abandoned AVGAS Pipeline
━	Phase 1 Site Assessment Footprint
▭	Site Boundary
─	Stream

Notes

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

N

0 375 750 1,500 Feet

Figure 13
Adit 3 Sampling Locations
Tank Closure Plan, Supplement 3
Red Hill Bulk Storage Facility
JBPHH, O'ahu, Hawai'i

(b) (3)

[redacted]

(b) (3)

[redacted]

Legend

●	Proposed Tank Farm Sampling
◕	Monitoring Well
- - - -	Abandoned 8-inch Slop Line
—	Abandoned AVGAS
☐	Site Boundary
—	Stream

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. FF# = frame foot marker
4. AFFF = aqueous film forming foam
5. FOR - fuel oil recovery

N

0 125 250 500 Feet

Figure 14
Tank Farm Study Area Sampling Locations
Tank Closure Plan, Supplement 3
Red Hill Bulk Storage Facility
JBPHH, O'ahu, Hawai'i

(b) (3)

[redacted]

(b) (3)

[redacted]

Legend

- ● Lower Access Tunnel Proposed Sampling Location
- ● Existing Adit 3 Sampling
- ◐ Monitoring Well
- — Abandoned AVGAS
- — Phase 1 Site Assessment
- ▭ Site Boundary
- — Stream

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. FF# = frame foot marker

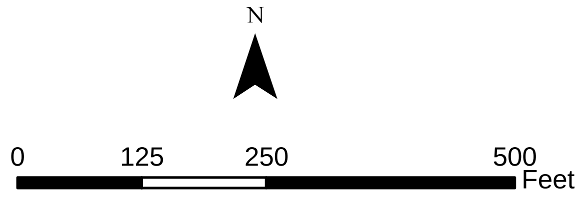


Figure 15
Lower Access Tunnel
Study Area Sampling Locations
Tank Closure Plan, Supplement 3
Red Hill Bulk Storage Facility
JBPHH, O'ahu, Hawai'i

(b) (3)

(b) (3)

Legend

●	Proposed Tank 311 Study Area Sampling Location
◕	Monitoring Well
━	Abandoned AVGAS
━	Oily Waste Disposal Facility Study Area Boundary
▭	Site 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

N

0 37.5 75 150
Feet

Figure 16
Study Areas Outside Adit 3 Sampling Locations
Tank Closure Plan, Supplement 3
Red Hill Bulk Storage Facility
JBPHH, O'ahu, Hawai'i

(b) (3)

(b) (3)

Legend

● Harbor Tunnel Proposed Sampling Location

● Existing Adit 3 Sampling Location

◐ Monitoring Well

— Abandoned AVGAS Pipeline

— Phase 1 Site Assessment Footprint

☐ Site Boundary

— Stream

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. FF### - frame foot marker

N

0 600 1,200 2,400 Feet

Figure 17
Harbor Tunnel Study Area Sampling Locations
Tank Closure Plan, Supplement 3
Red Hill Bulk Storage Facility
JBPHH, O'ahu, Hawai'i

(b) (3)

[redacted]

(b) (3)

[redacted]

Legend

●	Proposed Surge Tank Study Area Sampling Location
▬	Underground Injection Control (UIC) Line
▬	Phase 1 Site Assessment Footprint

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

N

0 75 150 300 Feet

Figure 18
Surge Tank Study Area Sampling Locations
Tank Closure Plan, Supplement 3
Red Hill Bulk Storage Facility
JBPHH, O'ahu, Hawai'i

(b) (3)

(b) (3)

Legend

● Former Standby Power Plant Study Area Sampling Location

◐ Monitoring Well

— Abandoned AVGAS Pipeline

— Phase 1 Site Assessment Footprint

▭ Site 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. Location and footprint of the Former Standby Power Plant are approximate.
4. Former Standby Power Plant Sampling Location placement is based on a 25' x 25' grid.

N

0 75 150 300 Feet

Figure 19
Former Standby Power Plant Study Area Sampling Locations
Tank Closure Plan, Supplement 3
Red Hill Bulk Storage Facility
JBPHH, O'ahu, Hawai'i

\\aecomssd.com\DCS_Isolated\N6274223F0149_60713203-HNL1900_CAD_GIS\920 GIS\02_Maps\Tank Closure\In-Prog\Draft\SAWP\Fig19_Standby_Power_Plant.mxd 5/15/2024

[redacted]

(b) (3)

[redacted]

(b) (3)

Legend

🔵	Proposed AVGAS Study Area Sampling Location
🟡	Proposed Slop Tank Study Area Sampling Location
◐	Monitoring Well
—	Abandoned AVGAS Pipeline
—	Phase 1 Site Assessment Footprint
▭	Site Boundary
—	Stream

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. Slop Tank Study Area sampling location placement is based on a 25' x 25' grid.
4. AFFF = aqueous film forming foam

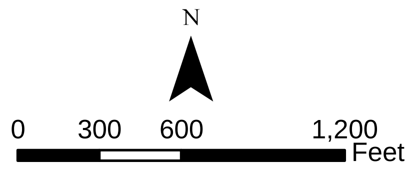


Figure 20
AVGAS Study Area Sampling Locations
Tank Closure Plan, Supplement 3
Red Hill Bulk Storage Facility
JBPHH, O'ahu, Hawai'i

Appendix B:
Frame Foot Mark Spreadsheet

APPENDIX F - FRAME FOOT MARK SPREADSHEET

The Frame Foot Mark Spreadsheet was developed as a location system for the Red Hill facility's Lower Access Tunnel. The spreadsheet uses the support frames located throughout the Lower Access Tunnel as location points. Each frame has been given a number, starting with frame number 1 and ending with frame number 690. The spreadsheet starts at tank 20 and ends at the entrance to the UGPH. Starting from tank 20 the distance to the entrance to the UGPH is 17,000 feet. The spreadsheet provides the frame number, feet from tank 20, delta from tank 20 (in feet), delta from the UGPH (in feet), feet from UGPH, and information and comments about items of interest located in the vicinity of the numbered frame (if applicable). Using this spreadsheet allows someone in the tunnel to know exactly how far they are from the UGPH or from Tank 20.

Table F.1: FRAME FOOT MARK SPREADSHEET

Frame	Feet From	Delta (From	Delta (from	Feet From	Information and Comments
TK 20	[redacted]	[redacted]	[redacted]	(b) (3) [redacted]	[redacted]
1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
4	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
5	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
6	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
7	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
8	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
9	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
10	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
11	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
12	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
13	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
14	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
15	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
16	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
17	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
18	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
19	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
20	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
21	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
22	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
23	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
24	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
25	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
26	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
27	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table F.1: FRAME FOOT MARK SPREADSHEET

(b) (3)

Frame	Feet From Tank 20	Delta (From Tank 20) Feet	Delta (from UGPH) Feet	Feet From UGPH	Information and Comments
28	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
29	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
30	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
31	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
32	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
33	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
34	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
35	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
36	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
37	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
38	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
39	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
40	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
41	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
42	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
43	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
44	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
45	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
46	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
47	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
48	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
49	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
50	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
51	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
52	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
53	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
54	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
55	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
56	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
57	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
58	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
59	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
60	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
61	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
62	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
63	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
64	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
65	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table F.1: FRAME FOOT MARK SPREADSHEET					
Frame	**Feet From Tank 20**	**Delta (From Tank 20) Feet**	**Delta (from UGPH) Feet**	**Feet From UGPH**	**Information and Comments**
66	[redacted]	[redacted]	[redacted]	(b) (3) [redacted]	[redacted]
67	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
68	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
69	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
70	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
71	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
72	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
73	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
74	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
75	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
76	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
77	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
78	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
79	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
80	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
81	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
82	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
83	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
84	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
85	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
86	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
87	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
88	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
89	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
90	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
91	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
92	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
93	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
94	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
95	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
96	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
97	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
98	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
99	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
100	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
101	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
102	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table F.1: FRAME FOOT MARK SPREADSHEET

Frame	Feet From Tank 20	Delta (From Tank 20) Feet	Delta (from UGPH) Feet	Feet From UGPH	Information and Comments
103	[redacted]	[redacted]	[redacted]	(b) (3) [redacted]	[redacted]
104	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
105	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
106	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
107	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
108	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
109	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
110	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
111	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
112	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
113	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
114	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
115	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
116	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
117	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
118	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
119	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
120	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
121	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
122	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
123	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
124	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
125	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
126	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
127	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
128	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
129	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
130	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
131	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
132	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
133	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
134	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
135	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
136	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
137	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
138	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
139	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
140	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
141	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
142	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table F.1: FRAME FOOT MARK SPREADSHEET

(b) (3)

Frame	Feet From Tank 20	Delta (From Tank 20) Feet	Delta (from UGPH) Feet	Feet From UGPH	Information and Comments
143	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
144	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
145	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
146	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
147	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
148	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
149	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
150	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
151	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
152	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
153	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
154	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
155	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
156	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
157	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
158	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
159	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
160	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
161	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
162	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
163	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
164	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
165	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
166	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
167	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
168	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
169	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
170	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
171	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
172	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
173	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
174	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
175	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
176	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
177	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
178	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
179	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
180	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
181	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table F.1: FRAME FOOT MARK SPREADSHEET

(b) (3)

Frame	Feet From Tank 20	Delta (From Tank 20) Feet	Delta (from UGPH) Feet	Feet From UGPH	Information and Comments
182	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
183	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
184	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
185	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
186	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
187	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
188	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
189	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
190	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
191	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
192	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
193	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
194	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
195	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
196	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
197	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
198	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
199	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
200	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
201	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
202	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
203	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
204	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
205	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
206	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
207	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
208	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
209	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
210	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
211	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
212	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
213	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
214	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
215	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
216	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
217	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
218	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table F.1: FRAME FOOT MARK SPREADSHEET

(b) (3)

Frame	Feet From Tank 20	Delta (From Tank 20) Feet	Delta (from UGPH) Feet	Feet From UGPH	Information and Comments
219	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
220	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
221	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
222	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
223	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
224	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
225	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
226	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
227	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
228	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
229	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
230	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
231	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
232	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
233	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
234	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
235	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
236	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
237	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
238	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
239	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
240	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
241	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
242	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
243	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
244	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
245	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
246	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
247	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
248	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
249	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
250	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
251	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
252	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
253	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
254	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
255	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
256	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
257	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
258	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table F.1: FRAME FOOT MARK SPREADSHEET

Frame	Feet From Tank 20	Delta (From Tank 20) Feet	Delta (from UGPH) Feet	Feet From UGPH	Information and Comments
259	[redacted]	[redacted]	[redacted]	(b) (3) [redacted]	[redacted]
260	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
261	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
262	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
263	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
264	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
265	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
266	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
267	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
268	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
269	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
270	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
271	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
272	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
273	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
274	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
275	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
276	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
277	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
278	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
279	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
280	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
281	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
282	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
283	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
284	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
285	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
286	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
287	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
288	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
289	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
290	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
291	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
292	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
293	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
294	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
295	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
296	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
297	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
298	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table F.1: FRAME FOOT MARK SPREADSHEET

(b) (3)

Frame	Feet From Tank 20	Delta (From Tank 20) Feet	Delta (from UGPH) Feet	Feet From UGPH	Information and Comments
299	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
300	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
301	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
302	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
303	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
304	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
305	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
306	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
307	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
308	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
309	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
310	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
311	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
312	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
313	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
314	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
315	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
316	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
317	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
318	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
319	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
320	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
321	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
322	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
323	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
324	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
325	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
326	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
327	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
328	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
329	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
330	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
331	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
332	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
333	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
334	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
335	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
336	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
337	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
338	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table F.1: FRAME FOOT MARK SPREADSHEET					
Frame	Feet From Tank 20	Delta (From Tank 20) Feet	Delta (from UGPH) Feet	Feet From UGPH	Information and Comments
339	[redacted]	[redacted]	[redacted]	(b) (3) [redacted]	[redacted]
340	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
341	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
342	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
343	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
344	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
345	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
346	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
347	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
348	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
349	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
350	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
351	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
352	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
353	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
354	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
355	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
356	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
357	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
358	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
359	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
360	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
361	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
362	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
363	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
364	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
365	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
366	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
367	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
368	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
369	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
370	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
371	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
372	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
373	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
374	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
375	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
376	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
377	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
378	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table F.1: FRAME FOOT MARK SPREADSHEET					
Frame	**Feet From Tank 20**	**Delta (From Tank 20) Feet**	**Delta (from UGPH) Feet**	**Feet From UGPH**	**Information and Comments**
379	[redacted]	[redacted]	[redacted]	[redacted] (b) (3)	[redacted]
380	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
381	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
382	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
383	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
384	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
385	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
386	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
387	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
388	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
389	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
390	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
391	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
392	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
393	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
394	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
395	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
396	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
397	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
398	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
399	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
400	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
401	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
402	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
403	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
404	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
405	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
406	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
407	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
408	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
409	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
410	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
411	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
412	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
413	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
414	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
415	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
416	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
417	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
418	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table F.1: FRAME FOOT MARK SPREADSHEET					
Frame	**Feet From Tank 20**	**Delta (From Tank 20) Feet**	**Delta (from UGPH) Feet**	**Feet From UGPH**	**Information and Comments**
419	[redacted]	[redacted]	[redacted]	(b) (3) [redacted]	[redacted]
420	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
421	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
422	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
423	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
424	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
425	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
426	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
427	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
428	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
429	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
430	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
431	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
432	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
433	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
434	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
435	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
436	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
437	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
438	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
439	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
440	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
441	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
442	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
443	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
444	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
445	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
446	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
447	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
448	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
449	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
450	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
451	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
452	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
453	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
454	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
455	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
456	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
457	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
458	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table F.1: FRAME FOOT MARK SPREADSHEET

(b) (3)

Frame	Feet From Tank 20	Delta (From Tank 20) Feet	Delta (from UGPH) Feet	Feet From UGPH	Information and Comments
459	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
460	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
461	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
462	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
463	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
464	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
465	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
466	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
467	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
468	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
469	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
470	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
471	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
472	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
473	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
474	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
475	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
476	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
477	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
478	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
479	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
480	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
481	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
482	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
483	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
484	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
485	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
486	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
487	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
488	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
489	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
490	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
491	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
492	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
493	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
494	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
495	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
496	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
497	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
498	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table F.1: FRAME FOOT MARK SPREADSHEET

Frame	Feet From Tank 20	Delta (From Tank 20) Feet	Delta (from UGPH) Feet	Feet From UGPH	Information and Comments
499	[redacted]	[redacted]	[redacted]	[redacted] (b) (3)	[redacted]
500	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
501	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
502	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
503	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
504	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
505	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
506	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
507	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
508	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
509	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
510	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
511	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
512	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
513	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
514	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
515	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
516	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
517	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
518	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
519	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
520	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
521	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
522	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
523	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
524	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
525	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
526	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
527	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
528	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
529	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
530	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
531	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
532	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
533	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
534	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
535	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
536	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
537	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
538	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table F.1: FRAME FOOT MARK SPREADSHEET

(b) (3)

Frame	Feet From Tank 20	Delta (From Tank 20) Feet	Delta (from UGPH) Feet	Feet From UGPH	Information and Comments
539	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
540	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
541	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
542	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
543	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
544	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
545	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
546	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
547	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
548	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
549	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
550	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
551	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
552	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
553	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
554	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
555	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
556	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
557	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
558	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
559	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
560	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
561	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
562	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
563	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
564	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
565	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
566	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
567	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
568	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
569	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
570	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
571	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
572	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
573	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
574	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
575	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
576	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
577	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table F.1: FRAME FOOT MARK SPREADSHEET

(b) (3)

Frame	Feet From Tank 20	Delta (From Tank 20) Feet	Delta (from UGPH) Feet	Feet From UGPH	Information and Comments
578	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
579	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
580	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
581	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
582	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
583	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
584	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
585	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
586	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
587	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
588	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
589	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
590	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
591	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
592	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
593	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
594	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
595	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
596	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
597	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
598	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
599	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
600	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
601	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
602	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
603	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
604	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
605	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
606	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
607	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
608	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
609	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
610	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
611	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
612	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
613	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
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Table F.1: FRAME FOOT MARK SPREADSHEET					
Frame	**Feet From Tank 20**	**Delta (From Tank 20) Feet**	**Delta (from UGPH) Feet**	**Feet From UGPH**	**Information and Comments**
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Table F.1: FRAME FOOT MARK SPREADSHEET					
Frame	**Feet From Tank 20**	**Delta (From Tank 20) Feet**	**Delta (from UGPH) Feet**	**Feet From UGPH**	**Information and Comments**
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Appendix C:
Field Equipment Documentation

BESURE
SAMPLE COLLECTION KIT™

Instructions for PSG Sampler Deployment, Retrieval and Return to Beacon Environmental

Following are instructions for the BeSure Sample Collection Kit™ for the deployment and retrieval of Beacon Passive Soil Gas Samplers. Before going into the field, confirm you have everything you need by checking the enclosed PSG Kit Inventory sheet. If at any time you have questions or need additional assistance, please call us at **1-410-838-8780**.

IMPORTANT: TRIP BLANKS ARE TO REMAIN CLOSED AT ALL TIMES
NO SMOKING WHILE HANDLING SAMPLES

DO NOT INSTALL A SECOND SAMPLER TO COLLECT A DUPLICATE!

Duplicate analysis can be performed for any field sample because each sampler contains two sets of adsorbent cartridges. To select field sample duplicates, note them on the CoC; a second (co-located) sample is not necessary. Add a second entry to the CoC with the field sample ID followed by “D” or “Dup” (i.e., PSG-08-Dup is the duplicate for PSG-08). There is an additional per sample charge for analysis of any duplicates.

NOTE: Do not deploy Samplers within 10 feet of a monitoring well, penetrometer, hydropunch shaft, or other intrusive sampling apparatus that could potentially create a preferential pathway for gases.

Sampler Deployment

Need help? Call 1-410-838-8780
or email help@beacon-usa.com

PSG KIT INSTRUCTIONS

SOIL / VEGETATION

1 Use a hammer drill and drill bits to create the soil vapor pathway. Drill a 1 1/4 inch to 1 1/2 inch diameter hole to a depth of 12-14 inches. Using a 1/2-inch drill bit, drill a hole to a depth of 30-36 inches.

See diagram on pg. 4

2 Place the sampling kit and these materials within easy access:

- 12-inch length of pipe
- Pipe cutter / Hack saw
- Tapping dowel
- Hammer
- Sampling cap
- Aluminum foil
- Beacon Sampler

3 Lower the pipe into the hole and push or tap the pipe 1/2 inch below grade using the tapping dowel and a hammer. If necessary, first cut the pipe so that it is flush or just below grade before tapping the pipe into the hole.

4 Remove a Beacon Sampler and unwind the retrieval wire wrapped around it, leaving a small coil of wire at the end. Extend the wire so that the Sampler will easily go into the pipe.

ASPHALT / CONCRETE

Sampler Deployment

SOIL / VEGETATION

5 Replace the solid white shipping cap with a Sampling Cap (black cap with screened hole). Place the solid cap in the Cap Storage container.

IMPORTANT: Make sure the black sampling cap is on the vial before installing the sampler.

ASPHALT / CONCRETE

6 Lower the Sampler, open-end down, into the metal pipe approximately four inches so that the retrieval wire sticks out of the hole.

7 Make sure the end of the retrieval wire remains above the surface.

IF ASPHALT / CONCRETE
Hook the end of the wire (with small coil) and hang it over the top and outside of the pipe.

8 Cover and plug the open end of the pipe with a balled-up wad of aluminum foil, pressing it tightly on top of the pipe with the tapping dowel so it forms a flattened seal on the pipe approximately 1/4 inch below grade.

Sampler Deployment

SOIL / VEGETATION

9 Cover the hole to grade with local soils or sand, leaving the end of the wire exposed above the surface of the ground. Use a hammer to collapse/pack the soil above the sampler. Coil the wire and lay it flat on the ground surface.

IF ASPHALT / CONCRETE

Cover the hole to grade with a 1/4 inch thick concrete patch. (If it is thicker it will be difficult to remove during retrieval.)

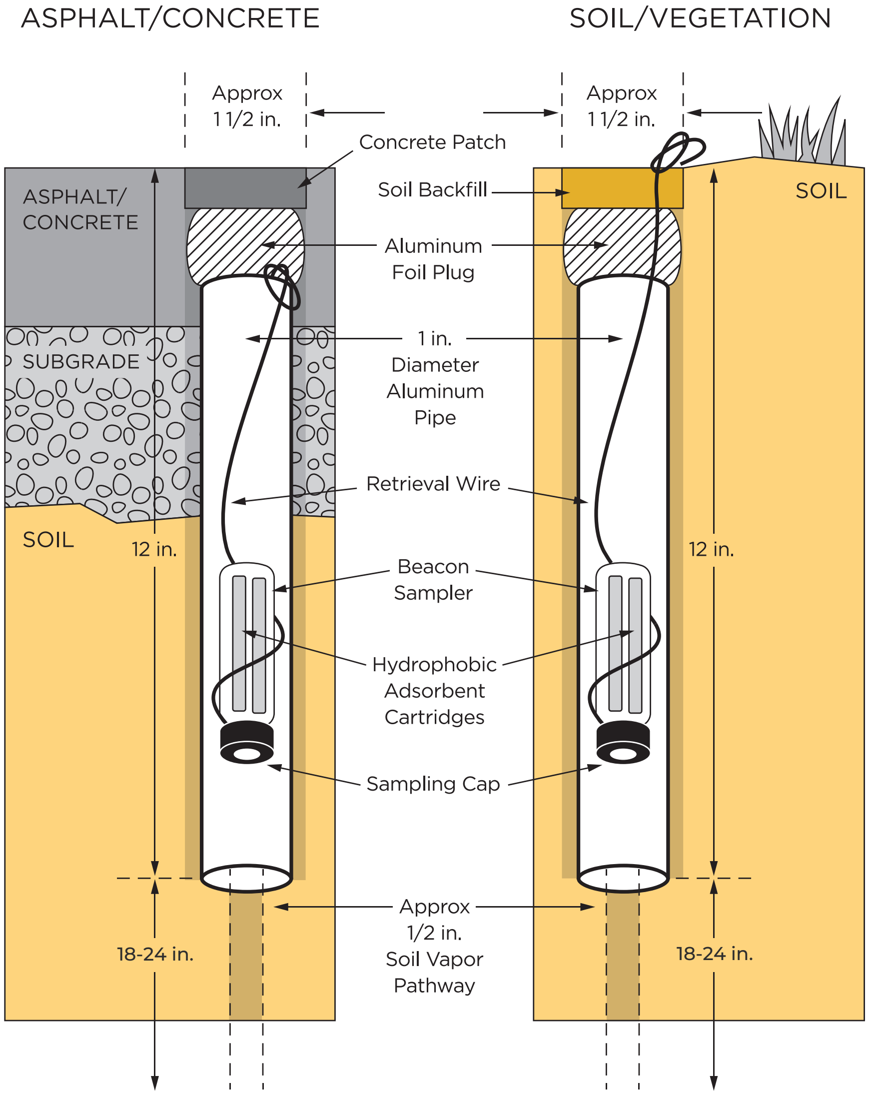
IMPORTANT: Only use Dry Concrete Mortar Mix. Do Not use Premixed Patching Compounds. They contain solvents.

ASPHALT / CONCRETE

10 Close the Field Kit and record the following info on the Chain-of-Custody: location ID, date/time of deployment (to the nearest minute) and other relevant information.

Repeat steps 1-10 until all samplers have been installed.

After deploying all samplers, place each Trip Blank in an Individual Sampler Bag. Store the Trip Blank(s) in the Return Shipment Bag(s) until retrieval. Make sure there is 1 Trip Blank in each Return Shipment Bag.



Sampler Retrieval

Need help? Call 1-410-838-8780
or email help@beacon-usa.com

SOIL / VEGETATION

1 Place the sampling kit and these materials within easy access:

- Small screwdriver
- Wire cutters
- White solid Shipping Cap
- Towel
- Gauze cloth
- Individual Sampler Bag
- Return Shipment Bag

IF ASPHALT / CONCRETE

- Hammer & chisel

2 Clear the soil and gently remove the aluminum foil plug using a small screwdriver, if necessary. Retrieve the Sampler from the hole by gently pulling the wire.

IF ASPHALT / CONCRETE
Remove the concrete plug with the hammer and chisel. Carefully remove the aluminum foil plug using the screwdriver. Retrieve the Sampler from the hole by gently pulling the wire.

3 Clean the sides of the Sampler with the towel and remove the black Sampling Cap. Do not return the used Sampling Caps.

Transport vials (green labels) are only used if a Sampler is broken during retrieval. If this occurs, transfer all contents from the broken Sampler to the transport vial.

4 Cut ALL wire from the Sampler using wire cutters, and clean the vial threads completely with the gauze cloth.

ASPHALT / CONCRETE

Sampler Retrieval

SOIL / VEGETATION

5 Firmly screw the solid cap onto the vial. Use a ballpoint pen to write the sample ID on the cap's label.

IMPORTANT: Do not use a Sharpie to mark the caps. It can contaminate the samples.

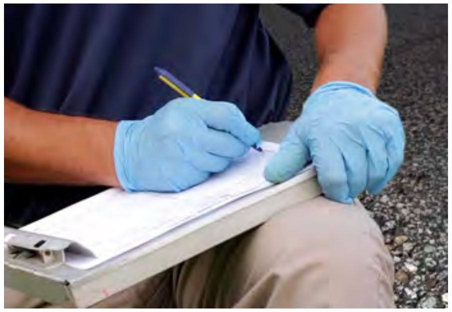
6 Place the sealed and labeled Beacon Sampler into the individual Sampler Bag. Write the sample ID on the white block on the bag using a ballpoint pen. Place the individually bagged and labeled sampler into the larger bag labeled "Return Shipment Bag."

7 Close the Field Kit and on the Chain-of-Custody, record the ID, date/time of retrieval (to the nearest minute) and other relevant information.

Move to next location. Repeat steps 1-7, until all Samplers are retrieved. Patch or back-fill holes as necessary.

8 To prepare for return shipment, verify that all Samplers are stored in the Return Shipment Bag, containing an adsorbent pak and a Trip Blank.

ASPHALT / CONCRETE



Sampler Retrieval

SOIL / VEGETATION

9 Seal the Return Shipment Bag and place it in the upper tray of the Field Kit and place the provided tools and materials below the tray, in the lower compartment (blocks, extra samplers, tools, etc.)

IMPORTANT: Do not return used sampling caps, used pipe, or wire with the field kit. They may bias the samplers.

ASPHALT / CONCRETE

10 Close the Field Kit, and secure it with the provided Custody Seal. Sign and date the Chain-of-Custody. Take a picture, scan or make a photocopy for your records.

11 Package the Field Kit into the original shipment box. Place the Chain of Custody on top of the kit. Seal the box, affix a FedEx Airbill and send to the address noted below:

Beacon Environmental
Attn: Sample Receiving
526 Underwood Lane
Bel Air, Maryland 21014, USA
1-410-838-8780

IMPORTANT: Do not use styrene peanuts, newspaper or other packing materials. They may contaminate the samples.

For questions or assistance
Call 1-410-838-8780 or
email help@beacon-usa.com

FAQs

Does Beacon receive samples on Weekends? No. If possible, store the samples in a clean environment until Monday and then ship.

How large of a diameter hole should I make? The preferred diameter is 3-4 cm. If you must make a hole larger than 4 cm, please contact Beacon.

Can I install samplers in the rain? Beacon's sorbent is hydrophobic. The only issues with precipitation are:

1. If the vadose zone is saturated and vapors are not able to migrate.
2. If there is so much rain during install that the holes are being filled with water.

   In these situations, please contact Beacon to discuss.

Can I install samplers in gravel? Yes, make sure that you clear away enough surface gravel until you reach soil that will stay open as you create your hole. If this is not possible, please contact Beacon to discuss options.

Tips

- Remember to remove all the wire during retrieval. There should be no wire on the Beacon Sampler.
- Return all extra Samplers, tools, wood blocks, and unused pipe to avoid replacement fees.
- Note any duplicates on the CoC.

DISCOVER THE BENEFITS OF LONG DURATION TIME-INTEGRATED AIR SAMPLING

To learn more, call **1-410-838-8780**, email **info@beacon-usa.com** or visit **beacon-usa.com**

Make the Switch to Beacon!

If you've been using Canisters for your Indoor and Ambient Air Sampling projects, **it's time to make the switch to Beacon Samplers**! Beacon Environmental's Passive Air Samplers are quickly becoming the industry standard for effective and reliable sample collection. Not only are they much smaller than canisters and easier to use, they can be used to sample over a brief period (hours) or extended periods (days or weeks) to provide more accurate time-weighted average concentration data.

Vapor Intrusion
Monitoring

Fenceline Air
Quality Monitoring

BEACON
ENVIRONMENTAL

Global Leader in Soil Gas and Air Analyses

Beacon Environmental is ISO/IEC 17025, DoD ELAP and NELAP accredited for the analysis of sorbent samples following US EPA Methods TO-17, TO-15, 8260C and 325B.

Beacon Environmental
DoD ELAP/ISO 17025 Accredited Laboratory, TNI NEFAP Accredited Field Sampling Organization, Accreditation No. 72690

BEACON
ENVIRONMENTAL

526 Underwood Lane
Bel Air, Maryland 21014 USA
1-410-838-8780
info@beacon-usa.com

TECHNICAL MEMORANDUM

Updated: January 26, 2024

Passive Soil Gas Testing: Standard for Site Characterization

Background and Introduction

Passive soil gas surveys utilize adsorbent samplers that are emplaced subsurface to adsorb volatile and semi-volatile organic compounds (VOCs and SVOCs) in soil gas without forcing the flow rate of gas, which can yield a more representative sample than active soil gas methods. Samplers are typically placed in a grid pattern to simultaneously sample trace levels of compounds in soil gas that originate from contamination in soil or groundwater. By sampling all locations at the same time, the temporal variations in soil-gas concentrations known to occur daily and even hourly are normalized. In addition, the spatial variability of contamination is better defined with a passive soil gas survey because the lower sampling and analytical costs of the method allow for more locations to be sampled than normally would be with a fixed budget. Passive soil gas (PSG) methods have been demonstrated to be more sensitive and reproducible than active soil gas methods and are able to target a broad range of organic compounds from vinyl chloride to polynuclear aromatic hydrocarbons (PAHs) and other SVOCs.

The analytical results of a passive soil gas method are presented in units of mass (e.g., nanograms of each individual compound) for comparison between sample locations to identify source areas, identify the potential for vapor intrusion, to delineate the lateral extent of contamination, including migration pathways, and to monitor remediation programs. When requested, the mass measured (ng) can be converted to a concentration by dividing the mass (ng) by the sampler uptake rate (ml/min) and the sampling period (min), which is then multiplied by a value of 1,000 to convert ng/ml to ug/m3. The Beacon PSG Sampler has verified uptake rates when sampling in air for a suite of chlorinated and BTEX compounds. For soil gas sampling, the concentrations reported represent the concentration of the identified compounds under steady state (natural) conditions by passive sampling, as opposed to active sampling with a pump or evacuated canister that may create a momentary vacuum in the soil during the time of sampling. If the soils at the site have low porosity, the formation itself could limit transport of soil gas to the samplers resulting in the reported concentration being biased low. In order to limit this bias from occurring, the Beacon sampler has a low and controlled uptake rate.

Passive soil gas (PSG) results are based on a higher level of QA/QC than can be achieved with other field screening methods. Measurements are based on a five-point initial calibration with the lowest point on the calibration curve at or below the practical quantitation limit of each compound. Internal standards and surrogates are included with each analysis – per EPA Method 8260C – to provide proof of performance that the system was operating properly for each sample and to provide

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consistent reference points for each analysis, which enables an accurate comparison of measured quantities. Trip blanks are analyzed with each batch of samples and because two sets of hydrophobic adsorbent cartridges are provided in each Sampler, duplicate or confirmatory analyses can be performed for any of the sample locations. A representative list of compounds that can be targeted with passive soil gas surveys is provided in Table 1.

Table 1

Passive Soil Gas Survey
Representative List of Target Compounds

TPH C5-C8
TPH C9-C15
Vinyl Chloride
1,1-Dichloroethene
Methylene Chloride
1,1,2-Trichlorotrifluoroethane (Freon 113)
trans-1,2-Dichloroethene
Methyl-t-butyl ether (MTBE)
1,1-Dichloroethane
cis-1,2-Dichloroethene
Chloroform
1,2-Dichloroethane
1,1,1-Trichloroethane
Carbon Tetrachloride
Benzene
Trichloroethene
1,4-Dioxane
1,1,2-Trichloroethane Toluene
1,2-Dibromoethane (EDB)
Tetrachloroethene
1,1,1,2-Tetrachloroethane
Chlorobenzene
Ethylbenzene
p & m-Xylene
o-Xylene
1,2,3-Trichloropropane
Isopropylbenzene
1,3,5-Trimethylbenzene
1,2,4-Trimethylbenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,2-Dichlorobenzene
1,2,4-Trichlorobenzene
Naphthalene
Hexachlorobutadiene
Trichlorobenzenes
2-Methylnaphthalene
Biphenyl
Acenaphthylene
Acenaphthene
Dibenzofuran
Fluorene

Note: Additional compounds may be targeted to meet project specific requirements. The standard reporting quantitation level (RQL) for each compound is 10 or 25 nanograms (ng); however, the demonstrated limit of quantitation (LOQ) for each compound is 10 ng. Concentration data can additionally be reported in units of ug/m3 with reporting limits based on the sampling period and uptake rates.

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The primary purpose of this document is to describe the methods and procedures used to perform a passive soil gas investigation. This document is broken into two separate parts:

1. General Overview of Passive Soil Gas Investigation for Site Characterization
2. Step-by-Step Passive Soil Gas Sampler Installation and Retrieval

For complete site characterization, Beacon Environmental recommends a passive soil gas survey be performed followed by a limited and focused soil and/or groundwater sampling program to measure the concentrations of identified compounds.

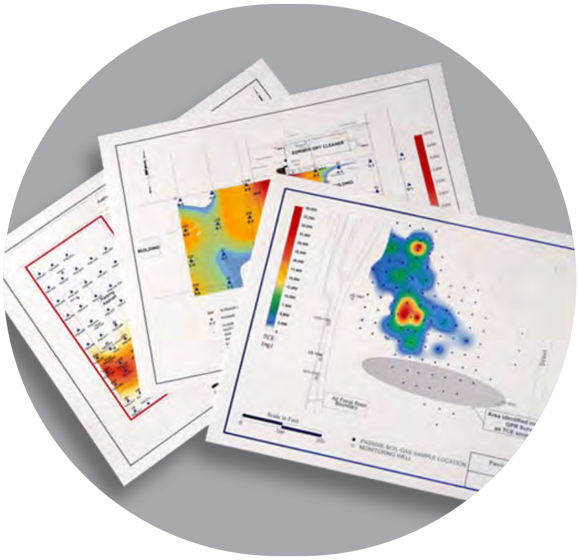
Part 1: General Overview of Passive Soil Gas Investigation for Site Characterization

1.0 Survey Design

The survey design varies depending on the amount of site information that is available prior to initiating the passive soil gas (PSG) survey. Typically an unbiased grid is established across the site with additional biased sample locations to target specific features. The spacing between sample locations is dependent upon the expected depth of the chemicals of concern (CoC), the soil types, and the size of the area to be investigated. Generally, a grid with 25-foot spacing between sample locations is used to identify source areas, but the actual spacing will be dependent on the size of the area of investigation and the project budget. Wider grids and transects are used to track groundwater contamination. Global positioning system (GPS) equipment can be used to collect the sample location coordinate data.

Beacon Environmental provides a BESURE Sample Collection Kit™ with detailed instructions to allow samples to be collected by an environmental field technician. Following collection in the field, the samplers are returned to Beacon Environmental's laboratory for analysis using thermal desorption-gas chromatography/mass spectrometry (TD-GC/MS) instrumentation following EPA Method 8260C. A comprehensive survey report is provided by Beacon Environmental that includes results in tabular form as well as on color isopleth maps showing the distribution of compounds identified in the investigation (see Figure 1 below).

Figure 1 – Color Isopleth Maps



2.0 Soil Gas Sampling Procedures

To perform the soil-gas investigation, Beacon Environmental provides a BESURE Sample Collection Kit™ with all the materials necessary to collect the requested number of soil-gas samples. To collect soil-gas samples, an approximately one-inch diameter hole is advanced to the appropriate depth to meet the objectives of the survey (e.g., one to three feet). The PSG Sampler (which contains two sets of ***hydrophobic adsorbent*** cartridges) is installed in the hole and covered with an aluminum foil plug and soil to seal the sampler in the ground. The adsorbent cartridges used by Beacon Environmental are hydrophobic, which allows the samplers to be effective even in water-saturated

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conditions. Extensive empirical evidence, which is supported by a government study, has proven that hydrophobic adsorbents work perfectly well in high moisture conditions and should not be encased by a hydrophobic membrane.

For locations covered by asphalt or concrete surfacing, an approximately 1 1/2-inch diameter hole is drilled through the surfacing to the underlying soils. A 1/5" to 1" diameter drill bit can then be used to advance the hole to a three-foot depth to increase the sensitivity of the method. The upper 12 inches of the hole is sleeved with a sanitized metal pipe provided in the Kit. After the Sampler is installed inside the metal pipe, the hole is patched with an aluminum foil plug and a thin concrete patch to effectively protect the sampler.

The samplers are exposed to subsurface gas for approximately three to 14 days, with the exact length of time appropriate to meet the objectives of the survey. The sampler is shipped to the site with a length of wire wrapped around the vial and twisted around the shoulder of the vial to expedite retrieval from the ground. Following the exposure period, the Samplers are retrieved and shipped to Beacon Environmental's laboratory for analysis. It is not necessary to use ice or preservatives during shipment; however, the samplers are sealed and shipped under established chain-of-custody procedures. Trip blanks, which remain with the other samples during preparation, shipment, and storage, are included at a typical rate of five percent of the total number of field samples. Figure 2 shows a PSG Sampler as it looks when received in the BESURE Kit™.

A two-person team can install approximately 50 to 100 samplers per day depending on the number of sample locations covered with asphalt, concrete, or gravel surfacing. For retrieval of the Samplers, one person can retrieve approximately 50 samplers per day and patch the holes through the surfacing. Figure 3 shows installation through asphalt and grass surfaces, respectively.

Figure 2 – Beacon PSG Sampler

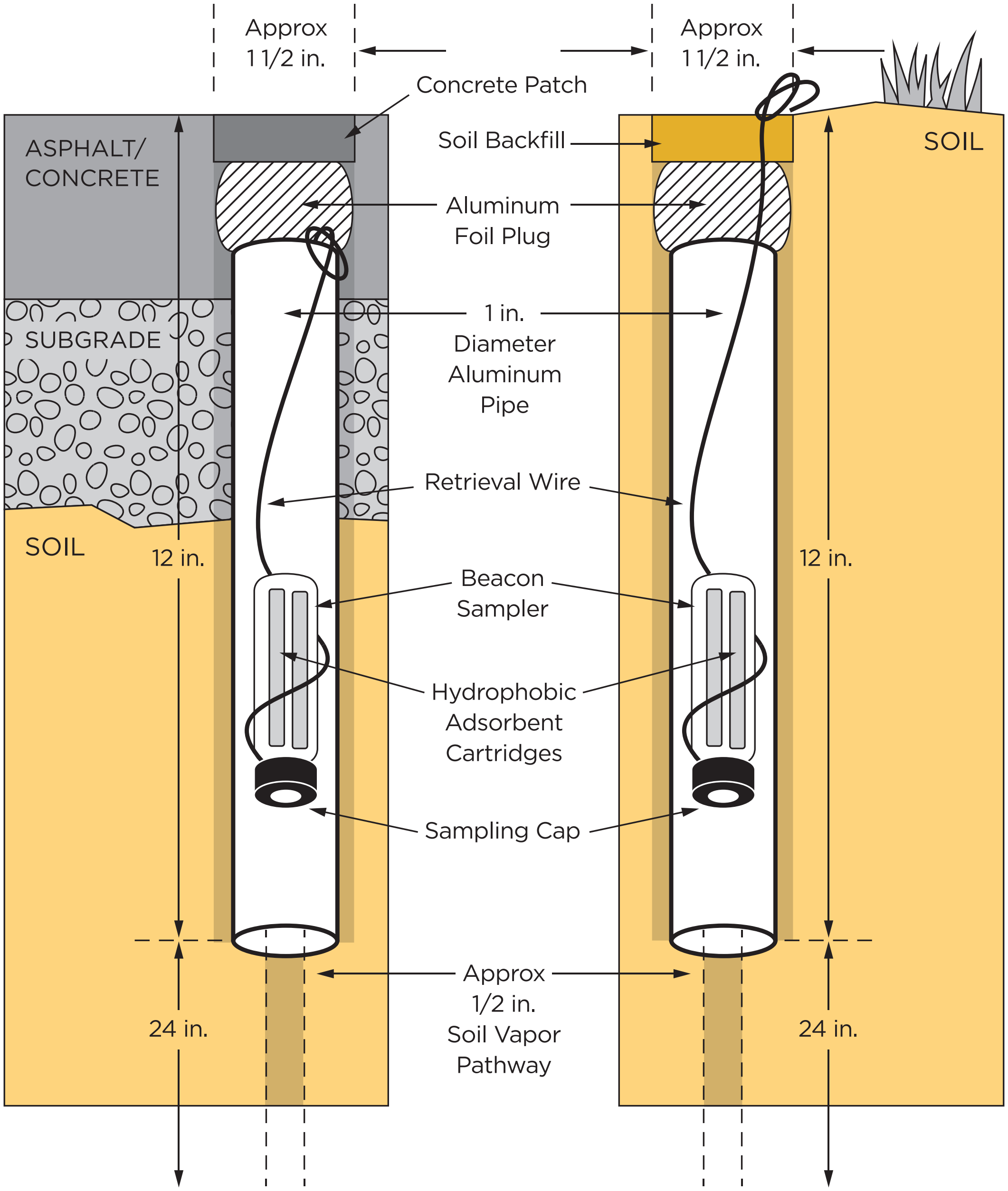
The amount of days required to complete the installation and retrieval procedures is dependent upon the number of personnel deployed for the execution of the fieldwork, weather conditions, and health and safety considerations.

3.0 Analytical Procedures

A chain-of-custody accompanies the field samples at all times from the time the samples are collected until final analysis. BESURE Kits™ are shipped with tug-tight custody seals to ensure that samplers are not tampered with during transport (see Figure 4). Once samples are received at the laboratory, the sample custodian receives the samples and logs the samples into the laboratory's Sample Receipt Log.

Beacon Environmental's laboratory is maintained in a safe and secure manner at all times. The facility is locked when not occupied and is monitored for fire and unauthorized access. Beacon Environmental personnel escort all visitors at all times while inside the facility. Neither soil nor water analyses are performed at Beacon Environmental, so no solvents are stored or used that can create background contamination problems as experienced by wet labs. This ensures that a clean laboratory environment is maintained for trace analyses.

Figure 3 – Beacon PSG Sampler Installation



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Soil gas samples are analyzed by Beacon Environmental using thermal desorption-gas chromatography/mass spectrometry (TD-GC/MS) instrumentation, following EPA Method 8260C procedures. Samples are routinely analyzed for a list of approximately 40 compounds, which can additionally include total petroleum hydrocarbons (TPH). Results are based on an ***initial five-point calibration***. In addition, a BFB tune is performed daily and a method blank is run following the daily calibration verifications. ***Internal standards and surrogates*** are included with each sample analysis. The laboratory's reported quantitation level (RQL) for each of the targeted compounds is 10 or 25 nanograms (ng); however, the limit of quantitation (LOQ) is 10 ng and the limit of detection (LOD) is 5 ng. MDL studies are performed, as well. As an option, tentatively identified compounds (TICs) can be reported for each sample, with the results based on the closest internal standard to the TIC.

Figure 4 – BeSure Sample Collection Kit™

Beacon Environmental is known for providing the highest level of accuracy and quality assurance and quality control (QA/QC) procedures for the analysis of soil gas samples in the industry. The table below summarizes these analytical procedures.

Summary of Analytical Procedures

Description	Included
Analysis by thermal desorption-gas chromatography/mass spectrometry (TD-GC/MS) following EPA Method 8260C - Accredited	√
Analytical results based on multi-point initial calibration	√
MDLs based on a seven replicate study	√
Limit of Detection (LOD) and Limit of Quantitation (LOQ) studies are performed quarterly	√
Internal standards and surrogates included with each run	√
BFB tunes (5 to 50 nanograms through GC, per method)	√
Continuing calibration checks and method blanks	√

Analyses of the samples are performed at Beacon Environmental's laboratory using the latest instruments listed below. The Markes thermal desorption instruments outperform older thermal desorption equipment, which cannot target as broad a range of compounds with as much sensitivity or accuracy.

- Markes TD100xr with auto recollection
- Markes Mass Flow Controller Module
- Agilent 7890 Gas Chromatograph / 5977B Mass Spectrometer

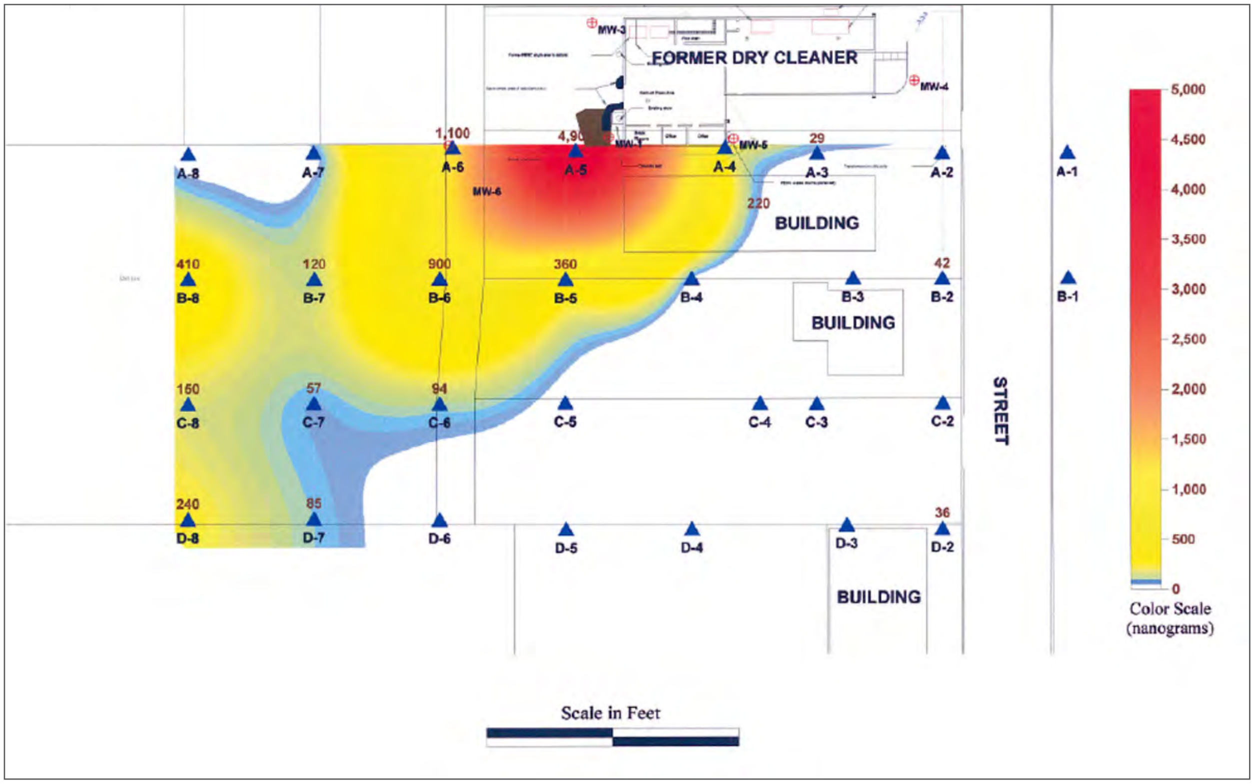
4.0 Reporting

Following analysis and a thorough data review, a comprehensive survey report is provided that contains:

- Project objectives
- Investigation plan
- QA/QC program and findings
- Laboratory data
- Color Isopleth Maps showing the distribution of detected compounds
- Field procedures
- Laboratory procedures
- Field Deployment Reports
- Chain-of-Custody documentation

Beacon Environmental requests a CAD drawing of the site is provided with coordinate data for each location to facilitate creation of color isopleth maps. BEACON can provide the color isopleth maps as layers for use with CAD software or provide data files of the contours for use with GIS software. Beacon Environmental provides post survey support to assist in interpreting the data, when requested.

Color Isopleth Map Example



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Biography of Author

Harry O'Neill is the President of Beacon Environmental and has managed soil gas and vapor intrusion investigations for more than 25 years, working on federal, state, and commercial projects throughout the United States, as well as internationally across six continents. Under his direction since 1999, Beacon Environmental has achieved DoD ELAP, NELAP, and ISO/IEC 17025 accreditation for the analysis of soil gas and air samples to target trace concentrations of organics using sorbent samplers. In addition, Mr. O'Neill oversaw the implementation of the quality program that enabled Beacon to become the first National Environmental Field Activities Program (NEFAP) and accredited field sampling and measurement organization (FSMO) in the United States.

The company's accreditation is for the collection of soil gas and air samples. Mr. O'Neill has been on the forefront of the acceptance of passive sampling technologies at the national and international level and has managed the implementation of thousands of soil gas and air sampling surveys. He is a member of AWMA, ITRC, and ASTM, and is the lead author of ASTM Standard D7758: Standard Practice for Passive Soil Gas Sampling in the Vadose Zone, and has published and presented findings throughout the United States, as well as internationally across four continents as an invited speaker. Mr. O'Neill can be contacted at Harry.ONeill@Beaconusa.com or by phone at 1-410-838-8780.

References

ASTM D7758-11, ***Standard Practice for Passive Soil Gas Sampling in the Vadose Zone for Source Identification, Spatial Variability Assessment, Monitoring, and Vapor Intrusion Evaluations***, ASTM International, West Conshohocken, PA, 2011, DOI: 10.1520/D7758-11

Brownfields Technology Primer: Vapor Intrusion Considerations for Redevelopment, U.S. EPA Office of Solid Waste and Emergency Response, EPA Document No. 542-R-08-001, 2008.

Byrnes, M.E., ***Field Sampling Methods for Remedial Investigations***, CRC Press, New York, 2009.

Clarke, J.N., et al. ***Application of Passive Soil Gas Technology to Determine the Source and Extent of a PCE Groundwater Plume in an Urban Environment***, The Journal of REMEDIATION, Wiley Periodicals, Inc., Vol. 18, No. 4, pp. 55-62, 2008.

Brewer, R., et al. ***Estimation of Generic Subslab Attenuation Factors for Vapor Intrusion Investigations***, Groundwater Monitoring & Remediation, Wiley Periodicals, Inc., Vol 34 No 4, pp. 79-92, 2014.

Hawaii Department of Health Hazard Evaluation and Emergency Response Office, ***Field Study of High-Density Passive Sampler and Large Volume Purge Methods to Characterize Subslab Vapor Plumes***, July 2017.

ITRC, ***Integrated DNAPL Site Characterization and Tools Selection***, Washington, D.C.: Interstate Technology & Regulatory Council, DNAPL Site Characterization Team, May 2015.

New Jersey Department of Environmental Protection Field Sampling Procedures Manual, 2005.

U.S. EPA Method 8260C, ***Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)***, 2006.

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Appendix D:
Tunnel Sampling Locations

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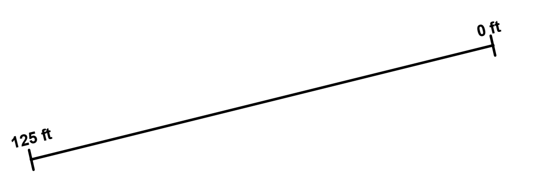
Figure Location



Legend

🟪	Overhead Fuel Pipeline
🟧	18-in Aboveground JP-5 Pipeline
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
┴┴	Tunnel Wall
▲ LAT	Proposed Passive Soil Vapor Monitoring Point
━	Underground FOR Pipeline
○	Existing Soil Vapor Monitoring Probe (SVMP)
⊕	In-Progress Groundwater Monitoring Well

Sheet 1
Proposed Sample Locations
Tank Gallery
Red Hill Closure
Site Assessment Work Plan
JBPHH, Oahu, Hawaii

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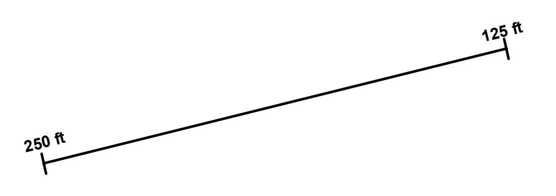
Figure Location



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🟪	Overhead Fuel Pipeline
🟧	18-in Aboveground JP-5 Pipeline
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
⊥	Tunnel Wall
▲ LAT	Proposed Passive Soil Vapor Monitoring Point
━	Underground FOR Pipeline
○	Existing Soil Vapor Monitoring Probe (SVMP)

Sheet 2
Proposed Sample Locations
Tank Gallery
Red Hill Closure
Site Assessment Work Plan
JBPHH, Oahu, Hawaii

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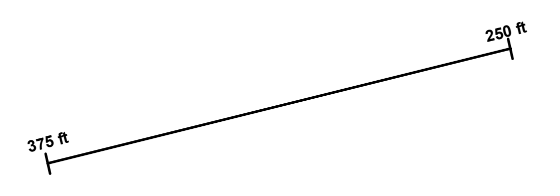
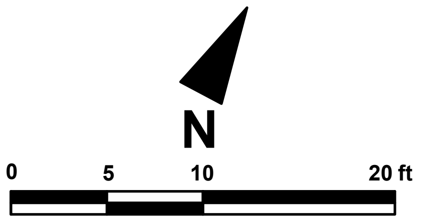


Legend

🟧	18-in Aboveground JP-5 Pipeline
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
┴─┴	Tunnel Wall
▲ LAT	Proposed Passive Soil Vapor Monitoring Point
▬	Underground FOR Pipeline



Graphic Scale 1" = 10 ft

Sheet 3
Proposed Sample Locations
Tank Gallery
Red Hill Closure
Site Assessment Work Plan
JBPHH, Oahu, Hawaii

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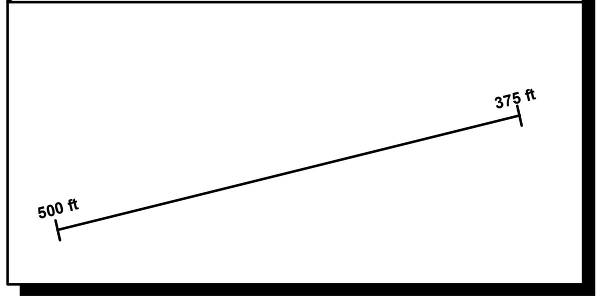
Figure Location



Legend

🟪	Overhead Fuel Pipeline
🟩	32-in Aboveground Fuel Pipeline
🟧	18-in Aboveground JP-5 Pipeline
🟨	16-in Aboveground Fuel Pipeline
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
┴─┴	Tunnel Wall
▲ LAT	Proposed Passive Soil Vapor Monitoring Point
═	Steel Beam
━	Underground FOR Pipeline
○	Existing Soil Vapor Monitoring Probe (SVMP)

Sheet 4
Proposed Sample Locations
Tank Gallery
Red Hill Closure
Site Assessment Work Plan
JBPHH, Oahu, Hawaii

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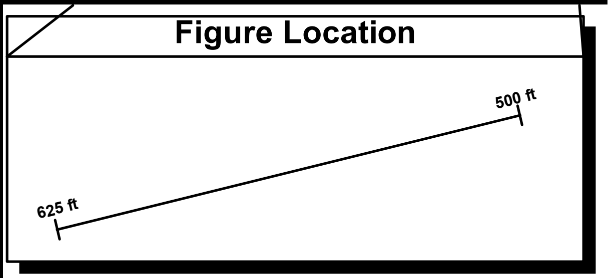

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🟩	32-in Aboveground Fuel Pipeline
🟧	18-in Aboveground JP-5 Pipeline
🟨	16-in Aboveground Fuel Pipeline
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
=	2-ft Wide Steel Rail Track
┴ ┴	Tunnel Wall
▲LAT	Proposed Passive Soil Vapor Monitoring Point
━	Underground FOR Pipeline
=	Steel Beam
◍	Existing Groundwater Monitoring Well
○	Existing Soil Vapor Monitoring Probe (SVMP)

Sheet 5
Proposed Sample Locations
Tank Gallery
Red Hill Closure
Site Assessment Work Plan
JBPHH, Oahu, Hawaii

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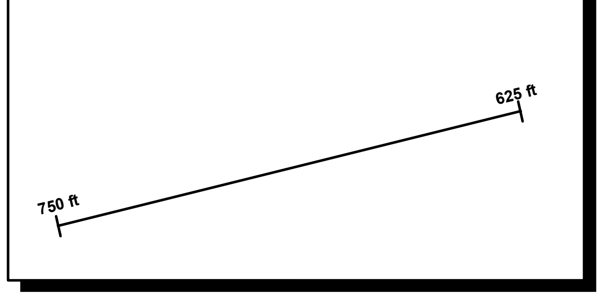

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🟪	Overhead Fuel Pipeline
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🟧	18-in Aboveground JP-5 Pipeline
🟨	16-in Aboveground Fuel Pipeline
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
┴─┴	Tunnel Wall
▲ LAT	Proposed Passive Soil Vapor Monitoring Point
▦	Sump / Floor Drain
━	Underground FOR Pipeline
═	Steel Beam
○	Existing Soil Vapor Monitoring Probe (SVMP)

Sheet 6
Proposed Sample Locations
Tank Gallery
Red Hill Closure
Site Assessment Work Plan
JBPHH, Oahu, Hawaii

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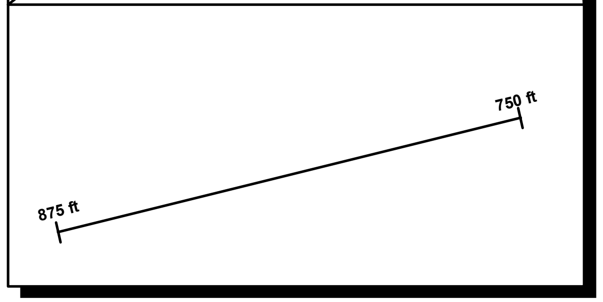

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🟪	Overhead Fuel Pipeline
🟩	32-in Aboveground Fuel Pipeline
🟧	18-in Aboveground JP-5 Pipeline
🟨	16-in Aboveground Fuel Pipeline
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
┴─┴	Tunnel Wall
▲ LAT	Proposed Passive Soil Vapor Monitoring Point
═	Steel Beam
━	Underground FOR Pipeline
○	Existing Soil Vapor Monitoring Probe (SVMP)

Sheet 7
Proposed Sample Locations
Tank Gallery
Red Hill Closure
Site Assessment Work Plan
JBPHH, Oahu, Hawaii

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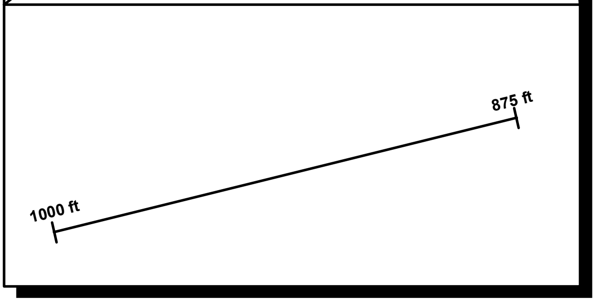

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🟨	16-in Aboveground Fuel Pipeline
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
┴─┴	Tunnel Wall
▲ LAT	Proposed Passive Soil Vapor Monitoring Point
═	Steel Beam
━	Underground FOR Pipeline

Sheet 8
Proposed Sample Locations
Tank Gallery
Red Hill Closure
Site Assessment Work Plan
JBPHH, Oahu, Hawaii

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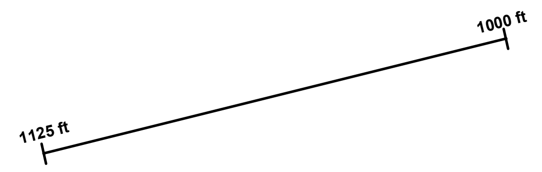

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🟪	Overhead Fuel Pipeline
🟩	32-in Aboveground Fuel Pipeline
🟧	18-in Aboveground JP-5 Pipeline
🟨	16-in Aboveground Fuel Pipeline
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
┴─┴	Tunnel Wall
▲ LAT	Proposed Passive Soil Vapor Monitoring Point
═	Steel Beam
▬	Underground FOR Pipeline
○	Existing Soil Vapor Monitoring Probe (SVMP)

Sheet 9
Proposed Sample Locations
Tank Gallery
Red Hill Closure
Site Assessment Work Plan
JBPHH, Oahu, Hawaii

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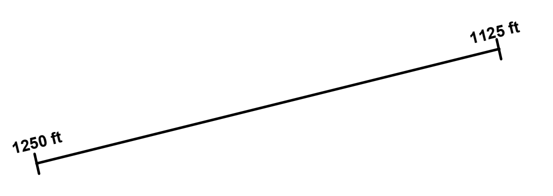

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🟪	Overhead Fuel Pipeline
🟩	32-in Aboveground Fuel Pipeline
🟧	18-in Aboveground JP-5 Pipeline
🟨	16-in Aboveground Fuel Pipeline
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
⊥	Tunnel Wall
▲ LAT	Proposed Passive Soil Vapor Monitoring Point
═	Steel Beam
━	Underground FOR Pipeline
○	Existing Soil Vapor Monitoring Probe (SVMP)

Sheet 10
Proposed Sample Locations
Tank Gallery
Red Hill Closure
Site Assessment Work Plan
JBPHH, Oahu, Hawaii

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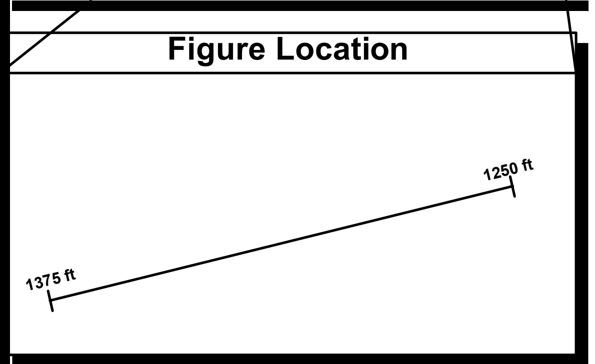
Figure Location



Legend

🟩	32-in Aboveground Fuel Pipeline
🟧	18-in Aboveground JP-5 Pipeline
🟨	16-in Aboveground Fuel Pipeline
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
┴─┴	Tunnel Wall
▲ LAT	Proposed Passive Soil Vapor Monitoring Point
━	Underground FOR Pipeline
═	Steel Beam

Sheet 11
Proposed Sample Locations
Tank Gallery
Red Hill Closure
Site Assessment Work Plan
JBPHH, Oahu, Hawaii

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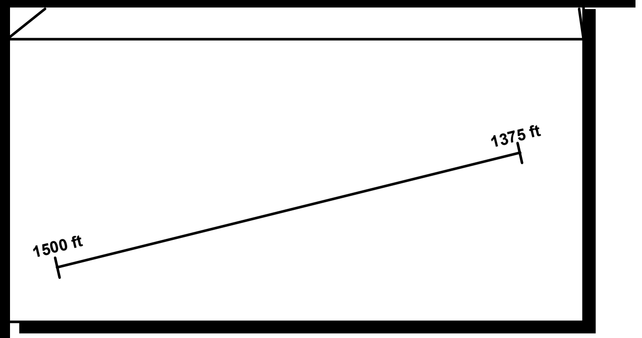

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🟪	Overhead Fuel Pipeline
🟩	32-in Aboveground Fuel Pipeline
🟧	18-in Aboveground JP-5 Pipeline
🟨	16-in Aboveground Fuel Pipeline
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
=	2-ft Wide Steel Rail Track
⊥	Tunnel Wall
▲ LAT	Proposed Passive Soil Vapor Monitoring Point
━	Underground FOR Pipeline
=	Steel Beam
▦	Sump / Floor Drain
◔	Existing Groundwater Monitoring Well
○	Existing Soil Vapor Monitoring Probe (SVMP)

Sheet 12
Proposed Sample Locations
Tank Gallery
Red Hill Closure
Site Assessment Work Plan
JBPHH, Oahu, Hawaii

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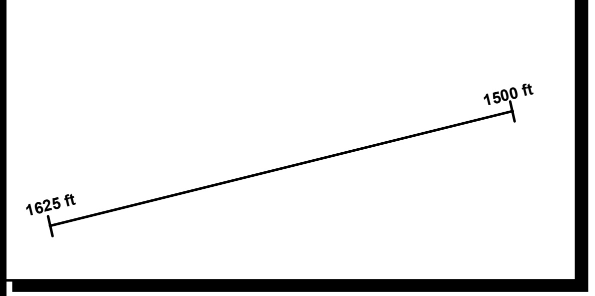
Figure Location



Legend

🟪	Overhead Fuel Pipeline
🟩	32-in Aboveground Fuel Pipeline
🟧	18-in Aboveground JP-5 Pipeline
🟨	16-in Aboveground Fuel Pipeline
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
⊥—⊥	Tunnel Wall
▲ LAT	Proposed Passive Soil Vapor Monitoring Point
━	Underground FOR Pipeline
═	Steel Beam

Sheet 13
Proposed Sample Locations
Tank Gallery
Red Hill Closure
Site Assessment Work Plan
JBPHH, Oahu, Hawaii

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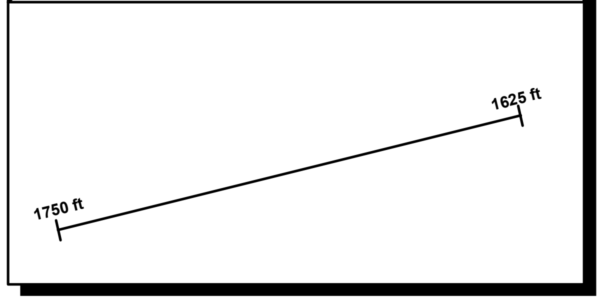

Legend

🟪	Overhead Fuel Pipeline
🟩	32-in Aboveground Fuel Pipeline
🟧	18-in Aboveground JP-5 Pipeline
🟨	16-in Aboveground Fuel Pipeline
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
┴─┴	Tunnel Wall
▲ LAT	Proposed Passive Soil Vapor Monitoring Point
━	Underground FOR Pipeline
═	Steel Beam
○	Existing Soil Vapor Monitoring Probe (SVMP)

Sheet 14
Proposed Sample Locations
Tank Gallery
Red Hill Closure
Site Assessment Work Plan
JBPHH, Oahu, Hawaii

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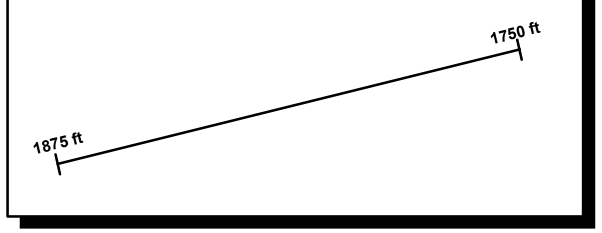
Figure Location



Legend

🟪	Overhead Fuel Pipeline
🟩	32-in Aboveground Fuel Pipeline
🟧	18-in Aboveground JP-5 Pipeline
🟨	16-in Aboveground Fuel Pipeline
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
=	2-ft Wide Steel Rail Track
⊥⊥	Tunnel Wall
▲ LAT	Proposed Passive Soil Vapor Monitoring Point
━	Underground FOR Pipeline
=	Steel Beam
▦	Sump / Floor Drain
○	Existing Soil Vapor Monitoring Probe (SVMP)

Sheet 15
Proposed Sample Locations
Tank Gallery
Red Hill Closure
Site Assessment Work Plan
JBPHH, Oahu, Hawaii

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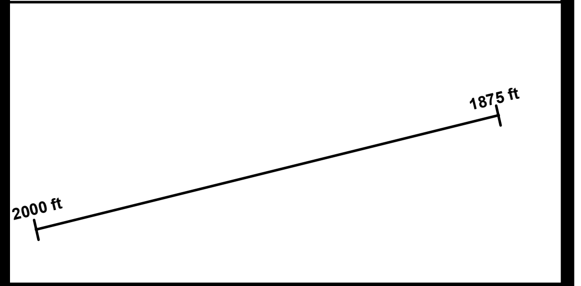
Figure Location



Legend

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🟧	18-in Aboveground JP-5 Pipeline
🟨	16-in Aboveground Fuel Pipeline
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
┴─┴	Tunnel Wall
▲ LAT	Proposed Passive Soil Vapor Monitoring Point
━	Underground FOR Pipeline
═	Steel Beam
▦	Sump / Floor Drain

Sheet 16
Proposed Sample Locations
Tank Gallery
Red Hill Closure
Site Assessment Work Plan
JBPHH, Oahu, Hawaii

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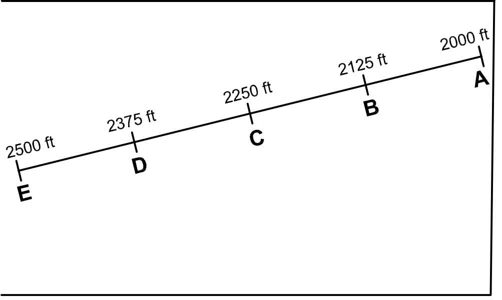
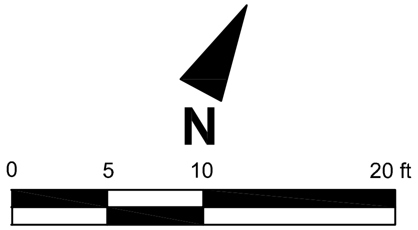
FIGURE LOCATION



LEGEND

Above Ground Pipeline (inch diameter)

🟦	32-in Water
🟩	32-in Fuel F-76
🟧	18-in Fuel JP-5
🟨	16-in Fuel F-24
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
=	2-ft Wide Steel Rail Track
⊥	Tunnel Wall
▲	Proposed PSGS/Soil Sample
▦	Floor Drain
⊗	Floor Drain



Graphic Scale 1" = 10 ft

Sheet 17
Proposed Sample Locations
(A-E)
Lower Access Tunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

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(b) (3)

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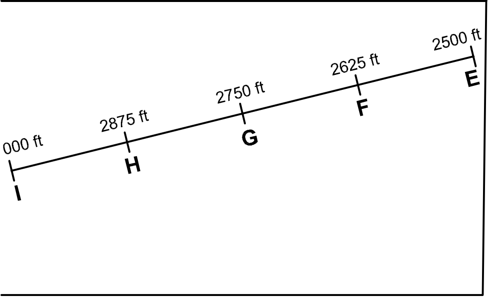
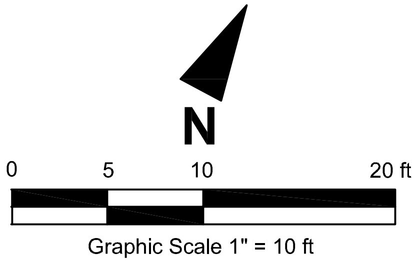
FIGURE LOCATION



LEGEND

Above Ground Pipeline (inch diameter)

🟦	32-in Water
🟩	32-in Fuel F-76
🟧	18-in Fuel JP-5
🟨	16-in Fuel F-24
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
⊥⊥	Tunnel Wall
▲	Proposed PSGS/Soil Sample
▦	Floor Drain
⊗	Floor Drain



Graphic Scale 1" = 10 ft

Sheet 18
Proposed Sample Locations
(E-I)
Lower Access Tunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

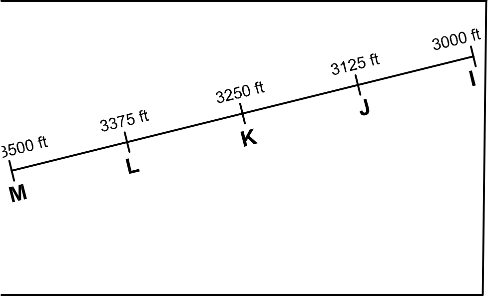
(b) (3)

[redacted]

(b) (3)

[redacted]

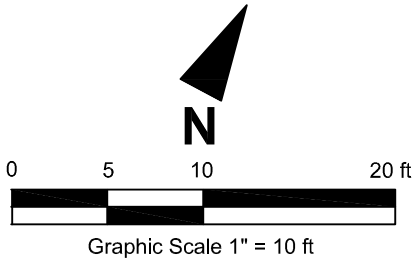
FIGURE LOCATION



LEGEND

Above Ground Pipeline (inch diameter)

🟦	32-in Water
🟩	32-in Fuel F-76
🟧	18-in Fuel JP-5
🟨	16-in Fuel F-24
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
=	2-ft Wide Steel Rail Track
⊥⊥	Tunnel Wall
▲	Proposed PSGS/Soil Sample
▦	Floor Drain
⊗	Floor Drain



Graphic Scale 1" = 10 ft

Sheet 19
Proposed Sample Locations (I-M)
Lower Access Tunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

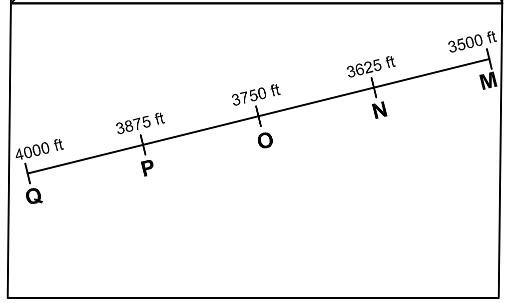
(b) (3)

[redacted]

(b) (3)

[redacted]

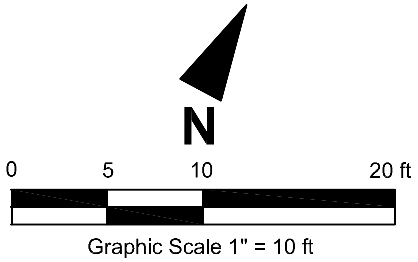
FIGURE LOCATION



LEGEND

Above Ground Pipeline (inch diameter)

🟦	32-in Water
🟩	32-in Fuel F-76
🟧	18-in Fuel JP-5
🟨	16-in Fuel F-24
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
=	2-ft Wide Steel Rail Track
⊥⊥	Tunnel Wall
▲	Proposed PSGS/Soil Sample
▦	Floor Drain
⊗	Floor Drain

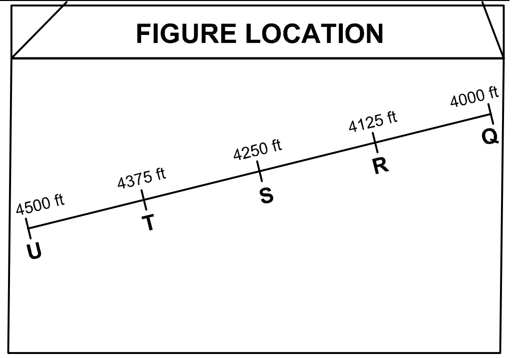


Sheet 20
Proposed Sample Locations
(M-Q)
Lower Access Tunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

(b) (3) (b) (3)

[redacted]

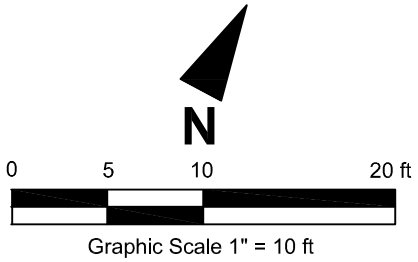
FIGURE LOCATION



LEGEND

Above Ground Pipeline (inch diameter)

🟦	32-in Water
🟩	32-in Fuel F-76
🟧	18-in Fuel JP-5
🟨	16-in Fuel F-24
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
─┘	Tunnel Wall
▲	Proposed PSGS/Soil Sample
▦	Floor Drain
⊗	Floor Drain
▲	Existing Active Soil Vapor Monitoring Point



Graphic Scale 1" = 10 ft

Sheet 21
Proposed Sample Locations
(Q-U)
Lower Access Tunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

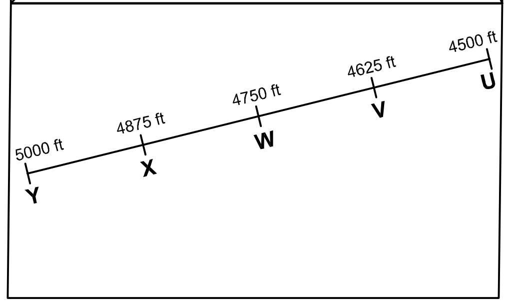
(b) (3)

[redacted]

(b) (3)

[redacted]

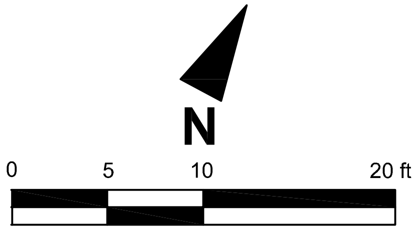
FIGURE LOCATION



LEGEND

Above Ground Pipeline (inch diameter)

🟦	32-in Water
🟩	32-in Fuel F-76
🟧	18-in Fuel JP-5
🟨	16-in Fuel F-24
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
	2-ft Wide Steel Rail Track
	Tunnel Wall
▲	Proposed PSGS/Soil Sample
▦	Floor Drain
⊗	Floor Drain
▲	Existing Active Soil Vapor Monitoring Point



Graphic Scale 1" = 10 ft

Sheet 22
Proposed Sample Locations
(U-Y)
Harbor Tunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

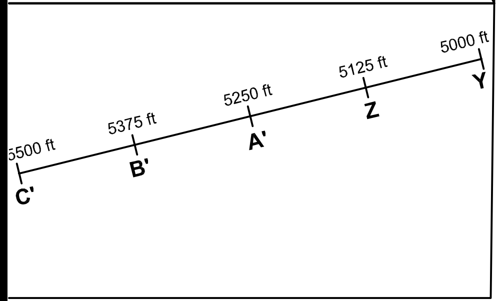
(b) (3)

[redacted]

(b) (3)

[redacted]

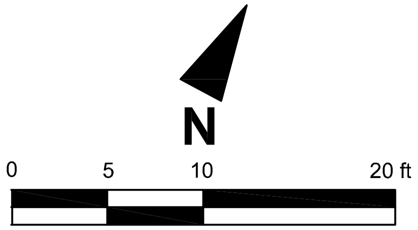
FIGURE LOCATION



LEGEND

Above Ground Pipeline (inch diameter)

🟦	32-in Water
🟩	32-in Fuel F-76
🟧	18-in Fuel JP-5
🟨	16-in Fuel F-24
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
=	2-ft Wide Steel Rail Track
⊥⊥	Tunnel Wall
▲	Proposed PSGS/Soil Sample
▦	Floor Drain
⊗	Floor Drain



Graphic Scale 1" = 10 ft

Sheet 23
Proposed Sample Locations
(Y-C')
HarborTunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

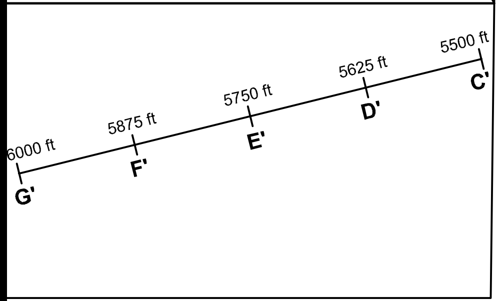
(b) (3)

[redacted]

(b) (3)

[redacted]

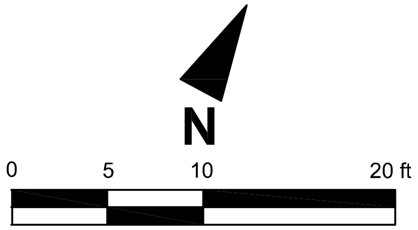
FIGURE LOCATION



LEGEND

Above Ground Pipeline (inch diameter)

🟦	32-in Water
🟩	32-in Fuel F-76
🟧	18-in Fuel JP-5
🟨	16-in Fuel F-24
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
⊥⊥	Tunnel Wall
▲	Proposed PSGS/Soil Sample
▦	Floor Drain
⊗	Floor Drain



Graphic Scale 1" = 10 ft

Sheet 24
Proposed Sample Locations
(C'-G')
HarborTunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

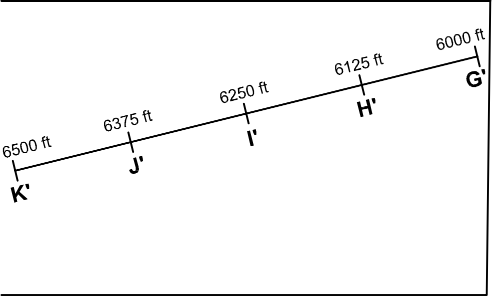
(b) (3)

[redacted]

(b) (3)

[redacted]

FIGURE LOCATION



LEGEND

Above Ground Pipeline (inch diameter)

🟦 32-in Water

🟩 32-in Fuel F-76

🟧 18-in Fuel JP-5

🟨 16-in Fuel F-24

FF113 Frame Foot Marker

14995 Distance from UGPH (feet)

2000 Distance from Tank 20 (feet)

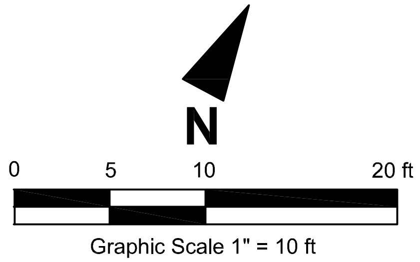
═ 2-ft Wide Steel Rail Track

┴ Tunnel Wall

▲ Proposed PSGS/Soil Sample

▦ Floor Drain

⊗ Floor Drain



Sheet 25
Proposed Sample Locations (G'-K')
HarborTunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

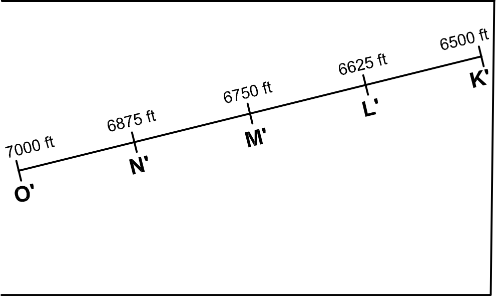
(b) (3)

[redacted]

(b) (3)

[redacted]

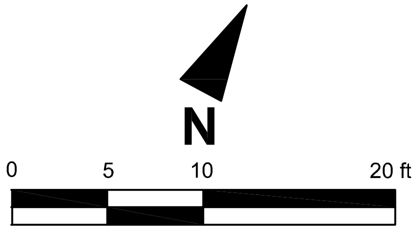
FIGURE LOCATION



LEGEND

Above Ground Pipeline (inch diameter)

🟦	32-in Water
🟩	32-in Fuel F-76
🟧	18-in Fuel JP-5
🟨	16-in Fuel F-24
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
=	2-ft Wide Steel Rail Track
⊥⊥	Tunnel Wall
▲	Proposed PSGS/Soil Sample
▦	Floor Drain
⊗	Floor Drain



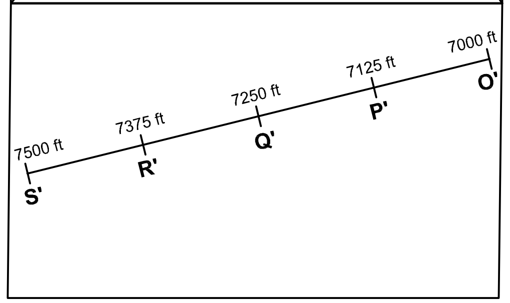
Graphic Scale 1" = 10 ft

Sheet 26
Proposed Sample Locations
(K'-O')
HarborTunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

(b) (3) (b) (3)

[redacted]

FIGURE LOCATION



LEGEND

Above Ground Pipeline (inch diameter)

🟦	32-in Water
🟩	32-in Fuel F-76
🟧	18-in Fuel JP-5
🟨	16-in Fuel F-24
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
=	2-ft Wide Steel Rail Track
⊥⊥	Tunnel Wall
▲	Proposed PSGS/Soil Sample
▦	Floor Drain
⊗	Floor Drain

N

0 5 10 20 ft

Graphic Scale 1" = 10 ft

Sheet 27
Proposed Sample Locations
(O'-S')
HarborTunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

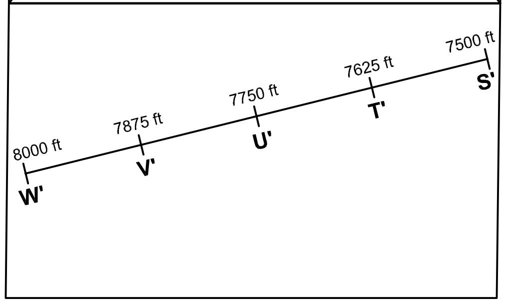
(b) (3)

[redacted]

(b) (3)

[redacted]

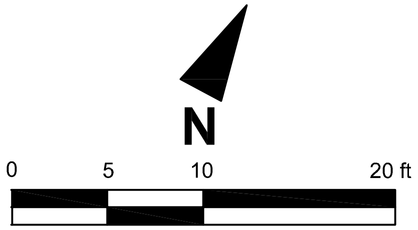
FIGURE LOCATION



LEGEND

Above Ground Pipeline (inch diameter)

🟦	32-in Water
🟩	32-in Fuel F-76
🟧	18-in Fuel JP-5
🟨	16-in Fuel F-24
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
⊥	Tunnel Wall
▲	Proposed PSGS/Soil Sample
▦	Floor Drain
⊗	Floor Drain



Graphic Scale 1" = 10 ft

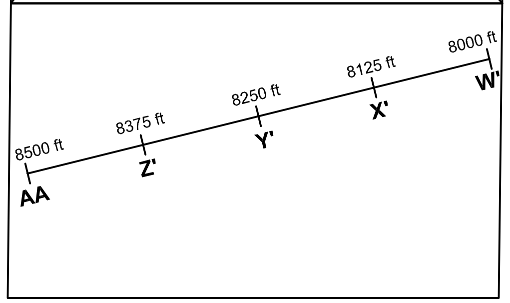
Sheet 28
Proposed Sample Locations
(S'-W')
HarborTunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

(b) (3)

(b) (3)

[redacted]

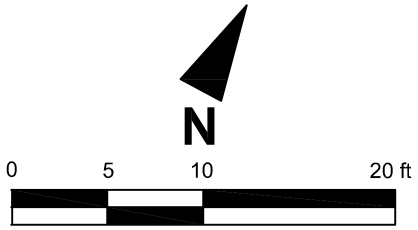
FIGURE LOCATION



LEGEND

Above Ground Pipeline (inch diameter)

🟦	32-in Water
🟩	32-in Fuel F-76
🟧	18-in Fuel JP-5
🟨	16-in Fuel F-24
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
⊥⊥	Tunnel Wall
▲	Proposed PSGS/Soil Sample
▦	Floor Drain
⊗	Floor Drain



Graphic Scale 1" = 10 ft

Sheet 29
Proposed Sample Locations
(W'-AA)
HarborTunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

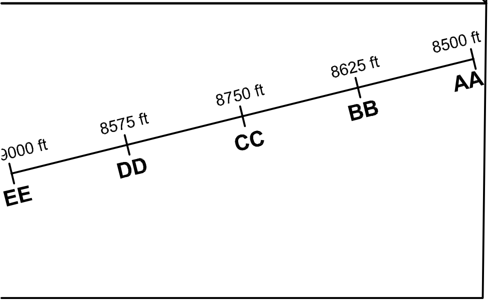
(b) (3)

[redacted]

(b) (3)

[redacted]

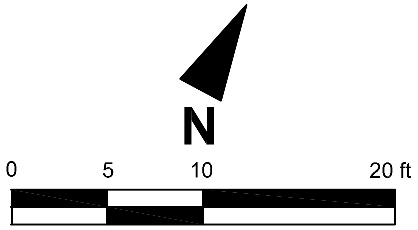
FIGURE LOCATION



LEGEND

Above Ground Pipeline (inch diameter)

🟦	32-in Water
🟩	32-in Fuel F-76
🟧	18-in Fuel JP-5
🟨	16-in Fuel F-24
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
⊥	Tunnel Wall
▲	Proposed PSGS/Soil Sample
▦	Floor Drain
⊗	Floor Drain



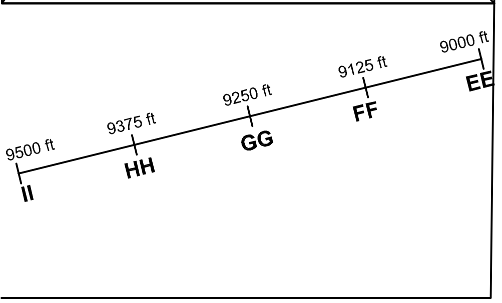
Graphic Scale 1" = 10 ft

Sheet 30
Proposed Sample Locations
(AA-EE)
HarborTunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

(b) (3) [redacted]

(b) (3) [redacted]

FIGURE LOCATION



LEGEND

Above Ground Pipeline (inch diameter)

🟦	32-in Water
🟩	32-in Fuel F-76
🟧	18-in Fuel JP-5
🟨	16-in Fuel F-24

FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
=	2-ft Wide Steel Rail Track
⊥⊥	Tunnel Wall
▲	Proposed PSGS/Soil Sample
▦	Floor Drain
⊗	Floor Drain

N

0 5 10 20 ft

Graphic Scale 1" = 10 ft

Sheet 31
Proposed Sample Locations
(EE-II)
HarborTunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

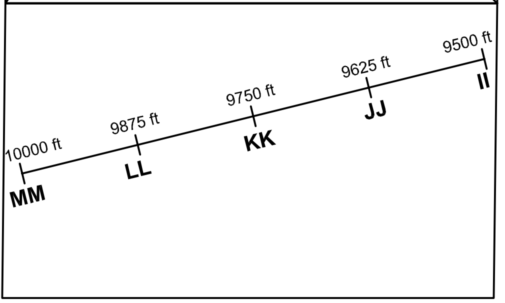
(b) (3)

[redacted]

(b) (3)

[redacted]

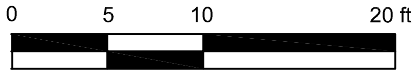
FIGURE LOCATION



LEGEND

Above Ground Pipeline (inch diameter)

🟦	32-in Water
🟩	32-in Fuel F-76
🟧	18-in Fuel JP-5
🟨	16-in Fuel F-24
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
⊥	Tunnel Wall
▲	Proposed PSGS/Soil Sample
▦	Floor Drain
⊗	Floor Drain



Graphic Scale 1" = 10 ft

Sheet 32
Proposed Sample Locations
(II-MM)
HarborTunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

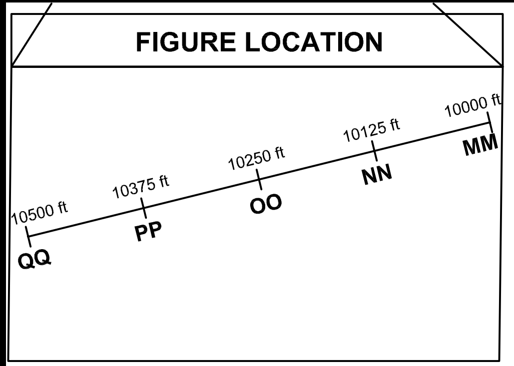
(b) (3)

[redacted]

(b) (3)

[redacted]

FIGURE LOCATION



LEGEND

Above Ground Pipeline (inch diameter)

🟦 32-in Water

🟩 32-in Fuel F-76

🟧 18-in Fuel JP-5

🟨 16-in Fuel F-24

FF113 Frame Foot Marker

14995 Distance from UGPH (feet)

2000 Distance from Tank 20 (feet)

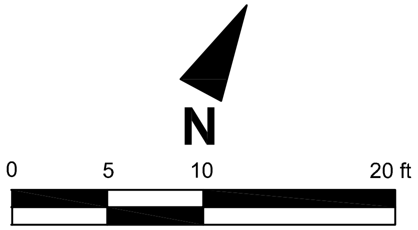
═ 2-ft Wide Steel Rail Track

┴ Tunnel Wall

▲ Proposed PSGS/Soil Sample

▦ Floor Drain

⊗ Floor Drain



Graphic Scale 1" = 10 ft

Sheet 33
Proposed Sample Locations
(MM-QQ)
HarborTunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

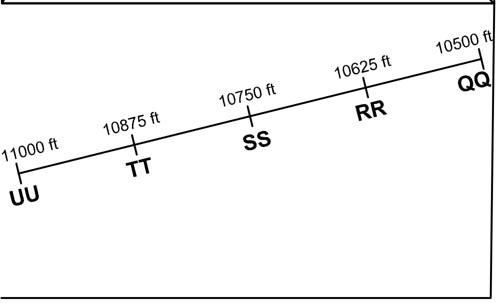
(b) (3)

[redacted]

(b) (3)

[redacted]

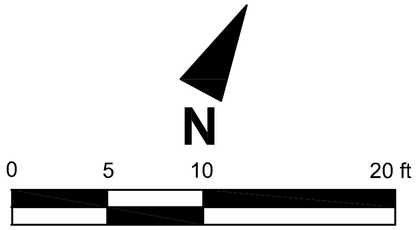
FIGURE LOCATION



LEGEND

Above Ground Pipeline (inch diameter)

🟦	32-in Water
🟩	32-in Fuel F-76
🟧	18-in Fuel JP-5
🟨	16-in Fuel F-24
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
⊥⊥	Tunnel Wall
▲	Proposed PSGS/Soil Sample
▦	Floor Drain
⊗	Floor Drain



Graphic Scale 1" = 10 ft

Sheet 34
Proposed Sample Locations
(QQ-UU)
HarborTunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

(b) (3)

(b) (3)

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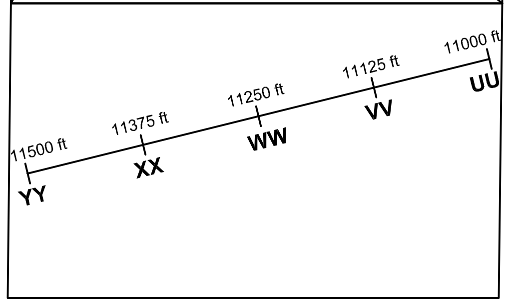
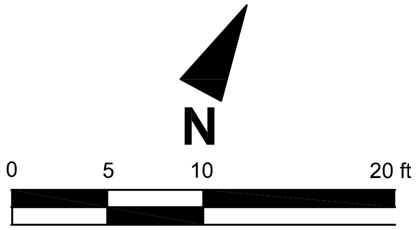
FIGURE LOCATION



LEGEND

Above Ground Pipeline (inch diameter)

🟦	32-in Water
🟩	32-in Fuel F-76
🟧	18-in Fuel JP-5
🟨	16-in Fuel F-24
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
┴┴	Tunnel Wall
▲	Proposed PSGS/Soil Sample
▦	Floor Drain
⊗	Floor Drain



Graphic Scale 1" = 10 ft

Sheet 35
Proposed Sample Locations
(UU-YY)
HarborTunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

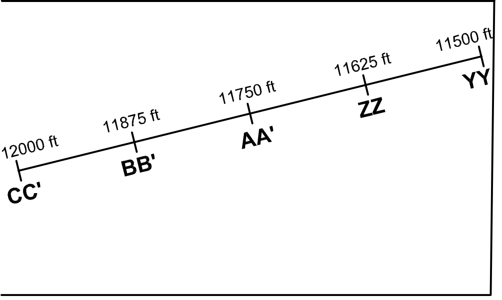
(b) (3)

[redacted]

(b) (3)

[redacted]

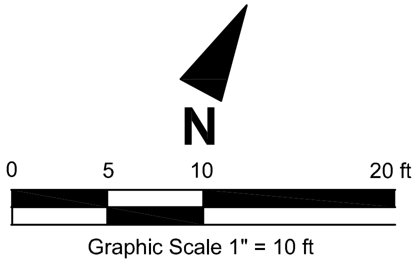
FIGURE LOCATION



LEGEND

Above Ground Pipeline (inch diameter)

🟦	32-in Water
🟩	32-in Fuel F-76
🟧	18-in Fuel JP-5
🟨	16-in Fuel F-24
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
⊥	Tunnel Wall
▲	Proposed PSGS/Soil Sample
▦	Floor Drain
⊗	Floor Drain



Sheet 36
Proposed Sample Locations
(YY-CC')
HarborTunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

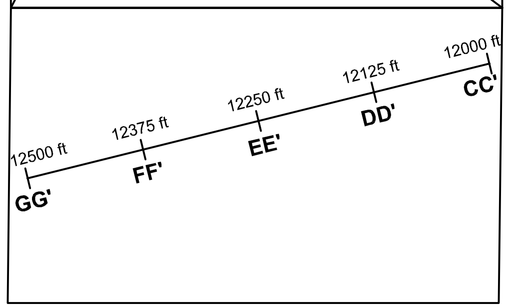
(b) (3)

[redacted]

(b) (3)

[redacted]

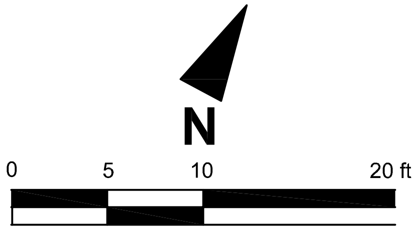
FIGURE LOCATION



LEGEND

Above Ground Pipeline (inch diameter)

🟦	32-in Water
🟩	32-in Fuel F-76
🟧	18-in Fuel JP-5
🟨	16-in Fuel F-24
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
⊥	Tunnel Wall
▲	Proposed PSGS/Soil Sample
▦	Floor Drain
⊗	Floor Drain



Graphic Scale 1" = 10 ft

Sheet 37
Proposed Sample Locations
(CC'-GG')
HarborTunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

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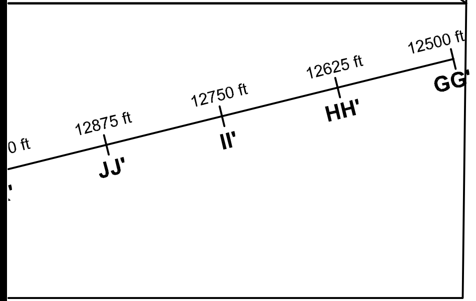
FIGURE LOCATION



LEGEND

bove Ground Pipeline (inch diameter)

🟦	32-in Water
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🟧	18-in Fuel JP-5
🟨	16-in Fuel F-24
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=	2-ft Wide Steel Rail Track
⊥	Tunnel Wall
▲	Proposed PSGS/Soil Sample
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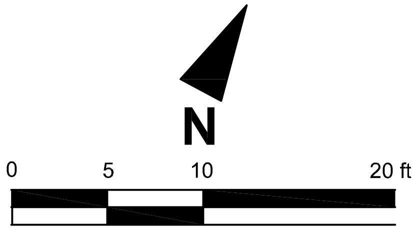
⊗	Floor Drain



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Sheet 38
Proposed Sample Locations
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HarborTunnel
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Assessment Work Plan
JBPHH, Oahu, Hawaii

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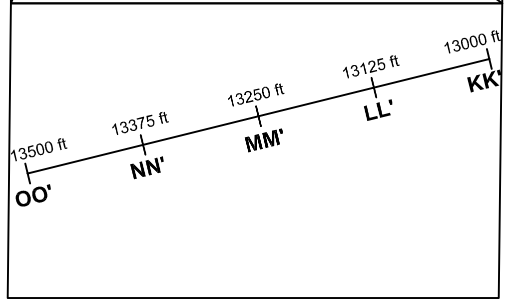
FIGURE LOCATION



LEGEND

Above Ground Pipeline (inch diameter)

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🟨	16-in Fuel F-24
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2000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
⊥	Tunnel Wall
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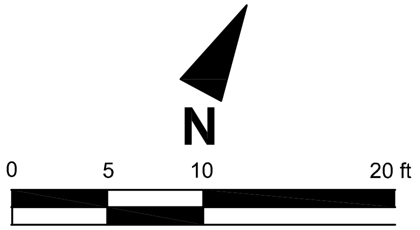
▦	Floor Drain
⊗	Floor Drain



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Sheet 39
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MakalapaTunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

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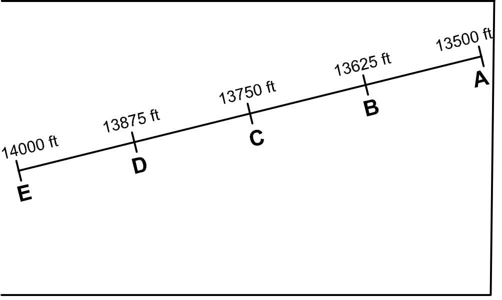
FIGURE LOCATION



LEGEND

Above Ground Pipeline (inch diameter)

🟦	32-in Water
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🟧	18-in Fuel JP-5
🟨	16-in Fuel F-24

FF113	Frame Foot Marker
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2000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
⊥⊥	Tunnel Wall
▲	Proposed PSGS/Soil Sample
▦	Floor Drain
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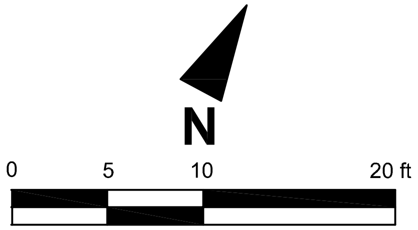

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Sheet 40
Proposed Sample Locations
(OO'-SS')
MakalapaTunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

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(b) (3)

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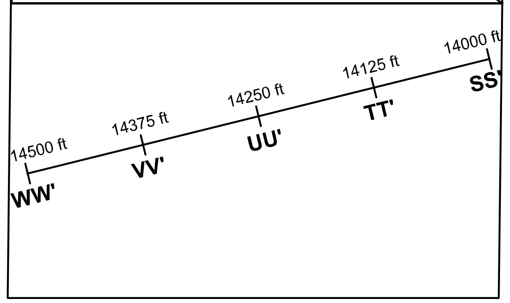

LEGEND

Above Ground Pipeline (inch diameter)

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🟨	16-in Fuel F-24
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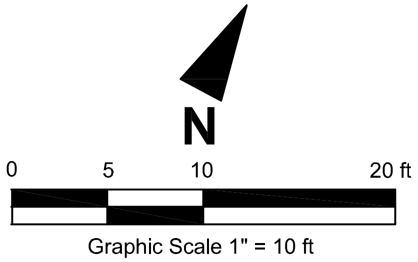
=	2-ft Wide Steel Rail Track
⊥	Tunnel Wall
▲	Proposed PSGS/Soil Sample
▦	Floor Drain
⊗	Floor Drain



Sheet 41
Proposed Sample Locations
(SS'-WW')
MakalapaTunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

(b) (3) (b) (3)

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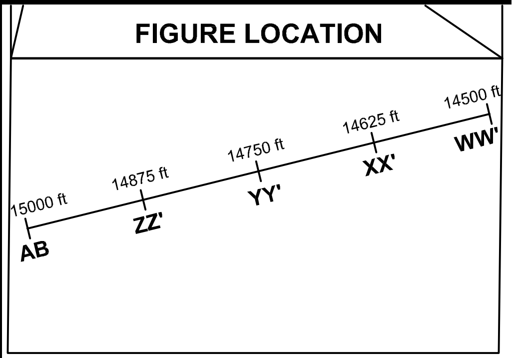
FIGURE LOCATION



LEGEND

Above Ground Pipeline (inch diameter)

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🟩	32-in Fuel F-76
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🟨	16-in Fuel F-24
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14995	Distance from UGPH (feet)
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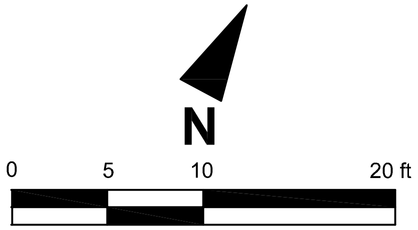
═	2-ft Wide Steel Rail Track
⊥⊥	Tunnel Wall
▲	Proposed PSGS/Soil Sample
▦	Floor Drain
⊗	Floor Drain



Graphic Scale 1" = 10 ft

Sheet 42
Proposed Sample Locations
(WW'-AB)
Adit 2 Tunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

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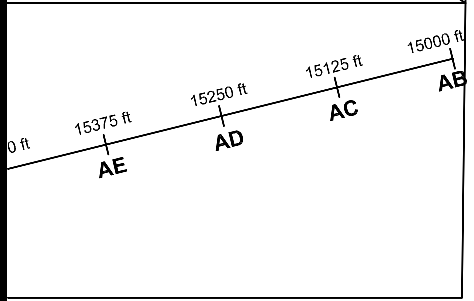
FIGURE LOCATION



LEGEND

bove Ground Pipeline (inch diameter)

🟦	32-in Water
🟩	32-in Fuel F-76
🟧	18-in Fuel JP-5
🟨	16-in Fuel F-24
F113	Frame Foot Marker
4995	Distance from UGPH (feet)
000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
⊥	Tunnel Wall
▲	Proposed PSGS/Soil Sample
▦	Floor Drain
⊗	Floor Drain

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Graphic Scale 1" = 10 ft

Sheet 43
Proposed Sample Locations
(AB-AF)
Adit 2 Tunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

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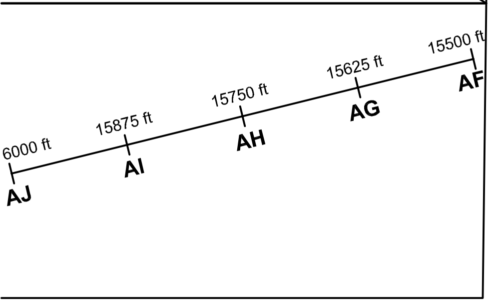

LEGEND

Above Ground Pipeline (inch diameter)

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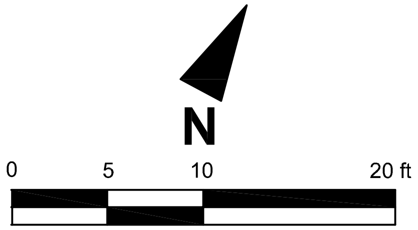
🟩	32-in Fuel F-76
🟧	18-in Fuel JP-5
🟨	16-in Fuel F-24
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
=	2-ft Wide Steel Rail Track
⊥⊥	Tunnel Wall
▲	Proposed PSGS/Soil Sample
▦	Floor Drain
⊗	Floor Drain



Graphic Scale 1" = 10 ft

Sheet 44
Proposed Sample Locations
(AF-AJ)
Adit 2 Tunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

(b) (3)

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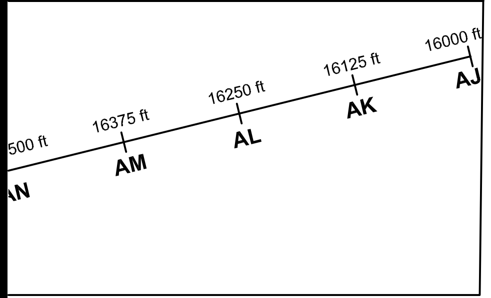
FIGURE LOCATION



LEGEND

Above Ground Pipeline (inch diameter)

🟦	32-in Water
🟩	32-in Fuel F-76
🟧	18-in Fuel JP-5
🟨	16-in Fuel F-24
FF113	Frame Foot Marker
14995	Distance from UGPH (feet)
2000	Distance from Tank 20 (feet)
═	2-ft Wide Steel Rail Track
┗┛	Tunnel Wall
▲	Proposed PSGS/Soil Sample
▦	Floor Drain
⊗	Floor Drain

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Graphic Scale 1" = 10 ft

Sheet 45
Proposed Sample Locations
(AJ-AN)
Adit 1 Tunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

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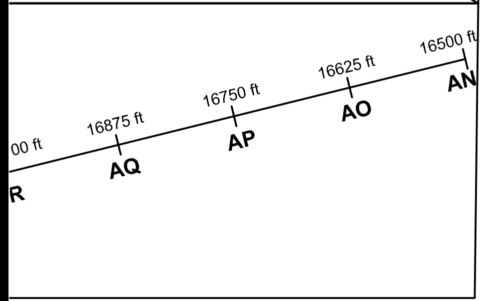
FIGURE LOCATION



LEGEND

Above Ground Pipeline (inch diameter)

🟦 32-in Water

🟩 32-in Fuel F-76

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FF113	Frame Foot Marker
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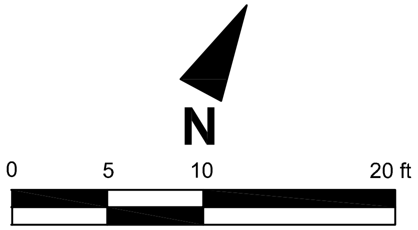
▦	Floor Drain
⊗	Floor Drain



Graphic Scale 1" = 10 ft

Sheet 46
Proposed Sample Locations
(AN-AR)
Adit 1 Tunnel
Red Hill Closure Site
Assessment Work Plan
JBPHH, Oahu, Hawaii

Appendix E:
NAVFAC Pacific Environmental Restoration Program Project Procedures and JBPHH Green Waste Policy

NAVFAC PACIFIC PROJECT PROCEDURES

I. Field Procedures

I-A Planning

- Procedure I-A-1 Development of Project Quality Objectives
- Procedure I-A-5 Utility Clearance
- Procedure I-A-6 Investigation-Derived Waste Management
- Procedure I-A-8 Sample Naming

I-B Sampling

- Procedure I-B-1 Soil Sampling
- Procedure I-B-2 Geophysical Testing

I-C Well Construction and Well Development

- Procedure I-C-1 Monitoring Well Installation and Abandonment
- Procedure I-C-3 Monitoring Well Sampling

Miscellaneous

- Procedure I-D-1 Drum Sampling
- Procedure I-E Soil and Rock Classification
- Procedure I-F Equipment Decontamination
- Procedure I-H Direct Push Sampling Techniques
- Procedure I-I Land Surveying

II. Data Validation Procedures

- Procedure II-B Level C and Level D Data Validation for GC/MS Volatile Organics by SW-846 8260
- Procedure II-H Level C and Level D Data Validation for Total Petroleum Hydrocarbons by SW-846 8015
- Procedure II-N Level C and Level D Data Validation for Polynuclear Aromatic Hydrocarbons by SW-846 8310
- Procedure II-Q Level C and Level D Data Validation for Metals by SW-846 6000/7000
- Procedure II-R Level C and Level D Data Validation for Wet Chemistry Analyses Procedure II-S Data Quality Assessment Report
- Procedure II-W Level C and Level D Data Validation for GC/FID/ECD Volatile Organics and Fixed Gases in Soil Gas/Vapor by EPA Method TO-03 and ASTM D1946
- Procedure II-X Level C and Level D Data Validation for GC/MS Volatile Organics and Fixed Gases in Soil Gas/Vapor by EPA Methods TO-14, TO-15, and TO-17

III. QC Procedures

- Procedure III-A Laboratory QC Samples (Water, Soil)
- Procedure III-B Field QC Samples (Water, Soil)
- Procedure III-D Logbooks
- Procedure III-E Record Keeping, Sample Labeling, and Chain-of-Custody
- Procedure III-F Sample Handling, Storage, and Shipping

JBPHH GREEN WASTE POLICY 2022

Development of Project Quality Objectives

1. Purpose

This standard operating procedure establishes standard guidelines for the United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel for the development of project quality objectives (PQOs) for a contract task order (CTO). These procedures will help ensure that CTOs meet the purpose and objectives of the task order, as well as the necessary documentation of the environmental decisions that need to be made and the level of data quality needed to ensure that those decisions are based on sound scientific data. The PQOs will be used to develop the work plan (WP), which provides the detailed project-specific objectives, specifications, and procedures needed to conduct a successful data collection activity. Data will be collected according to specifications set forth in the WP, and a data quality assessment will be performed to determine whether PQOs have been satisfied.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program. As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

ARARs include cleanup or control standards, regulatory requirements, or limitations promulgated under federal or state environmental laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance that applies to a particular CTO.

3.2 ANALYTES

Analytes are contaminants that might be present at a site as well as other chemical and physical properties for which the laboratory will analyze samples.

3.3 ANALYTICAL METHODS

Analytical methods are standardized procedures used to identify and quantify analytes in environmental samples.

3.4 PQOS

PQOs are qualitative and quantitative statements derived from a systematic planning process (e.g., U.S. Environmental Protection Agency [EPA] *Guidance on Systematic Planning Using the Data*

Quality Objectives Process (EPA 2006) that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors. PQOs will be used as the basis for establishing the quality and quantity of data needed to support decisions.

3.5 PQO PROCESS

The PQO process is a systematic planning tool based on the scientific method for establishing criteria for data quality and for developing a data collection design.

3.6 ACTION LEVEL

Action levels (ALs) are analyte concentrations that if exceeded in site media, indicate that some action is needed to address hazards associated with onsite contamination.

4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that development of PQOs is performed in compliance with this procedure and for identifying instances of noncompliance. The CTO Manager is responsible for ensuring that all personnel involved in sampling and/or testing shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

5. Procedures

PQOs shall be developed following performance of the site reconnaissance and prior to development of the WP for all CTOs. When critical environmental decisions need to be made,(e.g., final decision-making or compliance with a standard), the project team should follow a formal systematic planning process such as the data quality objectives (DQO) process described in the *Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4* (EPA 2006). The formal DQO process as described in EPA QA/G-4 requires statistical expertise to define the amount of error acceptable when making an environmental decision and includes the following seven steps:

1. State the problem.
2. Identify the goals of the study.
3. Identify information inputs.
4. Define the study boundaries.
5. Develop the analytic approach.
6. Specify performance or acceptance criteria.
7. Develop the plan for obtaining data.

Graded Approach

For data collection activities that are either exploratory or small in nature, or where specific decisions cannot be identified, the formal process is not necessary. For these projects, the project team should use an abbreviated systematic planning process (e.g., Steps 1-4) to help identify the PQOs and action limits, and to select appropriate sampling, analytical and assessment activities.

Incremental Sampling Approach

Incremental sampling methodology (ISM) is such an integral part of environmental investigations in Hawaii, and therefore, a discussion of ISM PQOs is necessary. The State Department of Health strongly encourages the use of incremental sampling (IS) to enhance the sample representativeness during environmental investigations when appropriate (DOH 2009). IS is a structured sampling protocol that enhances sample representativeness and reduces data variability in the investigation of contaminated soil. The objective of IS is to obtain a single sample for analysis that has an analyte concentration representative of a decision unit within the error limitations required for the project. IS improves the reliability and defensibility of sampling data by reducing variability when compared to conventional discrete sampling strategies. An IS approach requires site-specific information to be considered during the planning process. Therefore, the steps necessary to complete the DQO process as they apply to investigations where IS is used is detailed in Attachment I-A-1-1.

5.1 STEP 1: STATE THE PROBLEM

The first step of the PQO process is to state the problem. Clearly define the problem once it has been identified. Assemble a planning team to completely assess the problem. Designate one member of the planning team as the primary decision maker. The planning team shall compile and evaluate available information to develop a concise description of the problem and a conceptual site model (CSM). The CSM describes exposure pathways and exposure scenarios, facilitates identification of decisions that must be made, and identifies deficiencies in the existing information. Prepare a brief summary of the problem once these have been identified.

5.1.1 Identify Members of the Planning Team

The members of the planning team shall be appropriate for the size and complexity of the problem. PQO development requires that the data users be involved in the planning of CTO activities. Because of the interdisciplinary nature of activities, it is important to obtain the appropriate technical expertise in developing PQOs. Data users normally consist of the primary decision maker, and primary and secondary data users.

Primary data users generally consist of those individuals involved in the ongoing CTO activities. The CTO Manager must identify those technical staff needed for the project and involve them in the planning process. For example, if groundwater contamination is a concern, hydrogeologists must be involved. Persons with expertise in analytical chemistry must be involved to specify the type of analyses that may be used and the limitations of these analyses. Toxicologists or others familiar with risk assessment must also be involved to ensure that migration and exposure pathways, potential receptors, and contaminants and levels of concern are considered.

Secondary data users are those that use data to support their activities. These include Navy personnel, and state and federal regulatory enforcement agencies. The roles and responsibilities shall be determined for each member of the planning team. The objectives of the team are to develop a concise description of the problem, specify resources that are available, and determine deadlines for the study.

5.1.2 Identify the Primary Decision Makers

Identify the primary decision makers for the planning team. These individuals have the ultimate authority for making final decisions based on recommendations from the planning team. Examples of primary decision makers are the Navy personnel who must determine what the site will ultimately be used for and the project manager who determines how the investigation should be conducted to meet the investigation objectives.

5.1.3 Develop a Concise Description of the Problem

The planning team shall prepare a brief summary that concisely describes the problem and the conditions or circumstances that are causing the problem. This summary should be based on a site reconnaissance, and a review of site history and potential sources of contamination. Procedure Number I-A-4, *Site Reconnaissance* provides the procedures for conducting a site reconnaissance. Review literature and studies to ensure that the problem is correctly defined and has not been previously solved. Information regarding site history and potential sources of contamination can be obtained from previous studies and investigations.

The CSM may be helpful in developing a description of the problem. The Department of the Navy Environmental Restoration Program manual (DON 2006) and Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (EPA 1988) provide a general discussion about the development and use of the CSM. Additional CSM tools are available through the navy’s Environmental Restoration Technology Transfer Tool (DON 2010). If a CSM already exists, it may need to be refined. A CSM describes the site and its surroundings, potentially complete and complete exposure pathways for the particular media for both human and ecological receptors, and exposure pathways. It also presents hypotheses regarding the contaminants present, their routes of migration, and their potential site impact. The hypotheses are tested, refined, and modified through the WP activities, which shall be referenced by the CSM.

The areas to be assessed during development of the CSM include the following:

- Population, environmental, and welfare concerns
- Potential exposure routes and contaminant transport pathways
- Nature and extent of contamination at the site
- Extent to which the contamination has been defined and can be defined in the future
- Potential for migration from the site (if known)
- Extent to which site contamination levels have exceeded ARARs or other related environmental or public health standards or criteria (if known)

A complex problem may require division into separate studies.

5.1.4 Specify Available Resources and Relevant Study Deadlines

Specify the budget, personnel, and projected deadline in the summary. Discuss time constraints, such as base closures, if appropriate.

5.2 STEP 2: IDENTIFY THE GOALS OF THE STUDY

The second step of the PQO process is to identify the goals of the study. Identify relationships between this decision and any other current or subsequent decisions.

5.2.1 Identify the Principal Study Question

Identify a principal study question based on the problem. The principal study question focuses on pertinent information that is necessary to resolve the problem. State the principal study question as specifically as possible. In general, the question is whether the site poses a threat to human health and/or the environment. Specific examples are as follows:

- Does the contaminant concentration in groundwater exceed acceptable levels?
- Does the pollutant concentration exceed the National Ambient Air Quality Standard?
- Does a contaminant pose a human health or ecological risk?
- Is the contaminant concentration significantly above background levels (suggesting a release)?

5.2.2 Define Alternative Actions that Could Result from Resolution of the Principal Study Question

Possible answers to the study question could result in one or more alternative actions including no action. The following example illustrates how alternative actions are defined based on possible answers to the principal study question: “Does a contaminant pose a human health or ecological risk?” If the answer is yes, alternative actions could be site remediation through removal of contaminated soil, contaminant removal through a soil vapor extraction system, or bioremediation. A quarterly groundwater program may also be implemented to monitor the effect of the site contamination on groundwater. If the answer is no, then the site investigation will go to No Further Response Action Planned.

5.2.3 Combine the Principal Study Question and Alternative Actions into a Decision Statement

Create a decision statement by combining the principal study question with alternative actions. The format may be as follows: “Determine whether or not [unknown environmental conditions/issues/criteria from the principal study question] require (or support) [taking alternative actions].” Using the example above, the decision statement could be “Determine whether or not volatile organic constituent contamination from the site poses a risk to groundwater and requires quarterly groundwater sampling. If the answer is no, then no further action is required.”

5.2.4 Organize Multiple Decisions

If multiple decision statements are necessary to resolve the problem, they should be organized and prioritized. Describe the decision-making process, taking into account how the data from a previous phase will affect the following phase. Implement a phased approach to sampling if relationships exist between this decision and other current or subsequent decisions. A flowchart or diagram may be helpful.

5.3 STEP 3: IDENTIFY INFORMATION INPUTS

The third step of the PQO process is to identify the information needed and sources for each information input. Determine contaminant-specific ALs, sampling techniques, and analytical methods during this step.

5.3.1 Identify the Information Required To Resolve the Decision Statement

Collect various types of information in order to resolve the decision statement. Information types include data uses and types of data. Data uses can be described in terms of general categories, which include the following:

- Identification of the presence or absence of contamination at a site
- Site characterization (delineation of the nature and extent of contamination)
- Assessment of immediate public health or worker health and safety concerns for site investigation activities
- Completion of a risk assessment
- Evaluation and design of remedial action alternatives

Acquire information using either a monitoring or modeling approach, or a combination of both. Use this information with existing site information and the CSM to determine what type of data is required to meet the CTO objective. Data types generally consist of types of samples that need to be collected (soil, groundwater, aquifer hydraulic conductivity, and geotechnical), as well as sample analytes. Refer to Procedure Number I-A-2, *Selection of Analytes*, for procedures on selection of sample analytes.

5.3.2 Determine Sources for Each Informational Input

Identify and qualitatively evaluate for appropriateness the sources for each informational input. Information input sources include previous investigative results, historical records, regulatory guidance, professional judgment, or scientific literature. List those inputs that are obtained through environmental measurements.

5.3.3 Determine the Necessary Information for Establishing Action Levels

Determine the basis for establishing contaminant-specific ALs. The AL is the threshold value that provides the criterion for selecting an alternative action. Derive contaminant-specific action levels from regulatory thresholds or standards, technology based limits, or exposure assessment analysis.

ALs directly affect data quality requirements, in that the analytical methods chosen must have reporting limits that are well below the AL. Reporting limits depend upon the parameter and analytical method being considered.

5.3.4 Identify Potential Sampling Techniques and Appropriate Analytical Methods

Identify potential sampling techniques and appropriate analytical methods for environmental measurements that were previously listed. Use the Project Procedures Manual as the protocol for sampling, and identify significant deviations. Determine the detection limit, limit of detection, and limit of quantitation for each analytical method.

5.4 STEP 4: DEFINE THE STUDY BOUNDARIES

The fourth step of the PQO process is to define the spatial boundaries of the study and the temporal boundaries of the decision. The boundaries ensure that the data collection design incorporates the time periods during which the study shall be implemented, populations and geographic areas that shall be sampled, and the applicable time period. The study area may be stratified into subpopulations in order to reduce the complexity of the problem. The spatial boundaries or geographical region of the general study area may expand or contract with each phase of sampling and may include focused areas of sampling or hot spots. Define practical constraints on data collection during this step.

5.4.1 Specify the Characteristics that Define the Population of Interest

Specify the characteristics that define the population of interest. For example, Aroclor-1260 is more specific than polychlorinated biphenyls (PCBs), and adult construction worker receptor is more specific than human receptor.

5.4.2 Define the Geographic Area Applicable to the Decision(s)

Define the geographic area that is applicable to the decision. The property boundary, depth below ground surface, or natural habitat range for a particular animal species may define a specific geographic area.

5.4.3 Divide the Population into Strata with Relatively Homogeneous Characteristics

The population of the study area may be stratified into subpopulations with relatively homogeneous characteristics in order to reduce the complexity of the problem. Examples of characteristics include specific contaminants, age, and species type.

5.4.4 Determine the Decision Timeframe

Determine the timeframe to which the decision applies. Define time frames for the overall population and for any subpopulation of interest; then address discrepancies that may arise from the short time frame of data collection relative to the long time periods for implementing decisions.

5.4.5 Determine When to Collect Data

Determine the data collection time based upon the most favorable conditions. These conditions include weather, temperature, humidity, wind, or amount of sunlight. For example, a quarterly groundwater monitoring program could be implemented because seasonal changes could affect groundwater concentrations.

5.4.6 Determine the Scale of Decision Making

Determine the most appropriate scale of decision-making based on the spatial or temporal boundaries. For example, in a study where the decision statement is, “Determine whether volatile organic constituent contamination from the site is a risk to groundwater and requires quarterly groundwater monitoring,” the geographic area is the site boundary, and the population is benzene, toluene, ethyl benzene, and xylene (BTEX). The scale of decision-making could be set to a particular chemical that is associated with BTEX, such as benzene, which is a known carcinogen. A scale of decision-making based on temporal boundaries could specify the time between groundwater sampling events.

5.4.7 Identify Practical Constraints on Data Collection

Identify practical constraints that could potentially interfere with data collection, such as seasonal or meteorological conditions, access to property or buildings, time, or unavailable personnel.

5.5 STEP 5: DEVELOP THE ANALYTIC APPROACH

The fifth step of the PQO process is to develop the analytic approach. This procedure involves identifying the statistical parameter that characterizes the population of interest, specifying the ALs for the decision, and combining the outputs from the previous PQO steps in order to develop decision rules.

5.5.1 Specify the Statistical Parameter of the Population of Interest

Specify statistical parameters that characterize the population or parameter of interest. The parameter may be the mean, median, or percentile that will be used by the decision maker. Statistical parameters may be specified by the regulatory agency or the risk assessment analysis.

Using the mean as the statistical parameter is useful when the AL is based on long-term, average health effects, when the population is uniform, and generally requires fewer samples than the other statistical parameters. However, this may not be a representative measure for highly skewed populations or populations that contain a large number of nondetect measurements.

Using the median as the statistical parameter is useful when the AL is based on long-term, average health effects, is more representative than the mean when the population is skewed or contains a large number of nondetect measurements, and relies on few statistical assumptions. However, this approach may be impacted by extreme values and is still not a representative measure for highly skewed populations.

Using the upper proportion or percentile statistical parameter is useful for protection against extreme health effects, provides the best control of extreme values for highly variable populations, is useful for skewed distributions, may be appropriate for populations that contain a large number of nondetect measurements (provided the detection limit is less than the AL), and relies on few statistical assumptions. However, this approach requires larger sample sizes than the mean statistical parameter.

5.5.2 Specify the Action Level for the Study

The decision maker shall specify the AL for the study. For example, if the trichloroethene (TCE) concentration in groundwater samples exceeds the drinking water criteria of 5 micrograms per liter (µg/L), a particular action may be specified. If TCE is detectable at levels below 5 µg/L, another action may be specified. Specify the procedure for establishing background levels in this step.

5.5.3 Combine Outputs from the Previous PQO Steps into a Decision Rule

Incorporate the parameter of interest and action levels into a decision rule or an “if…then…” statement. If a parameter of interest exceeds a specified AL, then an alternative action will result. For example, if the concentration of TCE in groundwater samples exceeds 5 µg/L, then the production well that distributes this groundwater to the population for consumption will be shut off. If the production well is shut off due to elevated TCE concentrations, then remediation of groundwater may be necessary using a water treatment system.

5.6 STEP 6: SPECIFY PERFORMANCE OR ACCEPTANCE CRITERIA

When required by the project objectives, the sixth step is to specify performance or acceptance criteria. This step involves determining the possible range of the parameter of interest, defining the potential consequences of both types of decision errors, specifying a range of minor consequences for decision errors, assigning probability values to reflect the acceptable probability for decision errors to occur, and ensuring that decision errors accurately reflect consequences.

5.6.1 Determine the Possible Range of the Parameter of Interest

Determine the possible range of the parameter of interest by establishing upper and lower boundaries or control limits. Historical data may be used to establish the range of the parameter of interest. For example, the mean concentration of TCE may be between 0.5 and 10 μg/L based on quarterly groundwater sampling results. Only the range of parameters that are expected to drive risk is defined. In some instances, this will not be known and should be so stated.

5.6.2 Define the Potential Consequences of Decision Errors

Environmental sample data has inherent uncertainty associated with it. The uncertainty can be described in terms of sampling design error and measurement error. Sample design error is associated with both random and systematic errors at different stages of the sample acquisition.

Sampling design error arises when sampling plans don’t allow for complete variability of the site, thus not allowing an appropriate decision to be made for the site. This type of error can result in data variability or imprecision (random error) and bias data (systematic error).

Measurement error is variability resulting from imperfections in the measurement and analysis system. This type of error is introduced during sample collection, handling, preparation, and analysis. Other contributors to measurement error include data reduction, transmission, and storage.

Sampling design error together with measurement error is defined as “total study error” or “total variability.” It is necessary to manage the total study error by rigorous evaluation of the sample design and measurement systems to control decision errors to acceptable levels.

Perform the management of decision error through the use of hypothesis testing. Hypothesis testing requires that a baseline condition (i.e., contaminants are below the AL) and an alternative condition (i.e., contaminants exceed the AL) be defined. This test can be used to show that there is insufficient evidence to indicate that the baseline condition is false (acceptance that the baseline condition is true), or that the baseline condition is probably false (acceptance that the alternative condition is true). This process places the burden of proof on rejecting the baseline condition unless there is substantial evidence that the baseline condition is not true.

The two types of decision errors are false rejection errors and false acceptance errors. A false rejection error occurs when the limited amount of sample data leads to the belief that the baseline condition is probably false when it is really true. A false acceptance error occurs when the data leads to the belief that the baseline condition is true when it is really false. Define the false rejection and false acceptance errors for each decision rule and describe the potential consequences of each. For example, the baseline condition could be that a particular site has PCB contamination below AL; a false rejection error (of the baseline condition) could occur when PCB concentrations are determined to be above the AL, when the true PCB concentrations are below the AL. A false acceptance error (of the baseline condition) could occur when the PCB concentrations are determined to be below the AL when the true PCB concentrations are above the AL. Define and evaluate the potential consequences of each of these in terms such as human health and ecological risks, economic and social costs, and political and legal ramifications.

Decision errors can never be completely eliminated from environmental investigations but they can be managed. Careful evaluation of the sampling design and measurement methods will help ensure an adequate number of samples are collected utilizing the appropriate protocol and analyzing with the appropriate technique.

A comprehensive discussion of decision errors can be found in Section 6 Specify Tolerable Limits on Decision Errors in *Guidance on Systematic Planning Using the Data Quality Objectives Process. EPA QA/G-4.* (EPA 2006).

5.6.3 Specify a Range of Minor Consequences for Decision Errors

Specify a broad range of minor consequences or a gray region for decision errors when statistical sampling is used. The gray region is a range of possible parameter values where the consequences of false rejection or acceptance decision errors are relatively minor.

5.6.4 Assign Limits to Reflect the Acceptable Probability for Decision Errors to Occur

For statistical sampling, assign probability values to points above and below the gray region that reflect the decision maker’s tolerable limits for making an incorrect decision. At a minimum, the decision maker shall specify a false rejection decision error limit at the AL and a false acceptance decision error limit at the lower end of the gray range. Aggressive identification of reasonably high levels of error is recommended because the risk assessment procedures are relatively conservative.

5.6.5 Ensure that Decision Errors Accurately Reflect Consequences

For statistical sampling programs, check the limits on decision errors to ensure that they accurately reflect the relative consequences for each type of decision error.

5.7 STEP 7: DEVELOP THE PLAN FOR OBTAINING DATA

When required by the project objectives, the seventh step of the PQO process is to develop the plan for obtaining data. This procedure involves reviewing the PQO outputs and existing environmental data, developing general sampling and analysis design alternatives, verifying that PQOs are achieved for each design, selecting the most resource-effective design that satisfies all of the PQOs, and documenting the details and assumptions in the sampling and analysis plan.

5.7.1 Review PQO Outputs and Existing Environmental Data

Review the PQO outputs from the previous steps for internal consistency. Also review existing data and identify data significant to the design.

5.7.2 Develop General Sampling and Analysis Design Alternatives

Develop general sampling and analysis design alternatives based on the PQO outputs and other relevant information. These alternatives shall be cost effective and balance the sample size and measurement performance with the sample collection techniques and analytical methods available. Factors to be considered in this step include the phase, media, sample type, number of samples, sampling locations, analytical methods, and QA/quality control requirements. Also develop a schedule for all sampling activities. The output of this process is a well-defined WP.

For nonstatistical sampling programs, present a justification for using purposive sampling, as well as identification and rationale for using a phased approach and other sampling strategies that are somewhat unusual. Discuss alternative analytical and field sampling strategies and provide rationales for using them. Develop and describe several different sampling scenarios for statistically based plans.

5.7.3 Verify that PQOs Are Achieved for Each Design

Briefly show that the sampling design will achieve the PQOs. For statistically based plans, define a method for testing the hypothesis and a corresponding sample size formula (e.g., T-test), develop a statistical model that describes the relationship between the measured value and the true value, and develop a cost function that relates the number of samples to the total cost of sampling and analysis.

5.7.4 Select the Most Resource-Effective Design that Satisfies all of the PQOs

Evaluate each design option in order to select the most resource-effective and/or cost-effective design that satisfies all of the PQOs.

5.7.5 Document Details and Assumptions in the Work Plan

Document the operational details and theoretical assumptions of the selected design in the WP.

6. Records

None.

7. References

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: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2006. *Department of the Navy Environmental Restoration Program Manual.* Alexandria, VA: Naval Facilities Engineering Command. August.

——— 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Environmental Protection Agency, United States (EPA). 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*. Interim Final. EPA/540/G-89/004. Office of Emergency and Remedial Response. October.

——— 2006. *Guidance on Systematic Planning Using the Data Quality Objectives Process. EPA QA/G-4.* EPA/240/B-06/001. Office of Environmental Information. February.

Naval Facilities Engineering Command (NAVFAC). 2010. *NAVFAC Technology Transfer (T2) Program*.

Procedure I-A-2, *Selection of Analytes.*

Procedure I-A-4, *Site Reconnaissance.*

8. Attachments

Attachment I-A-1-1: DQO Process Using IS Approach

Attachment I-A-1-1
DQO Process Using IS Approach

The State of Hawaii, Department of Health, Hazard Evaluation and Emergency Response Office strongly encourages the use of incremental sampling (IS) to enhance sample representativeness in the investigation of contaminated soil (DOH 2009). IS is a structured composite sampling and processing protocol that reduces data variability and provides a reasonably unbiased estimate of mean contaminant concentrations in a volume of soil targeted for sampling. IS provides representative samples of specific soil volumes defined as decision units (DUs) by collecting numerous increments of soil (typically 30–100 increments) that are combined, processed, and subsampled according to specific protocols (DOH 2009 and ITRC 2012).

Similar to other sampling designs, systematic planning must be conducted and used to develop the scope of the investigation. The following subsections detail the steps needed to complete the data quality objective (DQO) process (EPA 2006) as they apply to IS investigations.

1. Define the problem that is prompting the investigation. This step should include:
   - A description of the problem
   - Development of a conceptual site model for the issue being investigated
   - Identification of the types of data needed along with alternative approaches
   - Identification of planning team members
   - A schedule, including constraints and deadlines, for the project
2. Identify the goals of the investigation. This step should include identification of the principle study questions (PSQs) and alternative outcomes for each PSQ. Decision statements can then be written based on the PSQs and various outcomes.
3. Identify what information is needed to address the problem statement and associated PSQs. This should include the environmental parameters or characteristics (i.e., data) that will be needed to answer the questions being asked at a site. The data could be historical or it could be that new, better, or additional data is needed. This should be identified in the sampling plan. Details of the specific data may include, but are not limited to the following:
   - Chemical parameters
   - Physical parameters
   - How many DUs
   - What size DUs are needed
   - How many replicate samples are needed
   - How many increments per sample are necessary (Anything less than 30 increments should have a full justification)

   Also included in this section is the type of data needed to meet the performance criteria for the site. The number and location of DUs proposed for field replicate sampling and the number of replicates for those DUs must be included. In addition to the field replicates, it must be determined whether laboratory replicates should be collected on the project. Laboratory replicates are used to determine the source of sampling error (i.e., field or laboratory) once your data is received from the laboratory.

4. Define the boundaries of the investigation. There is typically a spatial and temporal boundary for the investigation. This is where the target population of interest is identified which informs the size and thickness of the DUs, which is identified here. Also included in this section is the smallest unit on which decisions will be made. This is normally equal to the size of your DUs. Lastly, factors or site features that restrict the ability to collect all the data specified in step three above, should be identified here. These are usually access limitations, either physical or legal.
5. This section should introduce the decision rules for the investigation. These are comprised of a series of "if…then" statements. These if/then statements will be generated using the action level or screening criteria selected for the project and identified in your Uniform Federal Policy for Quality Assurance Project Plans Sampling and Analysis Plan (SAP).
6. This step should specify the acceptance criteria for the study. Acceptance criteria will typically be based on an evaluation of the total study error, which includes the field sampling error and the total laboratory error. The total study error is measured using the relative standard deviation (RSD) of the field replicates. The acceptance criterion should be an RSD less than or equal to 35 percent RSD. If the data do not meet this criterion, they will have to be evaluated further by the project stakeholders to decide whether the DQOs have been met. One factor for evaluating the data is whether the result is within an order of magnitude of the screening level. Data more than an order of magnitude from the screening level are unlikely to be affected sufficiently to prevent a good decision from being made. Another method to assist stakeholders with data that don't meet the acceptance criterion is to calculate a 95 percent upper confidence limit (UCL). Use of the 95 percent UCL rather than the laboratory reported value will give an additional level of confidence to decision makers that the reported values are protective of the receptors. In addition to the acceptance criterion, the detection limit, limit of detection, and limit of quantitation for the various analytes needed to achieve the performance objectives for the project should be provided in Worksheet #15 of the SAP.
7. The last step must include a compilation of all the information generated in the first six steps. This information should then be used to identify alternative sampling and analysis designs that meet the project objectives. This section should lay out how the samples will be collected, the size, shape, and depth of the DUs, reference to the sampling procedures that will be followed, the sampling instruments that will be used as well as the laboratory containers that will be used to send samples to the laboratory for analysis. Also, reference to the laboratory processing and sub-sampling procedures should be documented in this section. If the soil type at the site is unknown, it is recommended that at least one backup type of sampling tool be kept available in case the primary tool proves unusable for some reason. For instance, if the SAP called for a hand tool (e.g., slide hammer driven soil corer) and the soil turns out to be very hard, the project team should have a backup method to collect the increments such as some kind of power tool or direct push rig.

DU size, depth, and location will determine whether the data is able to satisfy your project objectives. It is imperative that your DUs are suitable for achieving these project objectives.

Things to consider when deciding DU size:

- If you need to make a decision about whether unrestricted use is appropriate for a site, then the DUs should be no larger than 5,000 square feet (default residential lot in Hawaii) unless regulators and Navy agree it can be larger.
- If commercial/industrial use is intended, then DUs can be larger than 5,000 square feet. The size of DUs should be agreed upon by project stakeholders upfront in the planning phase (e.g., SAP or work plan). Also, any land use other than unrestricted use will require LUCs on the property.
- Depending on the needs or goals of the investigation, DUs can be reduced in size to whatever is needed (e.g. DUs for remediation or confirmation sampling).
- Involve a risk assessor if risk assessment is planned with the data. You will need to determine what receptors and pathways will be evaluated in the risk assessment and the data must be able to satisfy those objectives. Risk assessment needs will often impact the size, location, and depth of your DUs.

Things to consider when deciding where to place DUs (Many of these same criteria should also be used to determine which DUs should have replicate samples collected, when less than 100 percent of the DUs will have replicate samples collected):

- Evaluate historical land use.
- Evaluate site features such as geology to identify different soil types or possible transport mechanisms.
- Identify potential source areas (current and past).
- Evaluate fate and transport properties of the chemicals of potential concern.
- Evaluate existing sampling data from the site.
- Consult a risk assessor if the data will be used in a risk assessment. Again, receptors and pathways must be evaluated to ensure the DUs will provide data to meet the risk assessment and project objectives. Risk assessors can also provide input on which DUs and how many should have replicate samples collected.
- Evaluate site access restrictions due to current site use that could affect where DUs are placed.

References

Department of Health, State of Hawaii (DOH). 2009. *Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan.* Interim Final. Honolulu: Office of Hazard Evaluation and Emergency Response. 21 June. http://www.hawaiidoh.org/tgm.aspx.

Environmental Protection Agency, United States (EPA). 2006. *Guidance on Systematic Planning Using the Data Quality Objectives Process. EPA QA/G-4.* EPA/240/B-06/001. Office of Environmental Information. February.

Interstate Technology and Regulatory Council (ITRC). 2012. *Incremental Sampling Methodology.* February.

Utility Clearance

1. Purpose

This standard operating procedure describes the process for determining the presence of subsurface utilities and other cultural features at locations where planned site activities involve the physical disturbance of subsurface materials. The procedure applies to the following activities: soil gas surveying, excavating, trenching, drilling of borings and installation of monitoring and extraction wells, use of soil recovery or slide-hammer hand augers, and all other intrusive sampling activities. The primary purpose of the procedure is to minimize the potential for damage to underground utilities and other subsurface features, which could result in physical injury, disruption of utility service, or disturbance of other subsurface cultural features.

2. Scope

This procedure applies to all United States Navy Environmental Restoration (ER) Program projects performed in the Naval Facilities Engineering Command, Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 UTILITY

For this procedure, a utility is defined as a manmade underground line or conduit, cable, pipe, vault or tank that is, or was, used for the transmission of material or energy (e.g., gas, electrical, telephone, steam, water or sewage, product transfer lines, or underground storage tanks).

3.2 AS-BUILT PLANS

As-built plans are plans or blueprints depicting the locations of structures and associated utilities on a property.

3.3 ONE-CALL

The Utility Notification Center is the one-call agency for Oregon, Washington, Montana, and Hawaii. The Utility Notification Center is open 24 hours a day, and accepts calls from anyone planning to dig in. The phone number for the Hawaii One Call Center is 1-866-423-7287 (or 811). Additional information can be found at http://www.callbeforeyoudig.org/hawaii/index.asp.

Calling before you dig ensures that any publicly owned underground lines will be marked, so that you can dig around them safely. Having the utility lines marked not only prevents accidental damage to the lines, but prevents property damage and personal injuries that could result in breaking a line.

The following information will need to be provided when a request is placed to One-Call:

- Your name, phone number, company name (if applicable), and mailing address.
- What type or work is being done. This should be a description of the specific reason for the work, not the method used.
- Who the work is being done for.
- The county and city the work is taking place in.
- The address or the street where the work is taking place.
- Marking instructions, (specific instructions as to where the work is taking place).

Under normal circumstances it takes between 2 days to 5 days from the time you call (not counting weekends or holidays) to have the underground lines marked. Because these laws vary from state to state, exactly how long it will take depends on where your worksite is located. You will be given an exact start time and date when your locate request is completed, which will comply with the laws in your area.

In the event of an emergency (any situation causing damage to life or property, or a service outage), lines can be marked sooner than the original given time if requested, but must be handled via voice contact with One-Call.

3.4 TONING

Toning is the process of surveying an area utilizing one or more surface geophysical methods to determine the presence or absence of underground utilities. Typically, toning is conducted after identifying the general location of utilities and carefully examining all available site utility plans. Each location is marked according to the type of utility being identified. In addition, areas cleared by toning are flagged or staked to indicate that all identified utilities in a given area have been toned.

4. Responsibilities

The prime contractor CTO Manager is responsible for verifying that these utility locating procedures are performed prior to the initiation of active subsurface exploration. The CTO Manager is responsible for ensuring that all personnel involved in sampling and/or testing shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The onsite Field Manager (FM) and Site Safety and Health Officer (SSHO) are responsible for planning utility clearance and for locating and marking underground utilities according to this procedure.

Field personnel are responsible for the implementation of this procedure.

5. Procedures

Follow the following steps at all sites where subsurface exploration will include excavations, drilling, or any other subsurface investigative method that could damage utilities at a site. In addition to the steps outlined below, always exercise caution while conducting subsurface exploratory work.

5.1 PREPARE PRELIMINARY SITE PLAN

Prepare a preliminary, scaled site plan depicting the proposed exploratory locations as part of the work plan. Include as many of the cultural and natural features as practical in this plan.

5.2 REVIEW BACKGROUND INFORMATION

Search existing plan files to review the as-built plans and available geographic information system databases to identify the known location of utilities at the site. In addition, the contractor should contact the Navy RPM to obtain the most updated GIS layers. Plot the locations of utilities identified onto a preliminary, scaled site plan. Inform the CTO Manager if utilities lie within close proximity to a proposed exploration or excavation location. The CTO Manager will determine if it is necessary to relocate proposed sampling or excavation locations.

Include the utility location information gathered during investigation (e.g., remedial investigation or remedial site evaluation) work in the project design documents for removal or remedial actions. In this manner, information regarding utility locations collected during implementation of a CTO can be shared with the other contractors during implementation of a particular task order. In many instances, this will help to reduce the amount of additional geophysical surveying work the other contractor may have to perform.

Conduct interviews with onsite and facility personnel familiar with the site to obtain additional information regarding the known and suspected locations of underground utilities. In addition, if appropriate, contact shall be made with local utility companies to request their help in locating underground lines. Pencil in the dimensions, orientation, and depth of utilities, other than those identified on the as-built plans, at their approximate locations on the preliminary plans. Enter the type of utility, the personnel who provided the information, and the date the information was provided into the field log.

During the pre-fieldwork interviewing process, the interviewer will determine which site personnel should be notified in the event of an incident involving damage to existing utilities. Record this information in the field logbook with the corresponding telephone numbers and addresses.

5.3 DIG PERMIT

Prior to all activities requiring excavation work that may disrupt utility services, vehicular or aircraft traffic flow, protection provided by fire and intrusion alarm systems, or routine activities at Navy bases (including Joint Base Pearl Harbor-Hickam and Naval Base Guam), as well as intrusive work at Marine Corps Base Hawaii, current procedures shall be followed. The dig permit process tries to identify, as much as practical, any known, potentially hazardous work condition related to excavation activities and is intended to prevent accidents. It also informs key Navy personnel of the digging work and coordinates the required work with these activities to minimize inconveniences (JBPHH 2013).

5.4 SITE VISIT – LOCATE UTILITIES – TONING

Prior to the initiation of field activities, the field task manager or similarly qualified staff personnel shall visit the site and note existing structures and evidence of associated utilities, such as fire hydrants, irrigation systems, manhole and vault box covers, standpipes, telephone switch boxes, free-standing light poles, gas or electric meters, pavement cuts, and linear depression. Compare notes of the actual site configuration to the preliminary site plan. Note deviations in the field logbook and on the preliminary site plan. Accurately locate or survey and clearly mark with stakes, pins, flags, paint, or other suitable devices all areas where subsurface exploration is proposed. These areas shall correspond with the locations drawn on the preliminary site plan.

Following the initial site visit by the FM, a trained utility locator will locate, identify, and tone all utilities depicted on the preliminary site plan. The locator should use appropriate sensing equipment to attempt to locate utilities that might not have appeared on the as-built plans. This may involve the use of surface geophysical methods (Procedure I-B-2, *Geophysical Testing*). At a minimum, use a utility locator, metal detector, and/or magnetometer; however, it is important to consider the possibility that non-metallic utilities or tanks might be present at the site. Use other appropriate surface geophysical methods, such as Ground Penetrating Radar, if non-metallic cultural features are likely to be present at the site. Clear proposed exploration areas of all utilities in the immediate area where subsurface exploration is proposed. Clearly tone all anomalous areas. Clearly identify all toned areas on the preliminary site plan. After toning the site and plotting all known or suspected buried utilities on the preliminary site plan, the utility locator shall provide the FM with a copy of the completed preliminary site plan. Alternatively, the FM or designee shall document the results of the survey on the preliminary site plan.

Report to the FM anomalous areas detected and toned that are in close proximity to the exploration or excavation areas. The FM shall determine the safe distance to maintain from the known or suspected utility. It may be necessary to relocate proposed exploration or excavation areas. If this is required, the FM or a similarly qualified individual shall relocate them and clearly mark them using the methods described above. Completely remove the markings at the prior location. Plot the new locations on the site plan and delete the prior locations from the plan. In some instances, such as in areas extremely congested with subsurface utilities, it may be necessary to dig by hand to determine the location of the utilities.

5.5 PREPARE SITE PLAN

Prior to the initiation of field activities, draft a final site plan that indicates the location of subsurface exploration areas and all known or suspected utilities present at the site. Provide copies of this site plan to the Contracting Officer's Representative (COR), the CTO Manager, and the subcontractor who is to conduct the subsurface exploration/excavation work. Review the site plan with the COR to verify its accuracy prior to initiating subsurface sampling activities.

6. Records

Keep a bound field logbook detailing all activities conducted during the utility locating procedure. The logbook will describe any changes and modifications made to the original exploration plan. The trained utility locator shall prepare a report and keep it in the project file. Also keep a copy of the final site plan on file.

7. Health and Safety

Field personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

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: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Joint Base Pearl Harbor-Hickam (JBPHH). 2013. *Dig Permit Requests.* JBPHH Instruction 11013.1. 15 March 2013.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual.* EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-B-2, *Geophysical Testing.*

9. Attachments

None.

Investigation-Derived Waste Management

1. Purpose

This standard operating procedure describes the activities and responsibilities of the United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific with regard to management of investigation-derived waste (IDW). The purpose of this procedure is to provide guidance for the minimization, handling, labeling, temporary storage, inventory, classification, and disposal of IDW generated under the ER Program. This procedure will also apply to personal protective equipment (PPE), sampling equipment, decontamination fluids, non-IDW trash, non-indigenous IDW, and hazardous waste generated during implementation of removal or remedial actions. The information presented will be used to prepare and implement work plans (WPs) for IDW-related field activities. The results from implementation of WPs will then be used to develop and implement final IDW disposal plans.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

This procedure focuses on the requirements for minimizing, segregating, handling, labeling, storing, and inventorying IDW in the field. Certain drum inventory requirements related to the screening, sampling, classification, and disposal of IDW are also noted in this procedure.

3. Definitions

3.1 IDW

IDW consists of all materials generated during site investigations that might be contaminated with chemicals of concern. IDW might consist of many types of potentially contaminated materials, including but not limited to, PPE, disposable sampling and decontamination equipment, investigation-derived soil, sludge, and sediment, well development and purge water, and decontamination fluids.

3.2 PPE

PPE, as defined in this procedure, refers to all disposable materials used to protect personnel from contact with potentially contaminated site media, such as inner and outer gloves, Tyvek suits and overboots, and disposable respirator cartridges. Non-consumable items, such as steel-toe boots, respirators, and hard hats are not included in this procedure.

3.3 DISPOSABLE SAMPLING EQUIPMENT

Disposable sampling equipment consists of all single-use equipment that might have come in contact with potentially contaminated site media, including sample bailers, Draeger air monitoring tubes, used soil sampling trowels and spatulas, plastic drop cloths, plastic bags and bucket liners, and sample containers from field analytical test kits.

3.4 INVESTIGATION-DERIVED SOIL, SLUDGE, AND SEDIMENT

Investigation-derived soil consists of all potentially contaminated soil that is disturbed as part of site investigation activities. The most commonly encountered form of IDW soil is drill cuttings brought to the ground surface by drilling. Other forms of disturbed soil, including trenching spoils and excess soil remaining from surface sampling, should not be stored as IDW. Excavated soil should be returned to its source if site conditions permit.

Investigation-derived sludge consists of all potentially contaminated sludge materials generated or disturbed during site investigation activities. Generated sludge might consist of drilling mud used or created during intrusive activities. Other sludge might include solvents or petroleum-based materials encountered at the bottom of storage tanks and grease traps.

Investigation-derived sediment consists of all potentially contaminated sediments that are generated or disturbed during site investigation activities. Generated sediments might include solids that settle out of suspension from well development, purge, or decontamination water (see Definitions 3.5 and 3.6) while stored in 55-gallon drums or during sample filtration. Disturbed sediments might also consist of catch basin sediments or excess sediment from surface water activities.

3.5 WELL DEVELOPMENT AND PURGE WATER

Development water consists of groundwater withdrawn from newly installed monitoring wells in preparation for well purging or pump testing. Monitoring well development methods are discussed in Procedure I-C-2, *Monitoring Well Development*.

Purge water consists of groundwater that is removed from monitoring wells immediately prior to sampling. Well purging methods are discussed in Procedure I-C-3, *Monitoring Well Sampling*. Groundwater derived during aquifer testing shall be addressed on a site-specific basis. Procedures for handling groundwater generated during aquifer testing shall be included in the WP or equivalent document for the CTO.

3.6 DECONTAMINATION FLUIDS

Decontamination fluids consist of all fluids used in decontamination procedures conducted during site investigation activities. These fluids consist of wash water, rinse water, and solvents used for the decontamination of non-consumable PPE, sampling equipment, and drilling equipment. Decontamination procedures are discussed in Procedure I-F, *Equipment Decontamination*.

3.7 NON-IDW TRASH

Non-IDW trash is all waste materials, such as waste paper, drink containers, food, and packaging, generated in the support zone that have not come in contact with potentially contaminated site media.

3.8 NON-INDIGENOUS IDW

Non-indigenous IDW consists of all waste materials from offsite sources that are generated in the transition or contamination reduction zones and have not come in contact with potentially contaminated site media. Non-indigenous IDW includes materials, such as PPE from "clean" field activities (e.g., field blank generation, water sampling events) and refuse from monitoring well installation (e.g., unused sections of well casing, used bentonite buckets, sand bags, and cement bags).

Non-indigenous waste does not include material/waste that is abandoned at the ER site (including the IDW waste storage area) by other parties not associated with the ER work. Disposal of abandoned material/waste in the vicinity of IDW is the responsibility of the property owner (e.g., Navy Region Hawaii) or party responsible for abandoning the material/waste. The ER contractor shall notify the Contracting Officer's Representative (COR) of the situation as soon as possible so that recovery actions can be coordinated by the Government.

3.9 RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) HAZARDOUS WASTE

Under the RCRA, a solid waste that is not excluded from regulation is defined as hazardous if it:

- Is "listed" as a hazardous waste in Chapter 40, Code of Federal Regulations (CFR), Parts 261.31 through 261.33
- Exhibits any of four hazardous "characteristics"—ignitability, corrosivity, reactivity, or toxicity (as determined using the Toxicity Characteristic Leachate Procedure [TCLP]) (40 CFR 261.20-24)
- Is subject to certain "mixture" or "derived-from" rules (40 CFR 261.3).

Under certain circumstances, petroleum- or polychlorinated biphenyl (PCB)-contaminated wastes are not considered RCRA hazardous when they only exhibit toxicity characteristic (40 CFR 261.4(b)(10) and 261.8). If IDW is determined to be RCRA hazardous waste, then RCRA storage, transport, and disposal requirements shall apply unless exempt.

3.10 RCRA LAND DISPOSAL RESTRICTIONS (LDR)

Land disposal, as defined in RCRA, is any placement of RCRA hazardous waste on the land in a waste pile, landfill, impoundment, well, land treatment area, etc. LDRs are regulatory restrictions placed on land disposal, including pre-treatment standards, engineered containment, capacity constraints, and reporting and permitting requirements.

3.11 AREA OF CONTAMINATION (AOC)

The U.S. Environmental Protection Agency (EPA) considers the RCRA AOC to be a single land-based disposal unit, usually a "landfill," and includes non-discrete land areas in which there is generally dispersed contamination. Storing IDW in a container (i.e., portable storage devices, such as drums and tanks) within the AOC and returning it to its source, whether RCRA hazardous or not, does not trigger RCRA LDRs. In addition, sampling and direct replacement of wastes within an AOC do *not* constitute land disposal.

3.12 CERCLA HAZARDOUS SUBSTANCES

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) hazardous substances are listed in 40 CFR Table 302.4 and include substances regulated by the RCRA Subtitle C, Clean Water Act (CWA), Clean Air Act (CAA), and Toxic Substances Control Act (TSCA). The CFR is updated annually; therefore, the most recent CFR should be referenced for the CERCLA hazardous waste list.

CERCLA hazardous substances are defined independent of their concentration level (i.e., any detection of a listed CERCLA constituent is considered a "CERCLA hazardous substance"). "Reportable quantities" identified for chemicals in 40 CFR Table 302.4 concern only CERCLA and RCRA requirements for notification to EPA when a release has occurred; they do not dictate whether a chemical is a hazardous substance.

The definition of CERCLA hazardous substances excludes "petroleum, including crude oil or any fraction thereof;" natural gas; natural gas liquids; liquefied natural gas; and synthetic gas usable for fuel, unless specifically listed or designated under the act. Excluded fractions of crude oil contain hazardous substances, such as benzene, that are indigenous in those petroleum substances or that are normally mixed with or added to petroleum during the refining process. However, hazardous substances that are (1) added to petroleum after the refining process, (2) increase in concentration as a result of contamination of the petroleum during use, or (3) commingled with petroleum after a release to the environment, are not considered part of the petroleum exclusion provision, and therefore, are regulated under CERCLA. In addition, some waste oils are regulated under CERCLA because they are specifically listed.

The scope of CERCLA hazardous substances includes the smaller subsets of RCRA hazardous wastes, PCB Aroclors, and other constituents. Therefore, a RCRA hazardous waste is always considered a CERCLA hazardous substance for a CERCLA-driven response action; however, a CERCLA hazardous substance is not always a RCRA hazardous waste.

CERCLA only regulates releases or threats of releases of hazardous substances into the environment. If there is no evidence that (1) a release has occurred (based on site history, visual observations, background metals evaluation), (2) there is a threat of release (as from abandoned, discarded, or non-maintained chemical receptacles), or (3) the release has entered the environment (as defined below), then CERCLA does not regulate the constituent even though it is identified on the CERCLA hazardous substance list.

3.12.1 CERCLA Hazardous Substances: TSCA/PCBs

PCBs are a CERCLA hazardous substance. PCBs belong to a broad family of man-made organic chemicals known as chlorinated hydrocarbons. PCBs were domestically manufactured from 1929 until their manufacture was banned in 1979. They have a range of toxicity and vary in consistency from thin, light-colored liquids to yellow or black waxy solids. Due to their non-flammability, chemical stability, high boiling point, and electrical insulating properties, PCBs were used in hundreds of industrial and commercial applications including electrical, heat transfer, and hydraulic equipment; as plasticizers in paints, plastics, and rubber products; in pigments, dyes, and carbonless copy paper; and many other industrial applications. Although no longer commercially produced in the United States, PCBs may be present in products and materials produced before the 1979 PCB ban.

If PCBs are detected at concentrations equal to or greater than 50 parts per million (ppm), the sample is considered TSCA-regulated. Current PCB regulations can be found in the CFR at 40 761. The EPA Q and A Manual (EPA 2009), referring to CFR 761.61 explains PCB remediation waste must be managed and disposed of based on the concentration at which the PCBs are found. It is unacceptable to dilute the as-found concentration of the contaminated soil by mixing it with clean soil during excavation or other IDW management activities.

3.13 ENVIRONMENT

Environment means navigable waters, ocean waters, surface water, groundwater, drinking water supply, land surface or subsurface strata, and ambient air, within the U.S. or under federal jurisdiction (see Section 101(8) of CERCLA or 40 CFR 300.5 for complete definition).

3.14 ONSITE AREA

The CERCLA onsite area is defined in 40 CFR 300.400(e)(1) as an area that includes:

- AOC
- All suitable areas in very close proximity to the contamination that are necessary for the implementation of the response action

The delineation of the onsite area is further discussed in Volume 55 Federal Register (FR) Page 8688 and EPA guidance.

Neither CERCLA, the National Oil and Hazardous Substances Pollution Contingency Plan, nor RCRA define the terms “area of contamination” or “contamination.” However, the area of contamination is interpreted as containing “varying types and concentrations of contaminants” (55 FR 8760) that may or may not pose a risk to human health or the environment.

The onsite area may also include several noncontiguous aerial extents of contaminations if they share a common nexus (55 FR 8690).

3.15 OFFSITE AREA

The offsite area consists of all areas outside the onsite area.

3.16 CERCLA OFFSITE RULE

The CERCLA offsite rule (400 CFR 300.440) states that IDW containing CERCLA hazardous substances (at any concentration) must be stored, treated, or disposed of offsite only at facilities having current EPA approval to accept such CERCLA wastes. RCRA-permitted facilities (Subtitle C and D) must also have specific EPA approval to accept waste generated at a CERCLA site (even if the waste is RCRA hazardous).

With some restrictions, the offsite rule does not apply to the following:

- Wastes generated during non-CERCLA actions
- Treatability study samples

- Wastes generated during emergency response actions
- Laboratory samples

CERCLA allows IDW to be managed, stored, and disposed of onsite within or near the AOC without the need for EPA approval (i.e., CERCLA facility approval) or RCRA permits. If IDW is to be stored or disposed of on site, the onsite area (and the AOC) should be delineated on a figure in the project field book and revised, based on best professional judgment, as site data become available.

4. Responsibilities

The prime contractor CTO Manager is responsible for preparing WPs and IDW disposal plans and reports in compliance with this procedure, and is responsible for documenting instances of noncompliance. The CTO Manager is responsible for ensuring that all personnel involved in sampling and/or testing shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for implementing this IDW procedure and ensuring that all project field staff follow these procedures.

Field personnel are responsible for the implementation of this procedure.

5. IDW Management Procedures

The procedures for IDW management in the field are described below.

5.1 PLANNING FOR IDW MANAGEMENT

The project team should begin planning for IDW issues early in the site investigation planning stage. The proper management of IDW involves all of the following tasks:

- Obtain Navy approval for a designated IDW storage area prior to commencement of field work
  - Complete Navy form, including IDW Tracking Sheet and provide to remedial project manager (RPM) for processing
- Waste generation and minimization
- Chemical screening and characterization of the waste
- Waste handling, storage, and associated maintenance in compliance with all regulations (prepare an IDW drum inventory, ensure storage areas are compliant with type of waste [double containment, TSCA requirements, etc.] maintain condition of drum and labeling, maintain safety and assess controls, comply with permit requirements [for offsite storage])
- Waste transport and disposal within required holding times
- Waste tracking, documentation, record keeping, and reporting

As part of IDW planning, the CTO Manager should consult with the COR and environmental regulatory agencies to clearly identify the primary federal or state regulatory authority that is driving the site investigation. This authority may be CERCLA, RCRA (Subtitle C), RCRA (subtitle I), TSCA, CWA, or an equivalent state program. The primary investigation authority and regulations promulgated under this authority set forth requirements for IDW management. These requirements may differ under the various response authorities. For CERCLA-driven actions, IDW storage and disposal should comply with all applicable or relevant and appropriate requirements (ARARs) and to-be-considered (TBC) criteria to the extent practicable.

Lastly, the CTO Manager should consider the disposal criteria of the anticipated disposal facility when developing the sampling and analysis plan (SAP). Some offsite facilities do not accept waste that is characterized by association with samples collected from the investigation site or they may require analytical data for chemicals that are not of potential concern at the site. Facility disposal criteria may dictate laboratory reporting limits.

If unknown waste is observed onsite, notify the project RPM and COR for further instructions.

5.2 IDW MINIMIZATION

Field managers (FMs) and their designates shall minimize the generation of onsite IDW to reduce the need for special storage or disposal requirements that might result in substantial additional costs and provide little or no reduction in site risks (EPA 1992b). Reduce the volume of IDW by applying minimization practices throughout the course of site investigation activities. These minimization strategies include substitution of biodegradable raw materials; using low-volume IDW-generating drilling techniques; where possible, returning excess material to the source location; using disposable sampling equipment versus generating more decontamination fluids from reusable sampling equipment; using bucket and drum liners; and separating trash from IDW.

Material substitution consists of selecting materials that degrade readily or have reduced potential for chemical impacts to the site and the environment. An example of this practice is the use of biodegradable detergents (e.g., Alconox or non-phosphate detergents) for decontamination of non-consumable PPE and sampling equipment. In addition, field equipment decontamination can be conducted using isopropyl alcohol rather than hexane or other solvents (for most analytes of concern) to reduce the potential onsite chemical impacts of the decontamination solvent. Select decontamination solvents carefully so that the solvents, and their known decomposition products, are *not* potentially RCRA hazardous waste, unless absolutely necessary.

Give priority to drilling methods that minimize potential IDW generation. Select hollow-stem auger and air rotary methods, where feasible, over mud rotary methods. Mud rotary drilling produces waste drilling mud, while hollow stem and air rotary drilling methods produce relatively low volumes of soil waste. Use small-diameter borings and cores when soil is the only matrix to be sampled at the boring location; however, the installation of monitoring wells requires the use of larger-diameter borings.

If possible, return soil, sludge, or sediment removed from borings, containment areas, and shallow test trenches to the source immediately after sampling and/or geological logging of the soils (EPA 1991, 1992b). Immediate replacement of solid waste in the source location during investigation activities avoids RCRA LDRs, which permit movement of IDW within the same AOC without considering land disposal to have occurred, even if the IDW is later determined to contain RCRA hazardous material (EPA 1991). Place soil IDW from borings and trenches on polyethylene sheeting (e.g., Visqueen) during excavation and segregate it by approximate depth and any apparent contamination (i.e., visible staining). Following excavation, replace the soil IDW from above the saturated layer into the boring or trench and compact it, if possible. Efforts should be made to return the waste to the approximate depth from which it was generated. Soil and sludge IDW generated at or below the saturated layer of a boring or trench should be placed in drums and not returned to the source area. Suspected contaminated soil and sludge IDW generated above the saturated layer of a boring or trench should not be returned below the saturated layer."

Often monitoring wells are constructed outside the area of concern for soil contamination to sample for potential groundwater contamination or collect characteristic background data. At these locations, soil cuttings generated from above the saturation zone may be immediately disposed of near the wellhead in a shallow pit covered with natural topsoil from the site, and compacted. Contain soil and sludge IDW generated at or below the saturated layer in drums.

Reduce the quantity of decontamination rinse water generated by using dedicated and disposable sampling equipment, such as plastic bailers, trowels, and drum thieves that do not require decontamination. In general, decontamination fluids, and well development and purge water should not be minimized because the integrity of the associated analytical data might be affected.

Minimize the storage of visibly soiled PPE and disposable sampling equipment IDW by implementing decontamination procedures. If, based upon the best professional judgment of the FM, the PPE and disposable sampling equipment can be rendered non-contaminated after decontamination, then double-bag the PPE and disposable sampling equipment and dispose of it off site at a (RCRA Subtitle D) municipal solid waste disposal facility at the end of each work day (EPA 1991, 1992b). Since the decontaminated waste does not contain CERCLA hazardous substances, it need not be disposed of at a CERCLA-approved disposal facility in accordance with the CERCLA offsite rule.

Bucket liners can be used in the decontamination program to reduce the volume of solid IDW generated, and reduce costs on larger projects. The plastic bucket liners can be crushed into a smaller volume than the buckets, and only a small number of plastic decontamination buckets are required for the entire project. The larger, heavy-duty, 55-gallon drum liners can be used for heavily contaminated IDW to provide secondary containment, and reduce the costs of disposal and drum recycling. Drum liners may extend the containment life of the drums in severe climates and will reduce the costs of cleaning out the drums prior to recycling.

All waste materials generated in the support zone are considered non-IDW trash. To minimize the total volume of IDW, separate all trash from IDW, seal it in garbage bags, and properly dispose of it off site as municipal waste at the end of each work day.

Keep excess cement, sand, and bentonite grout prepared for monitoring well construction to a minimum. FMs shall observe well construction to ensure that a sufficient, but not excessive, volume of grout is prepared. Some excess grout may be produced. Unused grout (that should not come in contact with potentially contaminated soil or groundwater) shall be considered non-hazardous trash, and the drilling subcontractor shall dispose of it off site. Surplus materials from monitoring well installation, such as scrap plastic sections, used bentonite buckets, and cement/sand bags that do not come in contact with potentially contaminated soil, shall be considered non-IDW trash, the drilling subcontractor shall dispose of it off site.

Following proper segregation procedures, as discussed in the next section, can minimize the quantity of contaminated IDW generated.

5.3 SEGREGATION OF IDW BY MATRIX AND LOCATION

It is necessary to properly segregate IDW in order to:

- Avoid commingling contaminated waste with clean waste, thereby creating a larger volume of waste that must be treated as contaminated
- Facilitate the sampling, screening, classification, and disposal of waste that may require different management methods

Take efforts to segregate IDW even when these activities will increase storage container and storage space requirements. These efforts will drastically reduce the sampling and documentation required for characterizing the waste and their associated costs.

In general, segregate IDW by matrix and source location and depth at the time it is generated. IDW from only one matrix shall be stored in a single drum (e.g., soil, sediment, water or PPE shall *not* be mixed in one drum). Groundwater and decontamination water should not be commingled; however, development and purge water from the same well may be stored together.

In general, IDW from separate sources should not be combined in a single drum or stockpile. Take efforts to segregate waste by increments of depth below ground surface. Most importantly, segregate soil IDW generated at or from below the saturated zone from soil generated above this zone (soil below this zone might be impacted by contaminated groundwater, whereas soil above the zone may be “clean”). Similarly, segregate soil above and below an underground storage tank (UST). Label each drum of soil to indicate the approximate depth range from which it was generated; this task may require cuttings to be segregated on plastic sheeting as they are generated or drums to be filled during the trenching or boring operation if this can be done in a safe manner.

It is possible that monitoring well development and purge water will contain suspended solids, which will settle to the bottom of the storage drum as sediment. Include significant observations on the turbidity or sediment load of the development or purge water in the logbook see Procedure III-D, *Logbooks* and Section 5.5). To avoid mixed matrices in a single drum (i.e., sediment and water), it may be necessary to decant the liquids into a separate drum after the sediments have settled out. This segregation may be accomplished during subsequent IDW sampling activities or during consolidation in a holding tank prior to disposal.

Place potentially contaminated well construction materials in a separate drum. No soil, sediment, sludge, or liquid IDW shall be placed in drums with potentially contaminated waste well construction materials. In addition, potentially contaminated well construction materials from separate monitoring wells shall not be commingled.

Store potentially contaminated PPE and disposable sampling equipment in drums separate from other IDW. Segregate PPE from generally clean field activities, such as water sampling, from visibly soiled PPE, double-bag it, and dispose of it off site as municipal waste. Disposable sampling equipment from activities, such as soil, sediment, and sludge sampling, includes plastic sheeting used as liner material in containment areas around drilling rigs and waste storage areas, disposable sampling equipment, and soiled decontamination equipment. If, according to the Field Manager's best professional judgment, the visibly soiled PPE can be decontaminated and rendered non-hazardous, then double-bag the decontaminated PPE and disposed of it off site as municipal waste (EPA 1991, 1992b). PPE and disposable sampling equipment generated on separate days in the field may be combined in a single drum, provided clean and visibly soiled IDW are segregated as discussed above.

IDW generated from the use of field analytical test kits consists of those parts of the kit that have come into contact with potentially contaminated site media, and used or excess extracting solvents and other reagents. Contain potentially contaminated solid test kit IDW in plastic bags and store it with contaminated PPE or disposable sampling equipment IDW from the same source area as soil material used for the analyses. Segregate the small volumes of waste solvents, reagents, and water samples used in field test kits, and dispose of it accordingly (based upon the characteristics of the solvents as described in this procedure). Most other test kit materials should be considered non-IDW trash, and be disposed of as municipal waste.

Store decontamination fluids in drums separate from groundwater and other IDW. If practical, decontamination fluids generated from different sources should not be stored in the same drum. If decontamination fluids generated over several days or from different sources are stored in a single drum, record information about the dates and IDW sources represented in the drum. Note this information in the field notebook, on the drum label (Section 5.4.3), and in the drum inventory (Section 5.5).

The FM and designated personnel should separate the liquid and sediment portions of the equipment decontamination fluid present in the containment unit used by the drilling or excavation field crew. The contents of this unit normally consist of turbid decontamination fluid above a layer of predominantly coarse-grained sediment. When the contents of the containment unit are to be removed for storage in IDW drums, the FM shall instruct the field crew to place as much of the liquid into drums as possible and transfer the remaining solids into separate drums. Note observations of the turbidity and sediment load of the liquid IDW in the field notebook, on the drum label (Section 5.4.3), and in attachments to the drum inventory (Section 5.5). It is likely that decontamination fluids will contain minor amounts of suspended solids that will settle out of suspension to become sediment at the bottom of IDW storage drums. As noted above, it may be necessary to segregate the drummed water from sediment during subsequent IDW sampling or disposal activities.

Documentation for waste storage containers should include IDW source and segregation information and be maintained as follows:

1. Field logbook should be updated, at least weekly, with all IDW drum additions – update storage area location map to include new drum position and drum number.

2. External drum log (hard copy and electronic copy) should be updated with each IDW drum addition (drum numbers, source, and generation date) and closure of drum (fill date).

5.4 DRUM FILLING, HANDLING, AND LABELING, AND INVENTORYING

Drum handling consists of those actions necessary to prepare an IDW drum for labeling. Drum labeling consists of those actions required to legibly and permanently identify the contents of an IDW drum.

5.4.1 Drum Filling

Each drum of solid IDW shall be completely filled, when possible. For liquid IDW, drums should be left with headspace of approximately 5 percent by volume to allow for expansion of the liquid and potential volatile contaminants.

5.4.2 Drum Handling

IDW shall be containerized using U.S. Department of Transportation-(DOT) approved drums. The drums shall be made of steel or plastic, have a 55-gallon capacity, be completely painted or opaque, and have removable lids (i.e., United Nations Code 1A2 or 1H2). Drums having removable lids with bung holes are preferred to facilitate verification of drum contents. Typically 55-gallon drums are used, however small drums may be used depending on the amount of waste generated. New steel drums are preferred over recycled drums. Recycled drums should not be used for hazardous waste, PCBs or other regulated shipments. For short-term storage of liquid IDW prior to discharge, double-walled bulk steel or plastic storage tanks may be used. For this scenario, consider the scheduling and cost-effectiveness of this type of bulk storage, treatment, and discharge system versus longer-term drum storage.

The Guam Environmental Protection Agency may require double-walled drums or other secondary containment for the storage of liquid IDW. For long-term IDW storage at other project locations, the DOT-approved drums with removable lids are recommended. Verify the integrity of the foam or rubber sealing ring located on the underside of some drum lids prior to sealing drums containing IDW liquids. If the ring is only partially attached to the drum lid, or if a portion of the ring is missing, select another drum lid with a sealing ring that is in sound condition.

To prepare IDW drums for labeling, wipe clean the outer wall surfaces and drum lids of all material that might prevent legible and permanent labeling. If potentially contaminated material adheres to the outer surface of a drum, wipe that material from the drum, and segregate the paper towel or rag used to remove the material with visibly soiled PPE and disposable sampling equipment. Label all IDW drums and place them on appropriate pallets prior to storage.

5.4.3 Drum Labeling

Proper labeling of IDW drums is essential to the success and cost-effectiveness of subsequent waste screening and disposal activities (see Attachment I-A-6-1 and Attachment I-A-6-2). Labels shall be permanent and descriptive to facilitate correlation of field analytical data with the contents of individual IDW drums. Label all IDW drums using the **three distinct labeling methods** described below to ensure durability of the information. These three methods are completing and affixing preprinted NAVFAC Pacific ER Program labels; marking information on drum surfaces with paint; and, affixing aluminum tags to the drum. **Use of the preprinted labels, painted labeling, and aluminum tags is *mandatory***. These methods are described below.

5.4.3.1 PREPRINTED LABELS

Complete **two** preprinted NAVFAC Pacific ER Program drum labels as described below and presented in Attachment I-A-6-1. Seal both labels in separate heavy-duty, clear plastic bags, or use permanent markers on weatherproof stickers, to prevent moisture damage.

1. Place one label on the outside of the drum with the label data facing outward. Affix the bag/sticker to the drum at the midpoint of the drum height using a sufficient quantity of adhesive tape (e.g., duct tape, packing/strapping tape) so the bag will remain on the drum as long as possible during storage.

2. Affix the second label (sealed as mentioned above) to the underside of the drum lid, sealing it inside the drum when the lid is replaced.

The use of two or more preprinted labels for outer IDW drum identification purposes should be considered as a short-term backup to the information on the aluminum tags discussed below.

Print the requested information legibly on the drum labels in black, indelible ink. Instructions for entering the required drum-specific information for each label field are presented below:

CTO: Enter the four-digit number of the CTO for the project during which the IDW was generated. Include any initial zeroes in the CTO number (e.g., CTO 0047).

Activity-Site: Enter the name of the Navy activity responsible for the project site (e.g., Naval Supply Center, Naval Facilities Engineering Command Hawaii) and the name of the site where the project is taking place (e.g., Orote, Landfill, Building [Bldg.] 18).

Drum#: Enter the drum identification number according to the convention described below.

(xxxx-AA-DMzzz);

Where:

xxxx	represents the four-digit CTO number
AA	represents the unique site identifier assigned by the CTO Manager for multiple site CTOs (e.g., for CTO 0047, OW denotes Old Westpac, OR denotes Orote)
DM	represents a *drum* identification number
zzz	the sequential drum number for the site, beginning with 001

Date Collected: Enter the date the IDW was generated and placed in the drum. If IDW was generated over a number of days, enter the start and end dates for the period.

Contents: Record the source identification number on the label. Enter a "√" in the box corresponding to the type of IDW placed in the drum. For "Soil" and "Water," use the line provided to record observations on the condition of the drum contents (e.g., diesel odor, high turbidity, specific liquid IDW type). Check "Solid Waste" for PPE and indicate that PPE is present in the drum. Check

"Other" for disposable sampling equipment and potentially contaminated monitoring well construction materials, and indicate the type of waste on the line provided.

Project Type: Enter a "√" in the box corresponding to the type of investigation. Choices are Remedial Investigation, RCRA Facility Inspection, UST, and Other. If "Other" is specified, indicate the type of project in the "Comments" area, as described below.

Comments: Enter any additional information regarding the drum contents that will assist individuals who will characterize and dispose of the contents of the drum. "Other" project types include Site Inspection, Feasibility Study, Removal/Remedial Action, and Emergency Response activity. In addition, use this space on the label to complete any descriptions that were too large to fit in preceding label fields, such as the turbidity of decontamination water or the site activities from which the PPE was generated.

For Information Contact: Enter the project COR activity / code, address, and phone number.

It is essential that all relevant information recorded on individual drum labels be repeated in the field notebook for later development of the drum inventory database (see Section 5.5 and Procedure III-D, *Logbooks*).

5.4.3.2 PAINTED LABELS

The second method for labeling drums is to paint label information directly on the outer surface of the drum. At a minimum, the information placed on the drum shall include the CTO number, the drum number (following the numbering convention given above), the source identification number and type, the generation date(s), and the telephone number provided at the bottom of the preprinted label appropriate for the project location. The drum surface shall be dry and free of material that could prevent legible labeling. Confine label information to the upper two-thirds of the total drum height. The top surface of the drum lid may be used as an additional labeling area, but this area should only be used *in addition* to the upper two-thirds of the sides of the drum. The printing on the drum shall be large enough to be easily legible. Yellow, white, black, or red paint markers (oil-based enamel paint) that are non-photodegradable are recommended to provide maximum durability and contrast with the drum surface.

5.4.3.3 ALUMINUM TAGS

The third method for labeling drums is to affix an aluminum tag to the drum with neatly printed information that shall consist of the **CTO number**, the **drum identification number**, the **type of contents**, the **generation date(s)**, the **source** identification number and type, and the **telephone number** provided at the bottom of the appropriate preprinted label. Attachment I-A-6-2 to this procedure presents an example of the aluminum tag, which shall measure approximately 1 inch by 3 inches, or larger. When a ballpoint pen is used to fill out the aluminum tag, the information is permanently recorded as indentations on the tag. A fine ballpoint pen shall be used, and block-printed lettering is required for legibility. Indentations on the tag shall be sufficiently deep to be legible after the label has been exposed to weathering for an extended period.

Complete aluminum tags after the drum has been sealed. Affix the tags to the drum using a wire, which passes through predrilled holes in the label and shall be wrapped around the bolt used to seal the drum lid. The wire is the most likely part of the aluminum tag to decay during exposure. Use of plastic insulated, copper-core electrical wire of appropriate diameter is recommended if long-term exposure to severe weathering is anticipated.

5.4.3.4 WASTE LABELS

Standard green and white non-hazardous and/or other hazardous waste stickers may be used in conjunction with, but not in lieu of, the above labeling procedures.

5.5 DRUM INVENTORY

Accurate preparation of an IDW drum inventory is essential to all subsequent activities associated with IDW drum tracking and disposal. Prepare an inventory for each project in which IDW is generated, stored, and disposed of. This information provided in the inventory report constitutes the results of preparing and implementing an IDW sampling, screening, characterization, and disposal program for each site.

The drum inventory information shall include 10 elements that identify drum contents and indicate their outcome. These elements are discussed in Sections 5.5.1 through 5.5.10.

5.5.1 Navy Activity (Generator)/Site Name

Inventory data shall include the Navy activity and the site name where the IDW was generated (e.g., Fleet Industrial Supply Center Pearl/Red Hill, Naval Magazine Headquarters/USTs).

5.5.2 CTO Number

Inventory data shall include the four-digit CTO number associated with each drum (e.g., 0089) and contract number as necessary.

5.5.3 Drum Number

Include the drum number assigned to each drum in the inventory database. Drum numbers shall adhere to the numbering convention presented in Section 5.4.3.1 (e.g., 0091-LF-DM006).

5.5.4 Storage Location Prior to Disposal

Include the storage location of each drum prior to disposal in the inventory database (e.g., Bldg. 394 Battery Disassembly Area, or Adjacent to West end of Bldg. 54). As part of the weekly inventory, a site visit to the IDW storage location shall be performed to observe the condition of the drums and covers. Drums and covers are considered acceptable when the integrity of the drums and covers are structurally intact, drum identification is legible, and the location of the drum storage is secure. An unacceptable classification will require recommendations to remedy the unacceptable classification.

5.5.5 Origin of Contents

Specify the source identification of the contents of each IDW drum in the inventory database (e.g., soil boring number, monitoring well number, sediment sampling location, or the multiple sources for PPE- or rinse water-generating activities).

5.5.6 IDW Type

Inventory data shall include the type of IDW in each drum (e.g., soil, PPE, disposable sampling equipment, sludge, sediment, development water, steam cleaning water, decontamination rinse water).

5.5.7 Waste Volume

Specify the amount of waste in each drum in the inventory database as a percentage of the total drum volume or an estimated percentage-filled level (e.g., 95 percent maximum for liquid IDW).

5.5.8 Generation Date

Inventory data shall include the date IDW was placed in each drum. If a drum contains IDW generated over more than one day, the start date for the period shall be specified in dd-mmm-yy format. This date is *not* to be confused with a RCRA hazardous waste accumulation date (40 CFR 262).

5.5.9 Expected Disposal Date

Specify the date each drum is expected to be disposed of as part of the inventory in mmm-yy format. This date is for the Navy's information only and shall not be considered contractually binding.

5.5.10 Actual Disposal Date

The actual drum disposal date occurs at the time of onsite disposal, or acceptance by the offsite treatment or disposal facility. Enter this date in the drum inventory data base only when such a date is available in dd-mmm-yy format.

Information required to complete all 10 of the inventory elements for the monthly inventory report described above and summarized in Attachment I-A-6-3, will be located on the IDW labels or provided by the CTO Manager.

Actual disposition of the IDW drum contents will be provided to the Navy.

5.6 IDW CLASSIFICATION

In general, the CTO Manager should follow IDW classification guidance contained in the *Generic IDW Disposal Plans* for Hawaii and Guam (Ogden 1994, 1995) and EPA guidance (EPA 1991, 1992a). The IDW classification process consists of chemical screening and characterization of the waste.

Various federal and state laws and guidance contain requirements for IDW management (handling, storage, transport, disposal, and recordkeeping) based on the type(s) and concentrations of chemicals present in the waste. To ensure that IDW is managed in compliance with these requirements and to evaluate disposal options, the CTO Manager should

- Directly sample and analyze the IDW or associate it with historical data, observed site conditions, and/or samples collected on site at the source of the waste
- Screen the waste to identify the maximum concentrations of individual chemicals in, or associated with, the waste

- Screen waste constituents against chemical background data, if available
- Characterize the waste based on regulated groups of chemical constituents present in the waste
- Screen waste constituents against risk-based health criteria, ARARs, and TBC criteria for onsite disposal, or disposal facility criteria for offsite disposal

Each of the above steps is distinct and should be performed separately to avoid potential mistakes in the IDW classification process. The following subsections discuss these steps in greater detail.

5.6.1 IDW Sampling and Chemical Screening

IDW should be screened to identify chemicals present in the waste and their maximum concentrations. Screening may be facilitated by (1) directly sampling the waste, (2) associating the waste with analytical results from samples collected at the source of the IDW (e.g., a well boring), (3) visual observation of the waste, (4) historical activity data from the site, or (5) a combination of these methods (e.g., association with limited sampling). Composite sampling may be required if the unit volume of IDW is non-homogeneous. Data from samples collected directly from the IDW should take precedence over associated site sample data when making waste management decisions. Procedure I-D-1, *Drum Sampling* discusses methods for drum sampling.

Typically, IDW is screened for chemicals of potential concern at the site and against background data if available. If IDW is generated from outside the suspected AOC (e.g., soil cuttings from the installation of a background monitoring well), assume it is clean, and dispose of it accordingly.

The CTO Manager should consider the disposal criteria of any offsite disposal facility anticipated to be used when developing the SAP. Some offsite facilities do not accept waste that is characterized by association with samples collected from the investigation site or they may require analytical data for chemicals that are not of potential concern at the site. Direct sampling and analysis of the waste may be required for these other constituents. Some disposal facilities prefer to collect and analyze the samples themselves. In addition, disposal facility criteria may dictate laboratory reporting limits. When possible, the CTO Manager should coordinate sampling and data requirements with the disposal subcontractor and anticipated disposal facility. Such efforts may allow IDW sampling to be conducted while the field team is mobilized for the site investigation, rather than conducting a separate IDW sampling event later.

5.6.2 IDW Characterization

Various federal and state laws and guidance contain requirements for IDW management (handling, storage, transport, disposal, and recordkeeping) based on the particular constituent or *group(s) of chemical constituents* present in the waste. Therefore, to ensure that IDW is managed in compliance with these requirements, characterize IDW based on the chemical screening results to determine whether any of the following regulated constituents are present in the waste:

- Petroleum hydrocarbons (regulated by RCRA Subtitle I when released from a UST; see 40 CFR Part 280)
- Hazardous wastes (regulated by RCRA Subtitle C; see 40 CFR 261-299)
- Non-hazardous, solid wastes (regulated by RCRA Subtitle D; see 40 CFR 257-258)

- Hazardous substances and commingled petroleum (regulated by CERCLA; see 40 CFR 300.400 and 302.4)
- PCBs (regulated by TSCA; see 40 CFR 700)
- Asbestos (regulated by CAA for disposal; see 40 CFR 61, Subpart M)
- Radioactive wastes (regulated by the Nuclear Regulatory Commission; see 10 CFR [various parts], 40 CFR, Subchapter F, and other applicable laws)

EPA regulations and guidance do not require IDW to be tested to properly characterize it. Instead waste may be characterized based on historical site data, site observations, analytical data from the source of the IDW, and professional judgment (EPA 1991). Specifically, the EPA has indicated that IDW may be assumed not to be "listed" wastes under RCRA unless available information about the site suggests otherwise (53 FR 51444). Similarly, RCRA procedures for determining whether waste exhibits RCRA hazardous characteristics do not require testing if the decision can be made by "applying knowledge of the hazard characteristic in light of the materials or process used" (40 CFR 262.11(c); EPA 1991). If applicable, the disposal plans and reports should state, "there is no evidence based on site data and observations that the IDW contains listed RCRA wastes or exhibits RCRA characteristics."

For soil IDW, the potential for exhibiting toxicity may be determined by comparing constituent concentrations in the waste against screening values that are 20 times the TCLP criteria as specified in Section 1.2 of EPA Method Solid Waste-846 1311 *Toxicity Characteristic Leaching Procedure* (EPA 2007). Otherwise, samples associated with the soil can be tested using the TCLP.

5.7 IDW STORAGE

In general, the CTO Manager should follow IDW storage guidance contained in the *Generic IDW Disposal Plans* for Hawaii and Guam (Ogden 1994, 1995) and EPA guidance (EPA 1990, 1991, 1992a).

Always store IDW in a manner that is secure, protected from weather, and protective of human health and the environment. It is preferable to store IDW within the AOC(s) or on site; however, the Navy may assign a specific IDW storage area away from the project site.

If the IDW is determined to be RCRA hazardous, then RCRA storage, transport, and disposal requirements may apply, including a limited **90-day** storage permit exemption period prior to required disposal. If onsite disposal is an option, store RCRA waste within the AOC so that RCRA LDRs will not apply in the future. LDRs may be triggered if the waste is stored within the onsite area, but outside of the AOC or if the waste is removed from and later returned to the AOC for disposal. The AOC concept does not affect the approach for managing IDW that did not come from the AOC, such as PPE, decontamination equipment and fluids, and groundwater. If RCRA hazardous, these wastes must be managed under RCRA and drummed and disposed of off site (EPA 1991).

RCRA waste should not be stored within the AOC prior to disposal when professional judgment suggests the IDW might pose an immediate or permanent public endangerment (EPA 1991b).

Offsite storage of CERCLA waste must comply with the CERCLA offsite rule (40 CFR 300.440).

If the IDW is determined to be TSCA-regulated, then TSCA storage requirements as described in CFR 764.65, transport, and disposal requirements apply, including a limited **30-day** storage period prior to required disposal. Storage requirements are as follows:

1. Storage facilities must provide an adequate roof and walls to prevent rain water from reaching the stored PCBs.

2. Storage facilities must provide an adequate floor that has continuous curbing with a minimum 6-inch-high curb.

3. Storage facilities must contain no drain valves, floor drains, expansion joints, sewer lines, or other openings that would permit liquids to flow from the curbed area.

4. Storage facilities must provide floors and curbing constructed of continuous smooth and impervious materials to minimize penetration of PCBs.

5. Storage facilities must not be located at a site that is below the 100-year flood water elevation.

6. PCBs in concentrations of 50 ppm or greater must be disposed of within 1 year after being placed in storage.

PCB waste can also be stored in a RCRA-approved waste storage area for 30 days from date of generation.

NAVFAC Pacific requires that all CERCLA, RCRA, and other types of waste be removed from JBPHH areas within 90 days of its generation, particularly within the shipyard area, and 30 days of generation for TSCA waste. Efforts should also be made to dispose of IDW within the 30- and 90-day periods at other Navy installations, unless the IDW will be managed with remediation waste to be generated during a cleanup action in the near future. The Navy may approve extensions of the storage time limit for wastes that are non-hazardous on a project-specific basis.

5.7.1 Drum Storage

Implement drum storage procedures to minimize potential human contact with the stored IDW and prevent extreme weathering of the stored drums. Place all IDW drums upright on pallets before the drums are stored. RCRA storage requirements include the following: containers shall be in good condition and closed during storage; wastes shall be compatible with containers; storage areas shall have a containment system; and spills or leaks shall be removed as necessary.

Place all IDW drums generated during field activities at a single AOC or designated IDW storage area together in a secure, fenced onsite area to prevent access to the drums by unauthorized personnel. When a secure area is not available, place drums in an area of the site with the least volume of human traffic. At a minimum, place plastic sheeting (or individual drum covers) around the stored drums. Post signage at the IDW storage area stating that drums should not be removed from the area without first contacting the Navy COR.

Liquid IDW drums must be stored under secondary containment (either secondary containment pallets or handmade plastic sheeting/polyvinyl chloride frame containment) and all IDW drums (soil and water) must utilize secondary containment when stored within 15 feet of a surface water body or storm drain inlet.

Drums from projects involving multiple AOCs shall remain at the respective source areas where the IDW was generated. IDW should not be transferred off site for storage elsewhere, except under rare circumstances, such as the lack of a secure onsite storage area.

Implement proper drum storage practices to minimize damage to the drums from weathering and possible human exposure to the environment. When possible, store drums in dry, shaded areas and cover them with impervious plastic sheeting or tarpaulin material. Make every effort to protect the preprinted drum labels from direct exposure to sunlight, which causes ink on the labels to fade. In addition, store drums in areas that are not prone to flooding. Secure the impervious drum covers appropriately to prevent dislodging by the wind. It may be possible to obtain impervious plastic covers designed to fit over individual drums; nonetheless, repeat the labeling information on the outside of these opaque covers.

Drums in storage shall be placed with sufficient space between rows of drum pallets and shall not be stacked, such that authorized personnel may access all drums for inspection. Proper placement will also render subsequent IDW screening, sampling, and disposal more efficient when individual drum removal is necessary. It is recommended that IDW drums be segregated in separate rows/areas by matrix (i.e., soil, liquid or PPE/other).

If repeated visits are made to the project site, inspect the IDW drums to clear encroaching vegetation, check the condition and integrity of each drum, secondary containment if applicable, check and replace aluminum tags as necessary, and replace or restore the tarpaulin covers.

5.7.2 IDW Stockpiles

Consider IDW stockpiling only when a very large quantity of IDW will be generated. Segregate stockpiled IDW, and inventory it by source location and depth to the extent practicable. Stockpiling and media mixing should not be used as methods to dilute chemical concentrations in the waste. Line stockpiles on the bottom, cover it with sturdy plastic, and locate it in areas where weather elements (e.g., wind, rainfall runoff) will not cause migration of the waste. Never dispose of liquid IDW on a stockpile; drum or store liquid waste in other appropriate containers. Follow applicable regulation and guidance when sampling stockpiled waste for characterization purposes.

5.8 IDW DISPOSAL

Various methods and requirements for onsite and offsite disposal of IDW are discussed in the *Generic IDW Disposal Plans* for Hawaii and Guam (Ogden 1994, 1995) and EPA guidance (EPA 1990, 1991, 1992b). This section explains the disposal evaluation process and highlights some of the more important requirements for onsite and offsite IDW disposal options.

IDW sampling, characterization, and disposal analysis, particularly for onsite disposal, can be unexpectedly complex and require compliance with many different laws (that act as ARARs for IDW management and disposal). Before preparing the IDW disposal plan, compare estimated costs for onsite vs. offsite disposal. Offsite disposal may be more cost effective than devising and documenting the justification for onsite disposal when the quantity of IDW is small (less than 10 drums) and/or the waste fails the initial conservative screening against conservative risk-based criteria. Also weigh cost savings against the policy preference of the EPA and State of Hawaii Department of Health to manage and dispose of IDW on site, when possible.

5.8.1 Onsite Disposal

In general, the EPA preference is to dispose of IDW on site when the disposal action:

- Does not pose an unacceptable long-term risk to human health and the environment
- Is in accordance with chemical-, location- and action-specific ARARs "to the extent practicable" (40 CFR 300.415(i); 55 FR 8756)
- Does not introduce contaminants into clean soil or other site media
- Does not mobilize or significantly increase concentrations of any hazardous constituents already present in the environment
- Is consistent with the final remedy planned for the site
- Takes into account any community concerns regarding waste storage and the disposal method

Base onsite disposal options on best professional judgment and available site-specific data. For some projects, it may be prudent to store the waste temporarily until additional site data become available (e.g., sample analytical data, preliminary risk-assessment results, AOC delineation, and establishment of background values). Factors to consider include, but are not limited to the following:

- The detected or suspected contaminants, their concentrations, and total volume of IDW
- Media potentially affected (e.g., groundwater drinking source)
- Background metals data for site media
- Site access, conditions, and potential receptors
- Current and future land use
- Public perceptions (especially if drum storage and/or disposal takes place in open view)
- Time limits for IDW storage
- Potential requirements to treat waste before disposing of it on site
- Lack of unpaved areas to disposed of waste on site
- Potential wind, erosion, runoff, or flood conditions that might cause offsite migration of disposed waste
- Proximity to the ocean, surface water, or environmentally sensitive habitats
- Natural attenuation processes
- Need for additional utility survey before excavating to backfill waste
- Need for land use controls required to limit exposure pathways (e.g., backfill waste, provide permanent security around site, replant site to prevent erosion)

Protection of human health can be evaluated by comparing chemical concentrations in the waste to the more conservative of EPA residential regional screening levels), environmental action levels, and chemical-specific ARARs and TBC criteria. Ecological receptors can be protected by screening the IDW against EPA ecological soil screening levels. Onsite disposal of surface and groundwater IDW can be evaluated by initially screening against EPA tap-water PRGs, State Safe Drinking Water Standards (maximum contaminant levels and non-zero maximum contaminant level goals), and/or State Surface Water Quality Standards. These criteria are not always ARARs for the disposal method or site conditions; however, they may be useful to affirmatively show that the disposal is protective. Alternatively, the IDW may be associated with human-health and eco-risk assessment results for the site if the onsite placement of IDW is consistent with exposure pathway assumptions made during the risk assessment (e.g., contaminated soil might not present an unacceptable health risk at depth, but could pose such a risk if disposed of at the ground surface).

In general, return IDW consisting of environmental media to or near its source, and return waste generated from depth to its original depth, if possible and approved by NAVFAC in advance. Bury all contaminated soil and water IDW to be disposed of on site below grade at a depth of at least 3 feet and cover it with clean soil to reduce the potential for future exposure to human and ecological receptors.

Dispose of non-indigenous IDW and contaminated decontamination fluids off site. The cleaning detergent Alconox, often used in the decontamination process, is itself non-hazardous and biodegradable. Small quantities of clean decontamination water containing Alconox may be disposed of to clean areas on site. If onsite disposal is appropriate for RCRA IDW, this waste should be disposed of within the AOC to avoid the need to comply with LDRs.

IDW from several non-contiguous onsite areas may be consolidated and disposed of at one of the areas, provided a nexus exists between the wastes generated and response projects (55 FR 8690-8691).

IDW may also be temporarily disposed of back to the AOC without detailed analysis or documentation if the waste will be addressed with other site contamination during a future response action and will not present a significant short-term threat to human health and the environment.

5.8.2 Offsite Disposal

If onsite disposal is not a viable option, dispose of the IDW at an appropriate offsite treatment and/or disposal facility. Offsite transport and disposal of IDW must comply with all applicable laws and criteria specific to the chosen disposal facility. These requirements may include, but are not limited to the following:

- RCRA LDRs
- RCRA waste storage permits and time limits
- National Pollutant Discharge Elimination System and sewer disposal criteria
- CERCLA offsite rule
- TSCA treatment requirements
- DOT hazardous material transport packaging, manifesting, and security provisions

- International Maritime Organization ocean transport rules
- Certifications and training for waste transport contractors
- State notification requirements when importing certain types of waste

The CERCLA offsite rule (40 CFR 300.440) requires that CERCLA waste be disposed of only at facilities specifically approved by the EPA to receive such waste for treatment, storage, or disposal. The acceptability status of a disposal facility can change quickly (e.g., if there is a release at the facility); therefore, the CTO Manager should contact the EPA Region 9 CERCLA Offsite Rule Coordinator no more than 60 days prior to disposal of the IDW to verify the facility's approval status. The offsite rule applies to any CERCLA-driven remedial or removal action involving the offsite transfer of waste containing hazardous substances regardless of the concentrations present.

RCRA hazardous waste manifests must always be signed by authorized Navy personnel. In some cases, the Navy may authorize contractors to sign non-hazardous manifests. Navy authorization to allow contractor signature of non-hazardous manifests shall be based upon a Navy review of the contractor's RCRA and DOT training records. In addition, the Navy shall always be allowed the opportunity to review/approve non-hazardous manifests and waste profiles prior to waste disposal efforts.

Disposal of liquid IDW into the Navy sanitary sewer shall occur only if first approved by the Navy. Requests for disposal to Navy facilities should be coordinated through the COR. Discharge to the public sewer system is discouraged and should occur only if approved by state and local government agencies.

5.9 RECORDS

The CTO Manager is responsible for completing and updating the site-specific IDW drum inventory spreadsheet and submitting it as needed, and reviewing the IDW disposal plan (IDW disposal paperwork).

FMs and designates are responsible for documenting all IDW-related field activities in the field notebook including most elements of the IDW drum inventory spreadsheet. The correct methods for developing and maintaining a field notebook are presented in Procedure III-D, *Logbooks*.

Guidance related to preparing an IDW disposal plan (if required) is presented in the *Generic IDW Disposal Plans* for Hawaii and Guam (Ogden 1994, 1995).

5.9.1 IDW Disposal Documentation

Upon receipt of analytical data from the investigation or from IDW-specific analytical data, the generator information request form will be completed and provided to the IDW subcontractor to begin IDW characterization. Completed IDW disposal paperwork received from the IDW subcontractor should be reviewed for accuracy prior to submitting for Navy review.

The CTO Manager is responsible for submitting backup documentation (actual site or drum sampling results) along with the IDW disposal paperwork to the Navy.

Navy-approved contractor personnel may sign non-hazardous waste IDW documentation. Hazardous waste IDW documentation must be signed by an authorized Navy Environmental Coordinator.

All manifests (non-hazardous and hazardous) must be tracked, and if completed manifests (signed by disposal facility) are not received within 30 days of initial transportation, then contractor must notify the RPM weekly of the shipping status (e-mail is acceptable). Hazardous waste must be disposed of within 45 days of initial transportation. If not, specific IDW transportation details must be supplied to the Navy in order to prepare and file an exception report.

TSCA-regulated waste must be physically destroyed and or buried within 1 year of generation (date placed in IDW drum). Disposal certificates should be provided by the waste facility to the IDW subcontractor and Navy contractor.

Following disposal of IDW, the CTO Manager should prepare a short IDW disposal report summarizing the disposal operation and appending any associated records (e.g., final drum log, waste profiles, transport manifests, bills of lading, disposal facility certifications). Minimal topics to include in the report:

- IDW inventory and storage
- IDW chemical screening and characterization
- IDW transport and disposal
- Manifests
- Drum storage photographs
- Site figure

6. Health and Safety

Field Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

7. References

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: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Environmental Protection Agency, United States (EPA). 1990. *Guidance on Remedial Actions for Superfund Sites with PCB Contamination*. EPA/540/G-90-007. OSWER 9355.4-01. Office of Solid Waste and Emergency Response. August.

———. 1991. *Management of Investigation-Derived Wastes During Site Inspections.* EPA-540-G-91-009. Office of Emergency and Remedial Response. May.

———. 1992a. *Guidance for Performing Site Inspections under CERCLA.* EPA/540/R-92/021. Office of Emergency and Remedial Response. September.

———. 1992b. *Guide to Management of Investigation-Derived Wastes.* Quick reference fact sheet. OSWER Dir. 9345.3-03FS. Office of Solid Waste and Emergency Response. January.

———. 2007. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* 3rd ed., Revision 6. Office of Solid Waste. November. On-line updates at: http://www.epa.gov/epawaste/hazard/testmethods/sw846/online/index.htm.

———. 2009. *Revisions to the PCB Q and A Manual*. January.

Ogden Environmental and Energy Services Company, Inc. (Ogden). 1994. *Final Generic IDW Screening, Sampling, Analysis, and Disposal Plan for Various Guam Naval Installations*. Pearl Harbor, HI: Pacific Division, Naval Facilities Engineering Command. September.

———. 1995. Generic IDW Screening, Sampling, Analysis, and Disposal Plan for Various Hawaii Naval Installations. Pearl Harbor, HI: Pacific Division, Naval Facilities Engineering Command. April.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual.* EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-C-2, *Monitoring Well Development*.

Procedure I-C-3, *Monitoring Well Sampling*.

Procedure I-D-1, *Drum Sampling.*

Procedure I-F, *Equipment Decontamination*.

Procedure III-D, *Logbooks.*

8. Attachments

Attachment I-A-6-1: IDW Drum Label

Attachment I-A-6-2: Drum Label – Aluminum Tag

Attachment I-A-6-3: Monthly IDW Drum Inventory Updates

Attachment I-A-6-1
IDW Drum Label

IDW Drum Label

Contract #:

CTO #:

ACTIVITY SITE:

DRUM # (_ _ _ _ - _ _ - D M _ _ _)

DATE COLLECTED

CONTENTS: (please ✓ and explain)

☐ Soil

☐ Water

☐ Solid Waste

☐ Other

PROJECT TYPE

☐ RI ☐ RFI ☐ UST ☐ Other

COMMENTS:

FOR INFORMATION CONTACT:

COR Activity/ Code:

Address:

Telephone:

Attachment I-A-6-2
Drum Label - Aluminum Tag

Drum Label - Aluminum Tag

Attachment I-A-6-3
Monthly IDW Drum Inventory Updates

Table I-A-6-1: Monthly IDW Drum Inventory Updates

Navy Activity / Site Name (Generator Site)	CTO Number (0bbb)	Drum Number (xxxx-AA-DMzzz)	Drum Storage Location	Origin of Contents (Source ID #)	IDW Type	Waste Volume (Fill level %)	Waste Generation Date (dd-Mon-yy)	Expected Disposal Date (Mon-yy)	Actual Disposal Date (dd-Mon-yy)
Inspector:									
Date of Inspection:									
NSC Pearl Harbor/ Landfill	0068	0068-LF-DM001	NSC, Bldg 7	SB-1	Soil Cuttings	100	16-Dec-92	Dec-93	N/A
		0068-LF-DM002	N/A	MW-1 MW-2 MW-3	Purge Water	75	20-Dec-92	Jul 93	26-Jul-93
		0068-LF-DM003	N/A	MW-1 MW-2 MW-3	Decon. Water	95	20-Dec-92	Jul-93	26-Jul-93
		0068-LF-DM004	NSC, Bldg.16	SB-1 SB-2 SB-3 SB-4 MW-1 MW-2 MW-3	PPE	50	16-Dec-92	Oct-93	N/A
NAVSTA Guam/ Drum Storage	0047	0047-DS-DM001	Hazmat Storage Area	SB-1 SB-2	Soil Cuttings	100	18-Feb-93	Sep-93	N/A

N/A Not Applicable

Sample Naming

1. Purpose

This standard operating procedure describes the naming convention for samples collected and analyzed, and whose resulting data will be stored in the database for the United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific projects. Unique sample names are used to facilitate tracking by laboratory personnel and project personnel, and for purposes of storing, sorting, and querying data in the database.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 CHAIN OF CUSTODY SAMPLE NUMBER

The chain of custody (COC) sample number is a five-character identification number that is used by the laboratory and project personnel for tracking purposes. A unique COC sample number must be used for each sample collected from a particular location at a particular time. It is useful for the first two characters to be letters unique to a particular site or project, while the remaining three characters may be digits from 001 to 999 (e.g., AA001). The COC sample number is the only identifier that should be presented to the laboratory.

3.2 SAMPLE IDENTIFICATION NUMBER

The sample identification number is a unique multi-alpha, multi-numeric identifier that is used by the field team to associate sampling results to the particular sampling location, sample type, number of times the location has been sampled, and depth. To avoid potential bias in sample analysis, the sample identifier is not provided to the laboratory. The sample identification number shall be recorded in the field logbook concurrently with the COC sample number.

4. Responsibilities

The prime contractor CTO Manager shall ensure that a proper sample naming convention is identified in the field sampling plan. The Field Quality Control (QC) Supervisor or other field-sampling leader shall ensure that the sample naming convention is implemented. The laboratory coordinator, CTO Manager, and/or other designated personnel shall ensure on a daily basis that unique, appropriate COC sample numbers and sample identifiers have been assigned. The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The prime contractor Technical Director will designate one person in each office (e.g., the laboratory coordinator) to track site designations used in the COC sample number.

5. Procedures

A COC sample number and sample identifier shall be assigned as described below. It is critical that each sample name have a unique COC sample number and sample identifier; otherwise, data cannot be properly stored and tracked in the database.

5.1 COC SAMPLE NUMBER

Use the following format for the COC sample number:

abccc

Where:

a = A letter indicating the office managing the CTO

b = A letter indicating the project or site, for example

    A = first site

    B = second site

    C = third site, etc.

ccc = Chronological number, for example

    001 = first sample from the site

    002 = second sample from the site

    105 = 105th sample from the site

    Field QC samples should be included in this chronological sequence

For example, the 23rd sample from the Carpentry Shop Dip Tank site (assigned project “A” for b above; the office will be assigned “D”) being investigated would be referred to as “DA023.” This might be a soil sample, water sample, trip blank, equipment blank, field duplicate, or other sample type. Using this COC sample number, the samples will be submitted to the laboratory “blind,” that is, the laboratory should not know whether each sample received is a site or field QC sample.

If a sample is lost during shipping, the replacement sample must be assigned a new COC sample number. If different containers for the same sample are shipped on different days, a new COC sample number must be assigned.

When numbering reaches the letter Z, the 26th site, it may begin with a new first letter “a,” which must be coordinated with the prime contractor QA Manager or Technical Director and Coordinator or designee to ensure that it has not been used by another CTO.

Alternatively, the "ab" designators can serve to identify a unique project field, such as "RH" for the Red Hill site.

5.2 SAMPLE IDENTIFICATION NUMBER

The following format is provided as a suggested guidance. Individual site objectives may necessitate variations to the suggested guidance. Coordinate with the prime contractor QA Manager or Technical Director when considering deviating from this guidance.

AA-bbcc-dee-Dff.f

Where:

AA = Designates the site identification

bb = Sample type and matrix (see Table I-A-8-1)

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

d = Field QC sample type (see Table I-A-8-2)

ee = Chronological sample number from a particular sampling location (e.g., 01, 02, 03)

D = The letter "D" denoting depth

ff.f = Depth of sample in feet bgs (to the measured decimal place). For field blanks, trip blanks and equipment blanks, the depth field will contain the month and date of collection.

For example, the first subsurface soil sample collected from the Foundry Building (FB) borehole location four at a depth of 10 feet would be designated "FB-BS04-S01-D10.0." These characters will establish a unique sample identifier that can be used when evaluating data.

Table I-A-8-1 presents the character identifiers to be used in the sample and matrix portion of the sample identification number. In all cases, the second letter indicates the sample matrix. Note grab, composite, and undisturbed sample designations in the field logbook.

Table I-A-8-1: Sample Type and Matrix Identifiers

Identifier	Sample Type	Matrix
SS	Surface Soil	Soil
IS	Surface Soil (ISM)	Soil
IB	Subsurface Soil (ISM)	Soil
BS	Subsurface Soil	Soil
BG	Subsurface Soil (Geotechnical)	Soil
SD	Sediment	Sediment
GW	Groundwater	Water
SW	Surface Water	Water
FP	Free Product	Oil
WQ	Water Blanks	Water
SG	Soil Gas	Soil gas
CC	Concrete Chips	Concrete

Identifier	Sample Type	Matrix
WS	Waste (IDW)	Soil
WW	Waste (IDW)	Water

IDW	investigation-derived waste
ISM	incremental sampling methodology

Table I-A-8-2 describes the field QC designator types. These field QC designators clarify the type of sample collected.

Table I-A-8-2: Field QC Sample Type Identifiers

Identifier	QC Sample Type	Description
S	Normal (Primary) Sample	All non-field QC samples
D	Duplicate	Collocate (adjacent liners)
R	Triplicate	Replicate
E	Equipment Rinsate	Water
B	Field Blank	Water
T	Trip Blank	Analytical-laboratory-prepared sample -Water
M	Trip Blank	Analytical-laboratory-prepared sample – Methanol
L	Batch Test Sample	Batch Test Leaching Model Sample
P	Blind Spike	Performance testing sample

6. Records

Sample identifiers (and COC sample numbers, if appropriate) shall be identified in advance if the exact numbers of samples to be collected are known; these numbers may be listed on a spreadsheet along with requested analyses to be used as a reference by field sampling personnel.

The COC/analytical request form must be used to track all sample names. Copies of each COC form shall be sent daily to the CTO Laboratory Coordinator and with the samples to the analytical laboratory. An example of a COC form is included as Attachment III-E-2 of Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*.

In the field, personnel shall record in the field logbook the COC sample number of each sample collected, as well as additional information, such as the sampling, date, time, and pertinent comments.

7. Health and Safety

Not applicable.

8. References

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: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*.

9. Attachments

None.

Soil Sampling

1. Purpose

This section sets forth the standard operating procedure for soil sampling (surface samples, trench samples, and boring samples) to be used by United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

None.

4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that these standard soil sampling procedures are followed during projects conducted under the NAVFAC Pacific ER Program, and that they are conducted or supervised by a qualified individual. A qualified individual for subsurface sampling is defined as a person with a degree in geology, hydrogeology, or geotechnical/civil engineering with at least 1 year of experience in the supervision of soil boring construction. A qualified individual for trenching, excavation (e.g., pit), or surface sampling supervision is one who has sufficient training and experience to accomplish the objectives of the sampling program. The CTO Manager shall also ensure that a qualified person, as defined in Procedure I-E, *Soil and Rock Classification,* conducts soil classification during all types of soil sampling. The CTO Manager is responsible for ensuring that all personnel involved in sampling and/or testing shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for ensuring that all project field staff follow these procedures.

Field sampling personnel are responsible for the implementation of this procedure.

5. Procedures

5.1 CONSIDERATIONS FOR MUNITIONS AND EXPLOSIVES OF CONCERN

Potential Munitions and Explosives of Concern (MEC) hazards may be encountered in any area formerly or currently occupied or used by the Department of Defense (DoD). MEC hazards may occur on the ground surface, in the subsurface, and within bodies of water, and may not always be readily observable, or identifiable. As a result, whether or not munitions-related activities ever occurred on the specific work area or within waters in which Navy operations/activities will take place, special care should always be taken when conducting field operations, especially intrusive activities, in the event that MEC may be encountered.

If the site is currently recognized as belonging in the Military Munitions Response Program and has a current, Naval Ordnance Safety and Security-accepted, site-specific Explosives Safety Submission (ESS) (per DON 2010), then field activities, especially intrusive activities, shall adhere to the safety procedures outlined within the ESS.

If suspected MEC is encountered on an active DoD installation, immediately notify your supervisor, DoD Point of Contact, and installation Point of Contact, who will contact and facilitate military Explosive Ordnance Disposal response.

5.2 SUBSURFACE SOIL SAMPLING

The purpose of subsurface soil sampling is to acquire accurate, representative information about subsurface materials penetrated during drilling or trenching. This is accomplished by logging lithologic information, classifying lithologic materials, and collecting lithologic samples for analysis using geotechnical or chemical methods.

5.2.1 Inspection of Equipment

The collection of reliable samples of subsurface materials depends partly on the types of samples that can be collected when using various subsurface exploration techniques. These procedures are described in Section 5.2. In all cases, the equipment shall be inspected prior to commencement of drilling for signs of fluid leakage, which could introduce contaminants into the soil. If, at any time during subsurface exploration, fluid is observed leaking from the rig, operations shall cease and the leak shall be immediately repaired or contained. All soil and other materials affected by the leak will be collected, containerized, and labeled for proper disposal (Procedure I-A-6, *Investigation-Derived Waste Management*).

5.2.2 Preparation of Site

Proper preparation of the site prior to the commencement of subsurface exploration is essential for smooth drilling operations. It is required to protect the health and safety of site personnel. First, the site shall be inspected to ensure that there are no overhead hazards that could affect subsurface exploration. Then, all subsurface sampling locations shall be assessed using geophysical methods to identify subsurface utilities or hazards. If possible, the area shall be excavated by hand to a depth of 2 to 3 feet before beginning drilling. If surface or shallow samples are required, it is suggested that the hand excavation be done as close to the actual subsurface exploration as possible. The drill rig must have a means to guard against employee contact with the auger (e.g., guard around the auger; barricade around the perimeter of the auger; electronic brake activated by a presence-sensing device). All members of the field crew shall know the location of the kill switch, which must be readily accessible, for the equipment.

The equipment shall be situated upwind or side-wind of the borehole. The area surrounding, and in the vicinity of, the borehole shall be covered with plastic, including the area where cuttings are placed into 55-gallon drums and the equipment decontamination area. The required exclusion zones shall be established by using plastic tape or cones to designate the various areas.

5.2.3 Equipment Decontamination

To avoid cross-contamination, all sampling equipment utilized for borehole drilling and soil sampling that may potentially come into contact with environmental samples shall be thoroughly decontaminated as described in Procedure I-F, *Equipment Decontamination*. All sampling tools shall be decontaminated between each sampling event and between each borehole or trench. At a minimum, all equipment shall be steam-cleaned or undergo the wash-and-rinse process. All wash-and-rinse water shall be collected, containerized, and labeled for proper disposal. Clean equipment (e.g., augers and samplers) shall be protected from contact with contaminated soils or other contaminated materials prior to sample collection. Equipment shall be kept on plastic or protected in another suitable fashion. After a borehole is completed, all augers and contaminated downhole equipment shall be stored on plastic sheeting.

5.2.4 Handling of Drill Cuttings

All soil cuttings from borehole drilling shall be placed into 55-gallon U.S. Department of Transportation (DOT)-approved drums or other appropriate containers, such as a roll-off bin. The containerized cuttings shall be stored in a centralized area pending sample analysis to determine their final disposition. The procedure on investigation-derived waste (IDW) (see Procedure I-A-6, *Investigation-Derived Waste Management*) details drum handling and labeling procedures.

5.3 SUBSURFACE SOIL SAMPLE COLLECTION METHODS

Table I-B-1-1 describes the characteristics of the sampling methods for the drilling techniques frequently used for soil borings and monitoring well installation, as described in Procedure I-C-1, *Monitoring Well Installation and Abandonment*. The split-spoon sampling method is the most commonly used soil sampling technique. However, in certain circumstances, other methods may have to be used to obtain optimal soil sampling results.

Sampling and handling procedures for samples submitted for volatile organic compound (VOC) analyses are provided in Attachment I-B-1-1. Considerations when using incremental sampling (IS) methods are provided in Attachment I-B-1-1.

Table I-B-1-1: Characteristics of Common Subsurface Formation-Sampling Methods

Type of Formation	Sample Collection Method	Sample Quality	Potential for Continuous Sample Collection?	Samples Suitable for Analytical Testing?	Discrete Zones Identifiable?
Unconsolidated	Bulk Sampling (Cuttings)	Poor	No	No	No
	Thin Wall	Good	Yes	Yes	Yes
	Split Spoon	Good	Yes	Yes	Yes
	Trench	Good	No	Yes	Yes
	Core Barrels	Good	Yes	Yes	Yes
Consolidated	Cuttings (direct rotary)	Poor	No	No	No
	Core Barrels	Good	Yes	Yes	Yes

The following text describes the primary soil sampling methods used for the NAVFAC Pacific ER Program.

5.3.1 Split-Spoon Samples

Split-spoon sampling is usually used in conjunction with the hollow-stem or solid-stem auger drilling method and can be used for sampling most unconsolidated and semi-consolidated sediments. It is used less frequently for air and mud rotary, and casing drive methods. It cannot normally be used to sample bedrock, such as basalt, limestone, or granite. The method can be used for highly unconsolidated sands and gravels if a stainless-steel sand catcher is placed in the lower end of the sampler.

The split-spoon sampler consists of a hardened metal barrel, 2 to 3 inches in diameter (2 to 2.5 inches inner diameter) with a threaded, removable fitting on the top end for connection to the drill rods and a threaded, removable “shoe” on the lower end that is used to penetrate the formation. The barrel can be split along its length to allow removal of the sample.

The following steps are required to obtain a representative soil sample using a split-spoon sampler:

- Advance the borehole by augering until the top of the desired sampling interval is reached. Then withdraw the drill bit from the hollow-stem augers.
- Equip the sampler with interior liners that are composed of materials compatible with the suspected contaminants if samples are to be retained for laboratory analytical analysis. Generally, these liners consist of brass or stainless steel and are slightly smaller than the inner diameter of the sampler. It is recommended to use stainless-steel liners rather than

brass if samples are to be analyzed for metals. Always evaluate the composition of the liners with respect to the types of contaminants that are suspected.

- Attach the properly decontaminated split-spoon sampler (equipped with liners) either to the drill rods or to a cable system and lower it to the bottom of the borehole through the augers.
- Drive the sampler into the formation by either a manual or automatic hammer (usually a 140-pound weight dropped through a 30-inch interval). Record the number of blows required to drive the sampler at 6-inch intervals in the boring log since blow counts provide an indication of the density/compaction of the soils being sampled. The field geologist, hydrogeologist, or geotechnical engineer shall carefully observe the internal measuring technique of the driller and keep track of sampling materials to ensure the accurate location of samples. Continuous samples can be collected with the split-spoon method by augering or drilling to the bottom of the previously sampled interval and repeating the operation. Whether continuous or intermittent, this collection method disturbs samples and cannot be used for certain geotechnical tests that require undisturbed samples.
- Bring the split-spoon sampler to ground surface and remove it from the drill rods or cable system following sample acquisition. Loosen the upper and lower fittings and take the sampler to the sample handling area. At the sample handling area, remove the fittings, split the barrel of the sampler, and remove one side of the sampler. At this time, it is important to observe and record the percentage of sample recovery.

Liners—Sampler liners can be used to collect and store samples for shipment to laboratories, for field index testing of samples, and for removing samples from solid barrel type samplers. Liners are available in plastic, Teflon, brass, and stainless steel. Other materials can be used as testing needs dictate. Liners are available in lengths from 6 inches (152.4 millimeters) to 5.0 feet (1.53 meters). Liner material selection often is based on the chemical composition of liner/soil to minimize sample reaction with liner. Most liner use is short-term as samples are subsampled and preserved immediately on site. Teflon may be required for mixed wastes and for long-term storage. Liners generally are split in the field for subsampling. Individually split liners are available in some sizes for field use. The liner should have a slightly larger inside diameter than the soil specimen to reduce soil friction and enhance recovery. When a slightly oversized liner is used, the potential for air space exists around the sample. Certain chemical samples may be affected by the enclosed air. Liners with less tolerance may be required and a shortened sample interval used to reduce friction in the liner. Metal liners can be reused after proper cleaning and decontamination. Plastic liners should be disposed of properly after use (ASTM 2005).

Immediately remove the liners containing the soil samples from the sampler. Generally, the lowermost liner is considered the least disturbed and shall be retained as the analytical laboratory sample. However, in certain circumstances (such as with the use of a sand catcher), other liners may be more appropriate for retention as the laboratory sample. If liners containing the sample material are to be submitted to the laboratory, then cover the ends of the sample liner to be retained as the analytical laboratory sample with Teflon film and sealed with plastic caps. While currently not preferred by the State of Hawaii, if liners are submitted, the laboratories should be instructed to prepare the soil from the liner as an incremental sample to prevent biasing the results that can occur when discretely collecting the analytical volume. The site geologist, hydrogeologist, or geotechnical engineer shall observe the ends of the liner destined for analytical sampling and describe the physical nature of the sample (e.g., soil or rock type, grain size, color, moisture, as indicated in Procedure I-E, *Soil and Rock Classification*.) Then label the sample according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*, and immediately place it on ice in a cooler as described in Procedure III-F, *Sample Handling, Storage, and Shipping*.

- Collect split-spoon soil samples submitted for VOC analysis using the procedure found in Attachment I-B-1-1.
- Collect split-spoon soil samples submitted for non-VOC analysis using the IS procedure found in Attachment I-B-1-1
- Any remaining liners collected from the sample can then be used for other purposes, such as providing a duplicate sample for field quality control or material for lithologic logging. These samples can also be used for headspace analysis as described in Section 5.4.
- Conduct lithologic logging of each sample in accordance with Procedure I-E, *Soil and Rock Classification*, and enter each sample into the boring log presented in Figure I-B-1-1. In most instances, an additional liner full of material is available for this purpose. Check to ensure that all liners contain similar material. If an extra liner full of material is not available, then log by collecting the extra material present in the end of the sampler shoe. Make a comparison to the material visible at the end of the sample liner destined for laboratory analysis to ensure that the entire sample consists of similar material. If not, then describe the different material to the extent possible by relating it to similar material that was encountered previously.
- If VOCs are suspected to be present, screen the sample with an organic vapor monitor (OVM) or equivalent, and collect headspace samples according to Section 5.4.
- Decontaminate all sampling equipment prior to each use according to Procedure I-F, *Equipment Decontamination*.

5.3.2 Thin-Wall Samples

The thin-wall or Shelby tube sampler is usually used in conjunction with the hollow-stem and solid-stem auger drilling methods and is most useful when sampling clay- and silt-rich sediments. It can also be used with air and mud rotary and casing drive drilling techniques. It is amenable only to lithologies that are relatively soft and, in some cases, is not capable of penetrating hard clays or compacted sands. In addition, samples of unconsolidated sands cannot normally be acquired because they cannot be retained within the sampler, although a sand catcher can be utilized, in some cases, with moderate success.

The thin-wall sampler often consists of a single thin tube that is 3 to 4 inches in outer diameter and 1 to 3 feet in length. The upper end of the sampler has a solid metal section with a fitting for drill rods. There is no fitting for the lower end of the sampler, and it is usually open to allow sample acquisition; however, when sampling in poorly consolidated materials, a sand catcher may be placed in the lower end to ensure retention of the sample.

The following steps are required to obtain a representative soil sample using a thin-wall sampler:

- Advance the borehole by augering or drilling until the top of the desired sampling interval is reached. Then withdraw the drill bit from the hollow-stem augers.
- Place the sampler on the end of the drill rods and lower it to the bottom of the borehole.
- Instead of driving the sampler, use the hydraulic apparatus associated with the kelly bar on the drilling rig to press the sampler into the undisturbed formation. The thin-wall sampler may lack sufficient structural strength to penetrate the materials, in which case another sampling technique may be required. The samples obtained using this method cannot be used for certain geotechnical tests where undisturbed samples are required.
- Thin-wall samples submitted for VOC analysis must be collected using the procedure found in Attachment I-B-1-1.
- Following sample acquisition, bring the thin-wall sampler to the ground surface, remove it from the drill rods, and take it to the sample handling area.
- Immediately cover the ends of the sample with Teflon film and sealed with plastic caps if the sample is to be retained as a laboratory sample. Then label the sample according to Procedure III-E*, Record Keeping Sample Labeling, and Chain of Custody* and immediately place it on ice in a cooler. Extrude the sample from the sampler and inspect it if the sample is to be used only for lithologic logging.
- Conduct lithologic logging of each sample in accordance with Procedure I-E*, Soil and Rock Classification* and enter each sample into the boring log presented in Figure I-B-1-1. If the sample is contained in a sleeve, observe the ends of the sample in the sleeve to assess lithologic and stratigraphic characteristics.
- If VOCs are suspected to be present, screen the sample with an OVM or equivalent, and collect headspace samples according to Section 5.4.
- Decontaminate all sampling equipment prior to each use according to Procedure I-F, *Equipment Decontamination.*

5.3.3 Cores

A core barrel is often used to obtain core samples from harder lithologic materials, such as basalt, granite, and limestone, in instances where undisturbed samples are required for geotechnical testing, and in cases where completely continuous sampling is required. Complete recovery of samples during coring is often difficult when sampling unconsolidated and semi-consolidated lithologies, such as clays, silts, and sands.

Field Log of Boring

BORING NUMBER	SHEET ____ OF _____

PROJECT NAME	PROJECT NUMBER	ELEVATION AND DATUM	LOCATION
DRILLING COMPANY	DRILLER	DATE AND TIME STARTED	DATE AND TIME COMPLETED
DRILLING EQUIPMENT	DRILLING METHOD	COMPLETION DEPTH	TOTAL NO. OF SAMPLES
SIZE AND TYPE OF BIT	HOLE DIAMETER	NO. OF SAMPLES BULK SS	DRIVE PITCHER
DRILLING FLUID	DRILLING ANGLE	WATER LEVEL FIRST	AFTER _______ HOURS
SAMPLE HAMMER TYPE DRIVING WT. DROP		HYDROGEOLOGIST/DATE	CHECKED BY/DATE

LITHOLOGY	DEPTH (FEET)	SAMPLES	RECOVERY	BLOW COUNT	DESCRIPTION	USCS SYMBOL	ESTIMATED PERCENT OF			COMMENTS
							GR	SA	FI	

Figure I-B-1-1: Field Log of Boring

ASTM International (ASTM) has standardized rock coring methods (D-2113) (ASTM 2006). Several standardized core sizes for bits, shells, and casings have been established (e.g., RX, NX, SW). Table I-B-1-2 summarizes the various size standards for core barrels and bits.

Table I-B-1-2: Standard Core Barrel Sizes (in inches)

Description	RX or RW	EX or EW	AX or AW	BX or BW	NX or NW	HX or HW	PX or PW	SX or SW	UX or UW	ZX or ZW
Bit Set Normal I.D.	0.750	0.845	1.185	1.655	2.155	3.000	—	—	—	—
Bit Set Normal and Thin-wall O.D.	1.160	1.470	1.875	2.345	2.965	3.890	—	—	—	—
Bit Set Thin-wall. I.D	0.735	0.905	1.281	1.750	2.313	3.187	—	—	—	—
Shell Set Normal and Thin-wall O.D.	1.175	1.485	1.890	2.360	2.980	3.907	—	—	—	—
Casing Bit Set I.D.	1.000	1.405	1.780	2.215	2.840	3.777	4.632	5.632	6.755	7.755
Casing Bit Set and Shoe O.D.	1.485	1.875	2.345	2.965	3.615	4.625	5.650	6.780	7.800	8.810

I.D.	Inner Diameter
O.D.	Outer Diameter

The selection of the most practical core barrel for the anticipated bedrock conditions is important. The selection of the correct drill bit is also essential to good recovery and drilling production. Although the final responsibility of bit selection usually rests with the drilling contractor, there is a tendency in the trade to use “whatever happens to be at hand.” The selection of the diamond size, bit crown contour, and number of water ports depends upon the characteristics of the rock mass. The use of an incorrect bit can be detrimental to the overall core recovery. Generally, fewer and larger diamonds are used to core soft formations, and more numerous, smaller diamonds, which are mounted on the more commonly used semi-round bit crowns, are used in hard formations. Special impregnated diamond core bits have been developed recently for use in severely weathered and fractured formations where bit abrasion can be very high.

Core barrels are manufactured in three basic types: single tube, double tube, and triple tube. These basic units all operate on the same principle of pumping drilling fluid through the drill rods and core barrel. This is done to cool the diamond bit during drilling and to carry the borehole cuttings to the surface. A variety of coring bits, core retainers, and liners are used in various combinations to maximize the recovery and penetration rate of the selected core barrel.

The simplest type of rotary core barrel is the single tube, which consists of a case hardened, hollow steel tube with a diamond drilling bit attached at the bottom. The diamond bit cuts an annular groove, or kerf, in the formation to allow passage of the drilling fluid and cuttings up the outside of the core barrel. The single tube core barrel cannot be employed in formations that are subject to erosion, slaking, or excessive swelling, as the drilling fluid passes over the recovered sample during drilling.

The most popular and widely used rotary core barrel is the double tube, which is basically a single tube barrel with a separate and additional inner liner that is available in either a rigid or swivel type of construction. In the rigid types, the inner liner is fixed to the outer core barrel so that it rotates with the outer tube. In contrast, the swivel type of inner liner is supported on a ball-bearing carrier, which allows the inner tube to remain stationary, or nearly so, during rotation of the outer barrel. The sample, or core, is cut by rotation of the diamond bit. The bit is in constant contact with the drilling fluid as it flushes out the borehole cuttings. The addition of bottom discharge bits and fluid control valves to the core barrel system minimizes the amount of drilling fluid and its contact with the sample, which further decreases sample disturbance.

The third and most recent advancement in rotary core barrel design is the triple tube core barrel, which adds another separate, non-rotating liner to the double tube core barrel. This liner, which retains the sample, consists of a clear plastic solid tube or a split, thin metal liner. Each type of liner has its distinct advantages and disadvantages; however, they are both capable of obtaining increased sample recovery in poor quality rock or semi-cemented soils, with the additional advantage of minimizing sample handling and disturbance during removal from the core barrel.

The rotary core barrels that are available range from 1 to 10 inches in diameter, and the majority may be used with water, drilling mud, or air for recovering soil samples. Of the three basic types of core barrels, the double tube core barrel is most frequently used in rock core sampling for geotechnical engineering applications. The triple tube core barrel is used in zones of highly variable hardness and consistency. The single tube is rarely used because of its sample recovery and disturbance problems.

Coring to obtain analytical samples requires only filtered air as the drilling fluid. The core barrel operates by rotating the outer barrel to allow the bit to penetrate the formation. The sample is retained in the inner liner, which in most samplers does not rotate with the outer barrel. As the outer barrel is advanced, the sample rises in the inner liner. In general, a secondary liner consisting of plastic or metal is present within the inner liner to ensure the integrity of acquired samples.

Obtain soil or rock core samples with a core barrel or a 5-foot split-spoon core barrel using the following procedure:

- Drill the core barrel to the appropriate sampling depth. It is important to use only clean, filtered air (i.e., particulate- and petroleum-free) as drilling fluid while coring to obtain samples for laboratory analysis. If necessary, distilled water may be added through the delivery system of the coring device by the driller, provided that the drilling returns cannot be brought to the surface by air alone.
- Retrieve the core barrel from the hole. Use care to ensure that the contents of the core barrel do not fall out of the bottom during withdrawal and handling.
- Open the core barrel by removing both the top and bottom fittings. Then remove the sample within the inner liner from the core barrel and take it to the sample handling area.

- Conduct lithologic logging of each sample in accordance with Procedure I-E, *Soil and Rock Classification*, and enter each sample into the boring log presented in Figure I-B-1-1.
- If VOCs are suspected to be present, screen the sample with an OVM or equivalent, and collect headspace samples according to Section 5.4.

Collect core samples submitted for VOC analysis using the procedure found in Attachment I-B-1-1.

- If rock core samples are to be recovered for analytical laboratory or geotechnical analyses, the core barrel will either be lined with a sample container (e.g. stainless steel or acrylic liner), or the samples will be transferred to an appropriate sample container (e.g. stainless steel / acrylic liner, glass jar). Samples collected or placed in stainless steel or acrylic liners shall have the ends of the liners covered with Teflon film and sealed with plastic end caps. The sample containers shall be labeled in accordance with Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*, and Procedure III-F, *Sample Handling, Storage, and Shipping*, and immediately placed on ice in a cooler.
- Place the samples in core boxes if samples are to be catalogued and stored. Affix the CTO number; site name; borehole number; start depth; end depth; date; and name of the geologist, hydrogeologist, or geotechnical engineer to the core box. Store the samples in a clean, dry area on site during the duration of field sampling; samples shall not be brought back to the office or equipment storage area. Document proper disposal at the completion of field sampling.
- Decontaminate all sampling equipment prior to each use according to Procedure I-F, *Equipment Decontamination*.

5.3.4 Bulk Samples

The term "bulk sample" represents a sample collected from borehole cuttings either from the hollow-stem auger flights or the discharge of any of the rotary or cable tool drilling techniques. This type of sample is useful for describing soils or consolidated materials, where no undisturbed samples representative of a specific depth are being collected. It should be noted that this type of sample is generally considered to be the least acceptable of the types of samples previously described in this section and shall be used only when detailed lithologic data are not needed.

Handling and lithologic logging of bulk samples should be performed in a manner consistent with that used for split-spoon samples. An estimate of the depth (or range of depths) from which the sample was obtained, and date and time of collection should be recorded on the boring log. Samples are usually collected every 5 feet, preferably at several different times during a 5-foot drilling run so that lithologic variations occurring over the drilling interval can be noted. Rock fragments commonly range in size from 1/16 to 1/2 inch, with many fragments larger than 1/4 inch. Larger fragments can often be obtained with reverse circulation rotary drilling. Rotary-tool samples usually contain some caved materials from above and, when drilling with mud or water rotary, the cuttings may contain soil and rock recirculated by the mud/water pump; therefore, care must be exercised when interpreting lithologic logs completed using data from this type of sample.

Because the collection of samples at the surface lags behind the actual drilling of a given lithologic bed at depth, the samples usually represent a depth less than that of the current depth of the drill bit. The amount of lag may be significant in deeper boreholes, but can be eliminated by collecting samples after circulating for a period of time sufficient to permit the most recently drilled materials to reach the surface.

5.3.5 Borehole Abandonment

Following completion of soil sampling, the borehole shall be properly abandoned unless a monitoring well is to be installed. Abandonment shall occur immediately following acquisition of the final sample in the boring and shall consist of the placement of a bentonite-cement grout from the bottom of the boring to within 2 feet of ground surface. The grout mixture shall consist of a mix of 7 to 9 gallons of water per 94-pound bag of Portland Type I or II cement with 3 to 5 percent by weight of powdered bentonite. Other commercial products such as Volclay are also acceptable with approval of the CTO Manager and QA Manager or Technical Director. The bentonite-cement grout shall be placed in one continuous pour from the bottom of the boring to within at least 0.5 foot to 2 feet of ground surface through a tremie pipe or hollow-stem augers. Additional grout may need to be placed if significant settlement occurs. The remaining portion of the boring can be filled with topsoil.

5.3.6 Trenching and Pit Sampling

Trenching is used in situations where the depth of investigation generally does not exceed 10 to 15 feet and is most suitable for assessing surface and near-surface contamination and geologic characteristics. In addition, trenching allows detailed observation of shallow subsurface features and exposes a wider area of the subsurface than is exposed in borings. Pit sampling is typically conducted in conjunction with a removal or remedial action.

A backhoe is usually used to excavate shallow trenches to a depth of no greater than 15 feet. Front-end loaders or bulldozers are used when it is not possible to use a backhoe; for example, when materials lack cohesion or are too stiff, or the terrain is too steep for a backhoe. Larger excavations (i.e., pits) may require additional equipment as described in the CTO work plan (WP) or equivalent document.

Typically, trenches have widths of one to two backhoe buckets and range in length from 5 to 20 feet, although larger trenches can be dug depending on the objectives of the study. Pits will vary in size depending upon the scope of the removal/remedial action. Soils removed from the trench/pit shall be carefully placed on plastic sheeting or other appropriate materials in the order of removal from the trench or excavation. The shallow excavated materials can be placed on one side of the trench/excavation and deeper materials on the other side to allow better segregation of shallow and deep materials.

Soil sampling locations within each trench or pit shall be chosen on the basis of visual inspection and any VOC screening results. Samples shall be collected from either the sidewalls or the bottom of the trenches/excavations. Soil sampling should be conducted outside the trench/excavation, and personnel generally should not enter a trench or pit if there is any other means (e.g., backhoe buckets, hand augers, shovels, or equivalent) to perform the work. If entry is unavoidable, then a competent person shall first determine acceptable entry conditions including sloping, shoring, and air monitoring requirements, personal protective equipment (PPE), and inspections. In addition, the site-specific health and safety plan must be amended to include applicable requirements of 29 Code of Federal Regulations (CFR) 1910.146.

Equipment used for trench/pit sampling may include hand augers, core samplers (slide hammer), liners inserted manually into the soil, or hand trowels. In addition, samples may be obtained directly from the trench or from the backhoe bucket. All samples shall be properly sealed and labeled according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*, and immediately placed on ice in a cooler as indicated in Procedure III-F, *Sample Handling, Storage, and Shipping*. Sample locations and descriptions shall be described and recorded on the field trench/pit log.

Trench or pit samples submitted for VOC analysis must be collected using the procedure found in Attachment I-B-1-1.

The exposed materials shall be observed for lithologic and contaminant characteristics following completion of the excavation activities. Detailed mapping of the exposed walls of the trench shall be conducted, although in no instance shall personnel enter a trench without first determining acceptable entry conditions including sloping, shoring, and air monitoring requirements, PPE, and inspections as defined in 29 CFR 1910.146. A useful mapping technique for extremely long trenches or large pits is to examine the vertical profile of the excavation at horizontal intervals of 5 to 10 feet, in a manner similar to the method typically used for preparation of a geologic cross-section using soil borings. Field observations shall be noted in the field logbook and described in detail on a trench/pit log. An example of a field trench/pit log is presented in Figure I-B-1-2. The lithologic description shall include all soil classification information listed in Procedure I-E, *Soil and Rock Classification*. A cross-section of the trench or pit should also be included on the field trench/pit log. Photographs of the trench/pit are also an excellent way to document important subsurface features.

During backfilling of the excavation, the materials excavated from the greatest depth should be placed back into the excavation first. Lithologic materials should be replaced in 2- to 4-foot lifts and recompacted by tamping with the backhoe bucket. For certain land uses or site restoration, more appropriate compaction methods may be required. These methods shall be described in the CTO WP and design documents. The backfilled trench/pit shall be capped with the original surface soil. If materials are encountered that cannot be placed back in the excavation, they should be placed either in DOT-approved open-top drums or placed on and covered with visqueen or equivalent material and treated as IDW in accordance with Procedure I-A-6, *Investigation-Derived Waste Management.*

5.4 SURFACE SOIL SAMPLING

All surface soil samples shall be accurately located on field maps in accordance with Procedure I-I, *Land Surveying.* Detailed soil classification descriptions shall be completed in accordance with

Procedure I-E, *Soil and Rock Classification* and recorded on the surface and shallow soil sample log (Figure I-B-1-3).

In general, surface soil samples are not to be analyzed for VOCs unless there is sufficient evidence to suggest the presence of such compounds.

Methods commonly used for collection of surface soil samples are described below. Considerations when using IS methods are provided in Attachment I-B-1-1.

5.4.1 Hand Trowel

A stainless-steel or disposable hand trowel may be used for sampling surface soil in instances where samples are not to be analyzed for volatile organics. The hand trowel is initially used to remove the uppermost 2 inches of soil and is then used to acquire a representative sample of deeper materials to a depth of 6 inches. Generally, only samples within the upper 6 inches of soil should be sampled using these methods. The depth of the sample shall be recorded in the surface and shallow soil sample log (Figure I-B-1-3). The soil classification shall include all the information outlined in Procedure I-E, *Soil and Rock Classification*.

Soil samples collected using a hand trowel are usually placed into pre-cleaned, wide-mouth glass jars. The jar is then sealed with a tight-fitting cap, labeled according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*, and placed on ice in a cooler in accordance with Procedure III-F, *Sample Handling, Storage, and Shipping*. All sampling equipment must be decontaminated prior to each use according to the methods presented in Procedure I-F, *Equipment Decontamination*.

5.4.2 Hand Auger

A soil recovery hand auger consisting of a metal rod, handle, detachable stainless-steel core barrel, and inner sleeves can be used to obtain both surface soil and trench samples. Multiple extensions can be connected to the sampler to facilitate the collection of samples at depths up to 15 feet below the existing ground surface.

Pre-cleaned sample liners are loaded into the core barrel prior to sampling. In general, these liners are used not only to collect samples, but also to serve as the sample container. Alternatively, in instances where VOCs are not to be analyzed or where not enough samples can be collected to completely fill a liner, samples can be transferred to wide-mouth glass jars. In either case, the sample shall be labeled according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody* and immediately placed on ice in a cooler as indicated in Procedure III-F, *Sample Handling, Storage, and Shipping*. To minimize possible cross-contamination, the soil recovery hand auger and sample liners shall be decontaminated prior to each use according to the procedures described in Procedure I-F, *Equipment Decontamination*.

5.4.3 Slide Hammer Sampling

In instances where the soil type precludes the collection of soil samples using the soil recovery hand auger, a manually operated slide hammer can be used to collect relatively undisturbed soil samples from excavations and surface soils. The slide hammer consists of a 6- to 12-inch core barrel that is connected to the slide hammer portion of the device using detachable extensions.

The core sampler is typically loaded with two to four sample liners, depending on the liner length, which are not only used to acquire the samples, but also serve as the sample container. Immediately following acquisition, samples shall be labeled according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody* and immediately placed on ice in a cooler as indicated in Procedure III-F, *Sample Handling, Storage, and Shipping*.

All of the sampling equipment that comes into contact with the sample medium shall be decontaminated in accordance with Procedure I-F, *Equipment Decontamination*. Split-barrel slide hammer core samplers, which have recently become available, are much easier to decontaminate than the older, single-piece core barrel, and should be used in place of the older core barrels where possible.

FIELD LOG OF TRENCH/PIT

Project Name							
Trench Number		Project Number	Elevation and Datum			Location	
Equipment Supplier		Operator	Date and Time Started			Date and Time Completed	
Equipment Type		Trench Orientation	Total Depth			Total Number of Samples	
Bucket Width	Trench Length	Trench Width	No. Of Samples	Bulk	Ss	Drive	Hand Auger
Geologist or Hydrogeologist/Date			Check by/Date				

SOIL DESCRIPTION

				Est. % of			
LITHOLOGY	DEPTH (FEET)	DESCRIPTION	USCS SYMBOL	G	S	F	COMMENTS
							Description taken _______ feet
							from ______ end of trench.

Figure I-B-1-2: Field Log of Trench/Pit

SURFACE AND SHALLOW SOIL SAMPLE LOG

Project Number	Project Name	Date	Time
Sample Identification Number and Time		Checked by	
Sampled by		Recorded by	

Method of Collection

Surface Description

Notes

Soil Sample Data

Location

Coordinates	Elevation

LITHOLOGY	DEPTH (FEET)	DESCRIPTION	USCS SYMBOL	Est. % of			COMMENTS
				G	S	F	

Figure I-B-1-3: Surface and Shallow Soil Sample Log

5.4.4 Hand Sampling Using Sample Liners

Surface soil samples can sometimes be collected by hand using just the sample liners. This method can be used in cases where the surface soils are soft or where it is advantageous to minimize the disturbance of the sample (such as when sampling for volatiles). Obtaining surface soil samples with this method consists merely of pushing or driving the sample tube into the ground by hand.

The sample liner (with the collected sample inside) is then removed from the ground and capped with Teflon film and plastic end caps. The sample is labeled according to Procedure III-E, *Record Keeping, Sampling Labeling, and Chain-Of-Custody* and immediately placed on ice in a cooler. All liners shall be decontaminated prior to use in accordance with Procedure I-F, *Equipment Decontamination*. Since the only pieces of equipment used are the sample liners, this method helps to minimize the required amount of equipment decontamination.

5.5 VOLATILE ORGANICS SCREENING AND HEADSPACE ANALYSIS

Volatile organics screening and headspace analysis is performed to preliminarily assess if the sample contains VOCs. Volatile organics screening and headspace analysis of samples shall be performed using a portable organic vapor analyzer (OVA), a portable photoionization detector (PID), or other similar instrument.

Volatile organics screening and headspace analysis is intended as a field screen for the presence of VOCs. The method measures the presence or absence of VOCs in the headspace (air) above a soil sample. Various factors affect the level of VOCs volatilizing from soils, such as concentration in the soil, temperature of the soil and air, organic carbon content of the soil, equilibration time, moisture content of the soil, and the chemical and physical characteristics of the VOCs. Therefore, headspace readings can only be regarded as qualitative assessments of volatiles, and caution should be exercised if using this technique to select samples for analytical testing. OVA and PID readings can vary because the two instruments have different sensitivities to the various VOCs and are usually calibrated relative to different gas standards (i.e., methane for the OVA and isobutylene for the PID).

In order to screen samples for VOCs, the instrument probe shall be inserted into the top of the sample liner immediately after the sampler is opened. The instrument response (normally in parts per million) is then recorded in the field notebook and/or the field log.

For headspace analysis, a portion of the sample is transferred into a zipper storage bag or pre-cleaned glass jar, which is then sealed and agitated. The VOCs are allowed to volatilize into the headspace and equilibrate for 15 to 30 minutes. Next, the instrument probe is then inserted into the container to sample the headspace, and the instrument response is recorded in the field notebook and/or the field log.

6. Records

Soil classification information collected during soil sampling should be documented in borehole, trench, and surface soil log forms. All log entries shall be made in indelible ink. Information concerning sampling activities shall be recorded on sample log forms or in the field logbook. The CTO Manager or designee shall review all field logs on at least a monthly basis. Procedures for these activities are contained in this manual. Copies of this information should be sent to the CTO Manager and to the project files.

7. Health and Safety

Field Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

ASTM International (ASTM). 2005. *Standard Guide for Direct Push Soil Sampling for Environmental Site Characterizations*. ASTM D6282-98. West Conshohocken, PA.

———. 2006. *Standard Practice for Rock Core Drilling and Sampling of Rock for Site Investigation.* D2113-06. West Conshohocken, PA.

Department of Defense, United States (DoD). 2005a. *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: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

———. 2005b. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B: Quality Assurance/quality Control Compendium: Minimum QA/QC Activities*. Final Version 1. DoD: DTIC ADA 426957, EPA-505-B-04-900B. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www2.epa.gov/sites/production/files/documents/qaqc_v1_0305.pdf.

———. 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2A: Optimized UFP-QAPP Worksheets*. Revision 1. March.

Department of the Navy (DON). 2007. *Environmental and Natural Resources Program Manual.* OPNAV Instruction 5090.1C. 30 October.

———. 2010. Ammunition and Explosives Safety Ashore. NAVSEA OP 5 Volume 1, 7th Revision, Change 11. 0640-LP-108-5790. Commander, Naval Sea Systems Command. July 1.United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual*. EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-A-6, *Investigation-Derived Waste Management.*

Procedure I-C-1, *Monitoring Well Installation and Abandonment.*

Procedure I-E, *Soil and Rock Classification*.

Procedure I-F, *Equipment Decontamination.*

Procedure I-I, *Land Surveying.*

Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody.*

Procedure III-F, *Sample Handling, Storage, and Shipping.*

9. Attachment

Attachment I-B-1-1: Sampling and Handling Procedure: Analysis of Soil for Volatile Organic Compounds

Attachment I-B-1-1
Sampling and Handling Procedure: Analysis of Soil for Volatile Organic Compounds

1. Laboratory Requirements

The laboratory must be capable of performing (1) United States (U.S.) Environmental Protection Agency (EPA) Solid Waste (SW)-846 Method 5035 and (2) Method 8260, 8021, or 8015 (purgeable hydrocarbons), depending on the project objectives (EPA 2007). The laboratory must have method performance data to verify this capability.

Sampling and handling procedures for the analysis of soil for volatile organic compounds (VOCs) will depend on the project objectives and the sampling approach. The laboratory is responsible for providing the necessary sample containers with preservatives (if applicable) that meet consumable certification requirements. The following section describes the consumable options for VOC soil sampling. In addition, sample containers must have a sample label and be weighed prior to shipment to the field for use. The laboratory is responsible for recording the weight of each container before and after sampling. Alternately, EnCore-type samplers may be employed.

The laboratory must provide a minimum of three prepared containers, or EnCore-type samplers, for each soil sample analyzed for VOCs.

2. Supplies

- Disposable coring devices (hereafter referred to as coring devices): either vendor-calibrated sample coring devices, or EnCore-type samplers. One coring device sampler per sampling location, plus additional coring devices (5 percent) in case of breakage.
- The number and type of laboratory prepared sample containers will depend upon the sampling scheme employed.
- For discrete soil VOCs, two 40 milliliter (mL) volatile organic analyte (VOA) vials with 5 mL of ASTM International (ASTM) Type II water, single-use magnetic stir bar with Teflon lined septa cap, one VOA vial with 5 mLs of methanol with a Teflon lined septa cap, and sample label, or three EnCore-type samplers.
- For incremental soil VOC samples, the total number of sample containers will depend upon the number of increments collected. The laboratory shall provide containers which contain a maximum of 30 mL of methanol (or as dictated by Federal Laws for transporting Exempted Limited Quantities of Dangerous Goods (49 CFR 100-185) with a Teflon lined septa cap, and sample label.
- Reagent/trip blanks: laboratory-prepared in identical fashion to sample vials.
- Temperature blanks: laboratory-prepared.
- 2-ounce glass jars with Teflon-lined lid: for dilution purposes and percent moisture determination.
- Nitrile or equivalent gloves.

3. Field Sampling

The following directions apply to all sampling techniques for soil coring devices: For reasons stated in section 3.4of this attachment and explained in detail in Sections 8.2.1.8 and A7.2 of EPA Method 5035, core-type (i.e., Terra Core, EnCore, etc.) samplers are recommended for sample collection, not sample collection and transport (EPA 2007).

- Always wear clean gloves while handling sample containers to help prevent soil and other debris from adding to the weight of the vial. Always don a new pair of gloves and use a new core sampler for each sampling location.
- Whenever possible, collect the soil samples for VOC analysis in place. If this is not possible, practical, or safe, collect the sample from a sample liner, or if absolutely necessary, from a backhoe bucket. Avoid having particles of soil adhering to the grooves of the screw cap or the container threads.
- Collect VOA samples as quickly as possible to avoid unnecessary VOC losses. EPA Region 9 recommends total exposure of the soil sample to ambient conditions should not exceed 10 seconds.
- Once the soil has been transferred to the sample container, screw the cap back on and mark the sample ID on the label with a ballpoint pen. Do not use a pen that has high solvent concentrations in the ink such as a Sharpie.
- Place the VOA vial inside a cooler containing either wet ice in sealed bags or gel ice.
- Collect the number of sample containers as describe in Section 2 of this standard operating procedure at each sampling location. The same core sampler may be used to prepare all containers. Duplicate samples require collecting additional sample containers. For percent moisture purposes, soil must also be collected in 2-ounce or greater glass jars with Teflon-lined lids at each sampling location. If other analyses are being conducted for the sampling location, then the percent moisture may be obtained from other sample containers. The 2-ounce jar will be completely filled with zero headspace. If other analyses are not being conducted at the sampling location, then an additional sample must be collected in another 2-ounce glass jar for percent moisture.
- When incrementally collecting samples from a liner for non-VOC analysis, a core sampler may be used to obtain equal incremental sample volumes. The liner will have been sliced open prior to incremental sample collection for access to the entire length of the sample.
- Depending on the 1) pre-selected volume to be collected per sample, 2) the sample/liner length available for incremental sampling, and 3) the size of the core tool, collect as many cores from the entire soil sample/liner section that will total to the required sample volume. For example, if 30 grams is the volume to be collected per sample location, the sample/liner length is 6 inches, and a 5 gram core tool is used, then 6 incremental samples, located throughout the sample length to provide adequate, representative coverage of the entire

6 inches of sample, would be collected (i.e., 6 incremental samples could be taken at equally spaced locations across the sample length, totaling 30 grams of sample).

- Collect one equipment blank per laboratory or vendor shipment of Terra Core, as described in Procedure III-B, *Field QC Samples (Water, Soil)*, unless the syringes are certified clean (e.g., certificate of analysis or equivalent documentation) by the vendor.
- Place samples in bubble wrap or other protective covering. Place custody seals on the covering. Custody seals or tape must not be placed directly on the sample vials, as this will interfere with the analytical instrumentation, final weight of the sample, and ultimate sample VOC concentration.

The following additional directions for VOC soil sample collection are taken from EPA SW-846 Method 5035A Appendix A7.0 (EPA 2002).

Collection of Samples for Analysis

After a fresh surface of the solid material is exposed to the atmosphere, the subsample collection process should be completed in the least amount of time to minimize the loss of VOCs due to volatilization. Removing a subsample from a material should be done with the least amount of disruption (disaggregation) as possible. Additionally, rough trimming of the sampling location's surface layers should be considered if the material may have already lost VOCs (been exposed for more than a couple of minutes) or if it might be contaminated by other waste, different soil strata, or vegetation. Removal of surface layers can be accomplished by scraping the surface using a clean spatula, scoop, knife, or shovel (ASTM 2005, Hewitt et al. 1999).

Subsampling of Cohesive Granular but Uncemented Materials Using Devices Designed to Obtain a Sample Appropriate Analysis

Collect subsamples of the appropriate size for analysis using a metal or rigid plastic coring tool. For example, coring tools for the purpose of transferring a subsample can be made from disposable plastic syringes by cutting off the tapered front end and removing the rubber cap from the plunger or can be purchased as either plastic or stainless-steel coring devices. These smaller coring devices help to maintain the sample structure during collection and transfer to the VOA vials, as do their larger counterparts used to retrieve subsurface materials. When inserting a clean coring tool into a fresh surface for sample collection, air should not be trapped behind the sample. If air is trapped, it could either pass through the sampled material causing VOCs to be lost or push the sample prematurely from the coring tool.

The commercially available EasyDraw Syringe, Powerstop Handle, and Terra Core sampler coring devices are designed to prevent headspace air above the sample contents. For greater ease in pushing into the solid matrix, sharpen the front edge of these tools. The optimum diameter of the coring tool depends on the following:

- Size of the opening on the collection vial or bottle (tool should fit inside mouth)
- Dimensions of the original sample, particle size of the solid materials (e.g., gravel-size particles would require larger samplers)
- Volume of sample required for analysis

For example, when a 5-gram (g) subsample of soil is specified, only a single 3-cubic-centimeter (cm^3) volume of soil has to be collected (assuming the soil has density of 1.7 g/cm^3). Larger subsample masses or more subsample increments are preferred as the heterogeneity of the material increases. After an undisturbed sample has been obtained by pushing the barrel of the coring tool into a freshly exposed surface and then removing the filled corer, quickly wipe the exterior of the barrel with a clean disposable towel.

The next step varies depending on whether the coring device is used for sample storage and transfer or solely for transfer. If the coring tool is used as a storage container, cap the open end after ensuring that the sealing surfaces are cleaned. If the device is to be solely used for collection and not for storage, immediately extrude the sample into a VOA vial or bottle by gently pushing the plunger while tilting the VOA vial at an angle (to avoid splashing any deionized water or methanol). The volume of material collected should not cause excessive stress on the coring tool during intrusion into the material, or be so large that the sample easily falls apart during extrusion. Obtain and transfer samples rapidly (<10 seconds) to reduce volatilization losses. If the vial or bottle contains ASTM reagent Type II water, hold it at an angle when extruding the sample into the container to minimize splashing. Just before capping, visually inspect the lip and threads of the sample vessel, and remove any foreign debris with a clean towel, allowing an airtight seal to form.

Devices that Can Be Used for Subsampling a Cemented Material

The material requiring sampling may be so hard that even metal coring tools cannot penetrate it. Subsamples of such materials can be collected by fragmenting a larger portion of the material using a clean chisel to generate aggregate(s) of a size that can be placed into a VOA vial or bottle. When transferring the aggregate(s), precautions must be taken to prevent compromising the sealing surfaces and threads of the container. Losses of VOCs by using this procedure are dependent on the location of the contaminant relative to the surface of the material being sampled. Therefore, take caution in the interpretation of the data obtained from materials that fit this description. As a last resort, when this task cannot be performed on site, a large sample can be collected in a vapor-tight container and transported to the laboratory for subsampling. Collect, fragment, and add the sample to a container as quickly as possible.

Devices that Can Be Used for Subsampling a Non-cohesive Granular Material

As a last resort, gravel, or a mixture of gravel and fines that cannot be easily obtained or transferred using coring tools, can be quickly sampled using a stainless-steel spatula or scoop. If the collection vial or bottle contains ASTM reagent Type II water, transfer samples with minimal splashing and without the spatula or scoop contacting the liquid contents. For some solids, a wide-bottom funnel or similar channeling device may be necessary to facilitate transfer to the container and prevent compromising the sealing surfaces of the container. Take caution when interpreting the data obtained from materials that fit this description. Loss of VOCs is likely due to the nature of the sampling method and the non-cohesive nature of the material, which exposes more surface area to the atmosphere than other types of samples. During the sampling process, non-cohesive materials also allow coarser materials to separate from fines, which can skew the concentration data if the different particle sizes, which have different surface areas, are not properly represented in the sample.

Use of the EnCore Sampler (or Equivalent) for Sample Transport and Storage

The EnCore sampler is a sampling device that can be used as both a simultaneous coring tool for cohesive soils and a transport device to a support laboratory (field or off site). The EnCore sampler is intended to be a combined sampler-storage device for soils until a receiving laboratory can initiate either immediate VOC analysis, or preserve extruded soil aliquots for later VOC analysis. It is meant to be disposed of after use. The commercially available device is constructed of an inert composite polymer. It uses a coring/storage chamber to collect either a 5-gram or 25-gram sample of cohesive soils. It has a press-on cap with hermetically a vapor-tight seal and locking arm mechanism. It also has a vapor-tight plunger for the non-disruptive extrusion of the sample into an appropriate container for VOC analysis of soil.

An individual disposable EnCore sampler (or equivalent) is needed for each soil aliquot collected for vapor partitioning or ASTM reagent Type II water sample preparation. Upon soil sample collection, store the EnCore sampler is at 4 ±2 degrees centigrade (°C) until laboratory receipt within 48 hours. Upon laboratory receipt, soil aliquots are extruded to appropriate tared and prepared VOA vials.

Validation data have been provided to support use of the EnCore sampler for VOC concentrations in soil between 5 and 10 parts per million, for two sandy soils, with a 2-day holding time at 4 ±2°C. Preliminary data (Soroni et al. 2001) demonstrate an effective 2-day (48-hour) holding time at 4 ±2°C for three sandy soil types with VOC concentrations at 100 parts per billion (ppb) (benzene and toluene at 300 ppb), as well as an effective 1- or 2-week holding time at <-7°C (freezing temperature). Recent published work (EPA 2001) neither definitively supports nor shows the EnCore device to be ineffective for sample storage at these preservation temperatures. Soils stored in the EnCore device for 2 calendar days at 4 ± 2°C are subject to loss of benzene, toluene, ethylbenzene, and xylene (BTEX) compounds by biodegradation if the soil is an aerated, biologically active soil (e.g., garden soil) (Soroni et al. 1999), but this BTEX loss is eliminated for up to 48 hours under freezing conditions (Hewitt 1999).

Further details on the EnCore sampler can be found in ASTM D4547-09 (ASTM 2009) or other publications.

Since Naval Facilities Engineering Command, Pacific action levels for VOCs in soil are typically associated with EPA Region 9 preliminary remediation goals for residential exposure scenarios, it is recommended that if EnCore samplers are used, they be frozen on site prior to shipment to the laboratory or extruded into a 40-mL VOA vial before shipment.

4. Sample Shipping and Holding Times

Samples preserved with water may be shipped either at 4 ±2°C or frozen at –7°C. The primary difference between the two shipping temperatures is the allowable holding time of the sample between sample collection and sample analysis. Samples shipped at 4 ±2°C must either be received and analyzed by the laboratory within 48 hours of sample collection or be received by the laboratory within 48 hours, frozen upon receipt, and analyzed within 14 days of sample collection. Samples shipped at –7°C and received/maintained by the laboratory in a frozen state must be analyzed within 14 days of sample collection.

If soil samples are to be field frozen, place the frozen samples in a cooler containing fresh, frozen gel packs or an ice and rock salt mixture, and ship the cooler using an overnight carrier. Dry ice may be used as a refrigerant for sample shipment, but must be coordinated with the overnight carrier in advance. The sample vials and caps must never be placed in direct contact with the dry ice since cracking may occur.

Soil or sediment samples contained in methanol and 2-ounce glass jars may be shipped in standard coolers using conventional shipping protocols described in Procedure III-F, *Sample Handling, Storage, and Shipping*, if the sample appears to have a moisture content that might cause the sample to expand and the glass jar to break due to freezing. If soil samples contained in 2-ounce glass jars are shipped in this manner, then trip blanks must accompany them during shipment.

Reagent/trip blanks that contain the same volume of ASTM Type II water and sample label used in the sample VOA vials must be included in each shipment. The reagent/trip blanks will be packaged, shipped, and analyzed in the same manner as field samples. Reagent/trip blanks will be analyzed to evaluate cross-contamination during shipment and to identify potential reagent contamination issues.

5. Laboratory Receipt

Upon receipt by the analytical laboratory, the sample temperature must be measured and recorded. The laboratory should note whether the samples are frozen. The samples must be logged in and assigned an analysis date to ensure that samples are analyzed within the 14-day holding time.

Once the samples have been logged in, they are placed in a freezer at 0°C or colder until they are analyzed. Samples arriving in a non-frozen state (greater than 0°C) are to be frozen upon receipt or analyzed within 48 hours of sample collection. If the duration of sample shipment exceeds 48 hours, the non-frozen samples should be analyzed on the day of laboratory receipt.

The laboratory will prepare the samples for analysis as dictated by laboratory standard operating procedures and SW-846 Method 5035, and analyzed by Method 8260, 8021, or 8015 (purgeable hydrocarbons), depending on the project objectives.

6. References

49 Code of Federal Regulations (CFR) 100-185. *Hazardous Materials and Oil Transportation*.

ASTM International (ASTM). 2005. *Standard Guide for Direct Push Soil Sampling for Environmental Site Characterizations*. ASTM D6282-98. West Conshohocken, PA.

———. 2009. *Standard Guide for Sampling Waste and Soils for Volatile Organic Compounds.* D4547-09. West Conshohocken, PA.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Environmental Protection Agency, United States (EPA). 2002. *Method 5035A Closed System Purge and Trap and Extraction for Volatile Organics in Soil and Waste Samples*, Draft Revision 1. Office of Solid Waste. July.

———. 2007. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* 3rd ed., Revision 6. Office of Solid Waste. November. On-line updates at: http://www.epa.gov/epawaste/hazard/testmethods/sw846/online/index.htm.

Hewitt, Alan. D. 1999. Frozen Storage of Soil Samples for VOC Analysis. *Environmental Testing & Analysis*, 8 (5), pp. 18–25, 46.

Hewitt, Alan. D. and K. F. Myers. 1999. *Sampling and On-Site Analytical Methods for Volatiles in Soil and Groundwater—Field Guidance Manual*; Special Report 99-16. Hanover, NH: U.S. Army Cold Regions Research and Engineering Laboratory. November.

Soroni, S. S. and J. F. Schaborn. 1999. *Performance of the Disposable EnCore Sampler for Storing Soil for Volatile Organic Analysis*. Proceedings of the 15th Annual Waste Testing and QA Symposium, EPA. Washington. pp. 129-134.

Soroni, S. S., J. F. Schaborn and J. F. Rovani. 2001. *Validation of a New Soil VOC Sampler: Performance of the En Core Sampler for Storage of Low VOC Concentrations and EPA Method 1311 Volatile Organic Analytes*. Topical Report WRI-01-R005; Laramie, WY: Western Research Institute.

Procedure III-B, *Field QC Samples (Water, Soil).*

Procedure III-F, *Sample Handling, Storage, and Shipping.*

Geophysical Testing

1. Purpose

This section sets forth the standard operating procedure for acquiring surface geophysical data to facilitate the collection of geologic, hydrogeologic, and geotechnical data related to hazardous waste site characterization. This procedure is for use by personnel working on the United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

This procedure has been developed to help personnel: (1) determine whether surface geophysics should be used at a site; (2) choose the most applicable methods for a particular objective; and (3) implement proper field procedures. The specific supporting information explaining how various geophysical techniques will be applied shall be defined in the project-specific work plan (WP).

3. Definitions

For a more complete set of terms and definitions, refer to R. E. Sheriff (1991).

3.1 COUPLING

Coupling is the interaction between systems, and includes the following:

- A device for fastening together, as the plugs for connecting electrical cables.
- Aspects, which affect energy transfer. Thus the “coupling of a geophone to the ground” involves the quality of the plant (how firmly the two are in contact) and also considerations of the geophone's weight and base area because the geophone-ground coupling system has natural resonances and introduces a filtering action.
- The type of mutual electrical relationship between two closely related circuits. As coupling would exclude dc voltages by employing a series capacitive element. Direct coupling may exclude higher frequency signals by using a capacitive element across the inputs or may allow all components to pass.

- Capacitive coupling may occur because of mutual capacitive impedance, as between the wires in induced polarization (IP) circuits (see Section 3.6) or between a wire and ground.
- Inductive coupling occurs because of mutual inductive impedance, such as between grounded IP transmitter and receiver circuits, especially at higher frequencies, greater distances, or lower earth resistivity. This may give rise to false IP anomalies. Also called electromagnetic (EM) coupling.
- Resistive coupling in IP surveying is due to leakage between wires, between a wire and ground, or through the resistance of the ground itself between two grounded circuits.

3.2 ELECTRICAL LOG

- A generic term that encompasses all electrical borehole logs (spontaneous potential [SP], normal, lateral, laterologs, induction, microresistivity logs).
- Also used for records of surface resistivity surveying; to compare electrical survey.
- Electrolog, a borehole log, which usually consists of SP and two or more resistivity logs, such as short and long normal and long lateral resistivity logs. Electrolog is a Dresser Atlas trade name.

3.3 ELECTRICAL SOUNDING

Electrical sounding is an IP, resistivity method, or electromagnetic method in which electrode or antenna spacing is increased to obtain information from successively greater depths at a given surface location. Electromagnetic sounding can also be done with a fixed spacing by varying the frequency (time-domain technique). Electrical sounding is intended to detect changes in resistivity of the earth with depth at this location (assuming horizontal layering).

Electrical Survey:

- Measurements at or near the earth’s surface of natural or induced electrical fields to map mineral concentrations or for geological or basement mapping. (See electrical profiling, electrical sounding, electromagnetic method, resistivity method, self-potential method, induced-polarization method, telluric method, and magnetotelluric method).
- Electrical logs run in a borehole.

3.4 ELECTROMAGNETIC METHODS

A method in which the magnetic or electrical fields associated with artificially generated subsurface currents are measured. In general, EM methods are those in which the electric and magnetic fields in the earth satisfy the diffusion equation (which ignores displacement currents) but not Laplace’s equation (which ignores induction effects) nor the wave equation (which includes displacement currents). One normally excludes methods that use microwave or higher frequencies (and that consequently have little effective penetration) and methods that use direct coupling or very low frequencies in which induction effects are not important (resistivity and IP methods). Some methods that employ natural energy as the source, such as Afmag, are usually classified as EM methods, whereas other methods using natural energy, such as the magnetotelluric method, are not.

3.5 GEOPHYSICS

- The study of the earth by quantitative physical methods, especially by seismic reflection and refraction, gravity, magnetic, electrical, and radiation methods.
- The application of physical principles to study the earth. Includes the branches of: (a) seismology (earthquakes and elastic waves); (b) geothermometry (heating of the earth, heat flow, and volcanology and hot springs); (c) hydrology (ground and surface water and sometimes including glaciology); (d) oceanography; (e) meteorology; (f) gravity and geodesy (the earth's gravitational field and the size and form of the earth); (g) atmospheric electricity and terrestrial magnetism (including ionosphere, Van Allen belts, telluric currents); (h) tectonophysics (geological processes in the earth); and (i) exploration and engineering geophysics. Geochronology (the dating of earth history) and geocosmogony (the origin of the earth). These are sometimes added to the foregoing list. Enthusiasts in particular branches are inclined to appropriate the word "geophysics" to their own branch exclusively, whether that branch be ionospheric studies or exploration for oil.
- Exploration geophysics is the use of seismic, gravity, magnetic, electrical, EM, etc., methods in the search for oil, gas, minerals, water, etc., for economic exploitation.

3.6 INDUCED POLARIZATION

- IP is an exploration method involving measurement of the slow decay of voltage in the ground following the cessation of an excitation current pulse (time-domain method) or low frequency (below 100 Hertz) variations of earth impedance (frequency-domain method). Also known as the overvoltage method. Refers particularly to electrode polarization (overvoltage) and membrane polarization of the earth. Also called induced potential, overvoltage, or interfacial polarization. Various electrode configurations are used.
- The production of a double layer of charge at mineral interfaces or of changes in such double layers as a result of applied electric or magnetic fluids.

3.7 LOW-VELOCITY LAYER

- Weathering; a near-surface belt of very low-velocity material.
- A layer of velocity lower than that of shallower refractors (i.e., blind zones).
- The B-layer in the upper mantle from 60 to 250 kilometers deep, where velocities are about 6 percent lower than in the outermost mantle.
- The region just inside the earth's core.

3.8 RESISTANCE

Resistance is the opposition to the flow of a direct current.

3.9 RESISTIVITY

Resistivity is the property of a material that resists the flow of electrical current. Also called specific resistance. The ratio of electric-field intensity to current density. The reciprocal of resistivity is conductivity. In nonisotropic material, the resistivity is a tensor.

3.10 RESISTIVITY LOGS

- Well logs that depend on electrical resistivity, normal, lateral, laterolog, and induction log. Most resistivity logs derive their readings from 10 to 100 cubic feet of material about the sonde. Microresistivity logs, however, derive their readings from a few cubic inches of material near the borehole wall.
- Records of surface resistivity methods.

3.11 RESISTIVITY METHOD

- Observation of electric fields caused by current introduced into the ground as a means for studying earth resistivity in geophysical exploration. The term is normally restricted to those methods in which a very low frequency or direct current is used to measure the apparent resistivity. Includes electrical profiling and electrical sounding. Various array types are used.
- Sometimes includes IP and EM survey methods also.

3.12 SEISMIC SURVEY

Seismic survey is a program for mapping geologic structure by creating seismic waves and observing the arrival time of the waves reflected from acoustic-impedance contrasts or refracted through high-velocity members. A reflection survey is usually implied unless refraction survey is specifically mentioned. The energy source for creating the waves is usually impulsive (i.e., energy is delivered to the earth for a very short period of time) although energy is introduced for considerable time with the Vibroseis method. The energy is detected by arrays of geophones or hydrophones connected to amplifiers, and the information is amplified and recorded for interpretation. The data often are processed to enhance the wanted information (signal) and displayed in record-section form. Signal is recognized as a coherent event, although noise often is coherent also. Events considered to be reflections from acoustic-impedance contrasts (reflectors) are used to locate the reflectors, it being assumed that their attitudes are that of the geologic structure. Events attributed to be head waves are used to locate the refractors of which they are characteristic, it being assumed that the attitudes of these refractors are those of the geologic structure. Velocity analysis is also done on reflection data where the offset varies.

3.13 SELF-POTENTIAL/SPONTANEOUS POTENTIAL

- The direct coupling or slowly varying natural ground voltage observed between nearby non-polarizing electrodes in field surveying. In many mineralized areas, this is caused by electrochemical reaction at an electrically conducting sulfide body.
- A well log of the difference between the potential of a movable electrode in the borehole and a fixed reference electrode at the surface. The SP results from electrochemical SP and electrokinetic potentials, which are present at the interface between permeable beds adjacent to shale. In impermeable shales, the SP is fairly constant at the shale base-line value. In permeable formations, the deflection depends on the contrast between the ion content of the formation water and the drilling fluid, the clay content, the bed thickness, invasion, and bed-boundary effects, etc. In thick, permeable, clean non-shale formations, the SP has the fairly constant sand line value, which will change if the salinity of the formation water changes. In sands containing disseminated clay (shale), the SP will not reach the sand line and a pseudostatic SP value will be recorded. The SP is positive with respect to the shale base line in sands filled with fluids fresher than the borehole fluid.

3.14 TELLURIC

Telluric means of the earth, and often refers specifically to telluric currents.

3.15 TELLURIC CURRENT

Telluric current is a natural electrical earth current of very low frequency that extends over large regions and may vary cyclically in that direction. Telluric currents are widespread, originating in variations of the earth's magnetic field.

4. Responsibilities

CTO Managers are responsible for determining whether surface geophysical methods should be used on a project and if so, which methods should be used. This information should be included in the project-specific WP. The objectives of the geophysical investigation shall be stated explicitly in the subcontract WP. Further, deliverables by the subcontractor shall be clearly identified in the WP so the prime contractor knows what to expect from the subcontractor. The CTO Manager is responsible for ensuring that all personnel involved in sampling and/or testing shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager (FM) is responsible for ensuring that the appropriate selected procedures are conducted according to the instructions in this manual and the project specific sampling plan. In many cases, subcontractors will conduct these procedures. In these situations, the FM is responsible for overseeing and directing the activities of the subcontractor. The need to establish site-specific quality control procedures is particularly important.

Field personnel are responsible for the implementation of this procedure.

5. Procedures

5.1 METHOD SUMMARY

A wide variety of surface-based geophysical methods exist that may apply to contamination delineation, geologic, hydrogeologic, or other site characterization/investigation requirements. In general, geophysical exploration methods provide for a non-invasive mapping of subsurface features through the measurement of the physical properties of a subsurface. Typically, an active signal (e.g., acoustic or electrical) propagates into the earth and the interaction of the signal with the subsurface materials is measured at the surface. Interpretation of the data provides a map or image of the subsurface. For example, electrical conductivity of soil governs the propagation of an electrical signal through the subsurface. The geologic/hydrologic/waste characteristics are then inferred from an interpretation of the data or correlated with borehole data.

For a geophysical survey to be successful, the method of choice must be capable of resolving a particular physical characteristic that relates to the goals of the investigation. For example, if a zone of contaminated groundwater is being investigated by an electrical method, the electrical conductivity of the contaminated portion of the aquifer should be sufficiently different from the uncontaminated portion to allow for identification of the ‘plume’. If the target (i.e., the high-conductivity plume in this example) does not contrast sufficiently with the uncontaminated portion, then the geophysical survey will not be successful. Often, preliminary calculations or a trial survey can be performed to evaluate a particular method.

For purposes of this procedure, the geophysical methods discussed herein are classified as follows:

- *Seismic Methods:* These include seismic refraction and reflection methods and are typically applied to investigate depths to water or geologic structures (stratigraphic horizons or depth to bedrock).
- *Electrical Methods:* A wide variety of these exist including Direct Current (DC) Resistivity, Low-Frequency EM Induction (i.e., loop-loop methods), Very Low Frequency EM, Ground Penetrating Radar (GPR), Complex Resistivity/IP, metal detection equipment, and SP profiling. These respond to variations in the electrical properties of a site, specifically the electrical conductivity and (for GPR) the dielectric/permittivity constant. Applications include general geologic/hydrologic mapping, identification of solute ‘plumes,’ and the detection of conductive metallic debris/objects.
- *Potential Field Methods:* Some methods do not require an active signal source and instead measure naturally occurring potential fields of the earth. These include measurements of the earth’s magnetic or gravitational fields. Magnetic methods are often used to detect the response of the earth's magnetic field to metallic objects and can be very effective in locating buried metallic materials. Gravity methods respond to subtle density variations and are typically used to map the depth/thickness of alluvial basins or to detect cavities within consolidated sediments (e.g., Karst sinkholes).

While a number of geophysical methods may be applied at hazardous waste sites, the scope of this procedure is limited to the following commonly applied methods:

Seismic:	Refraction
Electrical:	DC Resistivity
	EM Induction (Loop-Loop)
	GPR
	Metal Detection
	IP
	SP Profiling
Potential Field:	Magnetics

Often, geophysical contractors specialize in a particular survey method. The following references may be useful to provide additional information:

Dobrin, M. B. and C. H. Savit. 1988. *Introduction to Geophysical Prospecting*. McGraw-Hill.

Journals: Geophysics (Society of Exploration Geophysics); Geophysical Exploration European Association of Exploration Geophysicists; occasionally - Groundwater, Groundwater Monitoring Review (National Water Well Association).

Sheriff, R. E. 1991. *Encyclopedic Dictionary of Exploration Geophysics*. Society of Exploration Geophysics.

Telford, W. M., L. P. Geldart, R. E. Sheriff, D.A. Keys. 1998. *Applied Geophysics*. Cambridge University Press.

5.2 METHOD LIMITATIONS/INTERFERENCES AND POTENTIAL PROBLEMS

Each of the geophysical methods discussed herein are typically designed and implemented on a site-specific basis. Exercise care to ensure that a particular method is applicable and that an identifiable target is likely to exist. A determination must be made that the exploration target can be resolved versus the background signal/site conditions and that cultural or other 'noise' problems will not interfere. 'Cultural Noise' is defined as near-surface or surficial features (e.g., power lines or traffic vibrations) that can potentially mask or overwhelm the signal produced by the subsurface target.

All of the survey methods require field instrumentation and electronics that might be impacted by extreme climactic variations. Check the equipment regularly (daily, at a minimum) to ensure internal calibration. Review the manufacturers' guidelines and specifications prior to field application.

5.2.1 Seismic Method Limitations and Potential Problems

5.2.1.1 REFRACTION SURVEYS

Care should be exercised in avoiding the following potential problems:

- Poorly emplaced geophones (e.g., in loose soil)
- Poor couplings of induced signal (e.g. strike plate) with ground
- Intermittent electrical shorts in geophone cable (never drag geophone cables)
- Wet geophone connections
- Vibration due to wind and traffic-induced noise
- Improper gain/filter settings
- Insufficient signal strength
- Topographic irregularities (an accurate topographic survey is often required prior to field operations)

5.2.2 Electrical Method Limitations and Potential Problems

5.2.2.1 DC RESISTIVITY

Measurement of electrical resistivity represents a bulk average of subsurface material resistivity. In some instances, the resistivity of the target material may not contrast sufficiently with 'background' material to be observed with this method, especially as the target material gets thinner and/or deeper. If highly conductive soil/rock are present at shallow depths, electrical current may not penetrate to depths beyond this layer. An electrical current always follows the path of least resistance.

Care should be exercised in avoiding the following potential problems:

- Poorly coupled electrodes (insufficient grounding)
- Unshielded wires causing intermittent shorts
- Background electrical noise, such as natural currents (SP or telluric effects)
- EM coupling with power lines, causing the introduction of induced electrical currents into the receiver wire
- Grounded fence lines and power lines interfering with the survey
- Inadequate signal power (increase current levels to produce sufficient signal to noise ratios)
- Very low resistivity layer at the surface preventing the electrical field from penetrating deeper layers
- Very high resistivity layer at the surface (e.g. dry sandy gravel) preventing the electrical field from penetrating the surface layer

5.2.2.2 EM METHOD

A variety of EM methods may be applied; however, in practice, the Geonics EM31-MK2 and EM34-3 Loop-Loop instruments are usually used in hazardous waste surveys. The EM methods are similar to DC methods in application and are sensitive to conductive materials, except for the basic distinction that they are not electrically grounded. Complications may arise in the EM method in developed sites because aboveground, metallic objects or electrical fields may interfere. Power lines, automobiles, train tracks, water tanks, and other objects may completely dominate data results and render the method useless.

5.2.2.3 GPR METHODS

GPR methods are seldom useful where highly conductive conditions or clay is present at shallow depths. The high-frequency signal propagates as a function of both electrical conductivity and dielectric constant (permittivity). The selection of transmission frequency is important because high frequencies are rapidly attenuated and the signal may not penetrate. Often, a choice of frequencies is available and it is suggested to perform site-specific field tests over known, observable targets to determine whether GPR is appropriate for use.

Care should be exercised in avoiding the following potential problems:

- Improperly adjusted/configured equipment (e.g., antenna gain, filter slopes or gain thresholds)
- Insufficient signal and/or poor transmission qualities of the materials found at a site (e.g. clay, saline water conditions)
- The influence of reflected signals outside of the immediate zone of investigation upon the radar record (e.g., fences, power poles, buildings)

5.2.2.4 METAL DETECTION

Metal objects that are not survey targets, including those worn or carried by the operator, might interfere with measurements.

5.2.3 Potential Field Method Limitations and Problems

5.2.3.1 MAGNETICS

The signal measured by a magnetometer varies with time and is subject to variations induced by solar storms. Care should be exercised in avoiding the following potential problems:

- Metal objects that are not survey targets, such as those worn or carried by the operator and surficial metallic objects, interfering with measurements
- Lack of base station control to measure background field fluctuations
- Failure to maintain a constant sensor height with respect to ground elevation

5.3 SURVEY DESIGN/PRE-FIELD PREPARATION

5.3.1 Survey Design

Prior to performing a field investigation, it is often possible to estimate the effectiveness of a surface geophysical survey by using data interpretation software relevant to the survey or by other calculation methods. A sensitivity analysis is usually performed to determine if a geophysical target possesses sufficient contrast with background conditions to be detected using surface geophysics. In some instances, available site data or prior geophysical investigations may be available to obtain estimates of the geophysical characteristics of the site.

5.3.2 Field Preparation

- Verify that the required geophysical equipment is pre-calibrated and operational.
- Establish grid locations or set up traverses for location of sampling stations.
- Survey the station locations and record them on a scaled site plan.
- Test and calibrate geophysical equipment.

5.4 FIELD PROCEDURES

The following procedures apply to geophysical surveys conducted at a hazardous waste site. Procedures may vary since equipment capabilities and methodologies are rapidly evolving. In general, survey field locations, accurately record them, and ensure that the equipment is functional and calibrated. Typically, a control or base station location will be established to check the equipment response over the duration of the field investigation. In addition, ensure a high signal to noise ratio can be maintained to obtain a geophysical response representative of the target/zone of interest.

5.4.1 Seismic Refraction Methods

Use seismic refraction techniques to determine the structure of a site based upon the travel time or velocity of seismic waves within layers. Interpretation of the travel time variation along a traverse of geophones can yield information regarding the thickness and depth of buried strata. Seismic methods are often used to determine depths to specific horizons of contrasting seismic velocities, such as bedrock, clay layers, or other lithologic contrasts, and the water table (under unconfined conditions).

Procedures

- Check the seismic signal and noise conditions on the instrument to verify the proper functioning of geophones and cables and to check the instrument settings.
- When the seismic field equipment does not produce hard copies of seismic records, immediately plot the arrival time selected from the electronic display on a time/distance graph in the field. Produce a hard copy of the data, and keep it in the record file. Problems with improper picks are often discovered by early inspection of these plots.
- Background or offsite data may be required for correlation to site conditions. Correlation of the seismic data with electrical method results, if obtained, or with borehole or outcrop data, may be a useful means of assigning thickness or seismic velocities.
- If possible, analyze boring logs or other data to determine if low velocity (inverse layers) or thin beds may be present that might not be detected otherwise.
- Run the seismic system at a known standard base station for periodic checks of instrument operation.
- Properly store the data in digital form for subsequent processing and data evaluation.

5.4.2 Electrical Methods

5.4.2.1 DC RESISTIVITY

The resistivity method provides a measurement of the bulk electrical resistivity of subsurface materials. Application of the method requires that a known electrical current be induced into the ground through a pair of surface electrodes. Measure the resulting potential field (voltage) between a second pair of surface electrodes. Evaluate the subsurface electrical properties based on the current, voltage, and electrode position (array configuration).

Given the length of the wire cables, their connections to the electrodes, and the coupling of the electrodes with the ground, there are a number of potential problems for obtaining reliable data (e.g., poor electrical contact, short and open circuits). These conditions can be minimized by careful observation of instrument readings and trends.

Procedures

- Calculate and plot apparent resistivities during field acquisition as a means of quality control. If vertical electrical sounding is performed, the data plots (curves) should be smooth, and discontinuous jumps in the data should not occur. Profiling data should also show a general trend in the data from one station to the next; however, abrupt changes may occur in both sounding and profiling data due to “noise” from near-surface inhomogeneities or electrode contact problems.
- The resistivity instrument can be calibrated using standard resistors or by using the internal calibration circuits often contained within the equipment. Calibration is particularly important if the data are to be compared to resistivity measurements from other instruments or other parameters, such as specific conductance of water samples.

5.4.2.2 EM METHODS

EM methods provide a means of measuring the electrical conductivity of subsurface soil, rock, and groundwater. Electrical conductivity (the inverse of electrical resistivity) is a function of the type of soil, porosity, permeability, and the conductivity of fluids in the pore spaces. The EM method can be used to map natural subsurface conditions and conductive contaminant plumes. Additionally, trench boundaries, buried conductive wastes, such as steel drums, metallic utility lines, and steel underground storage tanks, might potentially be located using EM techniques.

Following factory calibration, the instruments will normally retain their accuracy for long periods; however, the user should establish a secondary standard area at the field site for periodic recalibration. This will provide a reference base station to check “drift” in the instrument’s performance and to permit correlation between instruments.

While precision can be easily checked by comparing subsequent measurements with the instrument at a standard site, accuracy is much more difficult to establish and maintain.

EM instruments are often used to obtain relative measurements. For these applications, it is not critical to maintain absolute accuracy; however, the precision of the instrument can be important. For example, in the initial mapping of the spatial extent of a contaminant plume, a moderate level of precision is necessary. If the same site is to be resurveyed annually to detect small changes in plume migration and movement, a very high level of precision is necessary.

If the objective of the survey is to obtain quantitative results from the EM data for correlation to other measurable parameters (e.g., specific conditions), proper steps should be taken to ensure good instrument calibration. This is particularly important when performing surveys in areas of low conductivity, where measurement errors can be significant.

The dynamic range of EM instruments varies from 1 to 1,000 millimhos/meter (mmho/m). At the lower conductivities, near 1 mmho/m and less, it is difficult to induce sufficient current in the ground to produce a detectable response; hence, readings may become unreliable. At conductivity values greater than about 100 mmho/m, the received signal is no longer linearly proportional to subsurface conductivities, and corrections must be applied to the data, if it is to be used for quantitative purposes.

Procedures

- Maintain or verify calibration records from the equipment supplier or manufacturer. Calibrate the EM system regularly.
- Prior to conducting a survey, select a temporary site on location for daily calibration checks. Conduct calibration checks twice daily, before and after conducting daily survey operations. Readings shall repeat to +/-5 percent. Originals of all calibration records shall remain on site during field activities, and copies shall be submitted to the records file. The original calibration records shall be transferred to the project files upon completion of the fieldwork.

  Note: Conduct calibration checks outside the influence of power lines, buried utilities, buried metal objects, fences, etc. on a relatively flat surface.

- The field operating party shall check instrument stability when there is local or distant thunderstorm activity. EM radiation from thunderstorms can generate noise in the EM system. It may be necessary to postpone operations during rainstorms and resume them when they have passed.
- Exercise technical judgment such that conductivity readings recorded in the field are reasonable with respect to existing site conditions.
- Record instrument sensitivity settings in the field notebook as readings are taken. Submit the notebook to the records file.

5.4.2.3 GPR

GPR uses high frequency radio waves to acquire subsurface information. Energy is radiated downward into the subsurface through a small antenna, which is moved slowly across the surface of the ground. Energy is reflected back to the receiving antenna, where variations in the return signal are continuously recorded. This data produces a continuous cross sectional “picture” or profile of shallow subsurface conditions. These responses are caused by radar wave reflections from interfaces of materials having different electrical properties. Such reflections are often associated with natural hydrogeologic conditions, such as bedding, cementation, moisture content, clay content, voids, fractures, and intrusions, as well as manmade objects. The radar method has been used at numerous hazardous waste sites to evaluate natural soil and rock conditions, as well as to detect buried wastes and buried metallic objects.

The radar system measures two-way travel time from the transmitter antenna to a reflecting surface and back to the receiver antenna. Calibration of the radar system and data requires a two-step process:

- First, accurately determine the total time window (range) set by the operator.
- Second, determine the EM velocity (travel time) of the local soil-rock condition.

After completing these two steps, the radar data may then be calibrated for depths of particular features.

Calibrate the time window (range) that has been picked for the survey by using a pulse generator in the field. This generator is used to produce a series of time marks on the graphic display, measured in nanoseconds. These pulses are counted to determine the total time range of the radar. A calibration curve can be made up for each radar system.

In order to precisely relate travel time to actual depth units, determine the velocity (or two-way travel time per unit distance) for the particular soil or rock found at the site.

Various levels of accuracy in determining travel time can be used. These may range from first order estimates to precisely measured onsite values.

Using the depth of a known target (trenches, road cuts or buried pipes/road culverts can provide a radar target of known depth), a radar record taken over the known target, and a time scale provided by the pulse generator will provide basic calibration record. From these data, a two-way travel time can be accurately determined at the given target location. Because this approach may give accurate calibration at the specific site, it must be assumed that conditions in other areas to be surveyed are the same as in the calibration areas. If they are not, errors will occur in determining depths.

If significant changes in soil type or moisture content occur with depth, travel time will not be the same throughout the vertical radar profile, and the vertical radar depth scale may be non-linear. Such a condition is common, and occurs whenever an unsaturated zone exists over a saturated zone.

Procedures

- Check the time scale of the GPR unit regularly for accuracy. This can be done either on or off the site by placing the GPR unit at a known distance from the ground, a wall, etc., and measuring the two-way travel time to that reflecting surface in the air. The velocity of electromagnetic waves in air is 1 foot per nanosecond (3×10^8 meters per second). The following equation shall be used:

  $$t = 2d/c$$

  Where:

  t = two-way travel time from antenna to the surface (nanoseconds)
  d = distance of antenna to the surface (feet)
  c = velocity of light in air, (1 foot/nanosecond)

- Prior to conducting a survey, conduct a GPR traverse over a buried object of known depth (if available). From the two-way travel time and the measured burial depth of the object, the average electromagnetic wave velocity in soil can be calculated from the following equation:

  $$V = 2d/t$$

  The average dielectric constant of the soil is then calculated using:

  $$Er = c^2/v^2$$

  Where:

  Er = average relative dielectric constant of soil (unitless)
  c = velocity of light in air (1 foot/nanosecond)
  v = average electromagnetic wave velocity of the soil (feet/nanosecond)

  Note: The equation above assumes a soil with a relative magnetic permeability of 1. Exercise technical judgment such that soil velocity and relative dielectric constant values are reasonable with respect to existing site conditions.

- A short GPR traverse shall be repeated twice daily over a known feature prior to and after conducting daily operations. Exercise technical judgment to ensure that variations between repeat readings are due to changing soil conditions rather than the electronics.

5.4.2.4 METAL DETECTION - MAGNETOMETERS

Magnetometers are designed to provide measurements of the earth’s magnetic field. In hazardous waste site investigations, magnetometers are invaluable for detecting buried drums and for delineating the boundaries of areas containing ferrous metallic debris.

Procedures

- Check the proposed date of the magnetic survey for solar flares to ensure that anticipated background conditions do not occlude data collection (Bureau of Standards, Boulder, CO, Goldendale, WA).
- Obtain a daily background reading in the immediate vicinity of the site to be surveyed. This reading should be outside the influence of all sources of cultural magnetic fields (e.g., power lines, pipeline). Exercise technical judgment such that the background reading is reasonable with regard to published data for the total magnetic field intensity at the site latitude and longitude. This daily background reading should repeat to within reasonable diurnal variations in the earth's magnetic field.
- Take sequential readings twice daily, before and after normal magnetic surveying operations. Take these readings (within 10 seconds of each other) at any location on site, distant from cultural magnetic fields, and record them in the field notebook. Two or three sequential readings should be sufficient. In the absence of magnetic storms (sudden and violent variations in the earth’s magnetic field), the readings should compare within 0.1 to a few tenths of a gamma. Variations during magnetic storms may approach 1 gamma.
- Take base station readings so that the efforts of diurnal variation in the earth's magnetic field may be removed from the data. Magnetic storms can be detected if the base station sampling frequency is high enough. It may be necessary to postpone operations during magnetic storms and resume them when they have passed. Identification of such periods of rapid synoptic variation may be documented at a permanent base stations set up on site where continuous readings are automatically recorded every 10 to 15 minutes. Alternatively, readings may be manually recorded at base stations during the survey every 45 to 60 minutes.
- Use of automatic recording magnetometers requires recording the magnetometer readings for the first and last station of each traverse in a field notebook. At the end of the day, compare the data recorded in the field notebook with data from the automatic recording device. Data recorded in the field notebook should be within 1 gamma of the values derived from the recording device. It is recommended to transfer the data onto hard copies from the recording device on a daily basis.

Total field measurements may be corrected for these time variations by employing a reference base station magnetometer; changes in the earth's field are removed by subtracting fixed base station readings from the moving survey data. Gradiometers do not require the use of a base station, as they inherently eliminate time variation in the data.

5.4.2.5 SP PROFILING

This method is different from other electrical techniques in that no artificial current source is used to inject a signal into the ground; only the naturally occurring voltage potentials are measured between surface stakes. These natural voltages are produced by chemical oxidation reactions between groundwater and different soil and mineral types.

SP equipment consists of a digital, high-impedance volt meter; two porous pot electrodes; and cables. SP equipment should have a resolution of at least ±2 millivolts (mv) and accuracy within ±10 mv.

Procedures

- Calibrate equipment per the manufacturer's specifications. At a minimum, calibrate the equipment twice daily, once prior to beginning operations and once at the end of daily operations. Record calibration results in the field log.
- Each SP station shall be identified with a unique number and located on a site layout drawing. Record profiling results for each station using a field data form that includes the time of each measurement. Annotate the form to show any natural or cultural features near or between the SP stations.
- Establish a base station for the purpose of measuring instrument drift during the SP profiling activities. Take the instrument to the base station routinely during the day, and obtain readings from one location at the base station. Obtain base station readings at the beginning and end of each day and at interim intervals not exceeding 4 hours in duration.
- Reduce data by adjusting measurements obtained for instrument drift. Base station readings are plotted as a separate curve from profiling station measurements. The drift is interpolated (straight line) between base station readings as a function of time and the appropriate drift correction is subtracted from each profiling station measurement. Reduced data are used for interpretation.
- Interpret data by plotting reduced data (either for linear cross-sections of the study area or as surface contours over the study area surface). Anomalies are identified from these plots, and inferences regarding their sources are developed.

5.4.3 Post-Operations

Geophysical personnel working at a site should follow standard hazardous waste site protocols. In many cases, the geophysical survey may precede services that may result in personnel contact with hazardous waste/materials. Geophysical personnel at all sites should follow standard hazardous waste site decontamination procedures.

5.5 DATA REDUCTION/DATA INTERPRETATION

Geophysical surveys typically require significant data reduction and processing. The exact methodology depends upon the purpose, scope, and type of survey.

Data interpretation and presentation reports should include the following:

- Data reduction technique
- Data processing steps
- Technical basis for data processing

- Survey location data
- Site base map showing survey location or transects
- Dates and times of survey
- Interpretation results
- Theoretical assumptions for the interpretation
- Equipment used
- Data format (digital format, ASCII, SEG B.,)

5.6 QUALITY ASSURANCE/QUALITY CONTROL

The following QA procedures apply to all geophysical instrumentation and their use during data acquisition.

- Document all data transmittals on standard forms supplied by the geophysical subcontractor. Copies of these forms will be maintained with the field files on site.
- Operate geophysical instrumentation in accordance with operating instructions supplied by the manufacturer, unless otherwise specified in the work plan.
- Monitor battery voltage levels for all instruments each day throughout the survey. Charge or replace battery packs when voltage levels fall below the recommended level specified by geophysical equipment manufacturers.

6. Records

The FM is responsible for documenting all field activities in the field notebook. The FM should also oversee all subcontractor activities and ensure that their documentation is complete. The specific procedures used in the field shall be documented in the site characterization report or similar deliverable.

7. Health and Safety

Field Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

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: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Dobrin, M. B. and C. H. Savitt. 1988. *Introduction to Geophysical Prospecting*. McGraw-Hill.

Sheriff, R. E. 1991. *Encyclopedic Dictionary of Exploration Geophysics*. Tulsa, OK: Society of Exploration Geophysics.

Telford, W. M., L. P. Geldart, R. E. Sheriff, D. A. Keys. 1998. *Applied Geophysics*. Cambridge University Press.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual*. EM-385-1-1. Includes Changes 1–7. 13 July 2012.

9. Attachments

None.

Monitoring Well Installation and Abandonment

1. Purpose

This standard operating procedure describes the methods to be used by the United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel during the installation of groundwater monitoring wells. It describes the components of monitoring well design and installation and sets forth the rationale for use of various well installation techniques in specific situations.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 FILTER PACK

Filter pack is sand or gravel that is smooth, uniform, clean, well-rounded, and siliceous. It is placed in the annulus of the well between the borehole wall and the well screen to prevent formation materials from entering the well and to stabilize the adjacent formation.

3.2 ANNULUS

The annulus is the downhole space between the borehole wall and the well casing and screen.

3.3 BRIDGE

An obstruction in the drill hole or annulus. A bridge is usually formed by caving of the wall of the well bore, by the intrusion of a large boulder, or by filter pack materials during well completion. Bridging can also occur in the formation during well development.

3.4 GROUT

Grout is a fluid mixture of cement and water that can be forced through a pipe and emplaced in the annular space between the borehole and casing to form an impermeable seal. Various additives, such as sand, bentonite, and polymers, may be included in the mixture to meet certain requirements.

3.5 SIEVE ANALYSIS

Sieve analysis is the evaluation of the particle-size distribution of a soil, sediment, or rock by measuring the percentage of the particles that will pass through standard sieves of various sizes.

4. Responsibilities

CTO Managers are responsible for issuing WPs that reflect the procedures and specifications presented in this procedure. Individual municipalities, county agencies, and, possibly, state regulatory agencies enforce regulations that may include well construction and installation requirements. The CTO Manager shall be familiar with current local and state regulations, and ensure that these regulations are followed. Regulations are subject to constant revision. Every effort should be made to stay informed of these changes through contact with the agencies that oversee work in specific project areas, prior to initiation of field activities. The CTO Manager or designee shall review all well construction logs on a minimum monthly basis. The CTO Manager is responsible for ensuring that all personnel involved in monitoring well installation and abandonment have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager (FM) is responsible for direct supervision of the installation of monitoring wells and ensuring that procedures and specifications are implemented in the field. The qualifications for the FM include a degree in geology, hydrogeology, civil/geotechnical/environmental engineering, or equivalent with at least 2 years of field experience in the installation of monitoring wells.

Field sampling personnel are responsible for the implementation of this procedure.

The onsite geologist/hydrogeologist/engineer is expected to obtain a description of the lithologic samples obtained during the excavation and construction of a monitoring well. These data are often required to provide guidance regarding the installation of specific components of the monitoring well. Guidance for lithologic sample collection and sample description is contained within Procedure I-B-1, *Soil Sampling.*

5. Procedures

5.1 CONSIDERATIONS FOR MUNITIONS AND EXPLOSIVES OF CONCERN

Potential Munitions and Explosives of Concern (MEC) hazards may be encountered in any area formerly or currently occupied or used by the Department of Defense (DoD). MEC hazards may occur on the ground surface, in the subsurface, and within bodies of water, and may not always be readily observable, or identifiable. As a result, whether or not munitions-related activities ever occurred on the specific work area or within waters in which Navy operations/activities will take place, special care should always be taken when conducting field operations, especially intrusive activities, in the event that MEC may be encountered.

If the site is currently recognized as belonging in the Military Munitions Response Program and has a current, Naval Ordnance Safety and Security-accepted, site-specific Explosives Safety Submission

(ESS) (per DON 2010), then field activities, especially intrusive activities, shall adhere to the safety procedures outlined within the ESS.

If suspected MEC is encountered on an active DoD installation, immediately notify your supervisor, DoD Point of Contact, and installation Point of Contact, who will contact and facilitate military Explosive Ordnance Disposal response.

5.2 BACKGROUND INFORMATION

The primary objectives of installing a monitoring well at a site are: to observe groundwater levels and flow conditions; to obtain samples for determining groundwater quality; and to evaluate the hydraulic properties of water-bearing strata. To achieve these objectives, it is necessary to satisfy the following criteria:

- Construct the well with minimum disturbance to the formation.
- Construct the well with materials that are compatible with the anticipated geochemical environment.
- Properly complete the well in the desired zone.
- Adequately seal the well with materials that will not interfere with the collection of representative water samples.
- Sufficiently develop the well to remove drilling fluids or other additives or conditions associated with drilling, and provide unobstructed flow to the well.

The proper design and construction of monitoring wells requires an understanding of site geology and hydrogeology, and knowledge of contaminant transport in subsurface materials.

A significant difference between monitoring wells and production or “water” wells is that the intake section of monitoring wells is often purposely completed in a zone of poor water quality and/or poor yield. The quality of water entering a monitoring well can vary from drinking water to a hazardous waste or leachate. In contrast, production wells are normally designed to efficiently obtain water from highly productive zones containing good quality water. The screen of a monitoring well often extends only a short length (typically 10 feet or less) to monitor hydraulic conditions within, and obtain water samples from, selected water-bearing intervals. In contrast, water wells are often designed to obtain economic quantities of water from multiple zones of water-bearing strata.

5.3 MONITORING WELL DESIGN CONSIDERATIONS

The following information was compiled from a number of technical references. For additional information related to monitoring well installation, consult the references listed in Section 8.

5.3.1 Well Placement

Select the location of a monitoring well according to the purpose of the monitoring program, which will vary among different sites and may include detection of contaminants in groundwater, verification of contaminant migration predictions, the monitoring of leachate at a landfill site, or remediation of a contaminated site. Each of these purposes will require a specialized array of monitoring locations and completion intervals, and a specific sampling program. Therefore, design the monitoring well network to satisfy the needs of the particular situation.

Determine the position of a monitoring well in a contaminant flow path for a monitoring effort based on the interpretation of preliminary data. These data shall be sufficient to facilitate identification of potential contaminant sources. Also consider site history, topography, climate, surface hydrology, and the location of nearby pumping wells.

Design the layout of the groundwater monitoring network following preliminary evaluation of the approximate direction of groundwater flow. A minimum of three wells is necessary to estimate local hydraulic gradients. Ideally, at least one well will be located hydraulically upgradient, and two or more wells strategically located hydraulically downgradient of each potential contaminant source. Determination of the horizontal and vertical extent of a contaminant plume is often an iterative process requiring the installation and sampling of wells in several phases.

Install monitoring wells hydraulically downgradient and as close as physically possible to the areas of suspected contamination in order to immediately detect releases from a hazardous waste site. Locate additional monitoring wells based on the interception of potential groundwater flow paths and direction of contaminant migration.

The placement of groundwater monitoring wells shall also consider the three-dimensional nature of groundwater flow. Significant vertical gradients and heterogeneous and/or anisotropic hydraulic conditions may exist at a site. Thus, the direction of groundwater flow may not necessarily coincide with the apparent horizontal gradient observed by the triangulation provided by three monitoring wells. Determine the completion intervals of existing wells prior to the calculation of groundwater gradient directions. Consider temporal/seasonal groundwater flow conditions if the monitoring well network is located near existing active well fields, near tidal zones, or near ephemeral surface water (e.g., canals, dry river beds).

5.3.2 Well Depth and Screened Interval

A detailed understanding of the site stratigraphy, including both horizontal and vertical extent of geologic formations, is necessary to identify zones of different permeabilities, and discontinuities, such as bedding planes, fractures, or solution channels. Groundwater flow and/or contaminant transport beneath the site preferentially occur in the more permeable zones. Equally important is the identification of relatively low permeability zones that may impede migration of contaminants. The occurrence and movement of groundwater in the subsurface is closely related to lithology. Thus, geologic conditions will influence the location, design, and methods used to locate and install monitoring wells.

The depth of a monitoring well is determined by the depth of one or more water-bearing zones that are to be monitored. For example, if preliminary soil borings indicate that multiple water-bearing zones are present at a site, and it is believed that zones other than the uppermost zone may be impacted by surface contamination, a well should be completed in each individual water-bearing zone encountered. Where two or more saturated zones occur beneath a site, and the intent of the monitoring program is to monitor water quality in the lower zone, the monitoring well will generally require surface casing to isolate the upper water-bearing zone from the deeper zone prior to drilling into the deeper zone.

In multiple aquifer systems, highly variable conditions may occur. For example, an overlying unconfined aquifer may be contaminated, whereas the underlying confined aquifer may not contain contaminants. Exercise extreme care to ensure that the installation/completion of monitoring wells does not cause cross-contamination of the aquifers. In these cases, it may be preferable to install surface casing through the contaminated aquifer to minimize the possibility of cross-contamination to the lower aquifer system.

Characteristics of lithologic materials encountered at the site, such as the degree of consolidation and grain size, also influence the type of well completion. In unconsolidated alluvial deposits, screened well intakes are typically used. An emplaced filter pack, consisting of well-sorted, clean, inert silica sand with a grain size and well screen slot size appropriate for the formation, typically is used to filter out fine-grained materials present within formations encountered in the borehole. Where permeable, consolidated formations are present, casing may be extended through overlying unconsolidated deposits and the well may be completed with a section of open borehole in the consolidated water-bearing zone. Even in these cases, however, fine-grained materials may enter the well through fractures, and if severe enough, an artificial filter pack and screened intake may be required. Also, many regulatory agencies require a screened interval installed with filter pack for all well completions.

Placement of the screened interval depends primarily on two factors: the interval to be monitored and the type of contaminants. The desired interval to be monitored shall dictate the interval to be screened. Determine which stratigraphic horizons represent potential pathways for contaminant migration by the site characterization. Short screened sections provide more specific data on the vertical distribution of contaminants and hydraulic head, while long screen intervals can result in a cumulative dilution of contamination in one zone with uncontaminated groundwater in another zone, as well as less specific information on hydraulic head. In addition, a long screened interval could potentially create vertical conduits that might result in cross-contamination.

Consider the type of contaminants involved prior to well installation. Contaminants that have a density less than water migrate differently than contaminants with a density equal to or greater than water. For example, if the contaminant in an unconfined aquifer has a density lower than water, such as diesel or gasoline, it is important to ensure that the screened interval of the well extends above the maximum seasonal elevation of the water table. Doing so facilitates an accurate determination of apparent thickness of free product in a monitoring well. In general, the screen shall extend 3 to 5 feet above the highest anticipated level of the water table when monitoring the upper portions of an unconfined aquifer.

Conversely, if the contaminant of concern has a density higher than water, such as trichloroethene (TCE), the screened interval of one or more monitoring wells should be installed just above the lower confining bed of a potentially impacted aquifer. TCE may be transported at high concentrations as a dense, nonaqueous phase liquid (DNAPL) near the source area, and migrate along the top of a confining bed at the base of an impacted aquifer.

Give special attention to interpretation of site stratigraphy when assessing DNAPL, particularly with respect to dipping beds, as it is possible for DNAPLs to effectively move hydraulically upgradient if low permeability perching horizons dip in a direction opposite the hydraulic gradient. This type of situation is important to consider when selecting monitoring well locations.

If time and budget allow, correlate conventional borehole geophysical methods and continuous cores of soil samples to yield a more complete stratigraphic characterization. A continuous profile of borehole conditions is compared to field observations and is used to select screened intervals.

5.3.3 Well Permitting

All wells shall be permitted in accordance with the regulations of the jurisdiction where well installation is occurring, if this is Navy policy for the region of activity. Contact local authorities prior to establishing well construction requirements for the project.

The permit procedure may require permit fees, site inspections, and an application signed by a registered professional geologist or engineer. Permit requirements may impact field schedules and budgets. The driller may also be required by law to be licensed and bonded. Provide documentation that all legal requirements have been met to the appropriate agencies prior to the installation of a monitoring well.

5.4 SELECTION OF DRILLING METHOD

Monitoring well installation at hazardous waste sites may involve drilling through or near hazardous materials, in areas where the extent of contamination is unknown, or through more than one geologic material or aquifer. Use of any drilling method at a hazardous waste site involves an element of risk related to the potential spread of contamination or creation of a pathway through which contaminants can migrate. Selection of a method most appropriate for site-specific conditions is essential to minimize these risks. Table I-C-1-1 provides an interpretation of how geologic conditions may influence the selection of a particular drilling method.

Most drill rigs use gasoline or diesel fuel, as well as hydraulic fluid during operation. Because these fluids are all potential contaminants, it is important to protect the drill hole and immediate area from these substances. Whenever leaking fluid from the drill rig is detected, drilling operations shall cease as soon as practical following stabilization of the drill stem, and the rig shall be moved to a safe area to be repaired.

Table I-C-1-1: Relative Performance of Different Drilling Methods in Various Types of Geologic Formations; Commonly Utilized Drilling Methods

Type of Formation	Auger-Hollow Stem	Rotary Bucket Auger*	Rotary with Fluids (foam, mud)*	Air Rotary	Air Rotary with Casing Hammer	Down the Hole Air Hammer	Dual Tube/ Casing Hammer	Coring	Reverse Rotary with Fluids*	Reverse Rotary with Dual Tube	Direct Push **
Loose sand and gravel	G	P	P-G	NR	E	NR	E	NR	P-E	E	E
Loose boulders in alluvium	P	P-G	G	NR	E	NR	P	NR	P	G	NR
Clay, silt	E	G	E	NR	E	NR	E	P-G	E	E	G
Shale	P	NR	E	P	E	NR	NR	E	E	E	NR
Sandstone	P	NR	G	E	NR	NR	NR	E	G	E	P
Limestone with chert	NR	NR	G	E	NR	E	NR	E	G	G	NR
Limestone with and without fractures	NR	NR	G-E	E	NR	E	NR	E	P-E	E	P
Limestone, cavernous	NR	NR	P-G	P-G	NR	E	NR	E	NR	E	NR

Type of Formation	Auger-Hollow Stem	Rotary Bucket Auger*	Rotary with Fluids (foam, mud)*	Air Rotary	Air Rotary with Casing Hammer	Down the Hole Air Hammer	Dual Tube/ Casing Hammer	Coring	Reverse Rotary with Fluids*	Reverse Rotary with Dual Tube	Direct Push **
Dolomite	NR	NR	E	E	NR	E	NR	E	E	E	NR
Basalts-thin layers in sedimentary rocks	P	NR	G	E	NR	NR	NR	E	G	E	P
Tuff	P	NR	G	E	NR	E	NR	E	G	G	NR
Basalts-thick layers	NR	NR	P	G	NR	E	NR	E	G	G	NR
Basalts-highly fractured	NR	NR	NR	P	NR	G	NR	E	NR	G	NR
Metamorphic rocks	NR	NR	NR-P	G	NR	E	NR	E	G	G	NR
Granite	NR	NR	NR-P	E	NR	E	NR	E	G	G	NR

E	Excellent
G	Good
NR	Not Recommended
P	Poor

* Cannot be used for analytical soil sampling

** Procedure I-H, *Direct-Push Sampling Techniques* discusses protocol associated with direct push applications.

The following sections discuss commonly used drilling methods and their applicability to installation of monitoring wells. Regardless of the drilling method selected, decontaminate all drilling equipment using Procedure I-F, *Equipment Decontamination*. Follow these procedures before use and between borehole locations to prevent cross-contamination. In addition to selecting the proper drilling technique, take other precautions to prevent distribution of any existing contaminants throughout the borehole.

5.4.1 Hollow-stem Continuous-flight Auger

Hollow-stem continuous-flight auger (HSA) is the most frequently employed method used in the environmental industry for the drilling and installation of shallow monitoring wells in unconsolidated materials. Drilling with HSA is possible in loose sand and gravel, loose boulders in alluvium, clay, silt, shale, and sandstone. HSA drilling is usually limited to unconsolidated materials and depths of approximately 150 to 200 feet. HSA drill rigs are mobile, relatively inexpensive to operate, generally cause minimal disturbance to the subsurface materials, and have the additional advantage of not introducing drilling fluids (e.g., air, mud, or foam) to the formation.

Another advantage of the HSA method is that undisturbed samples are obtained by driving a split-spoon sampler below the lead auger. Soil samples can usually be easily collected in this manner with a minimum of tripping sampling tools into and out of the hole.

Moreover, in the HSA drilling method, the well is constructed inside the HSAs as the augers are gradually removed from the ground. This method decreases the possibility of the borehole collapsing before the well is installed. HSAs shall have a nominal outside auger-flight diameter of 10 to 12 inches and a minimum inside diameter of 8 inches. Larger inside diameter auger flights are sometimes available. Well casing diameter is usually limited to 4 inches or less when using the HSA method. The difference between the inner diameter (I.D.) of the auger and the outer diameter (O.D.) of the well casing shall be at least 4 inches (i.e., a minimum 2-inch annular space) to permit effective placement of filter pack, bentonite seal, and grout without bridging.

5.4.2 Rotary Bucket Auger

Rotary bucket auger drilling, or bucket auger drilling (BAD), utilizes a large-diameter bucket auger to excavate earth materials. Excavated material is collected in a cylindrical bucket that has auger-type cutting blades on the bottom of the bucket. The bucket is attached to the lower end of a kelly bar that passes through, and is rotated by, a large ring gear that serves as a rotary table.

The kelly bar is square in cross-section and consists of two or more lengths of square steel tubing, with each successive length of tubing telescoped inside the previous length. This design permits boring to a depth several times the collapsed length of the kelly bar before having to add a length of drill rod between the kelly and the bucket. In drilling with the telescoping kelly, the bucket is typically lifted and dumped without disconnecting, thereby speeding up the process when drilling deep holes. Depths of 75 to 100 feet are achievable with most telescoping kellys. It is possible to construct wells more than 250 feet deep by this method, although depths of 50 to 150 feet are more typical.

The BAD technique is most effective in semi-consolidated or clayey formations that stand open without caving. Drilling through unconsolidated materials within the saturated zone is difficult, but not impossible if the hole is kept full of water or mud (see direct rotary methods with foam or mud). Drilling mud may be necessary, particularly in loose formations consisting of unconsolidated fine- to medium-grained sands and silts. In the right conditions, a bucket auger bit will remove a cylinder of material 12 to 24 inches deep with each run. Therefore, samples obtained by the BAD method are representative of the formation being drilled, unless sloughing or caving of the borehole walls occurs.

Boreholes drilled with the BAD technique generally range from 18 to 48 inches in diameter. Because of the large diameter of the borehole drilled with this technique, and the common need to add either water or mud to maintain the borehole in unconsolidated, near-surface deposits, it is recommended to use this method only for the installation of surface casing through the first water-bearing unit at a hazardous waste site.

5.4.3 Direct Rotary with Foam or Mud

Direct rotary drilling (DRD) techniques involve the use of various types of drilling fluids, which typically include air, foam, and mud. In each of the DRD methods, drilling fluids are circulated down through the inside of the drilling pipe into the borehole, and then up through the annulus between the drilling pipe and the borehole wall to carry drill cuttings up to the surface. The drilling fluids may also be used for stabilizing the borehole wall, which may be especially useful in unconsolidated, caving formations. In this section, the DRD method and its use with either foam or mud are discussed.

A variety of bit types may be used with each of these drilling fluids, depending on the type of formational material encountered; however, typically, the tri-cone or roller bit is used. The drilling bit is attached directly to a heavy section of drill pipe called a drill collar, which is attached to help keep the borehole straight. The drill collar is in turn attached to the drill pipe and the kelly.

General types of drilling fluids available for use with the DRD method include water with clay additives, water with polymeric additives, water with clay and polymeric additives, and foams (comprised of air or water, surfactants, and occasionally clays or polymers). The drilling fluid density may be adjusted during drilling to improve or resume circulation within the borehole, or to attempt to stabilize the borehole wall. A major problem with the addition of these fluids is that it is almost impossible to estimate the amount introduced into the formation through the saturated and unsaturated zones. Additionally, it is also very difficult to estimate the magnitude and duration of the impact to groundwater quality by the use of these fluids.

The drilling fluids and associated cuttings shall not be allowed to flow over the site unrestricted. A downhole circulation system, or fluid diversion system shall be used to keep the fluids and cuttings contained in a reasonable manner, yet still allow the collection of grab samples for lithologic identification.

While in some geologic situations DRD may be the most efficient method of drilling a borehole, potential problems associated with the drilling fluids usually make DRD a last-resort drilling technique for environmental purposes; one that should be avoided whenever possible.

Potential Problems of DRD with Foam or Mud

- The chemistry of the drilling fluid could adversely affect the chemistry of groundwater samples, soil samples, or the efficiency of the well (when using mud).
- Bentonite mud reduces the effective porosity of the formation around the well, thereby compromising the estimates of well recovery. Bentonite may also affect groundwater pH. Additives to adjust viscosity and density may introduce contaminants to the system or force irrecoverable quantities of mud into the formation.
- Some organic polymers and compounds provide an environment for bacterial growth, which in turn, reduces the reliability of sampling results.
- Uncontained drilling foam and/or mud may create unsafe working conditions at the surface around the rig.

Solutions

- DRD should only be utilized as a last resort.
- The hydrogeologist should ensure that the fluids used will not affect the chemistry of the soil samples and groundwater samples. One possibility is to collect samples of the drilling fluid for laboratory analysis.
- The hydrogeologist shall keep track of the amount of water and fluids introduced to the borehole in order to purge this quantity during well development.
- Provisions to contain drilling mud and foam shall be discussed in the drilling contractor scope of work.

5.4.4 Air Rotary and Air Rotary with Casing Hammer

Air rotary drilling (ARD) and air rotary with casing hammer (ARCH) force air down the drill pipe and back up the borehole and remove drill cuttings in the same manner as DRD with foam or mud. Without a casing hammer, the use of ARD techniques is best suited to hard-rock formations where the borehole will stand open on its own and circulation loss is not a major concern. ARCH is most useful in unconsolidated sediments of all types due to the use of a hardened steel casing that is driven behind the bit with a pneumatic casing hammer to keep the hole open. A combination of these two drilling techniques is very useful where unconsolidated overburden overlies consolidated rock. In this case, the casing hammer attachment would be used to set the surface casing at the top of the consolidated formation while continuing with ARD. As a well is being installed or the hole is being abandoned, the casing can be retrieved for use on another hole, or left in place to serve as surface casing.

Air from the compressor shall be filtered to ensure that oil or hydraulic fluid is not introduced into the soils and/or groundwater system to be monitored. In addition, foam or hydrocarbon-based lubricating joint compounds for the drill rods shall not be used with any rotary drilling method due to the potential for introduction of contaminants into the native materials and/or groundwater. Teflon-based joint lubricating compounds that are typically mixed with vegetable oil are available for this purpose.

Potential Problems of ARD and ARCH

- In the case of sampling with a split-spoon sampler to collect soil samples for laboratory analysis, the high-pressure air from inside the drill pipe can cause volatilization of contaminants from the soils beneath the bit in unconsolidated sediments. If installing deep wells or boreholes, this problem may not be avoidable.
- Fine-grained saturated materials that may cause surging and heaving problems are common in many coastal areas. Heaving sediments may cause problems during sampling and well installation when drilling with ARD.
- Rocks and other drill cuttings may be ejected from the borehole at high velocities, creating a secondary hazard around the rig.

Solutions

- ARD and ARCH should not be used for soil sampling in shallow, unconsolidated situations where a HSA rig could be used as effectively.
- One method to compensate for heaving and surging aquifer materials is to over drill the borehole by 5 or 10 feet to provide space for heaving sediments to fill in while well completion is being performed.
- Another method to control heaving sands is to add clean water to a level above the water table to create a downward pressure on the heaving materials. This additional volume of water should also be extracted during well development.
- Drill rigs shall be equipped with cyclones or equivalent devices designed to contain formation projectiles.

5.4.5 Dual Tube Casing Hammer with Reverse Air Circulation

Dual tube casing hammer with reverse air circulation (DTCH) is useful in unconsolidated sediments, but is most effective as a method for drilling through thick sequences of materials, such as coarse-grained sands and gravels. The DTCH system operates by simultaneously driving a pair of heavy gauge steel pipes into the ground while using high pressure reverse air circulation to blow air down the annulus of the two pipes and bring air and unconsolidated lithologic materials out through the inside of the inner pipe. The method does not employ a typical bit in that the formational materials are not ground up, sliced, nor cut into pieces. Instead, the bit consists of a special shoe that is used to funnel materials either into, or away from, the inner pipe, depending on whether the formational material is fine- or coarse-grained, respectively.

Typically, the method can drill through 200 feet of gravel in a day with relative ease. The inside diameter of the inner pipe is about 6 inches, with the borehole diameter being about 10 inches. Cobbles with long axes of up to 6 inches come up through the inner pipe easily. Larger conglomerate clasts must be either pushed aside or broken up using the pneumatic hammer to drive the heavy shoe down onto the clast.

Conversely, the method works poorly in clay-rich materials. The shoe acts as a large cookie cutter, forcing a plug of clay into the inner pipe, which then must be forced to the surface and physically removed from the diverter/shoe assembly with the hammer. This method should probably be avoided where large thicknesses of clay are expected to be encountered in the subsurface.

Typically, the DTCH method can drill to approximately 200 feet with standard equipment. Deeper holes will likely require a larger air volume for circulation via an additional compressor hooked up to the drilling rig. Additionally, a variation of the DTCH called “triple tube” can be used to install larger-diameter wells to depths of about 200 feet depending upon the site. This method can also be used to supply a temporary surface casing to avoid cross-contamination of deeper zones while extending the boring to greater depths.

Potential Problems of DTCH

- In the case of soil sampling with a split-spoon sampler to collect samples for laboratory analysis, the high-pressure air from inside the drill pipe can cause volatilization of contaminants from the soils beneath the bit in unconsolidated sediments. If installing deep wells or boreholes, this problem may not be avoidable.

Solutions

- DTCH should not be used for sampling soil in shallow, unconsolidated situations where a HSA rig could be used as effectively.

5.5 MONITORING WELL DESIGN PROCEDURES

The designs of typical groundwater monitoring wells are depicted in Figure I-C-1-1 and Figure I-C-1-2. A discussion of the design of the individual components of a typical monitoring well is given in the following subsections.

5.5.1 Pre-installation Design Drawing

Develop a pre-installation design drawing after the borehole for the well has been completed and well-specific lithologic and hydrologic information are available. The pre-design drawing shall identify the anticipated depth of the well, the locations of the top and bottom of the screened interval, the anticipated top of the filter pack, the anticipated top of the bentonite seal, and the locations of centralizers (if applicable). In addition, calculate the volumes of sand, bentonite, and grout anticipated to be placed in the annular space of the well. Maintain the drawing as documentation of the well design.

5.5.2 Casing Selection

The cased section of a monitoring well is a pipe without slots or openings, which is installed to prevent the well from directly accessing formations above the screened interval. The casing isolates the screened interval.

The selection of appropriate casing materials must take into account several site-specific factors, such as: (1) geology, (2) geochemistry, (3) well depth, (4) size and type of equipment to be used in the well, and (5) the types and concentrations of suspected contaminants. In addition, consider several other logistical factors, including drilling method, cost, and availability.

Typical casing materials comprise polyvinyl chloride (PVC), chlorinated PVC, fiberglass reinforced plastic, Teflon, galvanized steel, carbon steel, Type 304 stainless steel, and Type 316 stainless steel. Casing materials must be compatible with the environment into which they will be placed. Metallic casings are most subject to corrosion, while thermoplastic casings are most subject to chemical degradation. Some thermoplastic materials are susceptible to sorption and desorption of chemicals. The extent to which these processes occur is related to water quality, the concentration of contaminants, and the type of casing materials. Choose casing material with knowledge of the existing or anticipated groundwater chemistry. If non-aqueous phase liquids (light non-aqueous-phase liquid or DNAPL) are potentially present at a site, careful consideration of the concentrations and types of chemicals that may come into contact with the casing must be made to insure the casing will not degrade over time. Table I-C-1-2 presents the relative compatibilities of some typical casing materials.Table I-C-1-2: Relative Chemical Compatibility of Rigid Well-Casing Material

	PVC [a] 1	Galvanized Steel	Carbon Steel	Low-Carbon Steel	Stainless [b] Steel 304	Stainless [b] Steel 316	Teflon [c]
Buffered weak acid	100	56	51	59	97	100	100
Weak acid	98	59	43	47	96	100	100
Mineral acid/high solids	100	48	57	60	80	82	100
Aqueous/organic mixtures	64	69	73	73	98	100	100
Percent overall rating [d]	91	58	56	59	93	96	100

[a] PVC casing shall not be installed in a groundwater environment containing chlorinated solvent or other destructive contaminants where the concentration of organics is greater than 1 part per million, and where the desired detection limit is less than 25 part per billion.

[b] Type 316 stainless steel screen and/or casing shall be used rather than type 304 when conditions are unknown and the lifespan of the monitoring well is to be greater than 5 years, or where the pH (indicates the hydrogen ion concentration – acidity or basicity) is less than 4.5, or where chloride concentration is greater than 1,000 part per million.

[c] Trademark of E.I. DuPont de Nemours

[d] Overall rating based on scale of 0 to 100 with 0 being the least compatible and 100 being the most compatible.

Besides chemical compatibility, a second consideration for specification of casing materials is the depth of the monitoring well. Well installations greater than 150 feet deep require casing materials of greater structural strength. In the case of PVC casing, Schedule 80 PVC rather than Schedule 40 may be required to prevent over-stressing of the casing couplings. The build-up of heat during grout setup might adversely affect some thermo-plastic materials.

Regardless of the type of casing materials, use only flush-threaded couplings. Flush-threaded couplings ensure that no screws, mechanical adapters, glues, or solvents are necessary to join individual sections. Steel conductor casing shall be welded at the joints, and the joint shall be at least as thick as the thickness of the casing wall. The weld shall be fully penetrating and shall meet the standards of the American Welding Society. Outside steel collars may be used to increase the strength of the welded joint. Do not use Teflon tape on PVC or stainless steel casing joints because it reduces the tensile strength of the joints.

The selection of an appropriate casing diameter is also important. The I.D. shall be 4 inches or greater to allow better access to the well and more rigorous well development than is commonly possible with smaller-diameter wells. Wells with casing smaller than 4-inch I.D. shall only be installed with the approval of the QA Manager or Technical Director. Wells greater than 150 feet in depth may require diameters larger than 4 inches to ensure that development and sampling equipment can be moved easily through the well. In addition, wells designed for groundwater extraction shall have a casing diameter large enough to accommodate a pump capable of achieving the appropriate pumping rate. The borehole in which the well is to be installed shall be a minimum of 4 inches larger in diameter than the O.D. of the well casing.

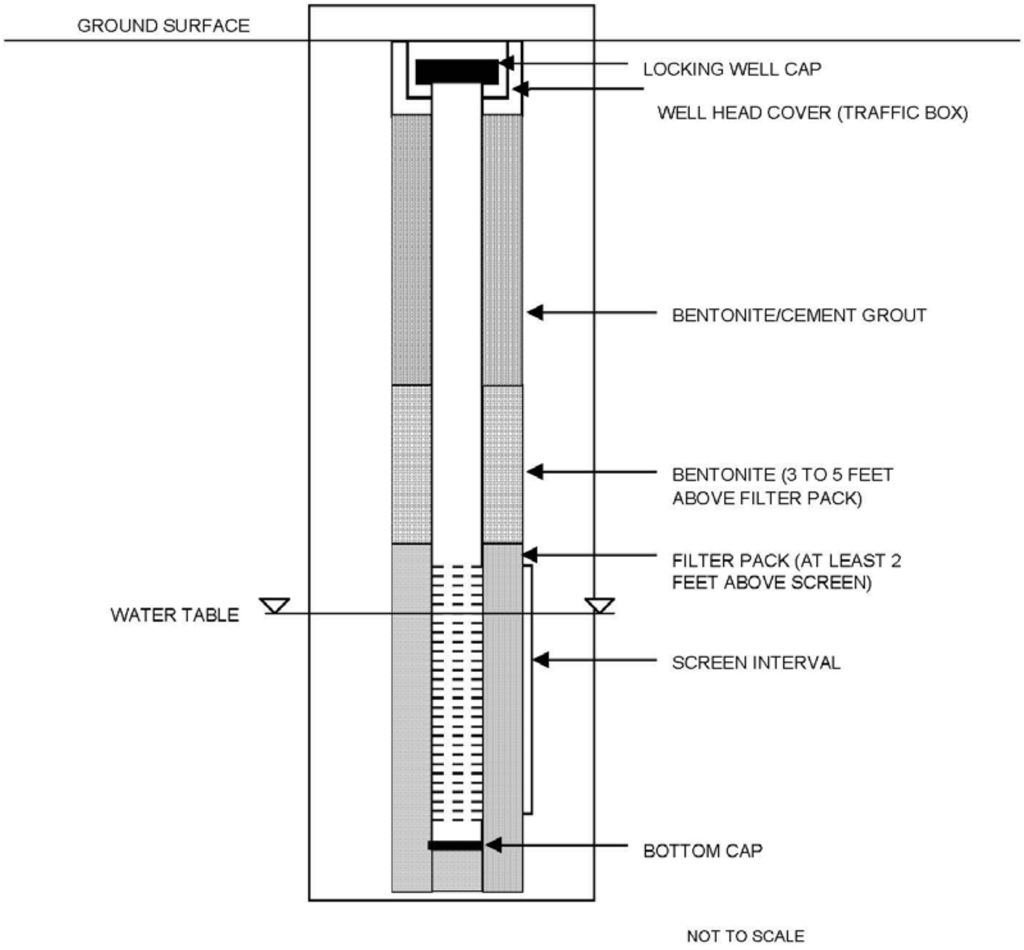


Figure I-C-1-1: General Cross Section of Monitoring Well, Unconfined Water Bearing Zone

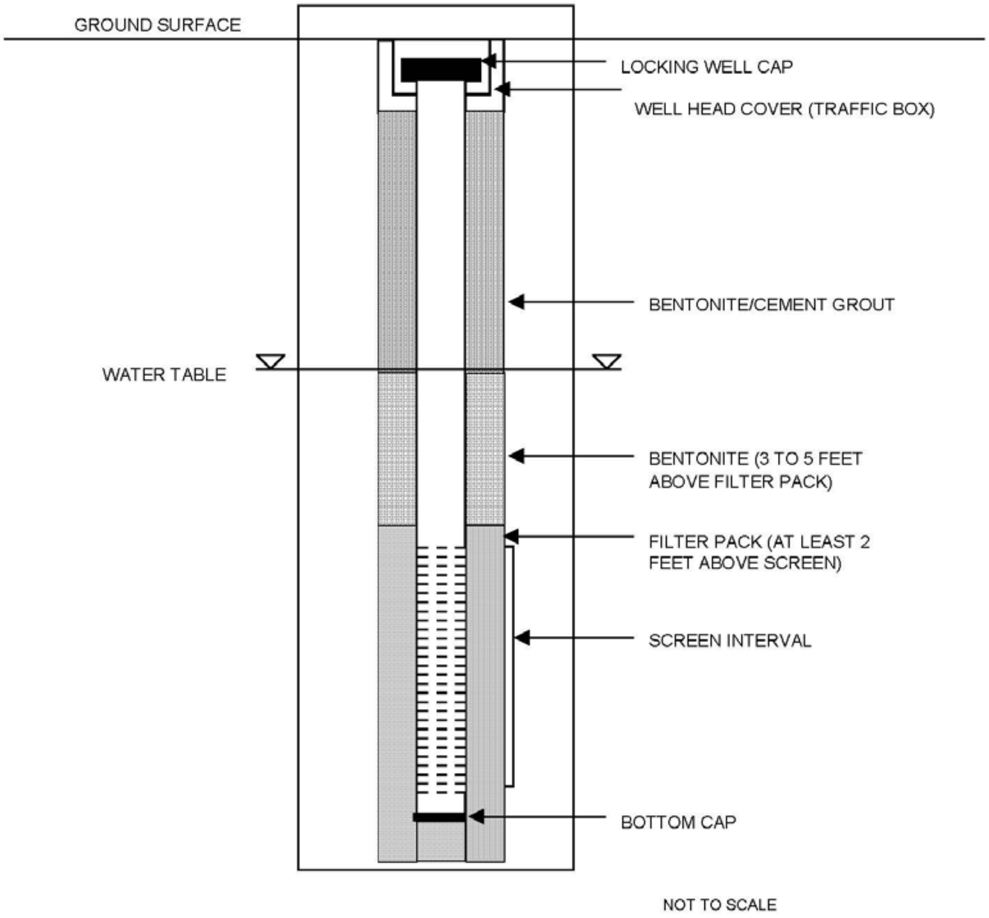


Figure I-C-1-2: General Cross Section of Monitoring Well, Confined Water Bearing Zone

5.5.3 Well Screen Selection

The screened section of the monitoring well allows groundwater to flow freely into the well, while retarding movement of fine-grained lithologic materials into the well. When designing a well screen, consider important factors, such as type of well screen material, length of the screened section, location of the screened section, the intake opening (slot) size, the type of intake opening, and size of filter pack to be utilized.

Five factors directly affect the performance of the monitoring well and are evaluated in the selection of an appropriate screen: (1) chemical resistance/interference, (2) screen length, (3) screen placement, (4) intended use of well (e.g., long-term groundwater extracted); and (5) intake opening size.

Selection of a screen material that provides chemical resistance and minimizes interference follows the same basic procedures as the selection of an appropriate casing material (see Table I-C-1-2). Some typical screen materials consist of PVC, Teflon, Type 304 stainless steel, and Type 316 stainless steel. Again, use only flush-threaded couplings. Screen sections constructed of different metals in the same well may cause electrochemical reactions that could rapidly degrade the casing or screen; therefore, do not use this type of composite well construction. In addition, construct wells intended for long-term groundwater extraction with well screen rather than slotted casing for facilitating redevelopment.

Selection of the screen length depends on its primary use(s). Most monitoring wells function as both groundwater sampling points and piezometers. Shorter-screened sections provide more specific data on vertically distributed contaminants, hydraulic head, and flow, and are generally preferred to longer-screened lengths. Saturated sections in groundwater monitoring wells shall be limited to between 5 and 10 feet in length; however, longer intervals may be justified in certain circumstances with approval of the QA Manager or Technical Director.

Placement of the screened interval within a groundwater monitoring well depends primarily upon two factors: the discrete interval and the type of contaminants to be monitored. The location of the discrete interval to be monitored will dictate the location of the screened interval within a monitoring well; however, also consider the characteristics of the contaminants to be monitored (i.e., light, non-aqueous phase liquid; dense, non-aqueous phase liquid) when choosing placement of the screened interval.

An additional consideration in the design of the screened section of the well is the hydraulic characteristics of the water-bearing zone that is to be monitored (i.e., confined or unconfined). If an unconfined zone is being monitored for contaminants that are less dense than water (e.g., gasoline, diesel, waste oil), place 3 to 5 feet of screened interval above the highest level of the water table to allow for evaluation of fluctuations in water level and to ensure that contaminant phases less dense than water can be observed. Conversely, if an unconfined zone is being monitored for contaminants that are denser than water (e.g., chlorinated solvents), place approximately 5 feet of screened interval (maximum) just above the confining unit at the base of the water-bearing zone to facilitate detection of the dense-phase contaminants. In the case of a confined water-bearing zone, use a maximum-screened interval of approximately 5 feet.

Selection of an appropriate intake opening size is critical to the performance of the monitoring well and to the integrity of groundwater samples obtained from the well. The size of the intake openings can only be determined following the selection of an appropriate filter pack, which itself is selected based upon the grain-size of the formation. An intake size is generally designed to hold back between 85 to 100 percent of the filter pack material. Figure I-C-1-3 can be used to select appropriate intake opening sizes. The screen slots shall be factory-made (or formed).

5.5.4 Filter Pack Design

Filter pack material shall be clean and chemically stable within the monitoring well environment to minimize addition to, or sorption from, the groundwater. Filter pack shall meet the following minimum specifications:

- Filter pack material shall be at least 95 percent silica, consisting of hard, durable grains that have been washed until free of dust and contamination, and graded.
- Filter pack material shall not be angular and non-uniform such that it will bridge in the annular space, leaving a void or poorly packed materials that can consolidate or settle after construction.
- Select filter pack to meet the grading specification determined from sieve analysis of the geologic formation to be screened, if available.
- Filter pack material shall be commercially packaged in bags that prevent the entrance of contaminants, and allow proper handling, delivery, and storage at the monitoring well site. Do not use material delivered in broken bags for monitoring well construction.

In investigations where there are limited data on site conditions prior to monitoring well installation, select the filter pack size prior to field activities based on available lithologic data. Use finer filter pack sizes if fine-grained formations are anticipated to be present, and use coarser-grained filter packs in coarser lithologies and consolidated formations.

In investigations where sieve analysis data exist for a site prior to field activities, base selection of a proper filter pack upon the grain size of the formation materials to be monitored. Use the sieve data for the finest lithology identified in the interval to be monitored for establishing filter pack size. The U.S. Environmental Protection Agency recommends that filter pack grain size be selected by multiplying the 70 percent retained grain size of the formation materials by a factor between 4 and 6. Use a factor of 4 if the formation materials are fine-grained and uniform, and use a factor of 6 if the formation materials are coarse-grained and non-uniform. In any case, the actual filter pack used should fall within the area defined by these two curves. An example of this technique is presented in Figure I-C-1-4.

5.5.5 Annular Seal

The annular seal is placed directly above the filter pack in the annulus between the borehole and the well casing. The annular space must be sealed to prevent the migration of water and contaminants through the annulus. The annular seal is also intended to hydraulically and chemically isolate discrete water-bearing zones.

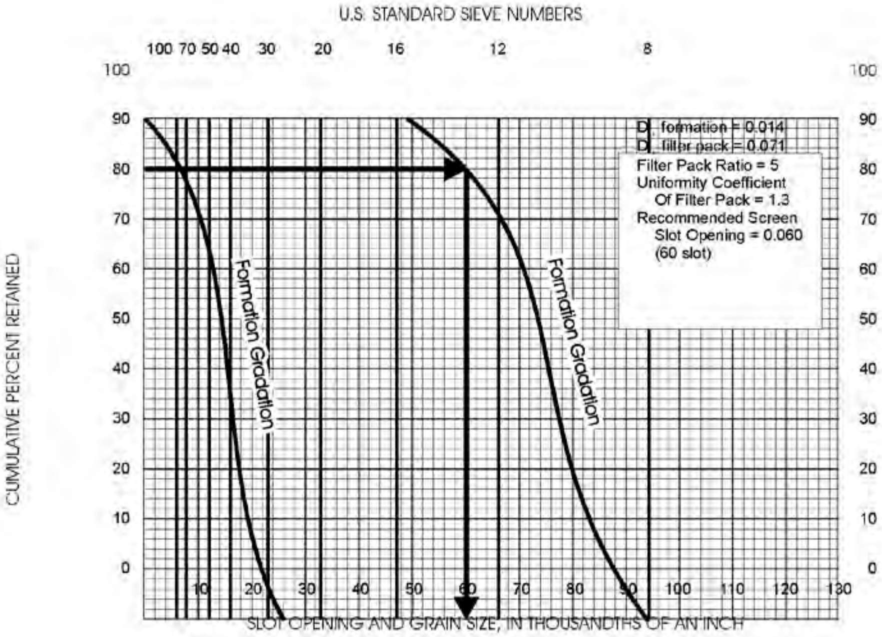


Figure I-C-1-3: Selecting Well Intake Slot Size Based on Filter Pack Grain Size

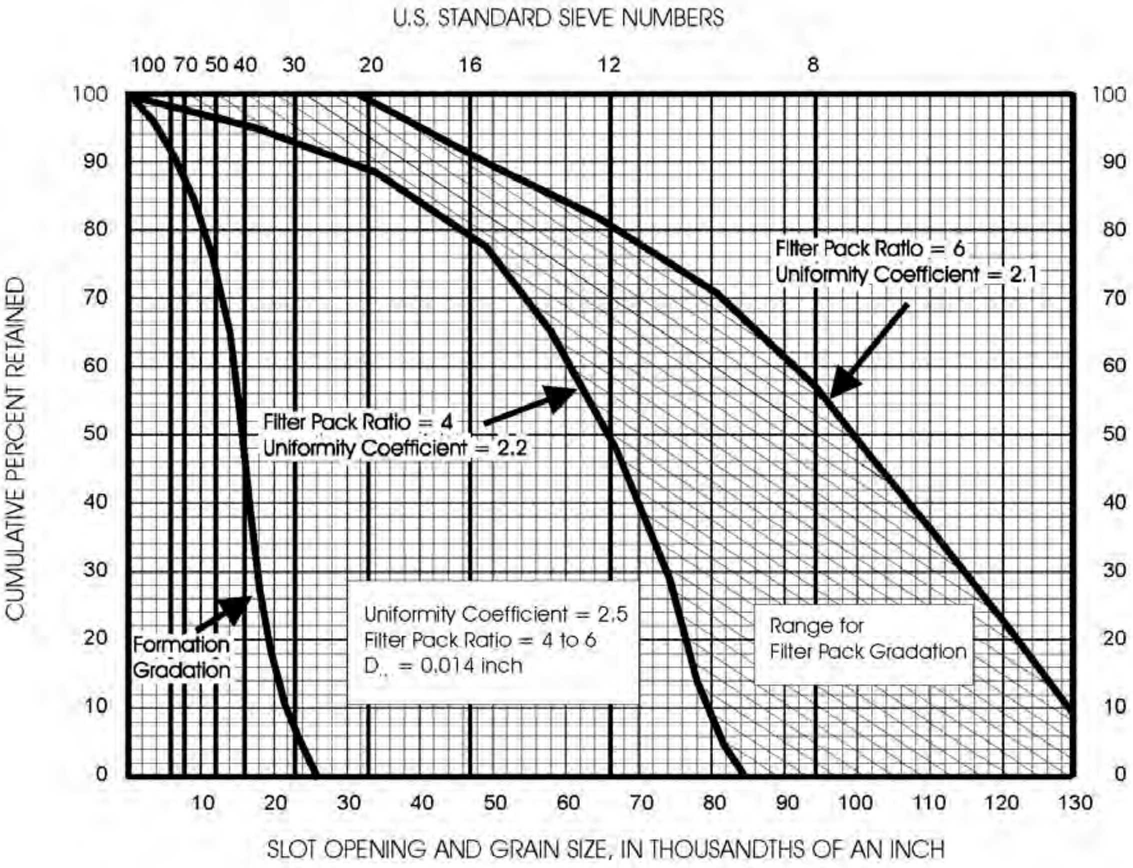


Figure I-C-1-4: Filter Pack Design Criteria

Typically, annular seals consist of two discrete sections. The first section, known as the bentonite seal, consists of a pure sodium bentonite seal. To be effective, the bentonite seal should be emplaced directly over the top of the filter pack and extend approximately 3 to 5 feet (no less than 3 feet thick). Typical materials for the seal consist of granular sodium bentonite, or sodium bentonite pellets or chips.

The second section of the annular seal typically contains grout slurry, which completely fills the remaining annular space from the bentonite seal to just below the ground surface. Grout consists of either sodium bentonite and Portland cement slurry or neat cement slurry. Give special consideration to the selection of annular seal material for wells installed in coastal areas where groundwater may contain elevated concentrations of sulfates. In this situation, use a sulfate resistant grout to prolong the usefulness of the well.

5.5.6 Surface Completion

The surface of the well shall be completed using either an above-grade (monument) style, or a flush-to-grade (traffic box) style. In either case, the protection of the wellhead at land surface is accomplished by means of a surface seal of concrete and a metal completion box surrounding the well casing. The surface seal serves to prevent infiltration of surface water and unauthorized entry, and where necessary, to provide protection from vehicular traffic.

5.6 MONITORING WELL INSTALLATION TECHNIQUES

The following general procedures describe the installation of groundwater monitoring wells.

5.6.1 General Casing and Screen Installation Techniques

Following completion of the borehole, the FM or designate will first measure the total depth of the hole to ensure that the desired depth has been attained. The lengths of casing and screen shall also be measured. These measurements shall be made with an accuracy of 0.01 feet using either a fiberglass or steel tape measure.

Installation of the casing and screen is normally accomplished by emplacing them into the well as an integral unit. Prior to installation, decontaminate individual lengths of the well casing and screen according to Procedure I-F, *Equipment Decontamination*, unless the casing and screen were certified by the manufacturer to have been properly pre-cleaned at the factory and sealed in plastic. Following decontamination, inspect each length to ensure that damaged or otherwise unsuitable sections are not used.

To ensure even distribution of filter pack, bentonite seal, and grout materials around the well within the borehole, suspend the casing and screen with a threaded hoisting plug and do not allow them to rest on the bottom of the boring unless the installation is less than 30 feet deep.

5.6.2 Centralizers

Install centralizers at the top and bottom of screened sections when using the air or mud rotary techniques for well installation. Also place centralizers at 20- to 40-foot intervals on blank casing; the FM will determine the spacing according to the depth of the well. Align the centralizers from top to bottom of the casing so that they do not interfere with the insertion and removal of the 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. Centralizers shall be constructed of stainless steel.

5.6.3 Filter Pack Installation

Prior to the addition of any filter pack material, cover the top of the well casing to prevent filter pack material from entering it.

The filter pack is usually installed through HSAs, conductor casing, or a tremie pipe depending on the drilling technique used; however, if the depth to the bottom of the screened interval is less than 10 feet, and lithologic materials are sufficiently consolidated to preclude the possibility of hole collapse, the filter pack may be poured into the annular space of the well from the ground surface. This procedure applies to any drilling method.

During installation, measure the level of the top of the filter pack periodically to ensure that no bridging has occurred, and to determine the depth to the top of the filter pack. Be sure that the filter pack encloses the entire length of the screened section. For wells less than 100 feet in total depth, the filter pack shall generally extend to 2 feet above the top of the screened section of the well. For wells greater than 100 feet in total depth, an additional 1 foot of filter pack may be emplaced above the screen for each 100 feet of well depth.

An alternative to conventional monitoring well construction and installation is through the use of small diameter pre-fabricated monitoring wells, commonly referred to as “pre-pack” wells. Pre-pack wells typically consist of a well screen (slotted PVC) surrounded by sand (filter-pack) held in place by a stainless steel or polyethylene mesh. The pre-pack well assembly is commonly used in conjunction with direct-push drilling methodologies, which allows a relatively quick installation of these small diameter wells. Having the filter pack around the slotted PVC before the well screen is installed ensures that the filter pack is located directly around the well screen and minimizes the effort required for the filter pack installation.

The filter pack is normally an inert (e.g., siliceous) granular material that has a grain-size distribution chosen to retain formation materials. A sleeved screen consists of a slotted pipe base over which a sleeve of stainless steel mesh filled with selected filter media is installed. Pre-packed or sleeved screens may be used for any formation conditions, but they are most often used where heaving, running or blowing sands make placement of conventional well screens and filter packs difficult, or where predominantly fine-grained formation materials are encountered (ASTM 2010). During installation, the boring is advanced using hollow drive rods with an expendable drive point. Upon reaching the desired monitoring well installation depth, the entire well assembly (i.e., pre-pack well) is lowered to the desired depth within the hollow drive rods. At the desired depth, the hollow drive rods are retracted to a point above the screen. At this step a barrier is placed directly above the screen to prevent grout or material from entering the screened interval as the hollow drive rods are extracted from the boring. This barrier can be created either by natural formation collapse (occurring during the initial rod retraction), by gravity installation of fine-grade sand through the rod annulus, or as part of the pre-pack monitoring well components (e.g. expanding foam bridge). With the barrier in place, granular bentonite or bentonite slurry is then installed in the annulus to form a well seal. When installing pre-pack screens additional sand must be used to fill in the annular space between the pre-pack and the edge of the borehole. Furthermore, filter sand should be installed to at least 2 feet above the top of the pre-packed well screen.

Vendors offer pre-pack monitoring well components with varying outer diameters, which is typically based on the inner diameter of the hollow drill rods. These types of wells may be sampled by several methods including peristaltic pump, mini-bailer, or bladder pump to yield data of similar quality to that of conventional monitoring wells.

Following the installation of the filter pack, a surge block or large bailer shall be placed into and removed from the casing for approximately 10 minutes to set and compact the filter pack and to begin well development. Then, check the level of the filter pack again. Add more filter pack material according to the procedures described above if any settling of the filter pack has occurred. After emplacement, note the volume of filter pack material placed in the well, record it in the well completion record (Figure I-C-1-5), and compare it to the calculated volume of filter pack that was expected to have been used.

5.6.4 Annular Seal Installation

The sodium bentonite seal shall have a minimum thickness of 3 feet. Generally, to be effective the bentonite seal should extend above the filter pack approximately 3 to 5 feet. It may be constructed of powdered, granular, or pelletized bentonite, and may be emplaced as a dry solid, powder, or slurry. Use only sodium bentonite manufactured specifically for use in the drilling and construction of water wells. Typically, granular or pelletized bentonite is emplaced dry. Powdered bentonite is usually mixed with potable water to produce a slurry. Depending on the type of installation method, the bentonite may be emplaced through the HSAs, conductor casing, or tremie pipe.

In dry form, place the bentonite directly on the top of the filter pack. After emplacing each 1-foot-thick layer of dry bentonite in the well, add approximately 5 gallons of water of known chemical quality to hydrate the bentonite. Allow a minimum of 15 minutes for hydration of the bentonite seal once it is completely installed.

When emplacing the bentonite in slurry form, take care to ensure that the bentonite is thoroughly mixed, with no visible lumps to ensure the proper consistency. Then place a 1-foot layer of fine-grained silica sand over the top of the filter pack. This fine-grained sand layer will prevent infiltration of the filter pack by the bentonite slurry.

Emplace the remaining annular seal following the installation of the bentonite seal. The annular seal shall be a slurry consisting of 7 to 9 gallons of water per 94-pound bag of Portland cement Type I or II and a minimum of 3 to 5 percent bentonite (1/4 to 1/2 bags of bentonite powder per five bags of Portland cement). The slurry may be emplaced through a HSA, conductor casing, or tremie pipe, depending on the method of installation. Thoroughly mix the grout to ensure the proper consistency with no visible lumps of dehydrated powder. The rates at which the augers or pipe are withdrawn and the slurry added will be such that the level of the grout within the well annulus is just below the lowermost auger or pipe.

If a tremie pipe is used, emplace the annular grout seal by pumping through a pipe with a minimum 1-inch I.D., in one continuous pour, from the top of the transition seal to the ground surface. Place the bottom of the tremie pipe about 5 to 10 feet above the transition seal, depending on the stability of the hole and impact velocity of the grout.

A tremie pipe is not required for annular seals less than 10 feet from the ground surface to the top of the transition seal or for grouting within dual wall drill strings or HSAs. Measure the volume of grout seal material placed in the well, record it in the well construction log, and compare it with the calculated volume. The slurry shall extend from the top of the bentonite seal to a depth of approximately 2 feet below ground surface (bgs).

5.6.5 Annular Seal "Set Time" and Setting

Let the annular grout seal set at least 12 hours before disturbing the casing or well so that separations or breaks do not occur between the seal and the casing, or between the seal and the borehole. Development of the well is prohibited until the grout seal has set. Likewise, the concrete slab, traffic box, and/or casing riser of the surface completion shall not be poured and constructed until the grout seal has set. Top off any settlement of the grout seal as soon as possible after it sets. Record all pertinent data on the well construction log.

5.6.6 Surface Completion

The surface of a groundwater monitoring well shall be either an above-ground completion or as a flush-to-ground completion. Regardless of the method, each monitoring well shall have, at a minimum, a casing cap, concrete slab and annular seal, and a locking protective casing or locking vault. Although wellheads vary in size, effort should be made to use a consistent size wellhead or similar completion per site.

In an above-ground completion, the protective casing or monument is installed around the top of the well casing within a cement surface seal. A 2-foot-long by 2-foot-wide cement pad with a minimum thickness of 3 inches is constructed around the protective casing. Type 1 Portland cement, which meets the requirements of CLASS A standards, is used for the surface seal. Inspect the monument prior to installation to ensure that no oils, coatings, or chemicals are present. Once installed, maintain the monument in a plumb position with 2 to 3 inches of clearance between the top of the well casing and the lid of the monument. The monument shall extend at least 18 inches above grade and at least 12 inches below grade. Construct a minimum of three concrete-filled posts around the well to protect it from vehicular damage.

Inside the monument, cut or scribe two permanent survey marks, approximately 0.25 inches apart, into the top of the well casing, and also permanently mark the well with its identification number. Permanent marks may include painting, marking, or engraving on the protective casing or surface completion. An alternate option may be to attach a non-corroding, imprinted metal tag to part of the well. Cover the top of the well casing with a slip cap or locking cap to prevent debris from entering the well. Fit the monument with a casehardened lock to prevent unauthorized entry.

In a flush-to-ground completion, the protective casing or traffic box is installed around the top of the well casing, which has been cut off slightly below grade. The traffic box has a lid that is held firmly in place by bolts and has a flexible O-ring or rubber gasket to prevent water from entering the box. Whenever possible, wells with flush completions should not be placed in low spots where surface water can accumulate. If this is unavoidable, consider an aboveground completion. The traffic box is set within a cement surface seal slightly above grade to deflect surface water flow away from the well. The surface seal must form an apron at ground surface that is at least 2 feet wide and 4 inches thick. The concrete apron must slope away from the well (a minimum of 1 percent) to prevent surface water leakage into the well head (DOH 2009). An effort should be made to standardize the appearance of the well completions at a particular site. Type 1 Portland cement, which meets the requirements of CLASS A standard, is used for the surface seal. Where monitoring well protection must be installed flush with the ground, an internal cap should be fitted on top of the riser within the manhole or vault. This cap should be leak-proof so that if the vault or manhole fills with water, the water will not enter the well casing. The cap should also be able to lock to prevent unwanted access or tampering with the well. Ideally, the manhole cover cap should also be leak-proof (ASTM 2010). Inspect the traffic box prior to installation to ensure that no oils, coatings, or chemicals are present. Once installed, maintain the traffic box in a level position that leaves 2 to 3 inches of clearance between the top of the well casing and the lid of the traffic box. Regular maintenance may be necessary to maintain the integrity of the seals and pads protecting the wells.

Cut two permanent survey marks into the top of the well casing, approximately 0.25 inches apart, and also permanently mark the well with its identification number. Cover the top of the well casing with a lockable cap to prevent debris from entering the well. Also fit the lockable cap with a casehardened lock to prevent unauthorized entry.

In areas where there is a high probability of damaging the well (high traffic, heavy equipment, poor visibility), it may be necessary to enhance the normal protection of the monitoring well through the use of posts, markers, signs, or other means. The level of protection should meet the damage threat posed by the location of the well (ASTM 2010).

5.6.7 Installation of Surface Casing

The use of surface casing may be required to minimize the potential for cross-contamination of different hydrogeologic zones within the subsurface of a site. The depth of placement of the surface casing shall be based on site-specific geologic knowledge obtained from lithologic samples collected in situ during the drilling of the well boring.

If a surface casing is to be installed permanently along with the well, grout it in place. The borehole shall be of sufficient diameter that a tremie or grout pipe can be easily placed between the borehole wall and the outside of the surface casing. After the desired placement depth is reached and the drilling tools are removed from the borehole, lower the casing into the borehole and center it. The bottom of the surface casing may be plugged or driven into the sediment at the base of the borehole to keep grout from entering the casing, if necessary.

Install grout through the tremie pipe and pump it from the bottom of the casing to ground surface. As the grout is being placed, raise the tremie pipe slowly to avoid excessive backpressure and potential clogging of the tremie pipe. After the grout has been allowed to set for at least 24 hours, drilling and subsequent well installation can continue. The required time for grout to set before drilling can continue depends on the volume of grout emplaced; the more grout used, the longer the delay time.

JOB NO.: ______ WELL NO. ______ HYDROGEOLOGIST: ______

CLIENT: ______ DRILLER: ______

WELL LOCATION: ______ DATE/TIME: ______

DETAILS OF CONSTRUCTION

Date Completed ______

Borehole Diameter (in.) ______

Type and Size of Casing (in.) ______

Type and Size of Screen (in.) ______

Screen Perforation Diameter (in.) ______

Screen Length (ft.) ______

Centralizer Depths (ft.) ______

Completion Technique

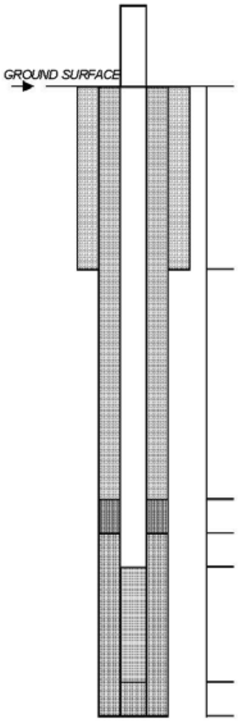
1. Type of Filter Pack and Placement Method ______
2. Type of Bentonite and Placement Method ______
3. Type of Grout Mixture and Placement Method ______

Description of Potential Problems With Well:

______

Development Technique

______



Well Head Elevation ______

Ground Surface Elev. ______

Well Head Completion Method ______

Drilling Method/Rig Type ______

Surface Casing: Type ______

Diameter ______

Length ______

MATERIALS

Cement (sks.) ______

Filter Pack Material (ft.^{3}) ______

Casing Material (ft.) ______

Bentonite (ft.^{3}) ______

Top of Bentonite Seal ______ ft.

Top of Filter Pack ______ ft.

Top of Screen ______ ft.

Bottom of Screen ______ ft.

Bottom of Hole ______ ft.

▨ GROUT
▩ BENTONITE
▦ FILTER PACK

NOTE: ALL DEPTHS ARE REFERENCED TO GROUND SURFACE

Figure I-C-1-5: Well Completion Record

5.6.8 Shallow Well Completion

Due to the occurrence of shallow groundwater in some areas, there are instances when the top of the screened interval must be placed at a depth so shallow that it is impossible to install the well using the typical design for annular materials (i.e., 2 feet above the screen for filter pack followed by a 3-foot thickness of bentonite seal). In cases where the top of the screen must be placed between 4 and 6 feet bgs, use the following design alteration:

- Place the filter pack 1 foot above the top of the screened interval.
- Place a minimum of 3 feet of bentonite seal above the filter pack.
- Fill the remainder of annular space with a 3 percent to 5 percent bentonite-cement grout.

In no case shall the top of the screen be brought higher than 4 feet bgs because it is difficult to install a reliable annular seal at these shallow depths.

5.6.9 Method-specific Well Installation Techniques

The following sections describe well installation techniques for groundwater monitoring at hazardous waste sites. Sections on troubleshooting common problems encountered when using each technique and potential solutions to the problems are included.

5.6.9.1 HSA

General methods of well installation using the HSA technique are listed below:

- Complete a pre-installation design drawing in accordance with Section 5.4.1.
- Prior to well installation, properly decontaminate and measure the well screen, cap, and casing to ensure accurate placement of well casing and screen. Mark the well casing near the ground surface to signal to the drillers where the casing should be placed.
- Remember that wells are constructed within the augers as the augers are removed from the ground.
- The diameter of the well casing constructed within an HSA is limited to 4 inches. *Note:* The difference between the I.D. of the HSA and O.D. of the well casing must be at least 4 inches to permit effective placement of filter pack, bentonite seal, and grout.
- Remove the inner rod and hammer quickly, measure the depth of the borehole, and place the well screen and casing quickly into the auger to the desired depth. *Note:* the well screen and casing shall be suspended in hole by the use of a hoisting bail in order to ensure proper depth and plumb construction. This may not be necessary for wells less than 30 feet in depth.
- Prior to adding filter pack, cover the top of the well casing to prevent filter pack material from entering it.
- The HSA acts as tremie pipe for placement of filter pack, bentonite, and grout.
- Slowly pour filter pack between the inside of the auger and the outside of the well casing.
- While the filter pack material is being poured, incrementally withdraw the auger. The rate of auger withdrawal and filter pack placement shall allow for the top of the filter pack level to be just below the lead auger. In general, the augers should be withdrawn in increments of

2 to 3 feet. *Note:* The level of the top of the filter pack shall be constantly tagged with a measuring tape during emplacement of the filter pack.

- Surge the well to consolidate the filter pack; add more if settlement occurs.
- Emplace bentonite pellets or chips through the HSA. Tag the level of the bentonite periodically to ensure accurate placement. For each foot of bentonite seal installed in an unsaturated completion, pour 5 gallons of water of known chemical quality into the well to hydrate the bentonite. If the bentonite seal is less than 10 feet bgs and the borehole is stable, the bentonite may be emplaced directly from the top of the borehole rather than through the HSA.
- After allowing 15 minutes for the bentonite seal to hydrate, emplace a grout seal through the HSA from the top of the bentonite seal to within 2 feet of ground surface. The grout shall be emplaced from bottom to top in one continuous pour. If the top of the bentonite seal is less than 10 feet bgs and the borehole is not subject to collapse, the grout may be emplaced directly from the top of the borehole. If the top of the bentonite seal is greater than 10 feet bgs, a tremie tube shall be used to emplace the grout. The composition of the grout is detailed in Section 5.4.5.
- Construct an above- or below-ground wellhead.

Potential Problems and Solutions

Bridging Filter Pack or Bentonite Seal

Bridging filter pack or bentonite can create unwanted void spaces or lock the well casing within the HSA.

Avoidance of Locked Well Casing

- Carefully tag the filter pack level and keep it just below the lead auger while the auger is inched up and sand is slowly added.
- Use an auger with a larger I.D.
- Use filter pack materials with a larger grain size.
- Add water of known chemical quality while pouring the sand filter pack. Try this only in cases where the filter pack is very fine.

Solutions for Unlocking Well Casing from Augers

- Gently hold the casing in place while lifting and twisting the auger (do not force).
- Insert the surge block into the casing and gently surge the water column if bridge is below water table.
- Add water between the well and auger if the sand bridge is above the water table.
- Attach an air compressor to a tremie pipe, and then gently blow the bridge away.
- Completely remove the casing and screen, and reinstall the well.
- Never drive the casing out of the auger with a hammer because this will break the casing.

Heaving, Surging Materials

Fine-grained saturated materials that might cause surging problems are common in coastal areas. Heaving sediments might cause problems when drilling with HSA.

Solutions for Heaving Sediments

- Over-drill the borehole by 5 or 10 feet to provide space for heaving sediments to fill in while well installation begins. Begin placement of filter pack as soon possible. Add it quickly until over-drilled space is filled.
- Add clean water to a level above the water table to create a downward pressure on the heaving materials. The volume of water added shall be recorded on the well installation log and extracted during well development.
- Drill an initial pilot borehole and sample with a 6-inch-diameter auger. The 6-inch auger may be fitted with plastic or metal core catcher on the lead auger, which will allow for soil sampling and prevent sediments from entering augers. After the total sampling depth is reached, the 6-inch auger is removed and 10-inch-diameter augers are substituted to ream out the borehole. Fit the lead auger with a tapered stainless steel plug. At a depth below the desired total depth of the well, use the sampling hammer and center rod to knock out the stainless steel plug. Then complete well installation.

5.6.9.2 DIRECT ROTARY WITH FOAM OR MUD

General well installation techniques using direct rotary with foam or mud are listed below:

- Complete a pre-installation design drawing in accordance with Section 5.4.1.
- Prior to well installation, measure the well screen, cap, and casing to ensure accurate placement of well casing and screen. Place mark on the portion of the well casing near ground surface to identify to the drillers where the casing should be placed. Place centralizers on the well casing and screen as discussed in Section 5.5.2.
- With DRD techniques, wells are constructed in the borehole after the bit and drill pipe are removed from the hole. For mud rotary drilling, first thin the mud sufficiently prior to removing the bit and drill pipe from the hole. Thinning the mud allows faster and more accurate placement of the annular materials within the borehole, which balances the density of the borehole fluids so they more closely match the density of the fluids used to install the filter pack and bentonite seal. It also reduces the potential for annular materials to be washed out of the borehole through the tremie.
- After the bit and drill pipe are retrieved from the hole as smoothly and quickly as possible, measure the total depth of the hole to verify its depth and to check its stability.
- Suspend the well screen and casing in the hole by the use of hoisting bail in order to ensure proper depth and a plumb construction. This may be unnecessary for wells less than 30 feet in depth. Place the casing and screen in the hole as fast as is safely possible to minimize the time that the borehole stays open.
- Prior to the addition of filter pack, cover the top of the well casing to prevent filter pack material from entering the well casing.

- Use a tremie pipe for placement of filter pack, bentonite, and grout. Also emplace the filter pack and bentonite seal as soon as possible to avoid potential collapse of the hole.
- Slowly pour the filter pack into the tremie pipe to avoid bridging within the tremie pipe at the water table. The level of the top of the filter pack shall be constantly tagged with measuring tape as the filter pack is being emplaced.
- Make the bentonite seal at least 3 feet thick. It should consist of bentonite pellets or chips emplaced through the tremie pipe. Tag the level of the bentonite periodically to ensure accurate placement. If the bentonite seal is less than 10 feet bgs and the borehole is stable, the bentonite may be placed directly from the top of the borehole rather than through the tremie pipe.
- After allowing 15 minutes for the bentonite seal to hydrate, emplace a grout seal through the tremie pipe from the top of the bentonite seal to within 2 feet of ground surface. The grout shall be placed from bottom to top in one continuous pour. If the top of the bentonite seal is less than 10 feet bgs, and the borehole is not subject to collapse and is not filled with drilling fluid, the grout may be placed directly from the top of the borehole. The composition of the grout is detailed in Section 5.4.5.
- Construct an above- or below-ground wellhead.

Potential Problems and Solutions

Bridging Filter Pack or Bentonite Seal

Bridging filter pack or bentonite can create unwanted void spaces that might collapse in the future.

Solution

Controlled pouring of the annular materials is the best solution for bridging. In the case of mud rotary, however, it may be necessary to perform emplacement of the filter pack and bentonite chips or pellets through the borehole without the aid of a tremie pipe. For wells greater than 10 feet deep, obtain the approval of the QA Manager or Technical Director.

5.6.9.3 AIR ROTARY AND AIR ROTARY WITH CASING HAMMER

General well installation techniques using ARD or ARCH are listed below:

- Prepare a pre-installation design drawing in accordance with Section 5.4.1.
- Prior to well installation, properly decontaminate and measure the well screen, cap, and casing to ensure the accurate placement of well casing and screen.
- Remember that with ARD techniques, wells are constructed in the borehole after the bit and drill pipe are removed from the hole. With ARCH, the driven casing remains in the ground and is slowly withdrawn as well installation proceeds.
- After the bit and drill pipe are retrieved from the hole as smoothly and quickly as possible, measure the total depth of the hole to verify its depth and to check its borehole stability.
- To ensure proper depth and a plumb construction, suspend the well screen and casing in the hole using a hoisting bail. Place the casing and screen in the borehole as fast as is safely possible to minimize the time that the hole stays open, particularly for ARD.

- Before adding filter pack, cover the top of the well casing to prevent filter pack material from entering it.
- For ARD, use a tremie pipe for placement of filter pack, bentonite, and grout. Emplace the filter pack and bentonite seal as soon as possible to avoid potential collapse of the hole. For ARCH, the annular materials can in most cases be placed directly between the driven casing and the well casing. A tremie pipe is advisable if exacting placement is required.
- For ARD, place the tremie pipe within 2 feet of the interval where the filter pack is to be placed. Slowly pour the filter pack into the tremie pipe to avoid bridging within the tremie pipe at the water table. The tremie pipe shall be slowly withdrawn during placement.
- Periodically tag the level of the top of the filter pack with measuring tape while the filter pack is being emplaced. Install bentonite in a similar manner.
- For ARCH, pour the filter pack slowly between the well casing and driven casing. The driven casing shall be withdrawn periodically while the filter pack is being emplaced. Withdraw the driven casing in increments no greater than 2 to 3 feet.
- For ARD, emplace bentonite pellets or chips through the tremie pipe to a minimum thickness of 3 feet. Tag the level of the bentonite periodically to ensure accurate placement. For each foot of bentonite seal installed in an unsaturated completion, add 5 gallons of water of known chemical quality into the well to hydrate the bentonite. If the bentonite seal is less than 10 feet bgs and the borehole is stable, the bentonite may be emplaced directly from the top of the borehole rather than through the tremie pipe. For ARCH, emplace the bentonite between the well casing and the driven casing while the driven casing is being withdrawn.
- Emplace a grout seal through the tremie pipe for the ARD method or through the driven casing for the ARCH method. Emplace the grout from the top of the bentonite seal to within 2 feet of ground surface. The driven casing or tremie pipe shall be withdrawn as the grout is placed. Emplace the grout from bottom to top in one continuous pour following placement of the bentonite seal. If the top of the bentonite seal is less than 10 feet bgs and the borehole is not subject to collapse, emplace the grout directly from the top of the borehole. The composition of the grout is detailed in Section 5.4.5.
- Construct an above- or below-ground wellhead.

Potential Drilling Problems

Bridging Filter Pack or Bentonite Seal

Bridging filter pack or bentonite can create unwanted void spaces that might collapse in the future.

Solutions

Controlled pouring of the annular materials is the best solution against bridging.

Heaving Sediment

Fine-grained saturated materials that might cause heaving problems are common in coastal areas. Difficulties caused by heaving sediments might create problems when drilling with ARCH. Heaving sediments cannot be drilled using ARD techniques.

Solutions for Heaving Sediments

- Over-drill the borehole by 5 or 10 feet to provide space for heaving sediments to fill in while well completion is begun.
- Add clean water to a level above the water table to create a downward pressure on the heaving materials. The volume of water added should be extracted during well development.
- Heaving sands may also be controlled by first removing the drill pipe from the hole, and then constructing an airlift line made from the tremie pipe. If there is sufficient water above the heaving sands, an air line connected approximately 10 feet from the bottom of the tremie pipe can be used to air lift out the fine-grained sediments at the base of the casing.
- Begin placement of filter pack as soon as possible and add it quickly until the over-drilled space is filled.

5.6.9.4 DTCH

General well installation techniques using DTCH are listed below:

- Prepare a pre-installation design drawing in accordance with Section 5.4.1.
- Prior to well installation, measure the well screen, cap, and casing to ensure accurate depth placement of well casing and screen. Place a mark near the top of the casing to identify to the drillers the proper position to place the casing and screen.
- Like HSA drilling techniques, wells are constructed within the dual tube pipe as the pipe is removed from the ground.
- Prior to setting the casing and screen in the hole, verify total depth of the hole by measuring it and check for surging materials. Suspend the well screen and casing in the hole using a hoisting bail in order to ensure proper depth and plumb construction.
- Prior to addition of filter pack, cover the top of the well casing to prevent filter pack material from entering the well casing.
- The inner pipe of the dual tube assembly shall act as tremie pipe for placement of filter pack, bentonite, and grout.
- Slowly pour the filter pack between the inside of the augers and the outside of the well casing to avoid potential bridging of the annular materials. While the filter pack material is being poured, the dual tube pipe shall be incrementally withdrawn. The rate of pipe withdrawal and filter pack emplacement shall allow for the top of the filter pack level to be just below the shoe of the dual tube assembly. The level of the top of the filter pack shall be constantly tagged with measuring tape.
- Use bentonite pellets or chips to construct the well seal, which shall be a minimum of 3-feet thick, and shall also be emplaced through the dual tube assembly. For each foot of bentonite seal installed in an unsaturated completion, 5 gallons of water of known chemical quality shall be poured into the well to hydrate the bentonite. Tag the level of the bentonite periodically to ensure accurate emplacement. If the bentonite seal is less than 10 feet bgs and the borehole is stable, the bentonite may be emplaced directly from the top of the borehole rather than through the tremie pipe.

- Emplace a grout seal through the dual tube assembly from the top of the bentonite seal to within 2 feet of ground surface. Emplace the grout from bottom to top in one continuous pour immediately following emplacement of the bentonite seal. If the top of the bentonite seal is less than 10 feet bgs, the grout may be emplaced directly from the top of the borehole. The composition of the grout is detailed in Section 5.4.5.
- Construct an above- or below-ground wellhead.

Potential Problems and Solutions

Bridging Filter Pack or Bentonite Seal

Bridging filter pack or bentonite can create unwanted void spaces or lock the well casing and dual tube pipe together.

Avoidance of Locked Well Casing

- Tag carefully and always keep the filter pack just below the shoe while inching the dual tube assembly up and slowly adding sand.
- Use a smaller-diameter well casing.
- Use a filter pack with a larger grain size.
- Add water while pouring the sand filter pack. Avoid this unless absolutely necessary.

Solutions for Unlocking Well Casing from Dual Tube Pipe

- Insert a surge block into casing and gently surge the water column if the bridge is below water table.
- Add water between the well and piping if the sand bridge is above the water table.
- Attach an air compressor to a tremie pipe, and gently blow the bridge away.

Heaving, Surging Materials

Fine-grained saturated materials that might cause surging problems are common in coastal areas. Heaving sediments might cause problems when drilling with DTCH.

Solutions for Heaving Sediments

- Over-drill the borehole by 5 or 10 feet to provide space for heaving sediments to fill in while well completion begins.
- Add clean water to a level above the water table to create a downward pressure on the heaving materials. The volume of water added should be extracted during well development.
- Remove the drill pipe from the hole, and then construct an airlift line made from the tremie pipe. If there is sufficient water above the heaving sands, an air line connected approximately 10 feet from the bottom of the tremie pipe can be used to air lift out the fine-grained sediments at the base of the casing.
- Begin emplacement of the filter pack as soon as possible, and add it quickly until the over-drilled space is filled.

5.6.10 Well Construction Record Keeping Procedures

A written well completion record (Figure I-C-1-5) detailing the timing, amount of materials, and methods of installation/construction for each step of monitoring well construction shall be prepared during construction of each monitoring well by the FM or designate. Construction records shall be kept in a hard-bound field notebook dedicated to the CTO. An "as-built" drawing illustrating the placement location and amounts of all materials used in construction of each monitoring well shall be prepared in the field at the time of construction. The well construction record shall be filled out with indelible ink. Construction records shall include the date/time and quantities of materials used at each of the following stages of monitoring well construction, including:

- Drilling
  - Drill rig type
  - Drilling method/coring method
  - Drill bit/core barrel diameter (hole diameter)
  - Drill company, driller, helper(s)
  - Field geologist, supervising geologist
  - Dates/times start and finish drilling hole, interval drilling rates
  - Total depth of hole
  - Drilling location, surveyed ground elevation
  - Inclination of hole from horizontal
- Borehole abandonment – type, volume, and surface seal
- Casing material – type
- Casing decontamination – document process and equipment used
- Casing diameter – nominal I.D. of casing
- Screen material
  - Type
  - Top and bottom of section as actually installed
  - Length
  - Slot type, size, shape
  - Type of bottom plug and/or cap used
- Filter pack material
  - Composition and size gradation
  - Manufacturer
  - Actual volume and depth of top and bottom of filter pack
  - Calculated volume versus actual volume used and explanation of discrepancies
- Transition seal

  - Composition and depth of top and bottom of seal
  - Size (or gradation) or material used (e.g., pellets, granulated, or powdered)
  - Time allowed for hydration prior to emplacement of annular grout slurry seal
- Annular slurry seal
  - Date and time of beginning and completion of annular seal
  - Type and actual volume of seal
  - Calculated volume versus actual volume and explanation of discrepancies
  - Set time allowed prior to commencement of additional work
- Surface completion
  - Type of construction
  - Nature of materials used for surface completion
  - Date/time of completion

5.6.11 Well Location

A registered land surveyor shall survey each monitoring well location for exact horizontal location to the nearest 0.5 foot, and exact vertical location to the nearest 0.01 foot, referenced to mean sea level or mean low low water. The vertical elevation shall be surveyed between the two notches cut in the top of the well casing, which is the point from which all water level measurements shall be made. The elevation of the ground or top of the concrete slab adjacent to the monitoring well shall also be surveyed, to the nearest 0.01 foot.

5.7 WELL ABANDONMENT/DESTRUCTION

Once a monitoring well is no longer needed as part of an investigation, or has been damaged to the extent that it cannot be repaired, it is essential that it be properly abandoned. The proper abandonment of a monitoring well ensures that the underlying groundwater supply is protected and preserved. In addition, proper well abandonment eliminates a potential physical hazard and liability. An additional permit and/or inspection may be required for abandonment, depending on state or local regulations.

The standard procedures for the abandonment of a groundwater monitoring well apply to the HSA drilling method. This type of installation was chosen because it is the primary method of abandoning groundwater monitoring wells. For wells abandoned on Guam, the current Guam Environmental Protection Agency Well Abandonment Procedures shall be followed (Attachment I-C-1-1).

The first step in abandoning a groundwater monitoring well is to remove the surface completion from around the top of the well casing. This is normally accomplished using a jackhammer to break the surface cement seal, and then removing the monument or traffic box. When the surface seal and the wellhead cover have been removed, over-drill the well to its total depth using HSAs. Once the total depth of the well has been reached, remove the casing and screen from the borehole. Then completely backfill the borehole with a grout seal. Typically, the grout seal is emplaced as slurry of Portland cement grout, which contains a minimum of 3 to 5 percent bentonite as described in

Section 5.4.5. When mixing the slurry, take care that the bentonite is mixed according to the manufacturer's specifications to ensure the proper consistency.

Emplace the slurry through the HSAs. The rates at which the augers are withdrawn and the slurry is added shall be such that the level of the slurry within the borehole is just below the lead auger. The borehole seal shall extend from the total depth of the borehole to a depth of approximately 1 foot bgs. Then repair the surface to prior conditions and grade.

If the monitoring well casing cannot be pulled or drilled out, perforate the well casing adjacent to the saturated zones so that the annular space and any nearby voids can be filled with sealing material. Fill the perforated well or borehole from the bottom up with an appropriate sealing material, such as neat cement. Inject the neat cement under pressure to force it into the annular space, nearby voids, and filter pack. Apply pressure for a sufficient time to allow the cementing mixture to set. After the cement has hardened, excavate a hole around the well (use a backhoe if necessary) to the depth specified in the Monitoring Well Abandonment Work Plan (WP) and ensure the excavation depth is in accordance with local regulatory agency guidelines (Attachment 1 for *Guam Monitoring Well Abandonment Procedure*) (GEPA 2006). Remove the uppermost portion of the casing, (if still in place), and pour a cement cap on top of the abandoned well, and backfill the remaining portion of the excavation with sealing material. Note, if personnel are required to enter the excavation to remove the upper portion of the casing, then proper sloping and shoring are required as per Section 25, *Excavations* of The Safety and Health Requirements Manual EM 385-1-1 (USACE 2008).

The State of Hawaii Department of Health Hazard Evaluation and Emergency Response must be notified at least 1 week prior to any well abandonment activities conducted in Hawaii (DOH 2009, Section 6.2.5.1). Additionally, an Abandonment of Monitoring Well Summary Report should be prepared using the form presented in Attachment 1-C-1-2. The record should include the following information:

- Well construction information:
  - Date of installation
  - Drilling company
  - Total depth
  - Casing material/length
  - Screen material/length
  - Annular material
- General abandonment information:
  - Drilling firm (contact, mailing address, and phone number).
  - Consulting firm (contact, mailing address, and phone number).
- Well abandonment information
  - Date of abandonment
  - Reason for abandonment

- Details of how the casing/screen was removed drilled out or perforated.
- Sealing material (weight/volume/bags/mix ratio)

5.8 VAPOR EXTRACTION/MONITORING WELLS

Vapor extraction/monitoring wells have most of the same design and installation considerations and procedures as groundwater-monitoring wells, with the exception that they are screened in the unsaturated zone. Vapor extraction/monitoring wells generally shall not be screened over an interval greater than 20 feet and shall not be screened over two or more lithologies that have air permeabilities that differ by more than one order of magnitude. Vapor extraction/monitoring wells shall be installed using drilling techniques that do not require drilling fluids other than filtered air. Vapor monitoring wells may have casing I.D.s of 2 inches or less while extraction wells shall generally have casing I.D.s of at least 4 inches. The design of vapor extraction/monitoring wells is dependent upon many site-specific factors, such as the depth of contamination, soil conditions, geology, and depth to groundwater. As a result, specifics related to the design of these wells shall be included in the CTO WP, field sampling plan, or plans and specifications.

5.9 DRIVE POINTS

An alternative to conventional monitoring well construction is, under limited conditions, the use of drive points. These consist of slotted steel pipe that is pushed, hammered, or hydraulically jetted into the ground. A filter pack is not constructed around the screen, so the width of the screen openings must be sufficiently small to prevent the passage of significant quantities of sediment into the well during the withdrawal of water for sampling. In some instances, the drive points are used only as piezometers.

Drive points are commonly used in hazardous waste investigations to sample ambient soil gases in the vadose zone. It is often possible to extend the drive point below the water table to collect water samples. In some instances, permits may be required because the drive points are considered in some jurisdictions to be equivalent to a temporary monitoring well.

5.10 DISCRETE DEPTH GROUNDWATER SAMPLING

Another alternative to conventional monitoring well construction is the use of a discrete groundwater sampling device such as a Hydropunch. The Hydropunch tool can be used in conjunction with a standard drill rig, a cone penetrometer rig, or possibly a vehicle capable of driving vapor probes to sample groundwater and non-aqueous phase liquid in unconsolidated formations. The Hydropunch tool is constructed of a stainless steel drive point, a perforated section of Teflon pipe for a sample intake, and a stainless steel sample chamber. The tool is 55.5 inches long, 2 inches in O.D., and weighs approximately 24 pounds.

Ideally, a standard HSA drilling rig is used to drill a pilot hole to a depth just above the desired sampling depth. The Hydropunch tool is then hydraulically pushed or driven 4 to 5 feet through the saturated zone at each sampling location. As the tool is advanced, the sample intake screen remains pristine within the watertight stainless steel chamber. When the desired sampling interval is reached, the steel sampling chamber is unscrewed and withdrawn 1 foot to several feet, depending on how long a sampling interval is needed. This exposes the intake screen to the groundwater. Under hydrostatic pressure, groundwater flows through the intake screen and fills the sample chamber, without aeration or agitation occurring. The drive cone, which is attached to the base of the screen, will remain in place by soil friction.

The pointed shape of the sampler and its smooth exterior surface prevent downward transport of surrounding soil and groundwater as the tool is advanced. Once in place, the intake screen will be sealed from groundwater above and below the interval being sampled, because the exterior of the Hydropunch tool is flush against the surrounding soil wall. Additionally, as the tool is advanced, the sample intake screen is retained within the steel watertight sample chamber.

A stainless steel or Teflon bailer with a bottom check valve is lowered into the sample chamber to collect the groundwater sample. Groundwater is then decanted at ground surface from the bailer into the appropriate sample containers.

6. Records

Monitoring well location, design, and construction shall be recorded in the field notebook for the CTO and on a well completion record form (Figure I-C-1-5). The field operations manager should provide a copy of this form to the CTO Manager for the project files.

7. Health and Safety

Field personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

ASTM International (ASTM) 2010. *Standard Practice for Design and Installation of Ground Water Monitoring Wells*. D5092-04^{e1}(Reapproved 2010). West Conshohocken, PA.

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: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of Health, State of Hawaii (DOH). 2009. *Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan.* Interim Final. Honolulu: Office of Hazard Evaluation and Emergency Response. 21 June.

Department of the Navy (DON). 2010. *Ammunition and Explosives Safety Ashore*. NAVSEA OP 5 Volume 1, 7th Revision, Change 11. 0640-LP-108-5790. Commander, Naval Sea Systems Command. July 1.

———.2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Guam Environmental Protection Agency (GEPA). 2006. *Well Abandonment Procedure*. Water Resources Management Program.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual.* EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-A-5, Utility Clearance.

Procedure I-B-1, Soil Sampling.

Procedure I-B-5, Surface Water Sampling.

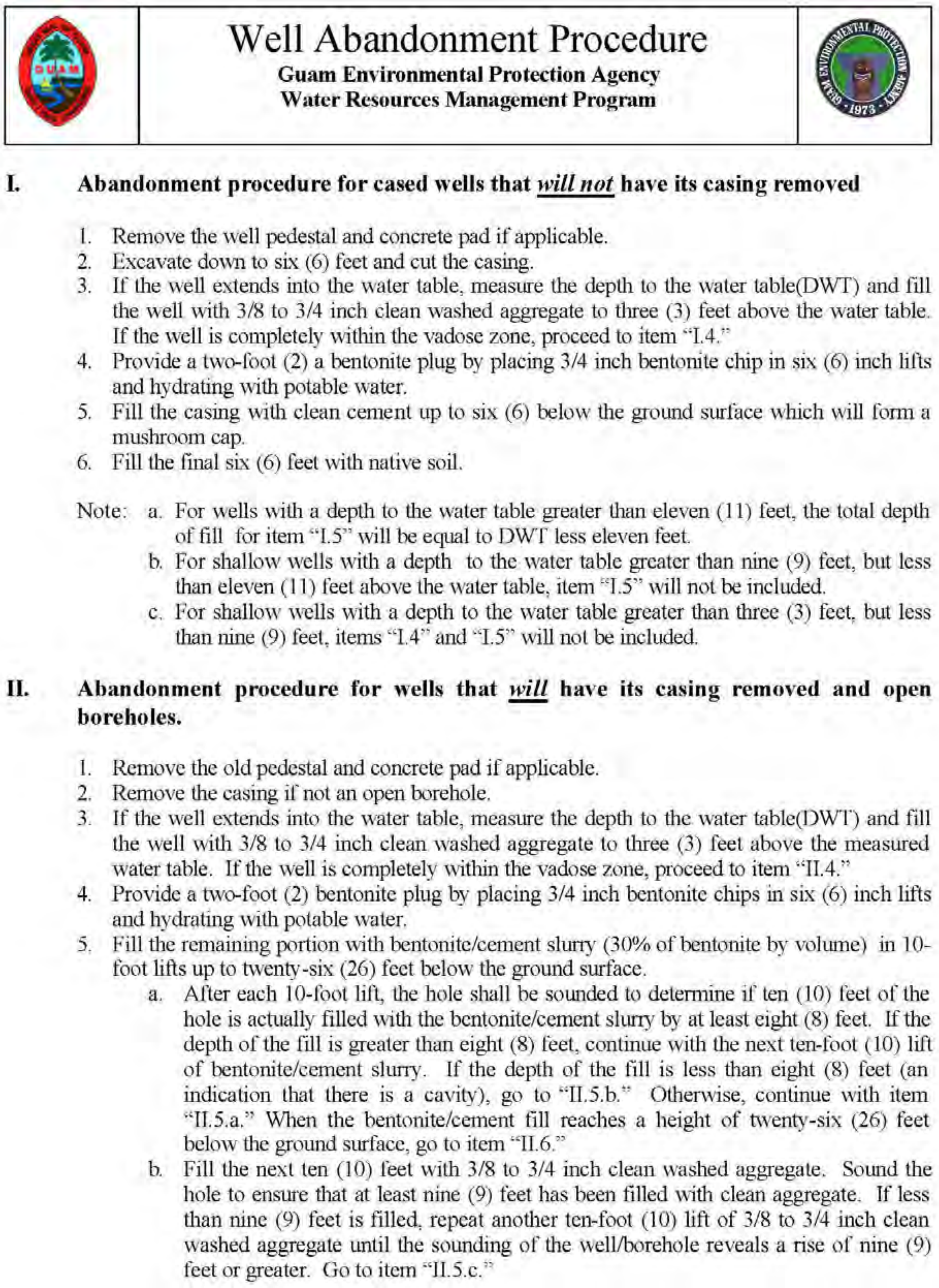
Procedure I-F, Equipment Decontamination.

9. Attachments

Attachment I-C-1-1, Guam Monitoring Well Abandonment Procedure

Attachment I-C-1-2, DOH Abandonment of Monitoring Well Summary Report Form

Attachment I-C-1-1
Guam Well Abandonment Procedure



Well Abandonment Procedure

Guam Environmental Protection Agency
Water Resources Management Program

I. Abandonment procedure for cased wells that ***will not*** have its casing removed

1. Remove the well pedestal and concrete pad if applicable.
2. Excavate down to six (6) feet and cut the casing.
3. If the well extends into the water table, measure the depth to the water table(DWT) and fill the well with 3/8 to 3/4 inch clean washed aggregate to three (3) feet above the water table. If the well is completely within the vadose zone, proceed to item "I.4."
4. Provide a two-foot (2) a bentonite plug by placing 3/4 inch bentonite chip in six (6) inch lifts and hydrating with potable water.
5. Fill the casing with clean cement up to six (6) below the ground surface which will form a mushroom cap.
6. Fill the final six (6) feet with native soil.

Note:
- a. For wells with a depth to the water table greater than eleven (11) feet, the total depth of fill for item "I.5" will be equal to DWT less eleven feet.
- b. For shallow wells with a depth to the water table greater than nine (9) feet, but less than eleven (11) feet above the water table, item "I.5" will not be included.
- c. For shallow wells with a depth to the water table greater than three (3) feet, but less than nine (9) feet, items "I.4" and "I.5" will not be included.

II. Abandonment procedure for wells that ***will*** have its casing removed and open boreholes.

1. Remove the old pedestal and concrete pad if applicable.
2. Remove the casing if not an open borehole.
3. If the well extends into the water table, measure the depth to the water table(DWT) and fill the well with 3/8 to 3/4 inch clean washed aggregate to three (3) feet above the measured water table. If the well is completely within the vadose zone, proceed to item "II.4."
4. Provide a two-foot (2) bentonite plug by placing 3/4 inch bentonite chips in six (6) inch lifts and hydrating with potable water.
5. Fill the remaining portion with bentonite/cement slurry (30% of bentonite by volume) in 10-foot lifts up to twenty-six (26) feet below the ground surface.
   - a. After each 10-foot lift, the hole shall be sounded to determine if ten (10) feet of the hole is actually filled with the bentonite/cement slurry by at least eight (8) feet. If the depth of the fill is greater than eight (8) feet, continue with the next ten-foot (10) lift of bentonite/cement slurry. If the depth of the fill is less than eight (8) feet (an indication that there is a cavity), go to "II.5.b." Otherwise, continue with item "II.5.a." When the bentonite/cement fill reaches a height of twenty-six (26) feet below the ground surface, go to item "II.6."
   - b. Fill the next ten (10) feet with 3/8 to 3/4 inch clean washed aggregate. Sound the hole to ensure that at least nine (9) feet has been filled with clean aggregate. If less than nine (9) feet is filled, repeat another ten-foot (10) lift of 3/8 to 3/4 inch clean washed aggregate until the sounding of the well/borehole reveals a rise of nine (9) feet or greater. Go to item "II.5.c."

   c. Provide a two-foot (2) bentonite plug above the clean aggregate by placing 3/4 inch bentonite chips in six (6) inch lifts and hydrating with potable water. Continue with item "II.5.a."

6. Fill the next twenty (20) feet above the bentonite/cement fill with neat cement.
7. The remaining six (6) feet shall be filled with native soil.

Note:
   a. For wells with a depth to the water table greater than thirty-one (31) feet, the total depth of fill for item "II.5" will be equal to DWT less thirty-one (31) feet.
   b. For shallow wells with a depth to the water table greater than eleven (11) feet, but less than thirty-one (31) feet above the water table, item "II.5" will not be included.
   c. For shallow wells with a depth to the water table greater than nine (9) feet, but less than eleven (11) feet above the water table, items "II.5" and "II.6" will not be included.
   d. For shallow wells with a depth to the water table greater than three (3) feet, but less than nine (9) feet, items "II.4", "II.5" and "II.6" will not be included.

General Notes:

a. The driller shall submit a well abandonment plan following the above procedure to Guam EPA for review/approval.
b. The driller shall notify Guam EPA administrator 48 hours prior to starting date of the the approved abandonment plan.
c. All above-ground materials shall be removed from the well site and disposed in a manner that conforms to the Guam EPA's solid waste regulations.
d. If a well is in an area that is covered with asphalt or concrete that is not to be removed (such as a parking lot or a driveway/street), the native soil fill may be excluded and the well may be filled to the top with neat cement and then covered with new asphalt or concrete.

Attachment I-C-1-2

DOH Abandonment of Monitoring Well Summary Report Form

Abandonment of Monitoring Well Summary Report

___________________ (Monitoring Well ID)

Submit form within 30 days of well abandonment or within 90 days if included in a site closure, monitoring, or investigation report. In addition, submit copies of the original boring log and well construction diagram for the monitoring well, a site map showing the location of the abandoned monitoring well, and the disposal documentation for wastes generated during the abandonment process. Submit all documentation to: Hawaii Department of Health, Hazard Evaluation and Emergency Response Office, Attention: SDAR, 919 Ala Moana Blvd, Rm. 206, Honolulu Hawaii 96814.

Location Information	**Owner Information**
Facility Name:	Well Owner:
Facility Address:	Contact Person:
	Mailing Address:
Latitude:	
Longitude:	Phone Number: Fax Number:
TMK:	Land Owner:
Location Description:	Contact Person:
	Mailing Address:
Monitoring Well Location Map Attached: Y N	Phone Number: Fax Number:
Well Construction Information	
Date of Installation:	Casing Material: Casing Diameter:
Drilling Company:	Casing Length: Casing Depth:
Total Depth:	Screen Material: Slot Size:
Depth to Water:	Screen Length: Screen Depth:
Was the Well Set in an Aquifer that is a Current or Potential	Annular Material: Depth:
Drinking Water Source: Y N	Annular Material: Depth:
Boring Log/Well Construction Diagram Attached: Y N	Annular Material: Depth:
General Abandonment Information	
Drilling Firm:	Consulting Firm:
Contact Person:	Contact Person:
Mailing Address:	Mailing Address:
Phone Number: Fax Number:	Phone Number: Fax Number:
Well Abandonment Information	
Date of Abandonment:	Sealing Material: Depth:
Reason for Abandonment:	Volume/Weight/Bags Mixing Ratio:
Casing/Screen Removed: Y N	Sealing Material: Depth:
If Yes, was annular material removed?: Y N	Volume/Weight/Bags Mixing Ratio:
If No, was casing cut off below the surface?: Y N	Method of Sealing Material Placement:
Comments:	
Driller's Signature:	Date:
Consultant's Signature:	Date:

Version: September 2005

Monitoring Well Sampling

1. Purpose

This standard operating procedure describes the monitoring well sampling procedures to be used by United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

None.

4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that these standard groundwater sampling activities are followed during projects conducted under the NAVFAC Pacific ER Program. The CTO Manager or designee shall review all groundwater sampling forms on a minimum monthly basis. The CTO Manager is responsible for ensuring that all personnel involved in monitoring well sampling shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for ensuring that all project field staff follow these procedures.

Field sampling personnel are responsible for the implementation of this procedure.

Minimum qualifications for sampling personnel require that one individual on the field team shall have a minimum of 1 year experience with sampling monitoring wells.

The field sampler and/or task manager is responsible for directly supervising the groundwater sampling procedures to ensure that they are conducted according to this procedure, and for recording all pertinent data collected during sampling. If deviations from the procedure are required because of anomalous field conditions, they must first be approved by the QA Manager or Technical Director and then documented in the field logbook and associated report or equivalent document.

5. Procedures

5.1 PURPOSE

This procedure establishes the method for sampling groundwater monitoring wells for water-borne contaminants and general groundwater chemistry. The objective is to obtain groundwater samples of aquifer conditions with as little alteration of water chemistry as possible.

5.2 PREPARATION

5.2.1 Site Background Information

Establish a thorough understanding of the purposes of the sampling event prior to field activities. Conduct a review of all available data obtained from the site and pertinent to the water sampling. Review well history data including, but not limited to, well locations, sampling history, purging rates, turbidity problems, previously used purging methods, well installation methods, well completion records (including depth of screened interval), well development methods, previous analytical results, presence of an immiscible phase, historical water levels, and general hydrogeologic conditions.

Previous groundwater development and sampling logs give a good indication of well purging rates and the types of problems that might be encountered during sampling, such as excessive turbidity and low well yield. They may also indicate where dedicated pumps are placed in the water column. To help minimize the potential for cross-contamination, well purging and sampling, and water level measurement collection shall proceed from the least contaminated to the most contaminated as indicated in previous analytical results. This order may be changed in the field if conditions warrant it, particularly if dedicated sampling equipment is used. A review of prior sampling procedures and results may also identify which purging and sampling techniques are appropriate for the parameters to be tested under a given set of field conditions.

5.2.2 Groundwater Analysis Selection

Establish the requisite field and laboratory analyses prior to water sampling. Decide on the types and numbers of QA/quality control (QC) samples to be collected (Procedure III-B, *Field QC Samples [Water, Soil]*), as well as the type and volume of sample preservatives, the number of sample containers (e.g., coolers), and the quantity of ice or other chilling materials. The sampling personnel shall ensure that the appropriate number and size sample containers are brought to the site, including extras in case of breakage or unexpected field conditions. Document the analytical requirements for groundwater analysis in the project-specific work plan.

5.3 GROUNDWATER SAMPLING PROCEDURES

Groundwater sampling procedures at a site shall include: (1) measurement of well depth to groundwater; (2) assessment of the presence or absence of an immiscible phase; (3) assessment of purge parameter stabilization; (4) purging of static water within the well and well bore; and (5) obtaining a groundwater sample. Each step is discussed in sequence below. Depending upon specific field conditions, additional steps may be necessary. As a rule, at least 24 hours should separate well development and well sampling events.

5.3.1 Measurement of Static Water Level Elevation

Measure the depth to standing water and the total depth of the well to the nearest 0.01 foot to provide baseline hydrologic data, to calculate the volume of water in the well, and to provide information on the integrity of the well (e.g., identification of siltation problems). Mark each well with a permanent, easily identified reference point for water level measurements whose location and elevation have been surveyed.

Before purging the well, measure water levels in all of the wells within the zone of influence of the well being purged. Measure water levels twice in quick succession and record each measurement. This will provide a water level database that describes water levels across the site at one time (a synoptic sampling). Measure the water level in each well immediately prior to purging the well.

The device used to measure the water level surface and depth of the well shall be sufficiently sensitive and accurate in order to obtain a measurement to the nearest 0.01 foot reliably. An electronic water level meter will usually be appropriate for this measurement; however, when the groundwater within a particular well is highly contaminated, an inexpensive weighted tape measure can be used to determine well depth to prevent adsorption of contaminants onto the meter tape. The presence of light, non-aqueous phase liquids (LNAPLs) and/or dense, non-aqueous phase liquids (DNAPLs) in a well requires measurement of the elevation of the top and the bottom of the product, generally using an interface probe. Water levels in such wells must then be corrected for density effects to accurately determine the elevation of the water table.

5.3.2 Decontamination of Equipment

Establish a decontamination station before beginning sampling. The station shall consist of an area of at least 4 feet by 2 feet covered with plastic sheeting and be located upwind of the well being sampled and far enough from potential contaminant sources to avoid contamination of clean equipment. The station shall be large enough to fit the appropriate number of wash and rinse buckets, and have sufficient room to place equipment after decontamination. One central cleaning area may be used throughout the entire sampling event. The area around the well being sampled shall also be covered with plastic sheeting to prevent spillage. Further details are presented in Procedure I-F, *Equipment Decontamination*.

Decontaminate each piece of equipment prior to entering the well. Also conduct decontamination prior to sampling at a site, even if the equipment has been decontaminated subsequent to its last usage. This precaution is taken to minimize the potential for cross-contamination. Additionally, decontaminate each piece of equipment used at the site prior to leaving the site. It is only necessary to decontaminate dedicated sampling equipment prior to installation within the well. Do not place clean sampling equipment directly on the ground or other contaminated surfaces prior to insertion into the well. Dedicated sampling equipment that has been certified by the manufacturer as being decontaminated can be placed in the well without onsite decontamination.

5.3.3 Detection of Immiscible Phase Layers

Complete the following steps for detecting the presence of LNAPL and DNAPL, as necessary, before the well is evacuated for conventional sampling:

1. Sample the headspace in the wellhead immediately after the well is opened for organic vapors using either a photoionization detector or an organic vapor analyzer (flame ionization detector), and record the measurements.

2. Lower an interface probe into the well to determine the existence of any immiscible layer(s), LNAPL and/or DNAPL, and record the measurements.
3. Confirm the presence or absence of an immiscible phase by slowly lowering a clear bailer to the appropriate depth, then visually observing the results after sample recovery.
4. In rare instances, such as when very viscous product is present, it may be necessary to utilize hydrocarbon- and water-sensitive pastes for measurement of LNAPL thickness. This is accomplished by smearing adjacent, thin layers of both hydrocarbon- and water-sensitive pastes along a steel measuring tape and inserting the tape into the well. An engineering tape showing tenths and hundredths of feet is required. Record depth to water, as shown by the mark on the water-sensitive paste, and depth to product, as shown by the mark on the product-sensitive paste. In wells where the approximate depth to water and product thickness are not known, it is best to apply both pastes to the tape over a fairly long interval (5 feet or more). Under these conditions, measurements are obtained by trial and error, and may require several insertions and retrievals of the tape before the paste-covered interval of the tape encounters product and water. In wells where approximate depths of air-product and product-water interfaces are known, pastes may be applied over shorter intervals. Water depth measurements should not be used in preparation of water-table contour maps until they are corrected for depression by the product.

If the well contains an immiscible phase, it may be desirable to sample this phase separately. Sections 5.3.5.1 and 5.3.5.2 present immiscible phase sampling procedures. It may not be meaningful to conduct water sample analysis of water obtained from a well containing LNAPLs or DNAPLs. Consult the CTO Manager and QA Manager or Technical Director if this situation is encountered.

5.3.4 Purging Equipment and Use

The water present in a well prior to sampling may not be representative of *in situ* groundwater quality and shall be removed prior to sampling. Handle all groundwater removed from potentially contaminated wells in accordance with the investigation-derived waste (IDW) handling procedures in Procedure I-A-6, *Investigation-Derived Waste Management*.

Purging shall be accomplished by removing groundwater from the well at low flow rates using a pump. According to the U.S. Environmental Protection Agency (EPA) (EPA 1996), the rate at which groundwater is removed from the well during purging ideally should be less than 0.2 to 0.3 liters/min. The EPA further states that wells should be purged at rates below those used to develop the well to prevent further development of the well, to prevent damage to the well, and to avoid disturbing accumulated corrosion or reaction products in the well. The EPA also indicates that wells should be purged at or below their recovery rate so that migration of water in the formation above the well screen does not occur.

Realistically, the purge rate should be low enough that substantial drawdown in the well does not occur during purging. The goal is minimal drawdown (less than 0.1 meter) during purging (EPA 1996). The amount of drawdown during purging should be recorded at the same time the other water parameters are measured. Also, a low purge rate will reduce the possibility of stripping volatile organic compounds (VOCs) from the water, and will reduce the likelihood of mobilizing colloids in the subsurface that are immobile under natural flow conditions.

The sampler shall ensure that purging does not cause formation water to cascade down the sides of the well screen. Wells shall not be purged to dryness if recharge causes the formation water to cascade down the sides of the screen, as this will cause an accelerated loss of volatiles. This problem should be anticipated. Water shall be purged from the well at a rate that does not cause recharge water to be excessively agitated unless an extremely slow recharging well is encountered where complete evacuation is unavoidable.

In high yield wells (wells that exhibit 80 percent recovery in less than 2 hours), purging shall be conducted at relatively low flow rates and shall remove water from the entire screened interval of the well to ensure that fresh water from the formation is present throughout the entire saturated interval. In general, place the intake of the purge pump 2 to 3 feet below the air-water interface within the well to allow purging and at the same time minimize disturbance/overdevelopment of the screened interval in the well. During the well purging procedure, collect water level and/or product level measurements to assess the hydraulic effects of purging. Sample the well when it recovers sufficiently to provide enough water for the analytical parameters specified.

Low yield wells (those that exhibit less than 80 percent recovery in less than 2 hours) require one borehole volume of water to be removed. Allow the well to recover sufficiently to provide enough water for the specified analytical parameters, and then sample it.

Evaluate water samples on a regular basis (approximately every 5 minutes) during well evacuation and analyze them in the field preferably using a multi-parameter meter and flow-through cell for temperature, pH (indicates the hydrogen ion concentration – acidity or basicity), specific conductivity, dissolved oxygen (DO), oxidation reduction potential (ORP), turbidity, salinity, and total dissolved solids (TDS). Take at least five readings during the purging process. These parameters are measured to demonstrate that the natural character of the formation water has been pumped into the well. Purging shall be considered complete when three consecutive sets of field parameter measurements stabilize within approximately 10 percent (EPA 2006). However, suggested ranges are ±0.2 degrees Celsius for temperature, ±0.1 standard units for pH, ±3 percent for specific conductance, ±10 percent for DO, and ±10 millivolts for redox potential (ASTM 2001). This criterion may not be applicable to temperature if a submersible pump is used during purging due to the heating of the water by the pump motor. Enter all information obtained during the purging and sampling process including drawdown, into a groundwater sampling log (Figure I-C-3-1). Complete all blanks on this field log during sampling.

In cases where an LNAPL has been detected in the monitoring well, insert a stilling tube of a minimum diameter of 2 inches into the well prior to well purging. The stilling tube shall be composed of a material that meets the performance guidelines for sampling devices. Insert the stilling tube into the well to a depth that allows groundwater from the screened interval to be purged and sampled, but that is below the upper portion of the screened interval where the LNAPL is entering the well screen. The goal is to sample the aqueous phase (groundwater) while preventing the LNAPL from entering the sampling device. To achieve this goal, insert the stilling tube into the well in a manner that prevents the LNAPL from entering the stilling tube. However, sampling groundwater beneath a NAPL layer is not generally recommended due to the fact that the interval with residual NAPL saturation is often unknown and the NAPL can be mobilized into the well from intervals below the water table.

One method of doing this is to cover the end of the stilling tube with a membrane or material that will be ruptured by the weight of the pump. A piece of aluminum foil can be placed over the end of the stilling tube. Slowly lower the stilling tube into the well to the appropriate depth and then attach it firmly to the top of the well casing. When the pump is inserted, the weight of the pump breaks the foil covering the end of the tube, and the well can be purged and sampled from below the LNAPL layer. Firmly fasten the membrane or material that is used to cover the end of the stilling tube so that it remains attached to the stilling tube when ruptured. Moreover, the membrane or material must retain its integrity after it is ruptured. Pieces of the membrane or material must not fall off of the stilling tube into the well. Although aluminum foil is mentioned in this discussion as an example of a material that can be used to cover the end of the tube, a more chemically inert material may be required, based on the site-specific situation. Thoroughly decontaminate stilling tubes prior to each use. Collect groundwater removed during purging, and store it on site until its disposition is determined based upon laboratory analytical results. Storage shall be in secured containers, such as U.S. Department of Transportation-approved drums. Label containers of purge water with the standard NAVFAC Pacific ER Program IDW label.

The following paragraphs list available purging equipment and methods for their use.

5.3.4.1 BAILERS AND PUMPS

Submersible Pump: A stainless steel submersible pump may be utilized for purging both shallow and deep wells prior to sampling groundwater for volatile, semivolatile, and non-volatile constituents. For wells over 200 feet deep, the submersible pump is one of the few technologies available to feasibly accomplish purging under any yield conditions. For shallow wells with low yields, submersible pumps are generally inappropriate due to over stressing of the wells (<1 gallon per minute), which causes increased aeration of the water within the well.

Steam clean or otherwise decontaminate the pump and discharge tubing prior to the placing the pump in the well. The submersible pump shall be equipped with an anti-backflow check valve to keep water from flowing back down the drop pipe into the well. Place the pump intake approximately 2 to 3 feet below the air-water interface within the well and maintain it in that position during purging. Additionally, when pulling the pump out of the well subsequent to purging, take care to avoid dumping water within the drop pipe and pump stages back into the well.

Bladder Pump: A stainless steel and/or Teflon bladder pump can be utilized for purging and sampling wells up to 200 feet in depth for volatile, semivolatile, and non-volatile constituents. Additionally, the bladder pump can be used for purging and obtaining groundwater samples overlain by a LNAPL layer as long as care is taken not to draw the product layer into the bladder pump. Use of the bladder pump is most effective in low to moderate yield wells.

Either a battery powered compressor, compressed dry nitrogen, or compressed dry air, depending upon availability, can operate the bladder pump. The driving gas utilized must be dry to avoid damage to the bladder pump control box. Decontaminate the bladder pump prior to use. Once purging is complete, collect the samples directly from the bladder pump.

Centrifugal or Diaphragm Pump: A centrifugal, or diaphragm, pump may be used to purge a well if the water level is within 20 feet of ground surface. A new, or properly decontaminated, hose is lowered into the well and water withdrawn at a rate that does not cause excessive well drawdown.

GROUNDWATER SAMPLING LOG

WELL NO. ____________ LOCATION: ____________ PROJECT NO. ____________

DATE: TIME: ____________ CLIMATIC CONDITIONS: ____________

TIDAL CONDITIONS: Rising ☐ Falling ☐ HIGH TIDE: LOW TIDE: CURRENT TIDE:

STATIC WATER LEVEL (FT.) and TIME: ____________ TOTAL DEPTH (FT.): ____________

WELL PURGING: LENGTH OF SATURATED ZONE: ____________ LINEAR FT.

a VOLUME OF WATER TO BE EVACUATED: _______ GALS. (Gals/Linear ft. X linear feet of saturation X 3-casing volumes)

METHOD OF REMOVAL: ____________ PUMPING RATE: ____________ mL/min

WELL PURGE DATA:

DATE/ TIME	DTW	GALLONS REMOVED	TDS (g/L)	pH	SP. COND. (mS/cm)	D.O. (mg/L)	TURB. (NTU)	TEMP. (°C)	ORP (mV)	SAL (ppt)

SAMPLE WITHDRAWAL METHOD: ____________

APPEARANCE OF SAMPLE: COLOR: ____________

SEDIMENT: ____________

OTHER: ____________

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES ____________

NUMBER AND TYPES OF SAMPLE CONTAINERS USED: ____________

SAMPLE IDENTIFICATION NUMBER(S) ____________

DECONTAMINATION PROCEDURES: ____________

NOTES: ____________

SAMPLED BY: ____________

SAMPLES DELIVERED TO: ____________ TRANSPORTER: ____________

DATE: ____________ TIME: ____________

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2"-0.16•4"-0.65•6"-1.47•8"-2.61•10"-4.08•12"-5.87

Figure I-C-3-1: Groundwater Sampling Log

Place the hose bottom approximately 2 to 3 feet below the air-water interface and maintain it in that position during purging.

Air Lift Pump: Airlift pumps are not appropriate for purging or sampling.

Bailer: Avoid using a bailer to purge a well because it can result in aeration of the water in the well and possibly cause excessive purge rates. If a bailer must be used, decontaminate the bailer, bailer wire, and reel as described in Section 5.3.2 prior to its use. Teflon-coated cable mounted on a reel is recommended for lowering the bailer in and out of the well.

Lower the bailer below the water level of the well with as little disturbance of the water as possible to minimize aeration of the water in the well. One way to gauge the depth of water on the reel is to mark the depth to water on the bailer wire with a stainless steel clip. In this manner, less time is spent trying to identify the water level in the well. The QA Manager or Technical Director shall approve use of bailers for purging monitoring wells in advance.

5.3.5 Monitoring Well Sampling Methodologies

5.3.5.1 SAMPLING LIGHT, NON-AQUEOUS PHASE LIQUIDS (LNAPL)

Collect LNAPL, if present, prior to any purging activities. The sampling device shall generally consist of a dedicated or disposable bailer equipped with a bottom-discharging device. Lower the bailer slowly until contact is made with the surface of the LNAPL, and to a depth less than that of the immiscible fluid/water interface depth as determined by measurement with the interface probe. Allow the bailer to fill with the LNAPL and retrieve it.

When sampling LNAPLs, never drop bailers into a well, and always remove them from the well in a manner that causes as little agitation of the sample as possible. For example, the bailer should not be removed in a jerky fashion or be allowed to continually bang against the well casing as it is raised. When using bailers to collect LNAPL samples for inorganic analyses, the bailer shall be composed of fluorocarbon resin. Bailers used to collect LNAPL samples for organic analyses shall be constructed of stainless steel. The cable used to raise and lower the bailer shall be composed of an inert material (e.g., stainless steel) or coated with an inert material (e.g., Teflon).

5.3.5.2 SAMPLING DENSE, NON-AQUEOUS PHASE LIQUIDS (DNAPL)

Collect DNAPL prior to any purging activities. The best method for collecting DNAPL is to use a double-check valve, stainless steel bailer, or a Kemmerer (discrete interval) sampler. The sample shall be collected by slow, controlled lowering of the bailer to the bottom of the well, activation of the closing device, and retrieval.

5.3.5.3 GROUNDWATER SAMPLING METHODOLOGY

The well shall be sampled when groundwater within it is representative of aquifer conditions and after it has recovered sufficiently to provide enough volume for the groundwater sampling parameters. A period of no more than 2 hours shall elapse between purging and sampling to prevent groundwater interaction with the casing and atmosphere. This may not be possible with a slowly recharging well. Measure and record the water level prior to sampling to demonstrate the degree of recovery of the well. Sampling equipment (e.g., especially bailers) shall never be dropped into the well, as this could cause aeration of the water upon impact. Additionally, the sampling methodology utilized shall allow for the collection of a groundwater sample in as undisturbed a condition as possible, minimizing the potential for volatilization or aeration. This includes minimizing agitation and aeration during transfer to sample containers.

Sampling equipment shall be constructed of inert material. Equipment with neoprene fittings, polyvinyl chloride bailers, tygon tubing, silicon rubber bladders, neoprene impellers, polyethylene, and viton is not acceptable. If bailers are used, an inert cable/chain (e.g., fluorocarbon resin-coated wire or single strand stainless steel wire) shall be used to raise and lower the bailer. Generally, bladder and submersible pumps are acceptable sampling devices for all analytical parameters. Dedicated equipment is highly recommended for all sampling programs. The following text describes sampling methods utilizing submersible pumps, bladder pumps, and bailers.

Submersible Pumps: When operated under low-flow rate conditions (100 to 300 milliliters [mL]/minute or less), submersible pumps are as effective as bladder pumps in acquiring samples for volatile organic analysis as well as other analytes. The submersible pump must be specifically designed for groundwater sampling (i.e., pump composed of stainless steel and Teflon, sample discharge lines composed of Teflon) and must have a controller mechanism allowing the required low flow rate. Adjust the pump rate so that flow is continuous and does not pulsate to avoid aeration and agitation within the sample discharge lines. Run the pump for several minutes at the low flow rate used for sampling to ensure that the groundwater in the lines was obtained at the low flow rate. Higher pumping rates than 100 to 300 mL/minute may be used when collecting samples to be analyzed for non-volatile constituents, if significant drawdown does not occur.

Bladder Pumps: A gas-operated Teflon or stainless steel bladder pump with adjustable flow control and equipped with Teflon-lined tubing can be effectively utilized to collect a groundwater sample and is considered to be the best overall device for sampling inorganic and organic constituents. Operate positive gas displacement bladder pumps in a continuous manner so that they minimize discharge pulsation that can aerate samples in the return tube or upon discharge. If a bladder pump is utilized for the well purging process, the same bladder pump can also be utilized for sample collection after purging is complete.

Most models of bladder pumps can be operated with a battery powered compressor and control box. The compressor can be powered with either a rechargeable battery pack (provided with the compressor), by running directly off of a vehicle battery (via alligator clips), or by plugging into the vehicle’s direct current connector (cigarette lighter receptacle). When using a vehicle to power a compressor, several precautions should be taken. First, position the vehicle downwind of the well. Second, ensure the purge water exiting the well is collected into a drum or bucket. Finally, connect the compression hose from the well cap to the control box. Do not connect the compression hose from the compressor to the control box until after the engine has been started.

When all precautions are completed and the engine has been started, connect the compression hose to the control box. Slowly adjust the control knobs so as to discharge water at a flow rate (purge rate) that minimizes drawdown in the well, usually around 100 to 300 mL/minute. The compressor should not be set as to discharge the water as hard as possible. The optimal setting is one that produces the required purge rate per minute (not per purge cycle) while maintaining a minimal drawdown.

Prior to sampling volatiles constituents, turn off the vehicle engine, and obtain a flow rate of 100 mL/minute so as not to cause fluctuation in pH, pH-sensitive analytes, the loss of volatile constituents, or draw down of the groundwater table. If necessary (when sampling wells that require a large sample volume) the vehicle engine may be turned back on after sampling volatile constituents. Higher flow rates (100 to 300 mL/minute) can be used once the samples for the analysis of volatile components have been collected, but should not allow for increased draw down in the well. At no time shall the sample flow rate exceed the flow rate used while purging. Preserve the natural conditions of the groundwater, as defined by pH, DO, specific conductivity, and reduction/oxidation (redox).

For those samples requiring filtration, it is recommended to use in-line high capacity filters after all nonfiltered samples have been collected.

Bailers: A single- or double-check valve Teflon or stainless steel bailer equipped with a bottom discharging device can be utilized to collect groundwater samples. Bailers have a number of disadvantages, however, including a tendency to alter the chemistry of groundwater samples due to degassing, volatilization, and aeration; the possibility of creating high groundwater entrance velocities; differences in operator techniques resulting in variable samples; and difficulty in determining where in the water column the sample was collected. Therefore, use bailers for groundwater sampling only when other types of sampling devices cannot be utilized for technical or logistical reasons. The QA Manager or Technical Director must approve the use of bailers for groundwater sampling in advance.

Thoroughly decontaminate the bailer before being lowering it into the well if it is not a disposable bailer sealed in plastic. Collect two to three rinse samples and discharge them prior to acquisition of the actual sample. Each time the bailer is lowered to the water table, lower it in such a way as to minimize disturbance and aeration of the water column within the well.

The preferred alternative when using bailers for sampling is to use disposable Teflon bailers equipped with bottom-discharging devices. Use of disposable bailers reduces decontamination time and limits the potential for cross-contamination.

Passive Sampling: Passive samplers include passive diffusion bags, HydraSleeve, Snap Sampler, Gore Sorbers, and rigid porous polyethylene samplers. Passive samplers generate minimal waste and purge water, if any. Passive samplers depend on ambient equilibrium with formation water. These are relatively inexpensive, simple to deploy and work well for low-yield wells. However, passive samplers have volume and or analyte limitations and may require consideration of contaminant stratification. Passive samplers should be handled in accordance with the manufacturer's instructions, Army guidance (USACE 2002), or ITRC guidance (ITRC 2007).

5.3.6 Sample Handling and Preservation

Many of the chemical constituents and physiochemical parameters to be measured or evaluated during groundwater monitoring programs are chemically unstable; therefore, preserve samples. The EPA document entitled, *Test Methods for Evaluating Solid Waste – Physical/Chemical Methods, SW-846* (EPA 2007)*,* includes a discussion of appropriate sample preservation procedures. In addition, SW-846 specifies the sample containers to use for each constituent or common set of parameters. In general, check with specific laboratory requirements prior to obtaining field samples. In many cases, the laboratory will supply the necessary sample bottles and required preservatives. In some cases, the field team may add preservatives in the field. Sample containers should be labeled in accordance with Procedure III-E, *Record Keeping, Sample Labeling, and Chain of Custody.*

Improper sample handling may alter the analytical results of the sample. Therefore, transfer samples in the field from the sampling equipment directly into the container that has been prepared specifically for that analysis or set of compatible parameters as described in the CTO-specific work plan. It is not an acceptable practice for samples to be composited in a common container in the field and then split in the laboratory, or poured first into a wide mouth container and then transferred into smaller containers.

Collect groundwater samples and place them in their proper containers in the order of decreasing volatility and increasing stability. A preferred collection order for some common groundwater parameters is:

1. VOCs and total organic halogens (TOX)
2. Dissolved gases, total organic carbon (TOC), total fuel hydrocarbons
3. Semivolatile organics, pesticides
4. Total metals, general minerals (unfiltered)
5. Dissolved metals, general minerals (filtered)
6. Phenols
7. Cyanide
8. Sulfate and chloride
9. Turbidity
10. Nitrate and ammonia
11. Radionuclides

When sampling for VOCs, collect water samples in vials or containers specifically designed to prevent loss of VOCs from the sample. An analytical laboratory shall provide these vials, preferably by the laboratory that will perform the analysis. Collect groundwater from the sampling device in vials by allowing the groundwater to slowly flow along the sides of the vial. Sampling equipment shall not touch the interior of the vial. Fill the vial above the top of the vial to form a positive meniscus with no overflow. No headspace shall be present in the sample container once the container has been capped. This can be checked by inverting the bottle once the sample is collected and tapping the side of the vial to dislodge air bubbles. Sometimes it is not possible to collect a sample without air bubbles, particularly water that is aerated. In these cases, the investigator shall note the problem to account for possible error. Cooling samples may also produce headspace, but this will typically disappear once the sample is warmed prior to analysis. In addition, if the samples are shipped by air, air bubbles form most of the time. Field logs and laboratory analysis reports shall note any headspace in the sample container(s) at the time of receipt by the laboratory, as well as at the time the sample was first transferred to the sample container at the wellhead.

5.3.6.1 SPECIAL HANDLING CONSIDERATIONS

Samples requiring analysis for organics shall not be filtered. Samples shall not be transferred from one container to another because this could cause aeration or a loss of organic material onto the walls of the container. TOX and TOC samples shall be handled and analyzed in the same manner as VOC samples.

Obtain groundwater samples to be analyzed for metals sequentially. One sample shall be obtained directly from the pump and be unfiltered. The second sample shall be filtered through a 0.45-micron membrane in-line filter. Both filtered and unfiltered samples shall be transferred to a container, preserved with nitric acid to a pH less than 2, and analyzed for dissolved metals. Remember to include a filter blank for each lot of filters used and always record the lot number of the filters. In addition, allow at least 500 mL of effluent to flow through the filter prior to sampling. Any difference in concentration between the total and dissolved fractions may be attributed to the original metallic ion content of the particles and adsorption of ions onto the particles.

5.3.6.2 FIELD SAMPLING PRESERVATION

Preserve samples immediately upon collection. Ideally, sampling containers will be pre-preserved with a known concentration and volume of preservative. For example, metals require storage in aqueous media at pH of 2 or less. Typically, 0.5 mL of 1:1 nitric acid added to 500 mL of groundwater will produce a pH less than 2. Certain matrices that have alkaline pH (greater than 7) may require more preservative than is typically required. An early assessment of preservation techniques, such as the use of pH strips after initial preservation, may therefore be appropriate. The introduction of preservatives will dilute samples, and may require normalization of results. Guidance for the preservation of environmental samples can be found in the EPA *Handbook for Sampling and Sample Preservation of Water and Wastewater* (EPA 1982). Additional guidance can be found in other EPA documents (EPA 1992, 1996).

5.3.6.3 FIELD SAMPLING LOG

A groundwater sampling log (Figure I-C-3-1) shall document the following:

- Identification of well
- Well depth
- Static water level depth and measurement technique
- Presence of immiscible layers and detection method
- Well yield
- Purge volume and pumping rate
- Time that the well was purged
- Collection method for immiscible layers
- Sample identification numbers
- Well evacuation procedure/equipment
- Sample withdrawal procedure/equipment
- Date and time of collection
- Well sampling sequence
- Types of sample containers used and sample identification numbers
- Preservative(s) used
- Parameters requested for analysis

- Field analysis data
- Sample distribution and transporter
- Field observations on sampling event
- Name of collector
- Climatic conditions including air temperature

6. Records

Document information collected during groundwater sampling on the groundwater sampling log form in indelible ink (Figure I-C-3-1). Send copies of this information to the CTO Manager and to the project files.

7. Health and Safety

Field personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

ASTM International (ASTM). 2001. *Standard Guide for Sampling Ground-Water Monitoring Wells*. D4448). Reapproved in 2013). West Conshohocken, PA.

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: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Environmental Protection Agency, United States (EPA). 1982. *Handbook for Sampling and Sample Preservation of Water and Wastewater.* EPA-600/4-82-029. Cincinnati: EPA Office of Research and Development, Environmental Monitoring and Support Laboratory.

———. 1992. *RCRA Groundwater Monitoring Draft Technical Guidance*. EPA/530/R-93/001. Office of Solid Waste. November.

———. 1996. *Ground Water Issue: Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*. EPA/540/S-95/504. Office of Solid Waste and Emergency Response. April.

———. 2006. *Systematic Planning: A Case Study for Hazardous Waste Site Investigations. EPA WA/CS-1.* EPA/240/B-06/004. Office of Environmental Information. March.

———. 2007. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* 3rd ed., Revision 6. Office of Solid Waste. November. On-line updates at: http://www.epa.gov/epawaste/hazard/testmethods/sw846/online/index.htm.

Interstate Technology and Regulatory Council (ITRC). 2007. *Protocol for Use of Five Passive Samplers to Sample for a Variety of Contaminants in Groundwater.* February.

United States Army Corps of Engineers (USACE). 2002. *Study of Five Discrete Interval-Type Groundwater Sampling Devices*. Cold Regions Research and Engineering Laboratory. Hanover, NH. August.

———. 2008. *Consolidated Safety and Health Requirements Manual.* EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-A-6, *Investigation-Derived Waste Management.*

Procedure I-F, *Equipment Decontamination.*

Procedure III-B, *Field QC Samples (Water, Soil).*

Procedure III-E, *Record Keeping, Sample Labeling, and Chain of Custody.*

9. Attachments

None.

Drum Sampling

1. Purpose

This standard operating procedure describes the methods by which United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel will sample drum(s) at hazardous waste and non-hazardous waste sites. Prior to disturbing and handling drums of unknown origin and/or with unknown contents, approval from the Navy will be required.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program. As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations

3. Definitions

None.

4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that drums of concern are handled and sampled according to this procedure. The CTO Manager is responsible for ensuring that all personnel involved in drum sampling have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for ensuring that these procedures and the work plan (WP) are followed when drums are sampled.

Field sampling personnel are responsible for the implementation of this procedure.

5. Procedures

5.1 METHOD SUMMARY

Prior to sampling, drums should be inventoried, staged, and opened. Inventorying entails recording the visible qualities of each drum and any characteristics pertinent to classification of the contents. Staging involves the organization, and sometimes consolidation, of drums containing similar wastes or that share characteristics. Closed drums may be opened manually or remotely. In the interest of worker safety, it is required to open drums remotely unless the drum contents are known not to present any potential physical or chemical threat to workers. Analytical results from associated field samples may be used to evaluate potential threats. The most widely used method of sampling a drum containing liquids involves the use of a glass thief. This method is quick, simple, relatively inexpensive, and does not require decontamination. Additional information related to drum sampling is available in Section 8, References.

5.2 INTERFERENCE AND POTENTIAL PROBLEMS

The practice of tapping drums to determine their contents is neither safe nor effective and should not be used. Any necessary air monitoring should be conducted when working near over-pressurized drums.

Do not move drums that are over-pressurized to the extent that the head is swollen several inches above the level of the chime (the protruding rings at the top and bottom of the drum). A number of devices have been developed for venting critically swollen drums. One method that has proven to be effective is a tube and spear device. A light aluminum tube (3 meters long) is positioned at the vapor space of the drum. A rigid, hooking device attached to the tube goes over the chime and holds the tube securely in place. The spear is inserted in the tube and positioned against the drum wall. A sharp blow on the end of the spear drives the sharpened tip through the drum, and the gas vents along the grooves. The venting should be done remotely (e.g., using a backhoe bucket) from behind a wall or barricade. Once the pressure has been relieved, the bung can be removed and the drum sampled. It is necessary that personnel experienced in sampling of over-pressurized or unknown drum contents, or known hazardous waste contents, perform this task. If project team personnel are not experienced in this type of sampling, it is recommended that a subcontractor experienced in this type of sampling implement this portion of the sampling.

5.3 EQUIPMENT/APPARATUS

The following are standard materials and equipment required for sampling:

- An approved site-specific sampling plan and health and safety plan (HSP)
- Personal protection equipment
- Sample containers appropriate for the matrix being sampled
- Uniquely numbered sample identification labels
- One-gallon covered cans half-filled with absorbent packing material, to be used as necessary to hold waste
- Chain-of-custody sheets
- Decontamination equipment (Procedure I-F, *Equipment Decontamination*.)
- Glass thieving tubes, composite liquid waste sampler (COLIWASA), or equivalent
- Drum-opening devices
- Monitoring equipment for the detection of toxic and explosive environments, whenever the contents are not known

5.3.1 Drum-Opening Devices

5.3.1.1 BUNG WRENCH

A common method for opening drums manually is using a universal bung wrench. The fittings on a bung wrench are made to remove nearly all commonly encountered bungs. They are usually constructed of cast iron, brass, or a bronze-beryllium, non-sparking alloy. The use of a non-sparking wrench does not eliminate the possibility of producing a spark.

5.3.1.2 DRUM DEHEADER

One means by which a drum can be opened manually when a bung is not removable with a bung wrench is by using a drum deheader. This tool is constructed of forged steel with an alloy steel blade and is designed to partially or completely cut off the lid of a drum by means of scissors-like cutting action. A limitation of this device is that it can be attached only to closed head drums. Drums with removable heads or over-pressurized drums should be opened by other means.

5.3.1.3 BACKHOE SPIKE

The most common means of opening drums remotely for sampling is the use of a metal spike attached or welded to a backhoe bucket. In addition to being very efficient, this method can greatly reduce the likelihood of personnel exposure.

5.3.1.4 HYDRAULIC DRUM OPENER

Hydraulic drum openers use hydraulic pressure to pierce the drum. It consists of a manually operated pump that pressurizes oil through a length of hydraulic line attached to a metal point that pierces the side or head of the drum.

5.3.1.5 PNEUMATIC DEVICES

A pneumatic bung remover consists of a compressed air supply that is controlled by a heavy-duty, two-stage regulator. A high-pressure air line of desired length delivers compressed air to a pneumatic drill, which is adapted to turn a bung fitting selected to fit the bung to be removed. An adjustable bracketing system positions and aligns the pneumatic drill over the bung. The bracketing system must be attached to the drum before the drill can be operated. Once the bung has been loosened, the bracketing system must be removed before the drum can be sampled. The pneumatic bung opener does not permit the slow venting of the container, and therefore, appropriate precautions must be taken. The pneumatic bung opener also requires the container to be upright and relatively level. This device cannot remove bungs that are rusted shut.

5.4 SAMPLING PROCEDURE

5.4.1 Drum Staging

Prior to sampling, stage the drums (if not already staged) for easy access. Ideally, the staging area should be located just far enough from the drum opening area to prevent a chain reaction if one drum with unknown contents or visibly over-pressurized should explode or catch fire when opened.

During staging, physically separate the drums into the following categories: those containing liquids; those containing solids; lab packs; gas cylinders; and those that are empty. The strategy for sampling and handling drum/containers in each of these categories will be different. Categories are determined by:

- Visual inspection of the drum and its labels, codes, etc. Solids and sludges are typically disposed of in open top drums. Closed head drums with a bung opening generally contain liquid.
- Visual inspection of the contents of the drum during sampling, followed by restaging, if needed.

For discovered drums that require excavation, eliminate immediate hazards by over packing or transferring the drum's contents to another suitable container, affixing with a numbered tag, and transferring to a staging area. Use color-coded tags, labels, or bands to mark similar waste types. Record a description of each drum, its condition, any unusual markings, and the location where it was buried or stored on a drum data sheet (see Attachment I-D-1-1.) This data sheet becomes the principal record-keeping tool for tracking the drum on site.

Where space allows, physically separate the unknown or suspected hazardous waste-containing or over-pressurized drum opening area from the drum removal and drum staging operations. Move drums from the staging area to the drum opening area one at a time using forklift trucks equipped with drum grabbers or a barrel grappler. In a large-scale drum handling operation, drums may be conveyed to the drum opening area using a roller conveyor.

5.4.2 Drum Opening

There are three techniques for opening drums at suspected or known hazardous waste sites:

- Manual opening with non-sparking bung wrenches
- Drum deheading
- Remote drum puncturing and bung removal

The choice of drum opening technique and accessories depends on the number of drums to be opened, their waste contents, and their physical condition. Remote drum opening equipment should always be considered to protect worker safety. Under Occupational Safety and Health Administration 1910.120 (OSHA 1998), manual drum opening with bung wrenches or deheaders should be performed only on structurally sound drums whose waste contents are known not to be shock sensitive, reactive, explosive, or flammable.

5.4.2.1 MANUAL DRUM OPENING

Bung Wrench

Do not perform manual drum opening with bung wrenches unless the drums are structurally sound (no evidence of bulging or deformation) and their contents are known to be non-explosive. If opening the drum with bung wrenches is deemed reasonably cost-effective and safe, then certain procedures should be implemented to minimize the hazard:

- Field personnel should be fully outfitted with protective gear.
- Continually monitor atmospheres for toxicity, explosivity, and if applicable, radioactivity.

- Position drums upright with the bung up, or, for drums with bungs on the side, laid on their sides with the bung plugs up.
- The wrenching motion should be a slow, steady pull across the drum. If the length of the bung wrench handle provides inadequate leverage for unscrewing the plug, attach a "cheater bar" to the handle to improve leverage.

5.4.2.2 DRUM DEHEADING

Do not perform drum deheading unless the drums are structurally sound (no evidence of bulging or deformation) and their contents are known to be non-explosive. Drums are opened with a drum deheader by first positioning the cutting edge just inside the top chime and then tightening the adjustment screw so that the deheader is held against the side of the drum. Moving the handle of the deheader up and down while sliding the deheader along the chime will enable the entire top to be rapidly cut off, if desired. If the top chime of a drum has been damaged or badly dented, it may not be possible to cut the entire top off. Because there is always the possibility that a drum may be under pressure, make the initial cut very slowly to allow for the gradual release of any built-up pressure. A safer technique would be to employ a remote method prior to using the deheader.

Self-propelled drum openers, which are either electrically or pneumatically driven, are available and can be used for quicker and more efficient deheading.

5.4.2.3 REMOTE OPENING

Remotely operated drum opening tools are the safest available means of opening a drum. Remote drum opening is slow, but provides a high degree of safety compared to manual methods of opening.

Backhoe Spike

"Stage" or place drums in rows with adequate aisle space to allow ease in backhoe maneuvering. Once staged, punching a hole in the drumhead or lid with the spike can quickly open the drums.

Decontaminate the spike after each drum is opened to prevent cross contamination. Even though some splash or spray may occur when this method is used, mounting a large shatter-resistant shield in front of the operator's cage can protect the operator of the backhoe. When combined with the normal personal protection gear, this practice should protect the operator. Providing the operator with an on-board air line system affords additional respiratory protection.

Hydraulic Devices

Hydraulic devices consist of a piercing device with a metal point that is attached to the end of a hydraulic line and is pushed into the drum by hydraulic pressure. The piercing device can be attached so that a hole for sampling can be made in either the side or the head of the drum. Some of the metal piercing devices are hollow or tube-like so that they can be left in place, if desired, to serve as a permanent tap or sampling port. The piercing device is designed to establish a tight seal after penetrating the container.

Pneumatic Devices

Pneumatically operated devices using compressed air have been designed to remove drum bungs remotely.

5.4.3 Drum Sampling

Immediately after the drum has been opened, sample the headspace gases within the drum using an explosimeter, organic vapor analyzer, and/or a photoionization detector, and record the data on the Drum Data Sheet (see Attachment I-D-1-1) as necessary. The CTO WP shall reference procedures listed in the site HSP.

In most cases, it is impossible to observe the contents of these sealed or partially sealed drums. Because some layering or stratification is likely in any solution left undisturbed over time, take a sample that represents the entire depth of the vessel. In addition, a sample of solid material collected from a drum should include the entire depth to be most representative of the drum contents.

When sampling a previously sealed drum, check for the presence of bottom sludge. This is easily accomplished by measuring the depth to apparent bottom, and then comparing it to the known interior depth.

5.4.3.1 GLASS THIEF SAMPLER

The most widely used implement for sampling liquids in a drum is a glass tube (glass thief, 6 millimeters inner diameter × 30.47 centimeters [cm] [48 inches] length). This tool is simple, cost effective, quick, and collects a sample without having to decontaminate.

Specific Sampling Procedure Using a Glass Thief

1. Remove the cover from the sample container.
2. Slowly insert the glass tubing almost to the bottom of the drum or until a solid layer is encountered. About 1 foot of tubing should extend above the drum.
3. Allow the waste in the drum to reach its natural level in the tube.
4. Cap the top of the sampling tube with a tapered stopper or thumb, ensuring liquid does not come into contact with the stopper.
5. Carefully remove the capped tube from the drum, and insert the uncapped end into the sample container. Do not spill liquid on the outside of the sample container.
6. Release the stopper, and allow the glass thief to drain completely into the sample container. Fill the container to about 2/3 of capacity.
7. Remove the tube from the sample container, carefully break it into pieces, and place the pieces in the drum.
8. Cap the sample container tightly, and place the pre-labeled sample container in a carrier.
9. Replace the bung or place plastic over the drum.
10. Transport the sample to the decontamination zone to be prepared for transport to the analytical laboratory.

In many instances, a drum containing waste material will have a sludge layer on the bottom. Slow insertion of the sampling tube down into this layer and then a gradual withdrawal will allow the sludge to act as a bottom plug to maintain the fluid in the tube. The plug can be gently removed and placed into the sample container by the use of a stainless steel lab spoon.

In some instances, disposal of the tube by breaking it into the drum might interfere with eventual plans for the removal of its contents. Clear this technique with NAVFAC Pacific personnel or evaluate other disposal techniques.

5.4.3.2 COLIWASA SAMPLER

The COLIWASA is a much-cited sampler designed to permit representative sampling of multiphase wastes from drums and other containerized wastes. It collects a sample from the full depth of a drum and maintains it in the transfer tube until delivery to the sample bottle. One configuration consists of a 152 cm by 4 cm-inner diameter section of tubing with a neoprene stopper at one end attached by a rod running the length of the tube to a locking mechanism at the other end. Manipulation of the locking mechanism opens and closes the sampler by raising and lowering the neoprene stopper.

The major drawbacks associated with using a COLIWASA include decontamination and cost. The sampler is difficult (if not impossible) to decontaminate in the field, and its high cost relative to alternative procedures (glass tubes) make it an impractical throwaway item. However, disposable, high-density, inert polyethylene COLIWASAs are available at a nominal cost. Although the applications of a disposable COLIWASA are limited, it is especially effective in instances where a true representation of a multiphase waste is absolutely necessary.

Procedures for Use

1. Open the sampler by placing the stopper rod handle in the T-position and pushing the rod down until the handle sits against the sampler's locking block.
2. Slowly lower the sampler into the liquid waste. Lower the sampler at a rate that permits the levels of the liquid inside and outside the sampler tube to be about the same. If the level of the liquid in the sample tube is lower than that outside the sampler, the sampling rate is too fast and will result in a non-representative sample.
3. When the sampler stopper hits the bottom of the waste container, push the sampler tube downward against the stopper to close the sampler. Lock the sampler in the closed position by turning the T-handle until it is upright and one end rests tightly on the locking block.
4. Slowly withdraw the sampler from the waste container with one hand while wiping the sampler tube with a disposable cloth or rag with the other hand.
5. Carefully discharge the sample into a suitable sample container by slowly pulling the lower end of the T-handle away from the locking block while the lower end of the sampler is positioned in a sample container.
6. Cap the sample container with a Teflon-lined cap, attach a label and seal, and record it on the sample data sheet.
7. Unscrew the T-handle of the sampler, and disengage the locking block.
8. Clean the sampler.

5.5 DRUM CLOSING

Upon completion of sampling activities, close the drums, and then store them in a secure area as described in Procedure I-A-6, *Investigation-Derived Waste Management*. If the bung opening and the bung are still intact, then close the drum by replacing the bung. In addition, open top drums that are still in good condition can be closed by replacing the top and securing the drum ring with the attached bolt.

If a drum cannot be closed in the manner discussed above, then secure it by placing it in an approved 85-gallon overpack drum (type UN 1A2/Y43/S). Fill the void spaces between the outer portion of the inner drum and the inside of the overpack drum with vermiculite to secure the drum contents to the extent possible.

5.6 EQUIPMENT DECONTAMINATION

Decontamination of sampling equipment should follow Procedure I-F, *Equipment Decontamination*.

5.7 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

1. Do not add preservatives to the sample unless specifically required by the analytical method or WP.
2. Place the labeled sample container in two re-sealable plastic bags.
3. If the contents of the investigation-derived waste drum are unknown, or known to contain hazardous waste, place each bagged sample container in a 1-gallon covered can containing absorbent packing material. Place the lid on the can.
4. Mark the sample identification number on the outside of the can.
5. Place the samples in a cooler, and fill the remaining space with absorbent packing material.
6. Fill out the chain-of-custody record for each cooler, place it in a re-sealable plastic bag, and affix it to the inside lid of the cooler.
7. Secure the lid of the cooler, and affix the custody seal.
9. Arrange for the appropriate transport mode consistent with the type of waste involved (hazardous or non-hazardous).

6. Records

Keep records of all sampling activities in the field notebook and on the Drum Data Sheets. Document sample custody on the chain-of-custody form. The CTO Manager shall review these documents at the completion of field activities, and, at least on a monthly basis for long-term projects.

7. Health and Safety

Field Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Occupational Safety and Health Administration (OSHA). 1998. *Occupational Safety and Health Standards* (29 CFR 1910); with special attention to Section 1910.120, *Hazardous Waste Operations and Emergency Response (HAZWOPER)*. Washington, DC: United States Department of Labor.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual.* EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-A-6, *Investigation-Derived Waste Management.*

Procedure I-F, *Equipment Decontamination.*

9. Attachments

Attachment I-D-1-1: Drum Data Sheet

Attachment I-D-1-1
Drum Data Sheet

DRUM DATA SHEET

CTO/DO #: ____________________ Date Sampled: ____________________

Drum I.D.#: ____________________ Time: ____________________

Estimated Liquid Quantity: ____________________

Original Drum Location: ____________________

Staging Location: ____________________

Sampler's Name: ____________________

Drum Condition: ____________________

Physical Appearance of the Drum/Bulk Contents: ____________________

Headspace Gas Concentration: ____________________

Odor: ____________________ Color: ____________________

pH: ____________________ % Liquid: ____________________

Laboratory Date of Analysis: ____________________

Analytical Data: ____________________

____

____

____

____

Compatibility: ____________________

Hazard: ____________________

Waste I.D.: ____________________

Treatment Disposal Recommendations: ____________________

____

____

____

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Soil and Rock Classification

1. Purpose

This section sets forth standard operating procedures for soil and rock classification for use by United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

None.

4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that these standard soil and rock classification procedures are followed during projects conducted under the ER Program and that a qualified individual conducts or supervises the projects. A qualified individual is defined as a person with a degree in geology, hydrogeology, soil science, or geotechnical/civil engineering with at least 1 year of experience classifying soil. Supervision is defined as onsite and continuous monitoring of the individual conducting soil classification. The CTO Manager is responsible for ensuring that all personnel involved in soil and rock classification have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The CTO Manager is responsible for reviewing copies of the field boring log forms on a monthly basis at a minimum. However, it is recommended that initially boring logs are reviewed daily to ensure accuracy.

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for field oversight to ensure that all project field staff follow these procedures.

Field personnel are responsible for the implementation of this procedure.

5. Procedures

5.1 SOIL CLASSIFICATION

The basic purpose of the classification of soil is to thoroughly describe the physical characteristics of the sample and to classify it according to an appropriate soil classification system for the NAVFAC Pacific ER Program. The Unified Soil Classification System (USCS) was developed so that soils could be described on a common basis by different investigators and serve as a "shorthand" description of soil. A classification of a soil in accordance with the USCS includes not only a group symbol and name, but also a complete word description.

Describing soil on a common basis is essential so that soil described by different site qualified personnel is comparable. Site individuals describing soil as part of site activities *must* use the classification system described herein to provide the most useful geologic database for all present and future subsurface investigations and remedial activities at NAVFAC Pacific ER Program sites.

The site geologist or other qualified individual shall describe the soil and record the description in a boring log or logbook. The essential items in any written soil description are as follows:

- Classification group name (e.g., silty sand)
- Color, moisture, and odor
- Range of particle sizes
- Approximate percentage of boulders, cobbles, gravel, sand, and fines
- Plasticity characteristics of the fines
- In-place conditions, such as density/consistency, compaction, amount of induration/cementation or weathering, retention of the parent rock fabric, and structure
- USCS classification symbol

The USCS serves as "shorthand" for classifying soil into 15 basic groups:

GW[1]	Well graded (poorly sorted) gravel (>50 percent gravel, <5percent fines)
GP[1]	Poorly graded (well sorted) gravel (>50percent gravel, <5percent fines)
GM[1]	Silty gravel (>50 percent gravel, >15 percent silt)
GC[1]	Clayey gravel (>50 percent gravel, >15 percent clay)
SW[1]	Well graded (poorly sorted) sand (>50 percent sand, <5 percent fines)
SP[1]	Poorly graded (well sorted) sand (>50 percent sand, <5 percent fines)
SM[1]	Silty sand (>50 percent sand, >15 percent silt)
SC[1]	Clayey sand (>50 percent sand, >15 percent clay)

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[1] If percentage of fine is 5 percent to 15 percent, a dual identification shall be given (e.g., a soil with more than 50 percent poorly sorted gravel and 10 percent clay is designated GW-GC.

ML[2]	Inorganic, low plasticity silt (slow to rapid dilatancy, low toughness, and plasticity)
CL[2]	Inorganic, low plasticity (lean) clay (no or slow dilatancy, medium toughness and plasticity)
MH[2]	Inorganic elastic silt (no to slow dilatancy, low to medium toughness and plasticity)
CH[2]	Inorganic, high plasticity (fat) clay (no dilatancy, high toughness, and plasticity)
OL	Organic low plasticity silt or organic silty clay
OH	Organic high plasticity clay or silt
PT	Peat and other highly organic soil

Figure I-E-1 defines the terminology of the USCS. Flow charts presented in Figure I-E-2 and Figure I-E-3 indicate the process for describing soil. The particle size distribution and the plasticity of the fines are the two properties of soil used for classification. In some cases, it may be appropriate to use a borderline classification (e.g., SC/CL) if the soil has been identified as having properties that do not distinctly place the soil into one group.

5.1.1 Estimation of Particle Size Distribution

One of the most important factors in classifying a soil is the estimated percentage of soil constituents in each particle size range. Being proficient in estimating this factor requires extensive practice and frequent checking. The steps involved in determining particle size distribution are listed below:

1. Select a representative sample (approximately 1/2 of a 6-inch long by 2.5-inch diameter sample liner).
2. Remove all particles larger than 3 inches from the sample. Estimate and record the percent by volume of these particles. Only the fraction of the sample smaller than 3 inches is classified.
3. Estimate and record the percentage of dry mass of gravel (less than 3 inches and greater than 1/4 inch).
4. Considering the rest of the sample, estimate, and record the percentage of dry mass of sand particles (about the smallest particle visible to the unaided eye).
5. Estimate and record the percentage of dry mass of fines in the sample (do not attempt to separate silts from clays).
6. Estimate percentages to the nearest 5 percent. If one of the components is present in a quantity considered less than 5 percent, indicate its presence by the term “trace.”
7. The percentages of gravel, sand, and fines must add up to 100 percent. “Trace” is not included in the 100 percent total.

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[2] If the soil is estimated to have 15 percent to 25 percent sand or gravel, or both, the words “with sand” or “with gravel” (whichever predominates) shall be added to the group name (e.g., clay with sand, CL; or silt with gravel, ML). If the soil is estimated to have 30 percent or more sand or gravel, or both, the words “sandy” or “gravely” (whichever predominates) shall be added to the group name (e.g., sandy clay, CL). If the percentage of sand is equal to the percent gravel, use “sandy.”

5.1.2 Soil Dilatancy, Toughness, and Plasticity

5.1.2.1 DILATANCY

To evaluate dilatancy, follow these procedures:

1. From the specimen, select enough material to mold into a ball about 1/2 inch (12 millimeters [mm]) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.
2. Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table I-E-1. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

Table I-E-1: Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in specimen.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

5.1.2.2 TOUGHNESS

Following the completion of the dilatancy test, shape the test specimen into an elongated pat and roll it by hand on a smooth surface or between the palms into a thread about 1/8 inch (3 mm) in diameter. (If the sample is too wet to roll easily, spread it into a thin layer and allow it to lose some water by evaporation.) Fold the sample threads and re-roll repeatedly until the thread crumbles at a diameter of about 1/8 inch. The thread will crumble at a diameter of 1/8 inch when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, lump the pieces together and knead it until the lump crumbles. Note the toughness of the material during kneading. Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table I-E-2.

Table I-E-2: Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft.
Medium	Medium pressure is required to roll the thread near the plastic limit. The thread and the lump have medium stiffness.
High	Considerable pressure is required to roll the thread near the plastic limit. The thread and the lump have very high stiffness.

DEFINITION OF TERMS				
MAJOR DIVISIONS			**SYMBOLS**	**TYPICAL DESCRIPTIONS**
COARSE GRAINED SOILS More Than Half of Material is Larger Than No. 200 Sieve Size	**GRAVELS** More Than Half of Coarse Fraction is Smaller Than No. 4 Sieve	**CLEAN GRAVELS** (Less than 6% Fines)	**GW**	Well graded gravels, gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines
		GRAVELS With Fines	**GM**	Silty gravels, gravel-sand-silt mixtures, non-plastic fines
			GC	Clayey gravels, gravel-sand-clay mixtures, plastic fines
	SANDS More Than Half of Coarse Fraction is Smaller Than No. 4 Sieve	**CLEAN SANDS** (Less than 6% Fines)	**SW**	Well graded sands, gravelly sands, little or no fines
			SP	Poorly graded sands, gravelly sands, little or no fines
		SANDS With Fines	**SM**	Silty sands, sand-silt mixtures, non-plastic fines
			SC	Clayey sands, sand-clay mixtures, plastic fines
FINE GRAINED SOILS More Than Half of Material is Smaller Than No. 200 Sieve Size	**SILTS AND CLAYS** Liquid Limit is Less Than 50%		**ML**	Inorganic silts, rock flour, fine sandy silts or clays, and clayey silts with non- or slightly-plastic fines
			CL	Inorganic clays of low to medium plasticity, gravelly clays, silty clays, sandy clays, lean clays
			OL	Organic silts and organic silty clays of low plasticity
	SILTS AND CLAYS Liquid Limit is Greater Than 50%		**MH**	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts, clayey silt
			CH	inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS			**PT**	Peat and other highly organic soils

GRAIN SIZES							
SILTS AND CLAYS	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		
200	40	10	4	3/4“	3“	12“	
U.S. STANDARD SERIES SIEVE				CLEAR SQUARE SIEVE OPENINGS			

Figure I-E-1: Unclassified Soil Classification System (USCS)

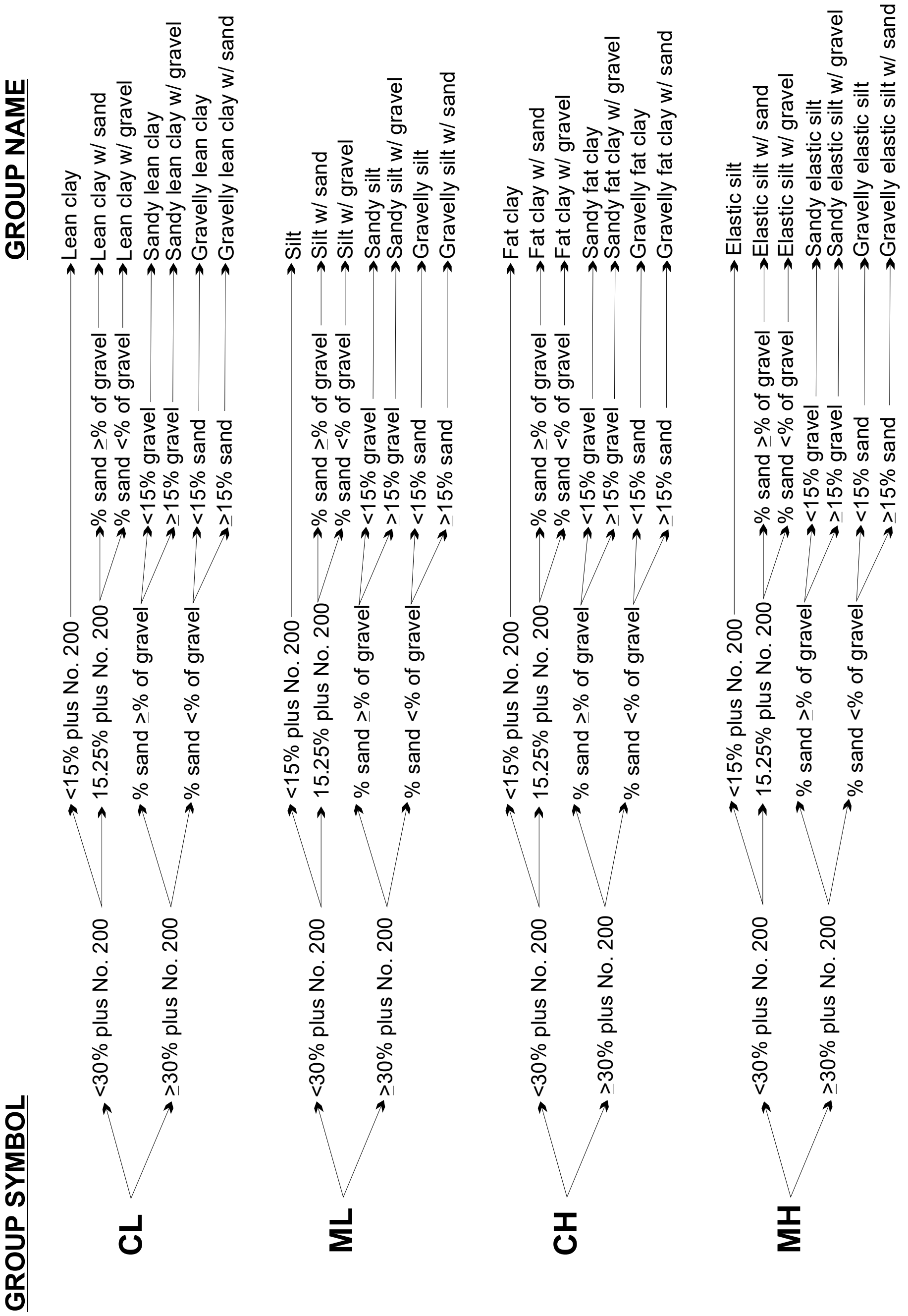


Figure I-E-2: Flow Chart for Fine Grain Soil Classification

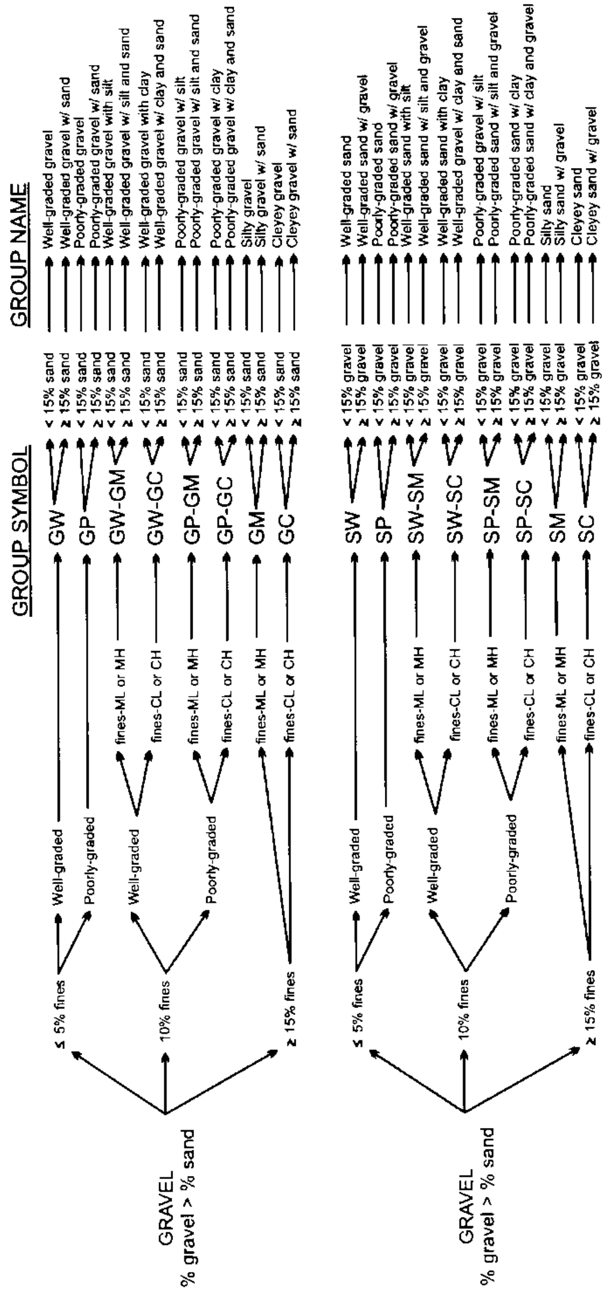


Figure I-E-3: Flow Chart for Soil with Gravel

5.1.2.3 PLASTICITY

The plasticity of a soil is defined by the ability of the soil to deform without cracking, the range of moisture content over which the soil remains in a plastic state, and the degree of cohesiveness at the plastic limit. The plasticity characteristic of clays and other cohesive materials is defined by the liquid limit and plastic limit. The liquid limit is defined as the soil moisture content at which soil passes from the liquid to the plastic state as moisture is removed. The test for the liquid limit is a laboratory, not a field, analysis.

The plastic limit is the soil moisture content at which a soil passes from the plastic to the semi-solid state as moisture is removed. The plastic limit test can be performed in the field and is indicated by the ability to roll a 1/8-inch (0.125-inch) diameter thread of fines, the time required to roll the thread, and the number of times the thread can be re-rolled when approaching the plastic limit.

The plasticity tests are not based on natural soil moisture content, but on soil that has been thoroughly mixed with water. If a soil sample is too dry in the field, add water prior to performing classification. If a soil sample is too sticky, spread the sample thin and allow it to lose some soil moisture.

Table I-E-3 presents the criteria for describing plasticity in the field using the rolled thread method.

Table I-E-3: Criteria for Describing Plasticity

Description	Criteria
Non-Plastic	A 1/8-inch thread cannot be rolled.
Low Plasticity	The thread can barely be rolled.
Medium Plasticity	The thread is easy to roll and not much time is required to reach the plastic limit.
High Plasticity	It takes considerable time rolling the thread to reach the plastic limit.

5.1.3 Angularity

The following criteria describe the angularity of the coarse sand and gravel particles:

- *Rounded* particles have smoothly-curved sides and no edges.
- *Subrounded* particles have nearly plane sides, but have well-rounded corners and edges.
- *Subangular* particles are similar to angular, but have somewhat rounded or smooth edgesand.
- *Angular* particles have sharp edges and relatively plane sides with unpolished surfaces. Freshly broken or crushed rock would be described as angular.

5.1.4 Color, Moisture, and Odor

The natural moisture content of soil is very important. Table I-E-4 shows the terms for describing the moisture condition and the criteria for each.

Table I-E-4: Soil Moisture Content Qualifiers

Qualifier	Criteria
Dry	Absence of moisture, dry to the touch
Moist	Damp but no visible water
Wet	Visible water, usually soil is below water table

Color is described by hue and chroma using the Munsell Soil Color Chart (Munsell 2000). For uniformity, all site geologists shall use this chart for soil classification. Doing so will facilitate correlation of geologic units between boreholes logged by different geologists The Munsell Color Chart is a small booklet of numbered color chips with names like “5YR 5/6, yellowish-red.” Note mottling or banding of colors. It is particularly important to note and describe staining because it may indicate contamination.

In general, wear a respirator if strong organic odors are present. If odors are noted, describe them if they are unusual or suspected to result from contamination. An organic odor may have the distinctive smell of decaying vegetation. Unusual odors may be related to hydrocarbons, solvents, or other chemicals in the subsurface. An organic vapor analyzer may be used to detect the presence of volatile organic contaminants.

5.1.5 In-Place Conditions

Describe the conditions of undisturbed soil samples in terms of their density/consistency (i.e., compactness), cementation, and structure utilizing the following guidelines:

5.1.5.1 DENSITY/CONSISTENCY

Density and consistency describe a physical property that reflects the relative resistance of a soil to penetration. The term “density” is commonly applied to coarse to medium-grained sediments (i.e., gravels, sands), whereas the term “consistency” is normally applied to fine-grained sediments (i.e., silts, clays). There are separate standards of measure for both density and consistency that are used to describe the properties of a soil.

The density or consistency of a soil is determined by observing the number of blows required to drive a 1 3/8-inch (35 mm) diameter split barrel sampler 18 inches using a drive hammer weighing 140 pounds (63.5 kilograms) dropped over a distance of 30 inches (0.76 meters). Record the number of blows required to penetrate each 6 inches of soil in the field boring log during sampling. The first 6 inches of penetration is considered to be a seating drive; therefore, the blow count associated with this seating drive is recorded, but not used in determining the soil density/consistency. The sum of the number of blows required for the second and third 6 inches of penetration is termed the “standard penetration resistance,” or the “N-value.” The observed number of blow counts must be corrected by an appropriate factor if a different type of sampling device (e.g., Modified California Sampler with liners) is used. For a 2 3/8-inch inner diameter Modified California Sampler equipped with brass or stainless steel liners and penetrating a cohesionless soil (sand/gravel), the N-value from the Modified California Sampler must be divided by 1.43 to provide data that can be compared to the 1 3/8-inch diameter sampler data.

For a cohesive soil (silt/clay), the N-value for the Modified California Sampler should be divided by a factor of 1.13 for comparison with 1 3/8-inch diameter sampler data.

Drive the sampler and record blow counts for each 6-inch increment of penetration until one of the following occurs:

- A total of 50 blows have been applied during any one of the three 6-inch increments; a 50-blow count occurrence shall be termed "refusal" and noted as such on the boring log.
- A total of 150 blows have been applied.
- The sampler is advanced the complete 18 inches without the limiting blow counts occurring, as described above.

If the sampler is driven less than 18 inches, record the number of blows per partial increment on the boring log. If refusal occurs during the first 6 inches of penetration, the number of blows will represent the N-value for this sampling interval. Table I-E-5 and Table I-E-6 present representative descriptions of soil density/consistency vs. N-values.

Table I-E-5: Measuring Soil Density with a California Sample – Relative Density (Sands, Gravels)

	Field Criteria (N-Value)	
Description	1 3/8 in. ID Sampler	2 in. ID Sampler using 1.43 factor
Very Loose	0–4	0–6
Loose	4–10	6–14
Medium Dense	10–30	14–43
Dense	30–50	43–71
Very Dense	>50	>71

Table I-E-6: Measuring Soil Density with a California Sampler – Fine Grained Cohesive Soil

	Field Criteria (N-Value)	
Description	1 3/8 in. ID Sampler	2 in. ID Sampler using 1.13 factor
Very Soft	0–2	0–2
Soft	2–4	2–4
Medium Stiff	4–8	4–9
Stiff	8–16	9–18
Very Stiff	16–32	18–36
Hard	>32	>36

For undisturbed fine-grained soil samples, it is also possible to measure consistency with a hand-held penetrometer. The measurement is made by placing the tip of the penetrometer against the surface of the soil contained within the sampling liner or shelby tube, pushing the penetrometer into the soil a distance specified by the penetrometer manufacturer, and recording the pressure resistance reading in pounds per square foot. The values are as follows (Table I-E-7):

Table I-E-7: Measuring Soil Consistency with a Hand-Held Penetrometer

Description	Pocket Penetrometer Reading (psf)
Very Soft	0–250
Soft	250–500
Medium Stiff	500–1,000
Stiff	1,000–2,000
Very Stiff	2,000–4,000
Hard	>4,000

Consistency can also be estimated using thumb pressure using Table I-E-8.

Table I-E-8: Measuring Soil Consistency Using Thumb Pressure

Description	Criteria
Very Soft	Thumb will penetrate soil more than 1 inch (25 mm)
Soft	Thumb will penetrate soil about 1 inch (25 mm)
Firm	Thumb will penetrate soil about 1/4 inch (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very Hard	Thumbnail will not indent soil

5.1.5.2 CEMENTATION

Cementation is used to describe the friability of a soil. Cements are chemical precipitates that provide important information as to conditions that prevailed at the time of deposition, or conversely, diagenetic effects that occurred following deposition. Seven types of chemical cements are recognized by Folk (1980). They are as follows:

1. Quartz – siliceous
2. Chert – chert-cemented or chalcedonic
3. Opal – opaline
4. Carbonate – calcitic, dolomitic, sideritic (if in doubt, calcareous should be used)
5. Iron oxides – hematitic, limonitic (if in doubt, ferruginous should be used)
6. Clay minerals – if the clay minerals are detrital or have formed by recrystallization of a previous clay matrix, they are not considered to be a cement. Only if they are chemical precipitates, filling previous pore space (usually in the form of accordion-like stacks or fringing radial crusts) should they be included as “kaolin-cemented,” “chlorite-cemented,” etc.
7. Miscellaneous minerals – pyritic, collophane-cemented, glauconite-cemented, gypsiferous, anhydrite-cemented, baritic, feldspar-cemented, etc.

The degree of cementation of a soil is determined qualitatively by utilizing finger pressure on the soil in one of the sample liners to disrupt the gross soil fabric. The three cementation descriptors are as follows:

1. Weak – friable; crumbles or breaks with handling or slight finger pressure
2. Moderate – friable; crumbles or breaks with considerable finger pressure
3. Strong – not friable; will not crumble or break with finger pressure

5.1.5.3 STRUCTURE

This variable is used to qualitatively describe physical characteristics of soil that are important to incorporate into hydrogeological and/or geotechnical descriptions of soil at a site. Appropriate soil structure descriptors are as follows:

- *Granular:* Spherically shaped aggregates with faces that do not accommodate adjoining faces
- *Stratified:* Alternating layers of varying material or color with layers at least 6 mm (1/4 inch) thick; note thickness
- *Laminated:* Alternating layers of varying material or color with layers less than 6 mm (1/4 inch) thick; note thickness
- Blocky: Cohesive soil that can be broken down into small angular or subangular lumps that resist further breakdown
- *Lensed:* Inclusion of a small pocket of different soil, such as small lenses of sand, should be described as homogeneous if it is not stratified, laminated, fissured, or blocky. If lenses of different soil are present, the soil being described can be termed homogeneous if the description of the lenses is included
- *Prismatic or Columnar:* Particles arranged about a vertical line, ped is bounded by planar, vertical faces that accommodate adjoining faces; prismatic has a flat top; columnar has a rounded top
- *Platy:* Particles are arranged about a horizontal plane

5.1.5.4 OTHER FEATURES

- *Mottled:* Soil that appears to consist of material of two or more colors in blotchy distribution
- *Fissured:* Breaks along definite planes of fracture with little resistance to fracturing (determined by applying moderate pressure to sample using thumb and index finger)
- *Slickensided:* Fracture planes appear polished or glossy, sometimes striated (parallel grooves or scratches)

5.1.6 Development of Soil Description

Develop standard soil descriptions according to the following examples. There are three principal categories under which all soil can be classified. They are described below.

5.1.6.1 COARSE-GRAINED SOIL

Coarse-grained soil is divided into sands and gravels. A soil is classified as a sand if over 50 percent of the coarse fraction is “sand-sized.” It is classified as a gravel if over 50 percent of the coarse fraction is composed of “gravel-sized” particles.

The written description of a coarse-grained soil shall contain, in order of appearance: Typical name including the second highest percentage constituent as an adjective, if applicable (underlined); grain size of coarse fraction; Munsell color and color number; moisture content; relative density; sorting; angularity; other features, such as stratification (sedimentary structures) and cementation, possible formational name, primary USCS classification, secondary USCS classification (when necessary), and approximate percentages of minor constituents (i.e., sand, gravel, shell fragments, rip-up clasts) in parentheses.

Example: POORLY SORTED SAND WITH SILT, medium- to coarse-grained, light olive gray, 5Y 6/2, saturated, loose, poorly sorted, subrounded clasts, SW/SM (minor silt with approximately 20 percent coarse-grained sand-sized shell fragments, and 80 percent medium-grained quartz sand, and 5 percent to 15 percent ML).

5.1.6.2 FINE-GRAINED SOIL

Fine-grained soil is further subdivided into clays and silts according to its plasticity. Clays are rather plastic, while silts have little or no plasticity.

The written description of a fine-grained soil should contain, in order of appearance: Typical name including the second highest percentage constituent as an adjective, if applicable (underlined); Munsell color; moisture content; consistency; plasticity; other features, such as stratification, possible formation name, primary USCS classification, secondary USCS classification (when necessary), and the percentage of minor constituents in parentheses.

Example: SANDY LEAN CLAY, dusky red, 2.5 YR 3/2, moist, firm, moderately plastic, thinly laminated, CL (70 percent fines, 30 percent sand, with minor amounts of disarticulated bivalves [about 5 percent]).

5.1.6.3 ORGANIC SOIL

For highly organic soil, describe the types of organic materials present as well as the type of soil constituents present using the methods described above. Identify the soil as an organic soil, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soil usually has a dark brown to black color and may have an organic odor. Often, organic soils will change color, (e.g., from black to brown) when exposed to air. Some organic soils will lighten in color significantly when air-dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

Example: ORGANIC CLAY, black, 2.5Y, 2.5/1, wet, soft, low plasticity, organic odor, OL (100 percent fines), weak reaction to HCl.

5.2 ROCK CLASSIFICATION

The purpose of rock classification is to thoroughly describe the physical and mineralogical characteristics of a specimen and to classify it according to an established system. The generalized rock classification system described below was developed for the NAVFAC Pacific ER Program because, unlike the USCS for soils, there is no universally accepted rock classification system. In some instances, a more detailed and thorough rock classification system may be appropriate. Any modifications to this classification system, or the use of an alternate classification system should be considered during preparation of the site work plan. Both the CTO Manager and the QA Manager or

Technical Director must approve any modifications to this classification system, or the use of another classification system.

Describing rock specimens on a common basis is essential so that rocks described by different site geologists are comparable. Site geologists describing rock specimens as a part of investigative activities must use the classification system described herein, or if necessary, another more detailed classification system. Use of a common classification system provides the most useful geologic database for all present and future subsurface investigations and remedial activities at NAVFAC Pacific ER Program sites.

A rock classification template has been designated as shown in Figure I-E-4 to provide a more consistent rock classification between geologists. The template includes the classification of rocks by origin and mineralogical composition. When classifying rocks, all site geologists shall use this template.

The site geologist shall describe the rock specimen and record the description in a borehole log or logbook. The items essential for classification include:

- Classification Name (i.e., schist)
- Color
- Mineralogical composition and percent
- Texture/Grain size (i.e., fine-grained, pegmatitic, aphanitic, glassy)
- Structure (i.e., foliated, fractured, lenticular)
- Rock Quality Designation (sum of all core pieces greater than two times the diameter of the core divided by the total length of the core run, expressed as a percentage)
- Classification symbol (i.e., MF)

Example: Metamorphic foliated schist: Olive gray, 5Y, 3/2, Garnet 25 percent, Quartz 45 percent, Chlorite 15 percent, Tourmaline 15 percent, Fine-grained with Pegmatite garnet, highly foliated, slightly wavy, MF.

6. Records

Document soil classification information collected during soil sampling onto the field boring logs, field trench logs, and into the field notebook. Procedure I-B-1, *Soil Sampling* presents copies of the field boring log form. Copies of this information shall be placed in the project files.

7. Health and Safety

Field Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

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: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Folk, Robert L. 1980. *Petrology of Sedimentary Rocks*. Austin, TX: Hemphill Publishing Company.

Munsell Color Company (Munsell). 2009. *Munsell Soil Color Chart*, (Revised). Baltimore.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual.* EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-B-1, *Soil Sampling.*

9. Attachments

None.

DEFINITION OF TERMS

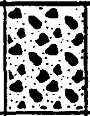
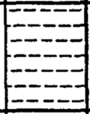
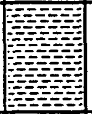
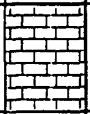
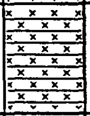
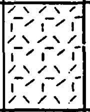
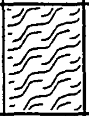
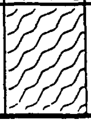
PRIMARY DIVISIONS			SYMBOLS		SECONDARY DIVISIONS
SEDIMENTARY ROCKS	Clastic Sediments	CONGLOMERATE		CG	Coarse-grained Clastic Sedimentary Rock types including: Conglomerates and Breccias
		SANDSTONE		SS	Clastic Sedimentary Rock types including: Sandstone, Arkose and Greywacke
		SHALE		SH	Fine-grained Clastic Sedimentary Rock types including: Shale, Siltstone, Mudstone and Claystone
	Chemical Precipitates	CARBONATES		LS	Chemical Precipitates including: Limestone, Crystalline Limestone, Fossiliferous Limestone Micrite and Dolomite
		EVAPORITES		EV	Evaporites including: Anhydrite, Gypsum, Halite, Travertine and Caliche
IGNEOUS ROCKS		EXTRUSIVE (Volcanic)		IE	Volcanic Rock types including: Basalt, Andesite, Rhyolite, Volcanic Tuff, and Volcanic Breccia
		INTRUSIVE (Plutonic)		II	Plutonic Rock types including: Granite, Diorite and Gabbro
METAMORPHIC ROCKS		FOLIATED		MF	Foliated Rock types including: Slate, Phyllite, Schist and Gneiss
		NON-FOLIATED		MN	Non-foliated Rock types including: Metaconglomerate, Quartzite and Marble

Figure I-E-4: Rock Classification System

Equipment Decontamination

1. Purpose

This standard operating procedure describes methods of equipment decontamination for use during site activities by United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

None.

4. Responsibilities

The prime contractor CTO Manager is responsible for identifying instances of non-compliance with this procedure and ensuring that decontamination activities comply with this procedure. The CTO Manager is responsible for ensuring that all personnel involved in equipment decontamination have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for field oversight to ensure that all project field staff follow these procedures.

Field personnel are responsible for the implementation of this procedure.

5. Procedures

Decontamination of equipment used in sampling of various media, groundwater monitoring, and well drilling and development is necessary to prevent cross-contamination and to maintain the highest integrity possible in collected samples. Planning a decontamination program requires consideration of the following factors:

- The location where the decontamination procedures will be conducted
- The types of equipment requiring decontamination
- The frequency of equipment decontamination
- The cleaning technique and types of cleaning solutions appropriate for the contaminants of concern
- The method for containing the residual contaminants and wash water from the decontamination process
- The use of a quality control measure to determine the effectiveness of the decontamination procedure

The following subsection describes standards for decontamination, including the frequency of decontamination, cleaning solutions and techniques, containment of residual contaminants and cleaning solutions, and effectiveness.

5.1 DECONTAMINATION AREA

Select an appropriate location for the decontamination area at a site based on the ability to control access to the area, the ability to control residual material removed from equipment, the need to store clean equipment, and the ability to restrict access to the area being investigated. Locate the decontamination area an adequate distance away and upwind from potential contaminant sources to avoid contamination of clean equipment.

It is the responsibility of the site safety and health officer (SSHO) to set up the site zones (i.e., exclusion, transition, and clean) and decontamination areas. Generally, the decontamination area is located within the transition zone, upwind of intrusive activities, and serves as the washing area for both personnel and equipment to minimize the spread of contamination into the clean zone. For equipment, a series of buckets are set up on a visqueen-lined bermed area. Separate spray bottles containing laboratory-grade isopropyl alcohol (or alternative cleaning solvent as described in the CTO work plan [WP]) and distilled water are used for final rinsing of equipment. Depending on the nature of the hazards and the site location, decontamination of heavy equipment, such as augers, pump drop pipe, and vehicles, may be accomplished using a variety of techniques.

5.2 TYPES OF EQUIPMENT

Drilling equipment that must be decontaminated includes drill bits, auger sections, drill-string tools, drill rods, split barrel samplers, tremie pipes, clamps, hand tools, and steel cable. Decontamination of monitoring well development and groundwater sampling equipment includes submersible pumps, bailers, interface probes, water level meters, bladder pumps, airlift pumps, peristaltic pumps, and lysimeters. Other sampling equipment that requires decontamination includes, but is not limited to, hand trowels, hand augers, slide hammer samplers, shovels, stainless-steel spoons and bowls, soil sample liners and caps, wipe sampling templates, composite liquid waste samplers, and dippers. However, equipment that is shipped pre-packaged from the vendor should not have to be decontaminated prior to first use. Equipment with a porous surface, such as rope, cloth hoses, and wooden blocks, cannot be thoroughly decontaminated and shall be properly disposed of after one use.

5.3 FREQUENCY OF EQUIPMENT DECONTAMINATION

Decontaminate down-hole drilling equipment and equipment used in monitoring well development and purging prior to initial use and between each borehole or well. Down-hole drilling equipment, however, may require more frequent cleaning to prevent cross-contamination between vertical zones within a single borehole. When drilling through a shallow contaminated zone and installing a surface casing to seal off the contaminated zone, decontaminate the drilling tools prior to drilling deeper. Initiate groundwater sampling by sampling groundwater from the monitoring well where the least contamination is suspected. Decontaminate groundwater, surface water, and soil sampling devices prior to initial use and between collection of each sample to prevent the possible introduction of contaminants into successive samples.

5.4 CLEANING SOLUTIONS AND TECHNIQUES

Decontamination can be accomplished using a variety of techniques and fluids. The preferred method of decontaminating major equipment, such as drill bits, augers, drill string, and pump drop-pipe, is steam cleaning. To steam clean, use a portable, high-pressure steam cleaner equipped with a pressure hose and fittings. For this method, thoroughly steam wash equipment, and rinse it with potable tap water to remove particulates and contaminants.

Where appropriate, disposable materials are recommended. A rinse decontamination procedure is acceptable for equipment, such as bailers, water level meters, new and re-used soil sample liners, and hand tools. The decontamination procedure shall consist of the following: (1) wash with a non-phosphate detergent (alconox, liquinox, or other suitable detergent) and potable water solution; (2) rinse in a bath with potable water; (3) spray with laboratory-grade isopropyl alcohol; (4) rinse in a bath with deionized or distilled water; and (5) spray with deionized or distilled water. If possible, disassemble equipment prior to cleaning. Add a second wash at the beginning of the process if equipment is very soiled.

Decontaminating submersible pumps requires additional effort because internal surfaces become contaminated during usage. Decontaminate these pumps by washing and rinsing the outside surfaces using the procedure described for small equipment or by steam cleaning. Decontaminate the internal surfaces by recirculating fluids through the pump while it is operating. This recirculation may be done using a relatively long (typically 4 feet) large-diameter pipe (4-inch or greater) equipped with a bottom cap. Fill the pipe with the decontamination fluids, place the pump within the capped pipe, and operate the pump while recirculating the fluids back into the pipe. The decontamination sequence shall include: (1) detergent and potable water; (2) potable water rinse; (3) potable water rinse; and (4) deionized water rinse. Change the decontamination fluids after each decontamination cycle.

Solvents other than isopropyl alcohol may be used, depending upon the contaminants involved. For example, if polychlorinated biphenyls or chlorinated pesticides are contaminants of concern, hexane may be used as the decontamination solvent. However, if samples are also to be analyzed for volatile organics, hexane shall not be used. In addition, some decontamination solvents have health effects that must be considered. Decontamination water shall consist of distilled or deionized water. Steam-distilled water shall not be used in the decontamination process as this type of water usually contains elevated concentrations of metals. Decontamination solvents to be used during field activities will be specified in CTO WP and site-specific health and safety plan.

Rinse equipment used for measuring field parameters, such as pH, temperature, specific conductivity, and turbidity with deionized or distilled water after each measurement. Also wash new, unused soil sample liners and caps with a fresh detergent solution and rinse them with potable water followed by distilled or deionized water to remove any dirt or cutting oils that might be on them prior to use.

5.5 CONTAINMENT OF RESIDUAL CONTAMINANTS AND CLEANING SOLUTIONS

A decontamination program for equipment exposed to potentially hazardous materials requires a provision for catchment and disposal of the contaminated material, cleaning solution, and wash water.

When contaminated material and cleaning fluids must be contained from heavy equipment, such as drilling rigs and support vehicles, the area must be properly floored, preferably with a concrete pad that slopes toward a sump pit. If a concrete pad is impractical, planking can be used to construct solid flooring that is then covered by a nonporous surface and sloped toward a collection sump. If the decontamination area lacks a collection sump, use plastic sheeting and blocks or other objects to create a bermed area for collection of equipment decontamination water. Situate items, such as auger flights, which can be placed on metal stands or other similar equipment, on this equipment during decontamination to prevent contact with fluids generated by previous equipment decontamination. Store clean equipment in a separate location to prevent recontamination. Collect decontamination fluids contained within the bermed area and store them in secured containers as described below.

Use wash buckets or tubs to catch fluids from the decontamination of lighter-weight drilling equipment and hand-held sampling devices. Collect the decontamination fluids and store them on site in secured containers, such as U.S. Department of Transportation-approved drums, until their disposition is determined by laboratory analytical results. Label containers in accordance with Procedure I-A-6, *Investigation-Derived Waste Management*.

5.6 EFFECTIVENESS OF DECONTAMINATION PROCEDURES

A decontamination program must incorporate quality control measures to determine the effectiveness of cleaning methods. Quality control measures typically include collection of equipment blank samples or wipe testing. Equipment blanks consist of analyte-free water that has been poured over or through the sample collection equipment after its final decontamination rinse. Wipe testing is performed by wiping a cloth over the surface of the equipment after cleaning. Procedure III-B, *Field QC Samples (Water, Soil)* provides further descriptions of these samples and their required frequency of collection. These quality control measures provide "after-the fact" information that may be useful in determining whether or not cleaning methods were effective in removing the contaminants of concern.

6. Records

Describe the decontamination process in the field logbook.

7. Health and Safety

Field Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

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: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual.* EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-A-6, *Investigation-Derived Waste Management.*

Procedure III-B, *Field QC Samples (Water, Soil).*

9. Attachments

None.

Direct-Push Sampling Techniques

1. Purpose

This standard operating procedure provides guidance on the use of direct-push techniques for the United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 DIRECT-PUSH TECHNIQUES

Direct-push techniques are methods for subsurface sampling or monitoring that involve the application of downward pressure (usually supplied through hydraulic means) without the benefit of cutting tool rotation to enter soil or rock. A variety of systems are available under several trade names, such as Geoprobe and Strataprobe. Equipment may be skid-mounted, trailered, or mounted directly on the frame of a vehicle.

3.2 MEMBRANE INTERFACE PROBE (MIP)

The membrane interface probe (MIP) is a continuous sampling tool advanced through the soil using a direct-push machine to log contaminant and lithologic data in real-time. A semipermeable membrane on the probe is heated to a temperature of 100 to 120 degrees Celsius. Clean carrier gas is circulated across the internal surface of the membrane carrying volatile organic contaminants, which have diffused through the membrane, to the surface for analysis by gas phase detectors. The MIP system is a timely and cost effective way to delineate volatile organic contaminants (e.g., benzene, toluene, solvents, trichloroethylene, tetrachloroethylene) with depth. The MIP provides real-time semi-quantitative measurements that can be used for optimizing the selection of sampling locations, particularly when using a dynamic work plan. By identifying the depth at which a contaminant is located, a more representative sample of soil or water can be collected. Correlation of a series of MIP logs across a site can provide 2-D and 3-D definition of the contaminant plume. When lithologic data are obtained (electrical conductivity, cone penetration test, hydraulic profiling tool, etc.) with the MIP data, contaminant migration pathways may be defined. The MIP logs provide a detailed record of contaminant distribution in the saturated and unsaturated formations. The MIP system does not provide specificity of analytes; however, it does use three different gas detectors. These detectors are a flame ionization detector, a photoionization detector, and a version of the electron capture detector. These three detectors allow the investigator to differentiate between certain classes of volatile contaminants such as petroleum fuels and chlorinated solvents. Soil and/or water samples must be collected and analyzed by a laboratory to identify specific analytes and quantitative concentrations. Only volatile organic compounds (VOCs) are detected by the MIP system. Detection limits are subject to the selectivity of the gas detector and the characteristics of the formation being penetrated (e.g., clay and organic carbon content) (ASTM 2012).

3.3 LASER-INDUCED FLUORESCENCE (LIF) TOOL

Laser-induced fluorescence (LIF) tools use the rapid emission of light from an atom or molecule after it has absorbed radiation from collimated and polarized monochromatic light source. LIF is a method for delineating the subsurface location of non-aqueous phase liquid (NAPL) petroleum hydrocarbons and other hydrocarbons using a fiber optic-based laser-induced fluorescence sensor system. The LIF tool uses a technique in which a laser emits pulsed ultraviolet light. The laser, mounted on the cone penetrometer platform, is linked via fiber optic cables to a window mounted on the side of a penetrometer probe. Laser energy emitted through the window causes fluorescence in adjacent contaminated media. The fluorescent radiation is transmitted to the surface via fiber optic cables for real-time spectral data acquisition and spectral analysis on the platform.

The LIF sensor responds to any material that fluoresces when excited by ultraviolet wavelengths produced by the laser, primarily the polynuclear aromatic, aromatic, and substituted hydrocarbons, along with a few heterocyclic hydrocarbons. The excitation energy causes all encountered fluorophores to fluoresce, including some minerals and some non-petroleum organic matter. However, because the sensor collects full spectral information, discrimination among the fluorophores may be accomplished by using the spectral features associated with the data. Soil samples should be taken to verify recurring spectral signatures to discriminate between fluorescing petroleum hydrocarbons and naturally occurring fluorophores.

3.4 HYDRAULIC PROFILING TOOL (HPT)

The hydraulic profiling tool (HPT) is a logging tool that can be used with LIF or MIP tools to better understand the details of soil permeability. The HPT measures the pressure required to inject a flow of water into the soil as the probe is advanced into the subsurface with a direct-push rig. The resulting injection pressure log is an indicator of formation permeability, which can be used to better understand contaminant mobility and migration.

4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that these standard direct-push technique procedures are followed during projects conducted under the ER Program and that a qualified individual conducts or supervises the projects. A qualified individual for subsurface sampling or monitoring using direct-push techniques is defined as a person with a degree in geology, hydrogeology, or geotechnical/civil engineering with at least 1 year of experience supervising soil boring construction using conventional drilling or direct-push techniques. The CTO Manager is responsible for ensuring that all personnel involved in direct-push sampling techniques have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for ensuring that all project field staff follow these procedures.

Field personnel are responsible for the implementation of this procedure.

5. Procedures

Direct-push techniques may be used as a cost-effective alternative to conventional drilling techniques for obtaining subsurface soil and groundwater samples and for monitoring subsurface conditions.

5.1 METHOD SELECTION

Base the decision to use direct-push techniques on: (1) their ability to achieve the required information at the required level of quality control and (2) their cost-effectiveness compared to conventional drilling methods. Major limitations of direct-push techniques are their inability to penetrate rock or cobbles and sometimes a shallow maximum depth of penetration. The capabilities of direct-push systems vary significantly among vendors. Consider these differences in capabilities when evaluating the method for a subsurface exploration program.

Use direct-push techniques to obtain groundwater samples for confirmatory analyses only if the screen placement method protects the screen from clogging during installation and allows the installation of a sand-pack around the exterior of the well screen. If semi-quantitative groundwater data is needed for screening purposes, direct-push tools are the best way to acquire that information.

The MIP can be effective in locating zones where dense nonaqueous phase liquids (DNAPL) may be present as well as dissolved phase concentrations of around 1 mg/L.

The LIF tool can provide accurate information on the location and characteristics of the contaminants encountered in the vadose zone and the saturated zone. Direct-push LIF is limited to soils that can be penetrated with the available equipment. The ability to penetrate strata is based on carrying vehicle weight, density of soil, and consistency of soil. Penetration may be limited by the delicacy of the window in the tool which can be damaged in certain ground conditions (ASTM 1997).

5.2 INSPECTION OF EQUIPMENT

Inspect direct-push equipment prior to use for signs of fluid leakage, which could introduce contaminants to the soil. If at any time during equipment operation, fluid is observed leaking from the rig, cease operations and immediately repair or contain the leak. Collect, containerize, and label soil and other materials affected by the leak for proper disposal (Procedure I-A-6, *Investigation-Derived Waste Management*).

5.3 PREPARATION OF WORK SITE

Inspect the work site prior to commencing operations to ensure that no overhead hazards exist that could impact the direct-push equipment. In addition, clear locations planned for subsurface exploration using geophysical methods, and hand excavate them to a depth of 2 to 3 feet prior to soil penetration, unless it is certain (by virtue of subsurface clearing activities) that no utilities or other hazardous obstructions will be encountered in the first 2 to 3 feet (Procedure I-B-2, *Geophysical Testing*). Hand excavation may be waived when it is not practical.

Locate the direct-push rig so that it is downslope from the penetration point, if the work is to be performed on a grade. Locate the rig downwind or crosswind of the penetration point, if possible. Cover the area surrounding, and in the vicinity of, the penetration point with plastic. Establish required exclusion zones using plastic tape or cones to designate the various areas.

5.4 EQUIPMENT DECONTAMINATION

Thoroughly decontaminate equipment used for direct-push exploration and sampling in accordance with Procedure I-F, *Equipment Decontamination*, to avoid cross-contamination. Decontaminate sampling tools and downhole equipment between each sampling event and between penetration points. At a minimum, steam clean or wash and rinse the equipment. Collect, containerize, and label all wash and rinse water for proper disposal. Clean equipment (e.g., drive rods and samplers) shall not come into contact with contaminated soils or other contaminated materials. Keep equipment on plastic or protect it in another suitable fashion. Store push rods and other equipment removed from a hole on plastic sheeting until properly decontaminated.

5.5 SOIL SAMPLING

Vendors of direct-push equipment offer a variety of sampling systems designed specifically for their equipment. Both continuous and discreet soil samples may be obtained using sampling equipment similar to that described in Procedure I-B-1, *Soil Sampling*. The preferred methods for soil sampling using direct-push techniques use brass or stainless steel split-tube samplers that are driven through the horizon to be sampled. Disposable polytetrafluoroethylene or acetate sleeves may also be used. However, if the liner appears melted or otherwise damaged upon retrieval from the borehole, do not use for collecting samples that are to be analyzed for VOCs or SVOCs.

5.6 GROUNDWATER SAMPLING

Direct-push vendors offer numerous methods for obtaining groundwater samples. Key differences among methods involve: (1) the maximum well diameter achievable; (2) the ability to protect the well screen from exposure to contaminated overburden soils during installation; (3) the ability to install filter packing around the screen; (4) flexibility in the size, materials of construction, and design of well screens; and (5) the ability to convert sampling points into permanent monitoring wells. The limitations and abilities of a given system must be thoroughly understood and matched to the needs of the project before committing to the collection of groundwater samples using direct-push techniques.

Use direct-push techniques only to collect screening samples unless it is confirmed that the system:

1. Effectively protects the well screen from exposure to contaminated overburden soils during installation
2. Allows the installation of effective packing around the well screen
3. Allows the well screen to be effectively sealed against the downward infiltration of overlying groundwater or surface precipitation

4. Is constructed of materials compatible with the intended sampling and analysis goals of the project
5. Allows the use of a well screen properly sized and slotted for the needs of the project

Additional information on the collection of groundwater samples can be found in Procedures I-C-1, *Monitoring Well Installation and Abandonment*, I-C-2, *Monitoring Well Development*, and I-C-3, *Monitoring Well Sampling.*

It is the responsibility of the CTO Manager to evaluate and determine the appropriateness of direct-push systems prior to committing to their use on any project involving groundwater sampling. As part of this evaluation, it is recommended to obtain concurrence from regulatory authorities in advance for the method selection.

5.7 BOREHOLE ABANDONMENT

Methods for abandoning boreholes created with direct-push systems will vary among vendors. Coordinate the desired method for abandonment with the vendor in the planning stages of the project to ensure proper abandonment.

Some direct-push boreholes will close naturally as the drive rods and sampling tools are withdrawn. This may occur in loose, unconsolidated soils, such as sands. Close all boreholes using one of the procedures described in this procedure, unless natural caving precludes such closure.

The three methods for closing direct-push boreholes are:

1. Add granulated or pelletized bentonite and hydrate in layers, proceeding from the bottom of the hole to the surface.
2. Pour premixed cement/water (or cement/water/bentonite) mixture into the hole.
3. Fill the entire hole with granular or pelletized bentonite and hydrate by means of a previously emplaced water tube that is gradually withdrawn as water is supplied to the bentonite.

The second method is recommended. For shallow holes less than 10 feet in depth, pour a cement/water/bentonite mix directly into the opening using a funnel. For deeper holes, use a conductor (tremie) pipe to carry the grout mix to the far reaches of the borehole. Lower the conductor pipe to within 2 inches of the bottom and gradually withdraw it as grout is added, keeping the lower end of the pipe submerged in grout at all times.

The recommended grout mixture for well abandonment is 7 to 9 gallons of water per 94-pound bag of Portland cement, with 3 percent to 5 percent by weight of powdered bentonite added to the mixture. Commercial products, such as Volcay are acceptable with pre-approval of the CTO Manager and the QA Manager or Technical Director.

Seal boreholes to within 0.5 to 2.0 feet of the surface. Inspect the abandoned borehole after 24 hours to ensure that grout shrinkage does not occur. If significant shrinkage has occurred, re-grout the borehole. Fill the remaining portion of the hole with local topsoil or appropriate paving materials.

6. Records

Document soil classification information collected during soil sampling onto borehole log forms (see Procedure I-B-1, *Soil Sampling*). Fill out all logs with indelible ink. Record information about sampling activities on sample log forms or in the field logbook. Send copies of this information to the CTO Manager and to the project files.

7. Health and Safety

Field personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

ASTM International (ASTM). 1997. *Standard Practice for Cone Penetrometer Technology Characterization of Petroleum Contaminated Sites with Nitrogen Laser-Induced Fluorescence*. D6187-97 (Reapproved 2012). West Conshohocken, PA.

———. 2007. *Standard Practice for Direct Push Technology for Volatile Contaminant Logging with the Membrane Interface Probe (MIP)*. D7352-07 (Reapproved 2012). West Conshohocken, PA.

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: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual.* EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-A-6, *Investigation-Derived Waste Management.*

Procedure I-A-7, *Analytical Data Validation Planning and Coordination.*

Procedure I-B-1, *Soil Sampling.*

Procedure I-B-2, *Geophysical Testing.*

Procedure I-C-1, *Monitoring Well Installation and Abandonment.*

Procedure I-F, *Equipment Decontamination.*

9. Attachments

None.

Procedure I-I
Land Surveying

Land Surveying

1. Purpose

This standard operating procedure sets forth protocols for acquiring land surveying data to facilitate the location and mapping of geologic, hydrologic, geotechnical data, and analytical sampling points and to establish topographic control over project sites for use by United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the *Uniform Federal Policy-Quality Assurance Project Plan* (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 BOUNDARY SURVEY

Boundary surveys are conducted by Certified Land Surveyors in order to delineate a legal property line for a site or section of a site.

3.2 GLOBAL POSITIONING SYSTEM (GPS)

A GPS is a system of satellites, computers, and receivers that is able to determine the latitude and longitude of a receiver on Earth by calculating the time difference for signals from different satellites to reach the receiver.

3.3 WAYPOINT

A waypoint is a reference point or set of coordinates that precisely identify a location.

4. Responsibilities

The prime contractor CTO Manager is responsible for determining the appropriate land surveying protocols for the project and ensuring this procedure is properly implemented. The CTO Manager is responsible for ensuring that all personnel involved in land surveying shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager (FM) is responsible for ensuring that the appropriate protocols are conducted according to this procedure and the project-specific sampling plan. In virtually all cases, subcontractors will conduct these procedures. The FM is responsible for overseeing the activities of the subcontractor and ensuring that sampling points and topographic features are properly surveyed.

Field personnel are responsible for the implementation of this procedure.

5. Procedures

5.1 THEODOLITE/ELECTRONIC DISTANCE MEASUREMENT (EDM)

Follow the procedures listed below during theodolite/EDM land surveying conducted under the NAVFAC Pacific ER Program:

- A land surveyor registered in the state or territory in which the work is being performed shall directly supervise all surveying work.
- An authorized manufacturer's representative shall inspect and calibrate survey instruments in accordance with the manufacturer's specifications regarding procedures and frequencies. At a minimum, instruments shall be calibrated no more than 6 months prior to the start of the survey work.
- Standards for all survey work shall be in accordance with National Oceanic and Atmospheric Administration standards and, at a minimum, with accuracy standards set forth below. The horizontal accuracy for the location of all grid intersection and planimetric features shall be (±) 0.1 feet. The horizontal accuracy for boundary surveys shall be 1 in 10,000 feet (1:10,000). The vertical accuracy for ground surface elevations shall be (±) 0.1 feet. Benchmark elevation accuracy and elevation of other permanent features, including monitoring wellheads, shall be (±) 0.01 feet.
- Reference surveys to the local established coordinate systems, and base all elevations and benchmarks established on U.S. Geological Survey datum, 1929 general adjustment.
- Reference surveyed points to mean sea level (lower low water level).
- Jointly determine appropriate horizontal and vertical control points prior to the start of survey activities. If discrepancies in the survey (e.g., anomalous water level elevations) are observed, the surveyor may be required to verify the survey by comparison to a known survey mark. If necessary, a verification survey may be conducted by a qualified third party.
- All field notes, sketches, and drawings shall clearly identify the horizontal and vertical control points by number designation, description, coordinates, and elevations. Map all surveyed locations using a base map or other site mapping, as specified by the CTO Manager.
- Begin and end all surveys at the designated horizontal and vertical control points to determine the degree of accuracy of the surveys.

- Iron pins used to mark control points shall be made of reinforcement steel or an equivalent material and shall be 18 inches long with a minimum diameter of 5/8 inch. Drive pins to a depth of 18 inches into the soil.
- Stakes used to mark survey lines and points shall be made from 3-foot lengths of 2-inch by 2-inch lumber and pointed at one end. Clearly mark them with brightly colored weatherproof flagging and biodegradable paint.
- Clearly mark the point on a monitoring well casing that is surveyed by filing grooves into the casing on either side of the surveyed point.

5.2 GLOBAL POSITIONING SYSTEM (GPS) TO CONDUCT LAND SURVEY

Follow the procedures listed below during GPS land surveying conducted under the NAVFAC Pacific ER Program:

- A land surveyor registered in the state or territory in which the work is being performed shall directly supervise all surveying work.
- An authorized manufacturer’s representative shall inspect and calibrate survey instruments in accordance with the manufacturer's specifications regarding procedures and frequencies. At a minimum, instruments shall be calibrated no more than 6 months prior to the start of the survey work.
- Standards for all survey work shall be in accordance with National Oceanic and Atmospheric Administration standards and, at a minimum, with accuracy standards set forth below. The horizontal accuracy for the location of all grid intersection and planimetric features shall be (±) 0.1 feet. The horizontal accuracy for boundary surveys shall be 1 in 10,000 feet (1:10,000). The vertical accuracy for ground surface elevations shall be (±) 0.1 feet. Benchmark elevation accuracy and elevation of other permanent features, including monitoring wellheads, shall be (±) 0.01 feet. Accuracy requirements shall be specified in the project work plan (WP).
- Reference surveys to the local established coordinate systems, and base all elevations and benchmarks established on U.S. Geological Survey datum, 1929 general adjustment.
- All field notes, sketches, and drawings shall clearly identify the horizontal and vertical control points by number designation, description, coordinates, and elevations. Map all surveyed locations using a base map or other site mapping, as specified in the project WP.
- Begin and end all surveys at the designated horizontal and vertical control points (as applicable) to determine the degree of accuracy of the surveys.
- Iron pins used to mark control points shall be made of reinforcement steel or an equivalent material and shall be 18 inches long with a minimum diameter of 5/8 inch. Drive pins to a depth of 18 inches into the soil.
- Stakes used to mark survey lines and points shall be made from 3-foot lengths of 2-inch by 2-inch lumber and pointed at one end. Clearly mark them with brightly colored weatherproof flagging and biodegradable paint.
- Clearly mark the point on a monitoring well casing that is surveyed by filing grooves into the casing on either side of the surveyed point.

5.3 GLOBAL POSITIONING SYSTEM (GPS) TO POSITION SAMPLE LOCATIONS OR LOCATE SITE FEATURES

Experienced field personnel may use a GPS system unit to position sample locations (e.g. grid positioned samples) at a site. The decision to use field personnel or a licensed land surveyor will depend on the objectives of the survey (e.g. vertical elevation is not required) and the levels of precision required. Typically when a level of precision greater than (±) 3 to 5 meters is required, a licensed surveyor will be required. When a level of precision of (±) 3 to 5 meters is sufficient to meet project requirements (i.e., when laying sampling grids, identifying significant site features, or locating features identified in geographic information system [GIS] figures) experienced field personnel may use commercially available, consumer-grade GPS units. Follow the procedures listed below to locate samples or site features using GPS:

- A commercially available GPS unit with wide angle averaging system (WAAS), topographic map display, and waypoint storage capabilities should be used.
- If waypoints are to be imported into a GIS database, the same grid projection system should be used. For Guam this is typically WGS84, Zone 55N. For Hawaii this will either be NAD83 Zone 3 and 4 or WGS84 Zone 5N.
- If a permanent reference point near the site is available, it is recommended that the reference point is surveyed each day the GPS unit is used.
- When laying out a sampling grid from a GIS map, upload the coordinates from GIS to the GPS unit, including coordinates for an easily identified, permanent, nearby feature (i.e., building corner, roadway intersection, or USGS benchmark).
- If during the initial site walk, the permanent feature identified does not overlay within (±) 5 meters as identified in the GPS unit, field corrections of the waypoints should be made.
- Field corrections can be made by adding/subtracting the difference in x,y coordinates between the field measurement of the permanent site feature and the anticipated x,y coordinates. This correction should then be applied to the x,y coordinates for each sampling location to be marked. Corrected x,y coordinates can then be uploaded into the GPS unit.
- Sampling points and site features can then be located in the field using the GPS units "Go To" function. When the distance to the sampling point or feature remains close to zero, the location can be marked.
- If no field corrections to the sampling location need to be made, or if sampling locations are to be surveyed by a licensed surveyor at a later date, no additional waypoints need to be taken. If significant changes to the sampling location are made, GPS coordinates at the corrected location shall be stored and labeled.
- It is recommended that GPS coordinates be uploaded to a storage device such as a personal computer at the end of each day.
- Field logs shall indicate manufacturer and model number for GPS unit used, map datum and projection used, and any field corrections made. If the GPS unit cannot lock onto a WAAS system at the site, this should also be noted.

6. Records

The surveyor shall record field notes daily using generally accepted practices. The data shall be neat, legible, and easily reproducible. Copies of the surveyor's field notes and calculation forms generated during the work shall be obtained and placed in the project files.

Surveyor's field notes shall, at a minimum, clearly indicate:

- The date of the survey
- General weather conditions
- The name of the surveying firm
- The names and job titles of personnel performing the survey work
- Equipment used, including serial numbers
- Field book designations, including page numbers

A land surveyor registered in the state or territory in which the work was done shall sign, seal, and certify the drawings and calculations submitted by the surveyor.

Dated records of land surveying equipment calibration shall be provided by the surveyor and placed in the project files. Equipment serial numbers shall be provided in the calibration records.

7. Health and Safety

Field personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

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: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual.* EM-385-1-1. Includes Changes 1–7. 13 July 2012.

9. Attachments

None.

Level C and Level D Data Validation for GC/MS Volatile Organics by SW-846 8260

1. Purpose

This data validation procedure sets forth the standard operating procedure for performance of Level C and Level D data validation of volatile organic data obtained under the United States (U.S.) Navy Environmental Restoration (ER) Program for Naval Facilities Engineering Command (NAVFAC), Pacific and is consistent with protocol in the *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories* (DoD QSM) (DoD 2013). Level B validation is addressed separately in Procedure II-A, *Data Validation*.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Responsibilities

The CTO Manager, the QA Manager or Technical Director, and the CTO QA Coordinator are responsible for ensuring that this procedure is implemented by data validation personnel.

Data validation personnel are responsible for implementing this procedure for validation of all gas chromatography/mass spectrometry (GC/MS) volatile data.

4. Procedure

This procedure addresses the validation of volatile organic data obtained using U.S. Environmental Protection Agency Method Solid Waste (SW)-846 8260 (EPA 2007). The quality control (QC) criteria identified in this procedure are those specified in the analytical method and the DoD QSM (DoD 2013). Where project specific criteria are identified in the CTO work plan, they will supersede the QC criteria identified in this procedure.

- Form I: Sample Results Summary Form
- Form II: Surrogate Recovery Summary Form
- Form III: Matrix Spike/Matrix Spike Duplicate or Blank Spike/Blank Spike Duplicate Recovery Summary Form

- Form IV: Method Blank Summary Form
- Form V: Instrument Performance Check Summary Form
- Form VI: Initial Calibration Summary Form
- Form VII: Continuing Calibration Summary Form
- Form VIII: Internal Standard Summary Form

Level C data validation consists of review of summary forms only, whereas Level D data validation requires review of both summary forms and all associated raw data. Data review guidelines and how they apply to the different validation levels are indicated in the following text.

4.1 SAMPLE MANAGEMENT

QA/QC criteria included under sample management are sample preservation, handling, and transport, chain of custody (COC), and holding times.

4.1.1 Sample Preservation, Handling, and Transport

Level C and Level D:

Evaluate sample collection, handling, transport, and laboratory receipt from COC and laboratory receipt checklists to ensure that the samples have been properly preserved and handled.

1. Water samples must be preserved with hydrochloric acid at or below a pH of 2 and refrigerated at above freezing to 6 degrees Celsius (°C).
2. Soil samples collected in volatile organic analysis (VOA) vials or coring devices must be refrigerated at or above freezing to 6°C. If the samples are to be analyzed after the 48-hour holding time, the laboratory must preserve the samples with sodium bisulfate or methanol or water or freeze upon receipt in accordance with SW-846 Method 5035.
3. If the analyzed aqueous VOA vial contains air bubbles or headspace, is cracked, or has a cracked cap, positive values shall be flagged as estimated “J” and nondetects as estimated “UJ.” The sample data may be qualified as unusable, “R,” if the container damage is extensive or improper sealing is identified.
4. VOA vials are to be shipped in coolers that are maintained at above freezing to 6°C. If the temperature exceeds 6°C, but is less than or equal to 10°C, note this in the data validation report. If the temperature of receipt is greater than or equal to 11°C, positive values shall be flagged as estimated “J” and nondetects as estimated “UJ.” If the temperature of receipt is greater than or equal to 15°C, positive values shall be flagged as estimated “J” and nondetects as unusable “R.” If the temperature is below 0°C, special note should be made that the samples were frozen and no qualification shall be required. In the event that both a cooler temperature and a temperature blank were measured, the temperature blank shall be evaluated for temperature compliance as it best assimilates the condition of the samples; however, both temperatures shall be noted in the data validation report.
5. If the temperature of the cooler upon receipt at the laboratory was not recorded, document that the laboratory is noncompliant.

6. If the receiving laboratory transferred the samples to another laboratory for analysis, apply the same temperature criteria to both the transfer COC and the original COC.

4.1.2 Chain of Custody

Level C and Level D:

Examine the COC form for legibility and check that all volatile analyses requested on the COC have been performed by the laboratory. Ensure that the COC Sample Number on the laboratory sample results form (Form I [or equivalent]) matches the Sample Identification on the COC. Read the laboratory case narrative for additional information.

1. Any samples received for analysis that were not analyzed shall be noted in the data validation report, along with the reason(s) for failure to analyze the samples, if the reason(s) can be determined. Conversely, samples that were analyzed for volatiles but were not requested should also be noted.
2. Any discrepancies in sample naming between the COC and sample results form shall be noted in the data validation report with the correct sample name being identified if the correct sample name can be determined.
3. If the receiving laboratory transferred the samples to another laboratory for analysis, both the original COCs and transfer COCs shall be present. Document in the data validation report if the transfer COCs are not present.
4. Internal COC is required for all samples, extracts, and digestates from receipt to disposal. Verify the internal COC forms for completeness. Document in the data validation report if the internal COC forms are not present.
5. Each individual cooler shall have an individual COC that lists only samples contained within that cooler. Document in the data validation report if multiple coolers appear on one COC.

4.1.3 Holding Times

Level C and Level D:

Holding times for volatile organics are measured from the time of collection (as shown on the COC) to the time of sample analysis (as shown on the sample results form and instrument performance check summary form [Forms I and V (or equivalent)]). Water samples must be preserved with hydrochloric acid and refrigerated at above freezing to 6°C. Preserved water samples shall be analyzed within 14 days from the collection date. If there is no indication of chemical preservation, assume samples are unpreserved. For unpreserved water samples, the holding time is 7 days from date collected for aromatic volatiles and 14 days from date collected for non-aromatic volatiles. Soil samples collected in VOA vials or coring devices that are unpreserved must be refrigerated at above freezing to 6°C and analyzed within 48 hours from the collection date. Soil samples that are preserved with sodium bisulfate or methanol, or frozen upon laboratory receipt shall be analyzed within 14 days from the collection date.

1. If the holding time is exceeded, flag all associated positive results as estimated “J” and all associated limits of detection (LODs) (nondetects) as estimated “UJ,” and document that holding times were exceeded.

2. If holding times are grossly exceeded by greater than a factor of 2.0 (e.g., a preserved water sample has a holding time of more than 28 days), detects will be qualified as estimated "J" and nondetects as unusable "R."

4.2 GC/MS INSTRUMENT PERFORMANCE CHECK

Level C and Level D:

GC/MS instrument performance checks or tune checks are performed to ensure mass resolution, identification, and to some degree, sensitivity. These criteria are not sample specific. Conformance is determined using standard reference materials; therefore, these criteria should be met in all circumstances.

The analysis of the instrument performance check solution must be performed at the beginning of each 12-hour period during which samples or standards are analyzed. The instrument performance check, bromofluorobenzene (BFB) for volatile analysis, must meet the ion abundance criteria given below.

Table II-B-1: Ion Abundance Criteria – BFB

m/z	Ion Abundance Criteria
50	15.0–40.0% of m/z 95
75	30.0–60.0% of m/z 95
95	Base peak, 100% relative abundance
96	5.0–9.0% of m/z 95
173	Less than 2.0% of m/z 174
174	Greater than 50.0% of m/z 95
175	5.0–9.0% of m/z 174
176	Greater than 95.0% but less than 101.0% of m/z 174
177	5.0–9.0% of m/z 176

%	percent
m/z	mass-to-charge ratio

Check that all sample runs are associated with an injection. Make certain that a BFB performance check is present for each 12-hour period samples are analyzed (Form V [or equivalent]). Verify that all samples were analyzed within 12 hours of BFB injection.

If ion abundance criteria are not met, professional judgment may be applied to determine to what extent the data may be utilized. The most important factors to consider are the empirical results that are relatively insensitive to location on the chromatographic profile and type of instrumentation; therefore, the critical ion abundance criteria for BFB are the mass-to-charge ratio (m/z) 95/96, 174/175, 174/176, and 176/177 ratios. The relative abundance of m/z 50 and 75 are of lesser importance. Use professional judgment when samples are analyzed beyond the 12-hour time limit.

Decisions to use analytical data associated with BFB instrument performance checks not meeting requirements should be noted in the data validation report.

Level D:

Verify by recalculating from the quantitation reports, mass spectra, and chromatograms that the mass assignment is correct and that the mass listing is normalized to the specified m/z. If transcription errors are discovered on the Form V (or equivalent), request a resubmittal from the laboratory. Validate the data using the criteria outlined above.

4.3 CALIBRATION

Compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable qualitative and quantitative data for compounds on the volatile target compound list.

4.3.1 Initial Calibration

Initial calibration demonstrates that the instrument is capable of acceptable performance in the beginning of the analytical run and of producing an acceptable calibration curve.

Level C and Level D:

1. Evaluate the average relative response factors (RRFs) for all target compounds by checking Form VI (or equivalent).
2. If any of the volatile target compounds listed in Table II-B-2 below has an average RRF of less than 0.01 except for 1,4-dioxane (≤0.005) or any of the other volatile target compounds has an average RRF of less than 0.05, flag positive results for that compound as estimated "J" and nondetects as unusable "R" in associated samples.

Table II-B-2: Volatile Compounds Exhibiting Poor Response

Acetone	1,2-Dibromo-3-chloropane
2-Butanone	Isopropylbenzene
Carbon disulfide	Methyl acetate
Chloroethane	Methylene chloride
Chloromethane	Methylcyclohexane
Cyclohexane	Methyl tert-butyl ether
1,2-Dibromoethane	trans-1,2-Dichloroethene
Dichlorodifluoromethane	4-Methyl-2-pentanone
1,2-Dichloropropane	2-Hexanone
cis-1,2-Dichloroethene	Trichlorofluoromethane
1,4-Dioxane	1,1,2-Trichloro-trifluoromethane

3. Check Form VI (or equivalent) and evaluate the percent relative standard deviation (%RSD) for all target compounds. If any volatile target compound has a %RSD of greater than 15 percent, flag detects for the affected compounds as "J" and nondetects as "UJ" in the associated samples that correspond to that initial calibration.

Level D:

1. Verify the files reported on Form VI (or equivalent) against the quantitation reports, mass spectra, and chromatograms. If the files do not match, the RRFs reported are likely to be

from another initial calibration and will have to be changed. Request a resubmittal from the laboratory.

2. Recalculate the average RRFs and %RSDs reported on Form VI (or equivalent) for one compound per internal standard (preferably compounds which were identified in the samples) on the low-point calibration standard and one additional calibration standard. If errors are discovered, request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.3.2 Initial Calibration Verification

The initial calibration curve must be verified with a standard that has been purchased or prepared from an independent source each time initial calibration is performed. A standard from the same manufacturer but independently prepared from different source materials may also be used as an independent source. This initial calibration verification (ICV) must contain all of the method target compounds.

Level C and Level D:

1. Verify the ICV was analyzed following the initial calibration and contained all method target compounds.
2. If any target analyte has a percent difference (%D) greater than 20 percent, flag detects for the affected compounds as estimated “J” and nondetects as estimated “UJ” in all samples associated with the initial calibration.

Level D:

1. Verify from the raw data that there were no calculation or transcription errors by recalculating a percentage of the ICV calculations.

4.3.3 Continuing Calibration

Compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable qualitative and quantitative data. Continuing calibration establishes the 12-hour relative response factors on which the quantitations are based and checks satisfactory performance of the instrument on a day-to-day basis.

Level C and Level D:

1. Continuing calibration standards containing both target compounds and system monitoring compounds must be analyzed every 12 hours during operation. Evaluate the continuing RRFs on Form VII (or equivalent).
2. Ensure that the average RRFs reported on Form VII (or equivalent) correspond to the average RRFs reported on Form VI (or equivalent) for the corresponding initial calibration.
3. If any of the volatile target compounds listed in Table II-B-2 has an average RRF of less than 0.01 except for 1,4-dioxane (≤0.005) or any of the other volatile target compounds has an average RRF of less than 0.05, flag positive results for that compound as estimated “J” and nondetects as unusable “R” in associated samples.

4. If any volatile target compound has a %D between the initial calibration average RRF and continuing calibration RRFs outside 20 percent, flag all detects as “J” and all nondetects as “UJ” in all associated samples that correspond to that continuing calibration.

5. An ending continuing calibration is required by DoD QSM Appendix B (an ending continuing calibration is not required by the method) and professional judgment should be used in qualifying associated data when the %D is outside 50 percent.

Level D:

1. Verify the file reported on Form VII (or equivalent) against the raw data for the continuing calibration. If the file does not match, the RRFs reported are likely to be from another continuing calibration and will have to be changed. Request a resubmittal from the laboratory.
2. Recalculate the reported RRFs and %Ds reported on Form VII (or equivalent) for one compound per internal standard. If errors are discovered, request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.4 BLANKS

Method blank analytical results are assessed to determine the existence and magnitude of contamination problems. If problems with any method blank exist, all associated data must be carefully evaluated to determine whether there is any bias associated with the data, or if the problem is an isolated occurrence not affecting other data. Results may not be corrected by subtracting any blank values.

Level C and Level D:

1. The reviewer should identify samples associated with each method blank using Form IV (or equivalent). Verify that method blank analysis has been reported per matrix and concentration level for each 12-hour time period on each GC/MS system used to analyze VOA samples. Each sample must have an associated method blank. Medium level samples (samples that are known to have high concentrations of compounds) should have an associated methanol extraction blank. Qualify positive results in samples with no method blank as unusable “R.” Nondetects do not require qualification.
2. Compare the results of each method blank with the associated sample results. The reviewer should note that the blank analyses may not involve the same weights, volumes, percent moistures, or dilution factors as the associated samples. These factors must be taken into consideration when applying the criteria discussed below, such that a comparison of the total amount of contamination is actually made.
3. If a compound is found in the blank, but not in the associated sample, no action is taken.
4. Any compound, other than those listed in Table II-B-3, detected in both the sample and the associated blank shall be qualified when the sample concentration is less than the limit of quantitation (LOQ) and the blank concentration is less than, greater than, or equal to the LOQ. Compounds listed in Table II-B-3 shall be qualified when the sample concentration is less than 2× the LOQ and the blank concentration is less than, greater than, or equal to 2× LOQ. Care should be taken to factor in the percent moisture when comparing detects in the

sample and the method blank. The applicable review qualifier(s) are summarized in Table II-B-4.

Table II-B-3: Common Laboratory Contaminants

1. Methylene chloride
2. Acetone
3. 2-Butanone

Table II-B-4: Blank Qualifications

Sample Result	Sample Value	Reviewer Qualifier(s)
Less than LOQ* and blank result is <, > or = LOQ*	Leave as reported	U
≥LOQ*, blank result is <LOQ*	Leave as reported	None
≥LOQ*, blank result is >LOQ* and sample result < blank result	Leave as reported	Use professional judgment
≥LOQ*, blank result is >LOQ* and sample result ≥ blank result	Leave as reported	Use professional judgment
≥LOQ* and blank result is = LOQ*	Leave as reported	Use professional judgment

* 2x LOQ for common laboratory contaminants

5. In the case wherein both the sample concentration and the blank concentration are greater than or equal to the LOQ, previously approved criteria as identified in the planning documents may be applied to qualify associated sample results. Otherwise qualify sample results as non-detect “U” when the sample concentration is less than or equal to 10 times the blank concentration (10× rule) for the compounds listed in Table II-B-3 and tentatively identified compounds (TICs). For all other compounds, qualify sample results as non-detect “U” when the sample concentration is less than or equal to 5 times the blank concentration (5× rule).
6. If gross contamination exists in the blanks (i.e., saturated peaks by GC/MS), all compounds affected shall be flagged as unusable “R” due to interference in all samples affected and this shall be noted in the data validation comments.
7. If target compounds other than common laboratory contaminants are found at low levels in the blank(s), it may be indicative of a problem at the laboratory and shall be noted in the data validation report.
8. Additionally, there may be instances where little or no contamination was present in the associated blanks, but qualification of the sample was deemed necessary. Contamination introduced through dilution water is one example. Although it is not always possible to determine, instances of this occurring can be detected when contaminants are found in the diluted sample result, but are absent in the undiluted sample result. It may be impossible to verify this source of contamination; however, if the reviewer determines that the contamination is from a source other than the sample, the data should be qualified The sample value shall be reported as a nondetect and the reason shall be documented in the data validation report. Qualification of the data will be performed as given in Table II-B-4.

Level D:

1. Verify all target compound and TIC detects found in the method blanks against the raw data.
2. Verify that the target compound detects have valid spectra, as defined in Section 4.10 and the tentative identity of any TICs against the raw data, as defined in Section 4.12. If the spectra are not valid or the tentative identity is in error, request for a corrected Form I for the method blank from the laboratory.
3. Verify detected concentrations of target compounds and TICs from the raw data, as defined in Section 4.11. After the validity of the target compounds and TICs is verified, validate the corresponding data using the criteria outlined above.

4.5 BLANK SPIKES AND LABORATORY CONTROL SAMPLES

Blank spike/laboratory control sample (LCS) recoveries must be within the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established for a given sample matrix. Use in-house limits if compounds are not listed in Appendix C or project limits are not specified.

Level C and Level D:

1. If the blank spike/LCS results are 0 percent, only the spiked compounds that showed low recovery in all associated samples shall be flagged as unusable "R" for nondetects and estimated "J" for detects.
2. If blank spike/LCS results are below the control limits (but above 0 percent), spiked compounds which showed low recovery in all associated samples shall be flagged as estimated "UJ" or "J."
3. If blank spike/LCS results are above the control limits, detects for only the spiked compounds which showed high recovery in all associated samples shall be flagged as estimated "J."
4. If the laboratory analyzes a blank spike duplicate/LCS duplicate (LCSD), evaluate and qualify the LCSD results using the criteria noted above.
5. If the relative percent differences (RPDs) between LCS and LCSD results are above the control limits (use the matrix spike [MS]/matrix spike duplicate [MSD] RPD control limits identified in DoD QSM Appendix B. if none are available use laboratory in-house limits), spiked compounds which showed high RPD in all associated samples shall be flagged as estimated "UJ" or "J."

Level D:

To check that the spike percent recovery was calculated and reported correctly using the following equation, recalculate one or more spike recoveries per matrix (and any spike that would result in the qualification of a sample).

$$\%\text{Recovery} = \frac{Q_D}{Q_A} \times 100$$

Where:

Q_D = Quantity determined by analysis

Q_A = Quantity added to samples/blanks

If transcription errors are discovered on Form III (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.6 SYSTEM MONITORING COMPOUNDS (SURROGATE SPIKES)

Laboratory performance on individual samples is established by means of surrogate spiking activities. All samples are spiked with surrogate compounds prior to sample preparation. The evaluation of the results of these surrogate spikes is not necessarily straightforward. The sample itself may produce effects due to such factors as interference and high concentrations of compounds. Because the effects of the sample matrix are frequently outside the control of the laboratory and may present relatively unique problems, the review and validation of data based on specific sample results is frequently subjective and demands analytical experience and professional judgment. These procedures shall be followed:

Level C and Level D:

1. Sample and blank surrogate recoveries for volatiles must be within the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established. Use in-house limits if surrogates are not listed in Appendix C or project limits are not specified. Verify that no samples or blanks have surrogates outside the criteria from Form II (or equivalent).
    a. If one surrogate for the VOA fraction is out of specification, then a re-analysis must be reported even though surrogate results are outside the criteria. (Note: When unacceptable surrogate recoveries are followed by successful re-analyses, the laboratory is required to report only the successful run. The laboratory does not have to re-analyze a sample if a MS/MSD was performed on the sample with out-of-control surrogate results showing the same matrix effects.) Medium level soils must be re-extracted and re-analyzed if the surrogate recoveries are outside the criteria.
    b. The laboratory has failed to perform satisfactorily if surrogate recoveries are out of specification with no evidence of re-purging. The non-surrogate recoveries shall be documented in the data validation report.
2. If surrogate spike recoveries are out of specification, samples will be qualified as follows:
    a. If any surrogate is below the lower acceptance limit but has a recovery greater than or equal to 10 percent, qualify positive results as estimated “J” and nondetects as estimated “UJ.”
    b. If any surrogate is above the upper acceptance limit, qualify detects in the sample as estimated “J.” Compounds with nondetects should not be qualified.

3. If any surrogate in a fraction shows less than 10 percent recovery, flag detects for that fraction as estimated "J," and nondetects for the fraction as unusable "R."
4. In the special case of blank analysis with surrogates out of specification, the reviewer must give special consideration to the validity of associated sample data. The basic concern is whether the blank problems represent an isolated problem with the blank alone, or whether there is a fundamental problem with the analytical process. For example, if the samples in the batch show acceptable surrogate recoveries, the reviewer may determine the blank problem to be an isolated occurrence for which no qualification of the data is required.
5. Surrogates may be reported as "diluted out" (D), if dilution is such that the surrogate can no longer be detected. If this is the case, note in the data validation report that surrogate evaluation could not be performed due to a high dilution factor. A full evaluation of the sample chromatogram and quantitation report may be necessary to determine that surrogates are truly "diluted out."

Level D:

To verify that the surrogate percent recovery was calculated and reported correctly using the following equation, recalculate all surrogate recoveries per matrix (and any surrogate that would result in the qualification of a sample).

$$\%\text{Recovery} = \frac{Q_D}{Q_A} \times 100$$

Where:

Q_D = Quantity determined by analysis

Q_A = Quantity added to samples/blanks

If transcription errors are discovered on Form II (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.7 MATRIX SPIKE/MATRIX SPIKE DUPLICATE

MS/MSD data are used to determine the effect of the matrix on a method's recovery efficiency and precision for a specific sample matrix.

No action is taken on MS/MSD data alone to qualify an entire data package. Using informed professional judgment; however, the data reviewer may use the MS/MSD results in conjunction with other QC criteria (i.e., surrogates and LCS) and determine the need for some qualification of the data.

In those instances where it can be determined that the results of the MS/MSD affect only the sample spiked, then qualification should be limited to this sample alone. It may be determined through the MS/MSD results, however, that a laboratory is having a systematic problem in the analysis of one or more compounds, which affects all associated samples.

If a field blank was used for the MS/MSD, the information must be included in the data validation summary. Sample matrix effects have not been observed with field blanks therefore the recoveries and precision do not reflect the analytical impact of the site matrix.

Level C and Level D:

The laboratory must spike and analyze an MS/MSD from the specific project site as required for each matrix type and analytical batch.

1. MS/MSD data should be reported on a MS/MSD summary form similar to Form III (or equivalent).
2. Compare the percent recovery (%R) and RPD for each spiked compound with the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established. Use in-house limits if spiked compounds are not listed in Appendix C or project limits are not specified.
3. If MS/MSD results are 0 percent, only the spiked compounds that showed low recovery in the parent sample shall be flagged as unusable “R” for nondetects and estimated “J” for detects.
4. If MS/MSD results are below the control limits (but above 0 percent), spiked compounds which showed low recovery in the parent sample shall be flagged as estimated “UJ” or “J.”
5. If MS/MSD results are above the control limits, detects for only the spiked compounds which showed high recovery in the parent sample shall be flagged as estimated “J.”
6. If the RPDs between MS and MSD results are greater than 20 percent, detects for only the spiked compounds which showed high RPD in the parent sample shall be flagged as estimated “J.”
7. Failure of MS/MSD due to the presence of a target compound in the parent sample at greater than two times the spike concentration or diluted by more than a factor of 2 should not result in any qualifications. Note the incident in the data validation report.

Level D:

Check the raw data and recalculate one or more %Rs and RPDs, especially %Rs and RPDs that resulted in the qualification of data, using the following equations to verify that results on Form III (or equivalent) are correct.

$$\%R = \frac{(SSR - SR)}{SA} \times 100$$

$$RPD = \frac{ABS|SSR - SDR|}{(SSR + SDR)/2} \times 100$$

Where:

SA = spike added

SR = sample result

SSR = spiked sample result

SDR = spiked duplicate result

ABS = absolute value

If transcription errors are discovered on Form III (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.8 FIELD QC SAMPLES

Field QC samples discussed in this section of this procedure are trip blanks, equipment blanks, field blanks, field duplicates, and field triplicates.

4.8.1 Trip Blanks

Volatile organic parameters detected in trip blanks indicate the possibility of contamination of site samples or cross-contamination between site samples due to sample handling and transport while in the cooler.

One trip blank shall accompany each cooler containing samples to be analyzed for volatile organics. Each trip blank shall be analyzed for all volatile organic parameters for which the associated samples are analyzed. If a cooler contains multiple trip blanks, all samples contained in the cooler shall be associated with the results from all trip blanks contained in the cooler.

Level C and Level D:

1. Check that all coolers containing samples to be analyzed for volatile organics contained a trip blank that was also analyzed for volatile organics. If a cooler requiring a trip blank did not have an associated trip blank, no qualification of the samples transported in the cooler is necessary, but the incident shall be discussed in the data validation report.
2. If volatile organic compounds are detected in the trip blanks, the procedure for the qualification of associated sample results using validated and/or qualified trip blank results is identical to the criteria outlined in Section 4.4 of this procedure.

Level D:

1. Verify all target compound and TIC detects found in the trip blanks against the raw data.
2. Verify that the target compound detects have valid spectra, as defined in Section 4.10 and verify the tentative identity of any TICs against the raw data, as defined in Section 4.12. If the spectra are not valid, or the tentative identity is in error, request for a corrected Form I (or equivalent) for the trip blank from the laboratory.

3. Verify detected concentrations of target compounds and TICs from the raw data, as defined in Section 4.11. After the validity of the target compounds and TICs is verified, validate the corresponding data using the criteria outlined above.

4.8.2 Equipment Blanks and Field Blanks

1. Compounds detected in equipment blanks indicate the possibility of cross-contamination between samples due to improper equipment decontamination.
2. A field blank sample may be collected from each source of water used during each sampling event. The field blank may be analyzed to assess whether the chemical nature of the water used in decontamination may have affected the analytical results of site samples.
3. If volatile organic compounds are detected in the equipment blanks and/or field blanks, the procedure for the qualification of associated sample results is identical to the criteria outlined in Section 4.4 of this procedure.

Level C and Level D:

1. Determine which field QC samples apply to samples in the sample delivery group (SDG).
2. Ensure that units are correct when applying field QC blank qualifications. If samples are soil matrix, results must first be converted to micrograms per liter (µg/L) from milligrams per kilogram to make correct comparisons.
3. Because of the way in which the field blanks and equipment blanks are sampled, equipment blanks are not qualified because of field blank contamination. The affected samples are qualified, however, by either the field blank or equipment blank results, whichever has the higher contaminant concentration.
4. Equipment blanks and field blanks are only qualified with method and trip blank results in order to account for laboratory contamination.

Level D:

1. Verify all target compound and TIC detects found in the equipment blanks and field blanks against the raw data.
2. Verify that the target compound detects have valid spectra, as defined in Section 4.10 and the tentative identity of any TICs against the raw data, as defined in Section 4.12. If the spectra are not valid, or if the tentative identity is in error, request for a corrected Form I (or equivalent) for the equipment blank or field blank from the laboratory.
3. Verify detected concentrations of target compounds and TICs from the raw data, as defined in Section 4.11. After the validity of the target compounds and TICs is verified, validate the corresponding data using the criteria outlined above.

4.8.3 Field Duplicates and Field Triplicates

Field duplicates consist of either collocated or subsampled samples. Field duplicates for ground water and surface water samples are generally considered to be collocates. Soil duplicate samples may be homogenized and subsampled in the field (or at the laboratory) to form an original and duplicate sample, or may be an additional volume of sample collected in a separate sample container to form a collocate sample. Field duplicate results are an indication of both field and laboratory precision; the results may be used to evaluate the consistency of sampling practices.

Field triplicates are collected from different, randomly selected locations to verify that an incremental sample truly represents a decision unit. Field triplicate results are more useful than field duplicates to statistically evaluate sampling precision.

Level C and Level D:

1. Check to ensure that field duplicates and/or field triplicates were collected and analyzed as specified in the project planning documents. If the sampling frequency is less than the frequency stated in the planning documents, no qualification of the associated sample results is necessary but the incident shall be discussed in the data validation report.
2. For field duplicate results, if the RPDs are greater than 50 percent for water or 100 percent for soil or as stated in the planning document if more conservative, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.
3. For field triplicate results, if the RSDs are greater than the QC limits stated in the planning document, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.

Level D:

1. Verify all target compound and TIC detects found in the field duplicates and/or field triplicates against the raw data.
2. Verify that the target compound detects have valid spectra, as defined in Section 4.10 and the tentative identity of any TICs against the raw data, as defined in Section 4.12. If the spectra are not valid, or if the tentative identity is in error, request for a corrected Form I for the field duplicates from the laboratory.
3. Verify detected concentrations of target compounds and TICs from the raw data, as defined in Section 4.11. After the validity of the target compounds and TICs is verified, validate the corresponding data using the criteria outlined above.

4.9 INTERNAL STANDARDS PERFORMANCE

Internal standards performance criteria ensure that GC/MS sensitivity and response are stable during every analytical run.

Level C and Level D:

1. If an internal standards area count for a sample is outside –50 percent or +100 percent of the area for the initial calibration midpoint standard:
    a. Positive results for compounds quantitated using an internal standards area count greater than 100 percent should be qualified as estimated "J." Nondetected compounds should not be qualified.

   b. Compounds quantitated using an internal standards area count less than 50 percent should be qualified as estimated "J" for detects and estimated "UJ" for nondetects.

   c. If extremely low area counts are reported (less than 20 percent of the area for associated standards), detected compounds should be qualified as estimated "J" and nondetected target compounds should then be qualified as unusable "R."

2. If an internal standards retention time (RT) varies by more than 10 seconds from the RT of the initial calibration midpoint standard, the nondetected target compounds should be qualified as unusable "R" at Level C validation. A Level D validation examination of the raw data should be recommended to the CTO Manager. The chromatographic profile for that sample must be examined to determine if any false positives or negatives exist. For shifts of a large magnitude, the reviewer may consider partial or total rejection of the data for that sample fraction. Positive results should be qualified as "NJ" if the mass spectral criteria are met.

Level D:

1. Verify the internal standard areas reported on Form VIII (or equivalent) from the raw data for at least one sample per SDG, and verify internal standard areas for samples that were qualified due to out-of-control internal standard areas. If errors are discovered between the raw data and the Form VIII (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.10 TARGET COMPOUND IDENTIFICATION

The objective of the criteria for GC/MS qualitative analysis is to minimize the number of erroneous identifications of target compounds. An erroneous identification can either be false positive (reporting a compound present when it is not) or a false negative (not reporting a compound that is present).

The identification criteria can be applied more easily in detecting false positives than false negatives. More information is available for false positives due to the requirement for submittal of data supporting positive identifications. However, negatives, or nondetected compounds, represent an absence of data and are therefore more difficult to assess. One example of detecting false negatives is the not reporting of a target compound that is reported as a TIC.

Level C:

Target compound identification is not evaluated for Level C validation since it requires the interpretation of mass spectral raw data.

Level D:

The following criteria should be followed when evaluating raw data.

1. The relative retention times (RRTs) must be within ± 0.06 RRT units of the standard RRT.
2. Mass spectra of the sample compound and a current laboratory-generated standard (i.e., the mass spectrum from the associated calibration standard) must match according to the following criteria:

a. All ions present in the standard mass spectrum at a relative intensity greater than 10 percent must be present in the sample spectrum.

b. The relative intensities of these ions must agree within ± 20 percent between the standard and sample spectra. (Example: For an ion with an abundance of 50 percent in the standard spectrum, the corresponding sample ion abundance must be between 30 percent and 70 percent.)

c. Ions present at greater than 10 percent in the sample mass spectrum, but not present in the standard spectrum, must be considered and accounted for.

d. The application of qualitative criteria for GC/MS analysis of target compounds requires professional judgment. It is up to the reviewer's discretion to obtain additional information from the laboratory and CTO Manager. If it is determined that incorrect identifications were made, all such data should be qualified as not detected "U" or unusable "R."

e. Professional judgment must be used to qualify the data if it is determined that cross-contamination has occurred. Any changes made to the reported compounds or concerns regarding target compound identifications should be clearly indicated in the data validation report.

4.11 COMPOUND QUANTITATION AND REPORTING LIMITS

The objective is to ensure that the reported quantitation results and reporting limits (i.e., LOQ, LOD, detection limit [DL]) are accurate. All soil sample results are reported on a dry weight basis.

Level C and Level D:

1. Verify that the reporting limits for nondetects are equal to the LODs. Verify that an annual DL study was performed or quarterly LOD/LOQ verification checks were performed in accordance with the DoD QSM. The LOD verification check must be evaluated to determine whether the laboratory can reliably detect and identify all target analytes at a spike concentration of approximately 2× but not more than four times the current reported DL. Qualify nondetects as unusable "R."
2. Check that reported nondetects and positive values have been adjusted to reflect sample dilutions and for soil samples, sample moisture. When a sample is analyzed at more than one dilution, the lowest LODs are used unless a QC criterion has been exceeded. In this case, the higher LODs from the diluted analysis are used. The least technically sound data will be flagged "R" with a qualification code "D."
3. Verify that reported limits for soils and sediments were calculated based on dry weight. If the LOQs/LODs were reported based on wet weight, the percent moisture must be factored in and the LOQs/LODs must be adjusted accordingly.
4. Verify that no results exceed the highest calibration standard without being diluted. If a result has exceeded the highest calibration standard, verify that a dilution was performed. If not, qualify the detected compound that required dilution as "J" and document the event in the data validation report.

Level D:

The compound quantitation must be evaluated for all detects by evaluating the raw data. Compound concentrations must be calculated based on the internal standards associated with that compound, as listed in the following equation. Quantitation must be based on the quantitation ion (m/z) specified in the analytical method for both the internal standards and target compounds. The compound quantitation must be based on the RRF from the appropriate ICAL standard.

Low Water

$$\mu g/L = \frac{A_x \times I_s \times D_f}{A_{is} \times ARRF \times V_o}$$

Where:

A_x = area of characteristic ion (extracted ion current profile) for compound being measured

I_s = amount of internal standard added (nanogram)

D_f = dilution factor

A_{is} = area of characteristic ion for the internal standard

ARRF = average relative response factor for compound being measured

V_o = volume of water purged (milliliter [mL])

Low Soil/Sediment

$$\text{Concentration } \mu g/kg \text{ (Dry weight basis)} = \frac{A_x \times I_s}{A_{is} \times ARRF \times W_s \times D}$$

Where:

A_x, I_s, A_{is} are as given for water.

ARRF = Relative response factor from the heated purge of the initial calibration standard

W_s = Weight of sample added to the purge tube, in grams (g)

$D = \frac{100 - \%\text{ moisture}}{100}$

Medium Soil/Sediment

$$\text{Concentration } \mu g/kg \text{ (Dry weight basis)} = \frac{A_x \times I_s \times V_t \times 1{,}000 \times D_f}{A_{is} \times ARRF \times V_a \times W_s \times D}$$

Where:

A_x, I_s, A_{is}, D are as given for water.

V_t = Total volume of the methanol extract in mL. Note: This volume is typically 10 mL, even though only 1 mL is transferred to the vial

ARRF = Average relative response factor from the ambient temperature purge of the initial calibration standard

V_a = Volume of the aliquot of the sample methanol extract (i.e., sample extract not including the methanol added to equal 100 microliters [µL]) in µL added to reagent water for purging

W_s = Weight of soil/sediment extracted, in grams (g)

D_f = Dilution factor. The dilution factor for analysis of soil/sediment samples for volatiles by medium level method is defined as:

$$\frac{\mu\text{L most conc. extract used to make dilution} + \mu\text{L clean solvent}}{\mu\text{L most conc. extract used to make dilution}}$$

The dilution factor is equal to 1.0 in all cases other than those requiring dilution of the sample methanol extract (V_t). The factor of 1,000 in the numerator converts the value of V_t from mL to µL.

If discrepancies are discovered in the quantitation, request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.12 TENTATIVELY IDENTIFIED COMPOUNDS

For each sample, the laboratory must conduct a mass spectral search of the spectral library and report the possible identity for up to 30 of the largest volatile fraction peaks that are not system monitoring compounds (surrogates), internal standards, or target compounds, but which have area or height greater than 10 percent of the area or height of the nearest internal standard. TIC results are reported for each sample on the Organic Analyses Data Sheet (Form I VOA-TIC [or equivalent]).

Level C and Level D:

1. All TIC results should be qualified "NJ," tentatively identified with approximated concentrations.
2. The reviewer should be aware of common laboratory artifacts and their sources such as siloxane compounds, which indicate capillary column degradation, and carbon dioxide which indicates a possible air leak in the system. These may be qualified as unusable "R."
3. If a target compound is identified as a TIC by non-target library search procedures, the reviewer should request that the laboratory recalculate the result using the proper quantitation ion.
4. TIC results that are not above the 10× level in the blank should be qualified as unusable, "R." (Dilutions and sample size must be taken into account when comparing the amounts present in blanks and samples.)

5. The reviewer may elect to report all similar compounds as a total (e.g., all alkanes may be summarized and reported as total hydrocarbons).

Level D:

Check each TIC for each sample using the following criteria.

1. Major ions (greater than 10 percent relative intensity) in the reference spectrum should be present in the sample spectrum.
2. The relative intensities of the major ions should agree within ± 20 percent between the sample and the reference spectra.
3. Molecular ions present in the reference spectrum should be present in the sample spectrum.
4. Ions present in the sample spectrum but not in the reference spectrum should be reviewed for possible background contamination, interference, or co-elution of additional TIC or target compounds.
5. When the above criteria are not met, but in the technical judgment of the data reviewer or mass spectral interpretation specialist, the identification is correct, the data validator may report the identification.
6. Since TIC library searches often yield several candidate compounds having a close matching score, all reasonable choices must be considered. The reviewer may use judgment to change the reported tentative identity.

5. Records

A Form I or equivalent that has been validated and verified, and has been determined by the data validator to accurately represent the appropriate sample results to be utilized, shall be stamped "NAVFAC PACIFIC VALIDATED." Additionally, sample result forms for which the data has been validated at the Level D validation level shall be stamped or noted "Level D."

Copies of all documents generated by the data validation personnel will be stored for no less than 10 years. The original validated laboratory data shall be archived to the Federal Records Center at project completion.

6. References

Department of Defense, United States (DoD). 2005a. *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: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

———. 2005b. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B: Quality Assurance/quality Control Compendium: Minimum QA/QC Activities*. Final Version 1. DoD: DTIC ADA 426957, EPA-505-B-04-900B. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www2.epa.gov/sites/production/files/documents/qaqc_v1_0305.pdf.

———. 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2A: Optimized UFP-QAPP Worksheets*. Revision 1. March.

———. 2013. *Department of Defense Quality Systems Manual for Environmental Laboratories.* Version 5.0. Draft Final. Prepared by DoD Environmental Data Quality Workgroup and Department of Energy Consolidated Audit Program Operations Team. July.

Environmental Protection Agency, United States (EPA). 2007. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* 3rd ed., Final Update IV. Office of Solid Waste. On-line updates at: www.epa.gov/epaoswer/hazwaste/test/new-meth.htm.

Procedure II-A, *Data Validation*.

7. Attachments

None.

Level C and Level D Data Validation for Total Petroleum Hydrocarbons by SW-846 8015

1. Purpose

This data validation procedure sets forth the standard operating procedure for performance of Level C and Level D data validation of total petroleum hydrocarbons (TPH) data obtained under the United States (U.S.) Navy Environmental Restoration (ER) Program for Naval Facilities Engineering Command (NAVFAC), Pacific and is consistent with protocol in the *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories* (DoD QSM) (DoD 2013). Level B validation is addressed separately in Procedure II-A, *Data Validation*.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Responsibilities

The CTO Manager, the QA Manager or Technical Director, and the CTO QA Coordinator are responsible for ensuring that this procedure is implemented by data validation personnel.

Data validation personnel are responsible for implementing this procedure for validation of all gas chromatography (GC) TPH data.

4. Procedure

This procedure addresses the validation of TPH data obtained using U.S. Environmental Protection Agency (EPA) Method Solid Waste (SW)-846 8015 (EPA 2007). The quality control (QC) criteria identified in this procedure are those specified in the analytical method and the DoD QSM (DoD 2013). Where project specific criteria are identified in the CTO work plan, they will supersede the QC criteria identified in this procedure.

- Form I: Sample Results Summary Form
- Form II: Surrogate Recovery Summary Form
- Form III: Matrix Spike/Matrix Spike Duplicate or Blank Spike/Blank Spike Duplicate Recovery Summary Form

- Form IV: Method Blank Summary Form
- Form VI: Initial Calibration Summary Form
- Form VII: Continuing Calibration Summary Form
- Form VIII: TPH Analytical Sequence Form

Level C data validation consists of review of summary forms only while Level D data validation requires review of both summary forms and all associated raw data. Data review guidelines and how they apply to the different validation levels are indicated in the following text.

4.1 SAMPLE MANAGEMENT

QA/QC criteria included under sample management are sample preservation, handling, and transport; chain of custody (COC); and holding times.

4.1.1 Sample Preservation, Handling, and Transport

Level C and Level D:

Evaluate sample collection, handling, transport, and laboratory receipt from COC and laboratory receipt checklists to ensure that the samples have been properly preserved and handled.

TPH as Gasoline

1. Water samples must be preserved with hydrochloric acid at or below a pH of 2 and refrigerated at above freezing to 6 degrees Celsius (°C).
2. Soil samples collected in volatile organic analysis (VOA) vials or coring devices must be refrigerated at above freezing to 6°C. If the samples are to be analyzed after the 48-hour holding time, the laboratory must preserve the samples with sodium bisulfate or methanol or freeze upon receipt in accordance with EPA SW-846 Method 5035 (EPA 2007).
3. If the analyzed aqueous VOA vial contains air bubbles or headspace, is cracked, or has a cracked cap, positive values shall be flagged as estimated “J” and nondetects as estimated “UJ.” The sample data may be qualified as unusable “R” if the container damage is extensive or improper sealing is identified.
4. VOA vials are to be shipped in coolers that are maintained at above freezing to 6°C. If the temperature exceeds 6°C, but is less than or equal to 10°C, note this in the data validation report. If the temperature of receipt is greater than or equal to 11°C, positive values shall be flagged as estimated “J” and nondetects as estimated “UJ.” If the temperature of receipt is greater than or equal to 15°C, positive values shall be flagged as estimated “J” and nondetects as unusable “R.” If the temperature is below 0°C, special note should be made that the samples were frozen and no qualification shall be required. In the event that both a cooler temperature and a temperature blank were measured, the temperature blank shall be evaluated for temperature compliance as it best assimilates the condition of the samples; however, both temperatures shall be noted in the data validation report.

TPH as Extractables

1. Samples are to be shipped in coolers that are maintained at above freezing to 6°C. If the temperature exceeds 6°C but is less than or equal to 10°C, note this in the data validation

report. If the temperature of receipt is greater than or equal to 11°C, positive values shall be flagged as estimated "J" and nondetects as estimated "UJ." If the temperature is below 0°C, special note should be made that the samples were frozen and no qualification shall be required. In the event that both a cooler temperature and a temperature blank were measured, the temperature blank shall be evaluated for temperature compliance as it best assimilates the condition of the samples; however, both temperatures shall be noted in the data validation report.

2. Water samples shall not be preserved; they shall only be kept cool. If the water samples were inappropriately preserved with acid, the samples should not be analyzed. Analysis of an inappropriately preserved sample by the laboratory may require that all results be reported as unusable "R."
3. If the temperature of the cooler upon receipt at the laboratory was not recorded, document that the laboratory is noncompliant.

If the receiving laboratory transferred the samples to another laboratory for analysis, apply the same temperature criteria to both the transfer COC and the original COC.

4.1.2 Chain of Custody

Level C and Level D:

Examine the COC for legibility and check that all TPH analyses requested on the COC have been performed by the laboratory. Ensure that the COC Sample Number on the laboratory Form I (or equivalent) matches the Sample Identification on the COC. Read the laboratory case narrative for additional information.

1. Any samples received for analysis that were not analyzed shall be noted in the data validation report, along with the reason(s) for failure to analyze the samples, if the reason(s) can be determined. Conversely, samples that were analyzed for TPH but were not requested should also be noted.
2. Any discrepancies in sample naming between the COC and Form I (or equivalent) shall be noted in the data validation report with the correct sample name being identified if the correct sample name can be determined.
3. If the receiving laboratory transferred the samples to another laboratory for analysis, both the original COCs and transfer COCs shall be present. Document in the data validation report if the transfer COCs are not present.
4. Internal COC is required for all samples, extracts, and digestates from receipt to disposal. Verify the internal COC forms for completeness. Document in the data validation report if the internal COC forms are not present.
5. Each individual cooler shall have an individual COC that lists only samples contained within that cooler. Document in the data validation report if multiple coolers appear on one COC.

4.1.3 Holding Times

Level C and Level D:

Holding times for TPH are measured from the time of collection (as shown on the COC) to the time of sample extraction and from the time of sample extraction to the time of sample analysis (as shown on the Form I [or equivalent]). Samples and extracts must be stored and refrigerated at above freezing to 6°C until the time of analysis.

TPH as Gasoline

1. Water samples must be preserved with hydrochloric acid and refrigerated at above freezing to 6°C. Preserved water samples shall be analyzed within 14 days from the collection date. If there is no indication of chemical preservation, assume samples are unpreserved. For unpreserved water samples, the holding time is 7 days from date collected.
2. Soil samples collected in VOA vials or coring devices that are unpreserved must be refrigerated at above freezing to 6°C and analyzed within 48 hours from the collection date. Soil samples that are preserved with sodium bisulfate or methanol, or frozen upon laboratory receipt shall be analyzed within 14 days from the collection date.

TPH as Extractables

Water samples shall be unpreserved and refrigerated at above freezing to 6°C and shall be extracted within 7 days of collection and analyzed within 40 days of extraction.

Soil samples shall be unpreserved and refrigerated at above freezing to 6°C and shall be extracted within 14 days of collection and analyzed within 40 days of extraction.

1. If the holding time is exceeded, flag all associated positive results as estimated “J” and all associated limits of detection (LODs) (nondetects) as estimated “UJ,” and document that holding times were exceeded.
2. If holding times are grossly exceeded by greater than a factor of 2.0 (e.g., a non-preserved water sample has an extraction holding time of more than 14 days), detects will be qualified as estimated “J” and nondetects as unusable “R.”

4.2 GC INSTRUMENT PERFORMANCE

Level C:

Instrument performance is not evaluated for Level C validation.

Level D:

Evaluate the blank, standard, laboratory control sample, and sample chromatograms to ascertain the performance of the chromatographic system. Professional judgment should be used to qualify the data when unacceptable chromatographic conditions preclude proper quantitation or identification of TPH.

4.3 CALIBRATION

Compliance requirements for satisfactory instrument calibration are established to ensure that an instrument is capable of producing acceptable quantitative data. Initial calibration demonstrates that an instrument is capable of acceptable performance at the beginning of a sequence, and continuing calibration checks document satisfactory maintenance and adjustment of the instrument on a day-to-day basis.

Level C and Level D:

1. The proper analytical sequence must be followed to ensure proper quantitation and identification of all target compounds. For the quantitation analysis, standards containing all target compounds, (specific hydrocarbon products or n-alkanes) must be analyzed in the initial calibration at the beginning of the sequence. If n-alkane ranges rather than specific hydrocarbon products are being reported, n-alkane standards must be run in the initial calibration and should be analyzed periodically to ensure proper identification of the n-alkane range reported. An initial calibration verification standard must be analyzed following each initial calibration. The mid-level standard of the initial calibration must be analyzed after every 10 samples as the continuing calibration and at the end of the sequence to ensure system performance has not degraded. If the proper sequence has not been analyzed, use professional judgment to assess the reliability of the data.
2. The laboratory should report retention time window data for each compound and each column used to analyze the samples. The retention time windows are used for qualitative identification. The laboratory should also report quantitation ranges used for integration when analyzing samples. If the compounds in the continuing calibration standard do not fall within the retention time windows established in the initial calibration, the associated sample results should be carefully evaluated, especially the retention time of the surrogate spike compound. All samples injected after the last in-control standard are potentially affected.

4.3.1 Initial Calibration

Level C and Level D:

For the initial calibration (at least five-points), the relative standard deviation (RSD) of the calibration factor (CF) for each target compound must be less than or equal to 20 percent. Verify the RSDs from the initial calibration summary forms. Alternatively, a linear curve may be used with a coefficient of determination; r^2 equal to or greater than 0.990. A second order calibration curve may also be used after evaluating the laboratory's acceptance criteria. If the initial calibration criteria are not met, flag all associated quantitative results as estimated “J” for detects and estimated “UJ” for nondetects.

Level D:

Verify the percent RSDs, r^2, or laboratory established measure of linearity for the initial calibration from the raw data. Verify the CF for each target compound from the raw data on the low-point calibration standard and one additional calibration standard. If errors are discovered, request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.3.2 Initial Calibration Verification

The initial calibration curve must be verified with a standard that has been purchased or prepared from an independent source each time initial calibration is performed. A standard from the same manufacturer but independently prepared from different source materials may also be used as an independent source. This initial calibration verification (ICV) must contain all of the method target compounds.

Level C and Level D:

1. Verify the ICV was analyzed following the initial calibration and contained all method target compounds.
2. If any target analyte has a percent difference (%D) greater than 20 percent, flag detects for the affected compounds as estimated "J" and nondetects as estimated "UJ" in all samples associated with the initial calibration.

Level D:

Verify from the raw data that there were no calculation or transcription errors by recalculating a percentage of the ICV calculations.

4.3.3 Continuing Calibration

Level C and Level D:

Verify the %D from the continuing calibration summary forms. For the continuing calibration, the %D between the CF from the continuing calibration and the average CF from the initial calibration must be less than 20 percent. Alternatively, if a linear (first-order) calibration curve is utilized in the initial calibration, the %D of the calculated amount and the true amount for each compound must be less than or equal to 20 percent. If the continuing calibration criteria are not met, qualify all associated results as estimated "J" for detects and "UJ" for nondetects.

Level D:

Verify the %Ds from the raw data.

4.4 BLANKS

Method blank analytical results are assessed to determine the existence and magnitude of contamination problems. If problems with any method blank exist, all associated data must be carefully evaluated to determine whether there is any bias associated with the data, or if the problem is an isolated occurrence not affecting other data. No contaminants should be present in the method blank(s). The method blank should be analyzed on each GC system used to analyze site samples.

1. The reviewer should identify samples associated with each method blank using Form IV (or equivalent). Verify that method blank analysis has been reported per matrix and concentration level for each set of samples. Each sample must have an associated method blank. Qualify positive results in samples with no method blank as unusable "R." Nondetects do not require qualification.
2. If the method blank was not analyzed on a GC used to analyze site samples, note the deficiency in the data validation report. Professional judgment shall be used for subsequent qualification of the data.
3. Compare the results of each method blank with the associated sample results. The reviewer should note that the blank analyses may not involve the same weights, volumes, percent moistures, or dilution factors as the associated samples. These factors must be taken into consideration when applying the criteria discussed below, such that a comparison of the total amount of contamination is actually made.

4. If a compound is found in the blank, but not in the associated sample, no action is taken.
5. Any compound detected in both the sample and the associated blank shall be qualified when the sample concentration is less than the limit of quantitation (LOQ) and the blank concentration is less than, greater than, or equal to the LOQ. Care should be taken to factor in the percent moisture when comparing detects in the sample and the method blank. The applicable review qualifier(s) are summarized in Table II-H-1.

Table II-H-1: Blank Qualifications

Sample Result	Sample Value	Reviewer Qualifier(s)
Less than LOQ and blank result is <, > or = LOQ	Leave as reported	U
≥LOQ, blank result is <LOQ	Leave as reported	None
≥LOQ, blank result is >LOQ and sample result <blank result	Leave as reported	Use professional judgment
≥LOQ, blank result is >LOQ and sample result ≥blank result	Leave as reported	Use professional judgment
≥LOQ and blank result is = LOQ	Leave as reported	Use professional judgment

6. In the case wherein both the sample concentration and the blank concentration are greater than or equal to the LOQ, previously approved criteria as identified in the project planning documents may be applied to qualify associated sample results. Otherwise, qualify sample results as non-detect “U” when the sample concentration is less than or equal to 5 times the blank concentration (5× rule).
7. Instances of contamination can be attributable to the dilution process. These occurrences are difficult to determine; however, the reviewers should qualify the sample data as nondetects, “U,” when the reviewer determines the contamination to be from a source other than the sample.
8. In the event of gross contamination (i.e., saturated peaks) in the blanks, the associated samples must be evaluated for gross contamination. If gross contamination exists in the samples, the affected compounds should be qualified as unusable, “R.”

Level D:

1. Verify from the preparation log that the information recorded on Form IV (or equivalent) is correct.
2. Review the results of all blank raw data and Form I (or equivalent) to ensure that there were no false negatives or false positives.
3. Verify all target compound detects found in the method blanks against the raw data. Follow the guidelines specified in Sections 4.9 and 4.10 of this procedure. After the validity of the target compounds are verified, validate the corresponding data using the criteria outlined above for Level C and Level D validation.

4.5 BLANK SPIKES AND LABORATORY CONTROL SAMPLES

Blank spike/laboratory control sample (LCS) recoveries must be within the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established for a given sample matrix. Use in-house limits if compounds are not listed in Appendix C or project limits are not specified.

Level C and Level D:

1. If the blank spike/LCS results are 0 percent, only the spiked compounds that showed low recovery in all associated samples shall be flagged as unusable “R” for nondetects and estimated “J” for detects.
2. If blank spike/LCS results are below the control limits (but above 0 percent), spiked compounds which showed low recovery in all associated samples shall be flagged as estimated “UJ” or “J.”
3. If blank spike/LCS results are above the control limits, detects for only the spiked compounds which showed high recovery in all associated samples shall be flagged as estimated “J.”
4. If the laboratory analyzes a blank spike duplicate/LCS duplicate (LCSD), evaluate and qualify the LCSD results using the criteria noted above.
5. If the relative percent differences (RPDs) between LCS and LCSD results are above the control limits (use the matrix spike [MS]/matrix spike duplicate [MSD] RPD control limits identified in DoD QSM Appendix B, if none are available use laboratory in-house limits), spiked compounds which showed high RPD in all associated samples shall be flagged as estimated “UJ” or “J.”

Level D:

To verify that the spike percent recovery was calculated and reported correctly using the following equation, recalculate one spike recovery per matrix (and any spike that would result in the qualification of a sample).

$$\%\text{Recovery} = \frac{Q_d}{Q_a} \times 100$$

Where:

Q_d = Quantity determined by analysis

Q_a = Quantity added to samples/blanks

If transcription errors are discovered on Form III (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.6 SURROGATE RECOVERY

Laboratory performance on individual samples is established by means of surrogate spiking activities. All samples are spiked with surrogate compounds prior to sample preparation. The evaluation of the results of these surrogate spikes is not necessarily straightforward. The sample itself may produce effects because of factors such as interferences and high concentrations of compounds. Since the effects of the sample matrix are frequently outside the control of the laboratory and may present relatively unique problems, the review and validation of data based on specific sample results is frequently subjective and demands analytical experience and professional judgment. The following procedures shall be followed:

Level C and Level D:

Sample and blank surrogate recoveries for TPH must be within the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established. Use in-house limits if surrogates are not listed in Appendix C or project limits are not specified. Verify that no samples or blanks have surrogates outside the criteria from Form II (or equivalent).

1. If recovery is below the QC limits for any of the surrogates, but above or equal to 10 percent, flag associated positive results as estimated “J” and nondetects as “UJ.”
2. If any surrogate recovery is less than 10 percent, flag all nondetects as unusable “R” and detects as estimated “J.” No qualification is applied if surrogates are diluted beyond detection but note in the data validation report that surrogate evaluation could not be performed due to the high dilution factor.
3. If any surrogate recovery is above the upper QC limit, flag associated positive results as estimated “J.” No qualification of nondetects is necessary in the case of high recoveries.
4. Surrogates may be reported as “diluted out” (D); if dilution is such that the surrogate can no longer be detected. If this is the case, note in the data validation report that surrogate evaluation could not be performed due to a high dilution factor. A full evaluation of the sample chromatogram may be necessary to determine that surrogates are truly “diluted out.”

Level D:

The reported surrogate recoveries on Form II should be verified from the raw data for a representative number of samples.

4.7 MATRIX SPIKE/MATRIX SPIKE DUPLICATE

MS/MSD data are used to determine the effect of the matrix on a method’s recovery efficiency and precision for a specific sample matrix.

No action is taken on MS/MSD data alone to qualify an entire data package. Using informed professional judgment; however, the data reviewer may use the MS/MSD results in conjunction with other QC criteria (i.e., surrogates and LCS) and determine the need for some qualification of the data.

The data reviewer should first try to determine the extent to which the results of the MS/MSD affect the associated data. This determination should be made with regard to the MS/MSD sample itself, as well as specific compounds for all samples associated with the MS/MSD.

In those instances where it can be determined that the results of the MS/MSD affect only the sample spiked, then qualification should be limited to this sample alone. It may be determined through the

MS/MSD results, however, that a laboratory is having a systematic problem in the analysis of one or more compounds, which affects all associated samples.

Note: If a field blank was used for the MS/MSD, the information must be included in the data validation summary. Sample matrix effects have not been observed with field blanks therefore the recoveries and precision do not reflect the analytical impact of the site matrix.

Level C and Level D:

The laboratory must spike and analyze a MS/MSD from the specific project site as required for each matrix type and analytical batch.

1. MS/MSD data should be reported on a MS/MSD summary form similar to Form III (or equivalent).
2. Compare the percent recovery (%R) and RPD for each spiked compound with the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established. Use in-house limits if spiked compounds are not listed in Appendix C or project limits are not specified.
3. If MS/MSD results are 0 percent, only the spiked compounds that showed low recovery in the parent sample shall be flagged as unusable “R” for nondetects and estimated “J” for detects.
4. If MS/MSD results are below the control limits (but above 0 percent), spiked compounds which showed low recovery in the parent sample shall be flagged as estimated “UJ” or “J.”
5. If MS/MSD results are above the control limits, detects for only the spiked compounds which showed high recovery in the parent sample shall be flagged as “J.”
6. If the RPDs between MS and MSD results are greater than 30 percent, detects for only the spiked compounds which showed high RPD in the parent sample shall be flagged as estimated “J.”
7. Failure of MS/MSD due to the presence of a target compound in the parent sample at greater than 2 times the spike concentration and or diluted by more than a factor of 2 should not result in any qualifications. Note the incident in the data validation report.

Level D:

Check the raw data and recalculate one or more %Rs and RPDs, especially %Rs and RPDs that resulted in the qualification of data, using the following equations to verify that results on Form III (or equivalent) are correct.

$$\%R = \frac{(SSR - SR)}{SA} \times 100$$

$$RPD = \frac{ABS|SSR - SDR|}{(SSR + SDR)/2} \times 100$$

Where:

SA = spike added

SR = sample result

SSR = spiked sample result

SDR = spiked duplicate result

ABS = absolute value

If transcription errors are discovered on Form III (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.8 FIELD QC SAMPLES

Field QC samples discussed in this section of the procedures are equipment blanks, field blanks, field duplicates, and field triplicates.

4.8.1 Equipment Blanks and Field Blanks

Compounds detected in equipment blanks indicate the possibility of cross-contamination between samples due to improper equipment decontamination.

A field blank sample may be collected from each source of water used during each sampling event. The field blank may be analyzed to assess whether the chemical nature of the water used in decontamination may have affected the analytical results of site samples.

If TPH compounds are detected in the equipment blanks and/or field blanks, the procedure for the qualification of associated sample results is identical to the criteria outlined in Section 4.4 of this procedure.

Level C and Level D:

1. Determine which field QC samples apply to samples in the sample deliver group.
2. Ensure that units are correct when applying field QC blank qualifications. If samples are soil matrix, results must first be converted to micrograms per liter from micrograms per kilogram to make correct comparisons.
3. Because of the way in which the field blanks and equipment blanks are sampled, equipment blanks are not qualified because of field blank contamination. The affected samples are qualified, however, by either the field blank or equipment blank results, whichever has the higher contaminant concentration.
4. Equipment blanks and field blanks are only qualified with method blank results in order to account for laboratory contamination.

Level D:

Compound identification and quantification of field blank and equipment blank samples must be verified. Follow the guidelines specified in Sections 4.9 and 4.10 of this procedure.

4.8.2 Field Duplicates and Field Triplicates

Field duplicates consist of either collocated or subsampled samples. Field duplicates for ground water and surface water samples are generally considered to be collocates. Soil duplicate samples may be homogenized and subsampled in the field (or at the laboratory) to form an original and duplicate sample, or may be an additional volume of sample collected in a separate sample container to form a collocate sample. Field duplicate results are an indication of both field and laboratory precision; the results may be used to evaluate the consistency of sampling practices.

Field triplicates are collected from different, randomly selected locations to verify that an incremental sample truly represents a decision unit. Field triplicate results are more useful than field duplicates to statistically evaluate sampling precision.

Level C and Level D:

1. Check to ensure that field duplicates were collected and analyzed as specified in the project planning documents. If the sampling frequency is less than the frequency stated in the planning documents, no qualification of the associated sample results is necessary but the incident shall be discussed in the data validation report.
2. For field duplicate results, if the RPDs are greater than 50 percent for water or 100 percent for soil or as stated in the planning document if more conservative, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.
3. For field triplicate results, if the RSDs are greater than the QC limits stated in the planning document, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.

Level D:

Before comparison of duplicates and/or triplicates, the compound identification and quantification must be verified. Follow the guidelines specified in Sections 4.9 and 4.10 of this procedure.

4.9 TARGET COMPOUND IDENTIFICATION

Qualitative criteria for compound identification have been established to minimize the number of erroneous identifications of compounds. An erroneous identification can be either a false positive (reporting a compound present when it is not) or a false negative (not reporting a compound that is present).

Level C:

Compound identification is not verified for Level C validation.

Level D:

1. Review Form I or equivalent. Check for errors.

2. Verify that the retention times of sample compounds reported on the Form X or equivalent fall within the calculated retention time windows.
3. Evaluate all sample chromatograms to ensure that the TPH results were properly identified. Presence of unknown single peaks may result in false positives or false negatives. The reviewer should use professional judgment in evaluating the effect of interference.

4.10 COMPOUND QUANTITATION AND REPORTING LIMITS

The objective is to ensure that the reported quantitation results and reporting limits (i.e., LOQ, LOD, detection limit [DL]) are accurate. All soil sample results are reported on a dry weight basis.

Level C:

Specific compound quantitation is not verified for Level C validation.

Level C and Level D:

1. Verify that the reporting limits for nondetects are equal to the LODs. Verify that an annual DL study was performed or quarterly LOD/LOQ verification checks were performed in accordance with the DoD QSM. The LOD/LOQ verification check must be evaluated to determine whether the laboratory can reliably detect and identify all target analytes at a spike concentration of approximately two times but not more than four times the current reported DL. Qualify nondetects as unusable “R.”
2. Check that reported nondetects and positive values have been adjusted to reflect sample dilutions and for soil samples, sample moisture. When a sample is analyzed at more than one dilution, the lowest LODs are used unless a QC criterion has been exceeded. In this case, the higher LODs from the diluted analysis are used. The least technically sound data will be flagged “R” with a qualification code “D.”
3. Verify that reported limits for soils and sediments were calculated based on dry weight. If the LOQs/LODs were reported based on wet weight, the percent moisture must be factored in and the LOQs/LODs must be adjusted accordingly.
4. If a sample requiring a dilution analysis due to a target compound detect exceeding the calibration linear range was not re-analyzed at a dilution, the compound exceeding calibration range shall be qualified as estimated “J.”
5. If the laboratory re-analyzed a sample and submitted both sample results, the reviewer must determine which of the two analyses has better data quality. Only one analysis should be reported and the other is rejected.

Level D:

1. Compound quantification should be verified by recalculation from the raw data for a representative number of samples.
2. Verify from the standard chromatograms that the instrument sensitivity is adequate to support the LODs. Poor sensitivity may result in elevated LODs.

5. Records

A Form I that has been validated and verified, and has been determined by the data validator to accurately represent the appropriate sample results to be utilized, shall be stamped "NAVFAC PACIFIC VALIDATED." Additionally, sample result forms for which the data has been validated at the Level D validation level shall be stamped or noted "Level D."

Copies of all documents generated by the data validation personnel will be stored for no less than 10 years. The original validated laboratory data shall be archived to the Federal Records Center at project completion.

6. References

Department of Defense, United States (DoD). 2005a. *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: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

———. 2005b. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B: Quality Assurance/quality Control Compendium: Minimum QA/QC Activities*. Final Version 1. DoD: DTIC ADA 426957, EPA-505-B-04-900B. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www2.epa.gov/sites/production/files/documents/qaqc_v1_0305.pdf.

———. 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2A: Optimized UFP-QAPP Worksheets*. Revision 1. March.

———. 2013. *Department of Defense Quality Systems Manual for Environmental Laboratories.* Version 5.0. Draft Final. Prepared by DoD Environmental Data Quality Workgroup and Department of Energy Consolidated Audit Program Operations Team. July.

Environmental Protection Agency, United States (EPA). 2007. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* 3rd ed., Final Update IV. Office of Solid Waste. Updates available: www.epa.gov/epaoswer/hazwaste/test/new-meth.htm.

Procedure II-A, *Data Validation*.

7. Attachments

None.

Level C and Level D Data Validation for Polynuclear Aromatic Hydrocarbons by SW-846 8310

1. Purpose

This data validation procedure sets forth the standard operating procedure for performance of Level C and Level D data validation of polynuclear aromatic hydrocarbon (PAH) data obtained under the United States (U.S.) Navy Environmental Restoration (ER) Program for Naval Facilities Engineering Command, Pacific (NAVFAC Pacific) and is consistent with protocol in the *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories* (DoD QSM) (DoD 2013). Level B validation is addressed separately in Procedure II-A, *Data Validation*.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Responsibilities

The CTO Manager, the QA Manager or Technical Director, and the CTO QA Coordinator are responsible for ensuring that this procedure is implemented by data validation personnel.

Data validation personnel are responsible for implementing this procedure for validation of all high-performance liquid chromatography (HPLC) PAH data.

4. Procedure

This procedure addresses the validation of PAH data obtained using U.S. Environmental Protection Agency (EPA) Method Solid Waste (SW)-846 8310 (EPA 2007). The quality control (QC) criteria identified in this procedure are those specified in the analytical method and the DoD QSM (DoD 2013). Where project specific criteria are identified in the CTO work plan, they will supersede the QC criteria identified in this procedure.

- Form I: Sample Results Summary Form
- Form II: Surrogate Recovery Summary Form
- Form III: Matrix Spike/Matrix Spike Duplicate or Blank Spike/Blank Spike Duplicate Recovery Summary Form

- Form IV: Method Blank Summary Form
- Form VI: Initial Calibration Summary Form
- Form VII: Continuing Calibration Summary Form
- Form VIII: PAH Analytical Sequence Form
- Form X: PAH Identification Form

Level C data validation consists of review of summary forms only while Level D data validation requires review of both summary forms and all associated raw data. Data review guidelines and how they apply to the different validation levels are indicated in the following text.

4.1 SAMPLE MANAGEMENT

QA/QC criteria included under sample management are sample preservation, handling, and transport; chain of custody (COC); and holding times.

4.1.1 Sample Preservation, Handling, and Transport

Level C and Level D:

Evaluate sample collection, handling, transport, and laboratory receipt from COC and laboratory receipt checklists to ensure that the samples have been properly preserved and handled.

1. Samples are to be shipped in coolers that are maintained at above freezing to 6 degrees Celsius (°C). If the temperature exceeds 6°C but is less than or equal to 10°C, note this in the data validation report. If the temperature of receipt is greater than or equal to 11°C, positive values shall be flagged as estimated "J" and nondetects as estimated "UJ." If the temperature is below 0°C, special note should be made that the samples were frozen and no qualification shall be required. In the event that both a cooler temperature and a temperature blank were measured, the temperature blank shall be evaluated for temperature compliance as it best assimilates the condition of the samples; however, both temperatures shall be noted in the data validation report.
2. If the temperature of the cooler upon receipt at the laboratory was not recorded, document that the laboratory is noncompliant.
3. Water samples shall not be preserved; they shall only be kept cool. If the water samples were inappropriately preserved with acid, the samples should not be analyzed. Analysis of an inappropriately preserved sample by the laboratory may require that all results be reported as unusable "R."
4. If the receiving laboratory transferred the samples to another laboratory for analysis, apply the same temperature criteria to both the transfer COC and the original COC.

4.1.2 Chain of Custody

Level C and Level D:

Examine the COC for legibility and check that all PAH analyses requested on the COC have been performed by the laboratory. Ensure that the COC Sample Number on the laboratory Form I (or equivalent) matches the Sample Identification on the COC. Read the laboratory case narrative for additional information.

1. Any samples received for analysis that were not analyzed shall be noted in the data validation report, along with the reason(s) for failure to analyze the samples, if the reason(s) can be determined. Conversely, samples that were analyzed for PAHs but were not requested should also be noted.
2. Any discrepancies in sample naming between the COC and Form I (or equivalent) form shall be noted in the data validation report with the correct sample name being identified if the correct sample name can be determined.
3. If the receiving laboratory transferred the samples to another laboratory for analysis, both the original COCs and transfer COCs shall be present. Document in the data validation report if the transfer COCs are not present.
4. Internal COC is required for all samples, extracts, and digestates from receipt to disposal. Verify the internal COC forms for completeness. Document in the data validation report if the internal COC forms are not present.
5. Each individual cooler shall have an individual COC that lists only samples contained within that cooler. Document in the data validation report if multiple coolers appear on one COC.

4.1.3 Holding Times

Level C and Level D:

Holding times for PAHs are measured from the time of collection (as shown on the COC) to the time of sample extraction and from the time of sample extraction to the time of sample analysis (as shown on the Form I [or equivalent]). Samples and extracts must be stored and refrigerated at above freezing to 6°C until the time of analysis.

Water samples shall be unpreserved and refrigerated at above freezing to 6°C and shall be extracted within 7 days of collection and analyzed within 40 days of extraction.

Soil samples shall be unpreserved and refrigerated at above freezing to 6°C and shall be extracted within 14 days of collection and analyzed within 40 days of extraction.

1. If the holding time is exceeded, flag all associated positive results as estimated “J” and all associated limits of detection (LODs) (nondetects) as estimated “UJ,” and document that holding times were exceeded.
2. If holding times are grossly exceeded by greater than a factor of 2.0 (e.g., a non-preserved water sample has an extraction holding time of more than 14 days), detects will be qualified as estimated “J” and nondetects as unusable “R.”

4.2 INSTRUMENT PERFORMANCE

The objective is to ensure that the instrument condition is adequate for proper identification and quantification of the compounds of interest. The chromatographic resolution and the sensitivity should be evaluated from the chromatograms.

Level C:

This section does not apply to Level C validation.

Level D:

Evaluate blank, standard, sample, and QC chromatograms to ensure that the chromatographic resolution and the sensitivity are adequate. Any shift in baseline, negative peaks, or peak tailing/splitting shall be discussed in the data validation report. If the data quality has been affected by poor instrument performance, the data should be qualified using the reviewer's professional judgment.

4.3 CALIBRATION

Compliance requirements for satisfactory instrument calibration are established to ensure that an instrument is capable of producing acceptable quantitative data. Initial calibration demonstrates that the instrument is capable of acceptable performance at the beginning of a sequence, and continuing calibration checks document satisfactory maintenance and adjustment of the instrument on a day-to-day basis.

4.3.1 Initial Calibration

The HPLC system can be calibrated using the external standard technique or internal standard technique. Because of the difficulty in selecting suitable internal standards, the external standard technique will often be the method of choice.

At the beginning of the analysis, sequence calibration standards must be run at a minimum of five concentration levels for each parameter of interest to establish the calibration curve and expected retention time windows for the compounds of interest. One of the standards should be at a concentration at or just above the limit of quantitation (LOQ), and the other concentrations should correspond to the expected range of concentrations found in real samples or should define the working range of the detector.

Level C and Level D:

Verify from the initial calibration summary form (Form VI equivalent) that the relative standard deviations (RSDs) reported are less than or equal to 20 percent. If a calibration curve is used, verify that the coefficient of determination (r^2) is greater than or equal to 0.990.

1. If the RSD for the calibration factors of the initial calibration runs is greater than 20 percent, qualify the data as estimated “J” or “UJ.” If RSDs are used as the linearity check, the quantitation should be performed using an average calibration factor.
2. If r^2 is less than 0.990, qualify the compounds with a low r^2 value as estimated “J” or “UJ.”

Level D:

Verify from the raw data that the calibration factors (CFs) and percent RSD (%RSDs) reported on the initial calibration form (Form VI equivalent) have been calculated correctly. Recalculate the CFs and %RSDs reported on Form VI (or equivalent) for one compound from the raw data (preferably compounds which were identified in the samples) on the low-point calibration standard and one additional calibration standard.

4.3.2 Initial Calibration Verification

The initial calibration curve must be verified with a standard that has been purchased or prepared from an independent source each time initial calibration is performed. A standard from the same manufacturer but independently prepared from different source materials may also be used as an independent source. This initial calibration verification (ICV) must contain all of the method target compounds.

Level C and Level D:

1. Verify the ICV was analyzed following the initial calibration and contained all method target compounds.
2. If any target analyte has a percent difference (%D) greater than 15 percent, flag detects for the affected compounds as estimated "J" and nondetects as estimated "UJ" in all samples associated with the initial calibration.

Level D:

Verify from the raw data that there were no calculation or transcription errors by recalculating a percentage of the ICV calculations.

4.3.3 Continuing Calibration

The working calibration curve or CF must be verified by the injection of a continuing calibration standard. A continuing calibration must also be analyzed after every 10 samples and at the end of the analysis sequence to ensure that system performance has not degraded. The continuing calibration standard shall be the mid-level standard or the standard with a contaminant concentration level that is potentially the most representative of contaminant concentrations in the next 10 samples.

Level C and Level D:

Verify the %D from the continuing calibration summary forms. The %D between the CF from the continuing calibration and the average CF from the initial calibration must be less than 15 percent. Alternatively, if a linear (first-order) calibration curve is utilized in the initial calibration, the %D between the calculated amount and the true amount for each compound must be less than or equal to 15 percent. If the continuing calibration criteria are not met for both detectors, flag all associated results as estimated "J" for detects or estimated "UJ" for nondetects.

Level D:

Verify from the raw data that the reported %D between the initial average calibration factor and the continuing calibration factor on the continuing calibration verification summary was correctly calculated for one or more compounds.

4.4 BLANKS

Method blank analytical results are assessed to determine the existence and magnitude of contamination problems. If problems with any method blank exist, all associated data must be carefully evaluated to determine whether there is any bias on the data, or if the problem is an isolated occurrence not affecting other data. No contaminants should be present in the method blank(s). The method blank should be analyzed on each HPLC system used to analyze site samples.

1. The reviewer should identify samples associated with each method blank using Form IV (or equivalent). Verify that method blank analysis has been reported per matrix and concentration level for each set of samples. Each sample must have an associated method blank. Qualify positive results in samples with no method blank as unusable "R." Nondetects do not require qualification.
2. If the method blank was not analyzed on a HPLC used to analyze site samples, note the deficiency in the data validation report. Professional judgment shall be used for subsequent qualification of the data.
3. Compare the results of each method blank with the associated sample results. The reviewer should note that the blank analyses may not involve the same weights, volumes, percent moistures, or dilution factors as the associated samples. These factors must be taken into consideration when applying the criteria discussed below, such that a comparison of the total amount of contamination is actually made.
4. If a compound is found in the blank, but not in the associated sample, no action is taken.
5. Any compound, detected in both the sample and the associated blank shall be qualified when the sample concentration is less than the LOQ and the blank concentration is less than, greater than, or equal to the LOQ. Care should be taken to factor in the percent moisture when comparing detects in the sample and the method blank. The applicable review qualifier(s) are summarized in Table II-N-1.

Table II-N-1: Blank Qualifications

Sample Result	Sample Value	Reviewer Qualifier(s)
Less than LOQ and blank result is <, > or = LOQ	Leave as reported	U
≥LOQ, blank result is <LOQ	Leave as reported	None
≥LOQ, blank result is >LOQ and sample result <blank result	Leave as reported	Use professional judgment
≥LOQ, blank result is >LOQ and sample result ≥blank result	Leave as reported	Use professional judgment
≥LOQ and blank result is = LOQ	Leave as reported	Use professional judgment

6. In the case wherein both the sample concentration and the blank concentration are greater than or equal to the LOQ, previously approved criteria as identified in the project planning documents may be applied to qualify associated sample results. Otherwise, qualify sample results as non-detect "U" when the sample concentration is less than or equal to 5 times the blank concentration (5× rule).
7. Instances of contamination can be attributable to the dilution process. These occurrences are difficult to determine; however, the reviewers should qualify the sample data as nondetects, "U," when the reviewer determines the contamination to be from a source other than the sample.
8. In the event of gross contamination (i.e., saturated peaks) in the blanks, the associated samples must be evaluated for gross contamination. If gross contamination exists in the samples, the affected compounds should be qualified as unusable, "R."

Level D:

1. Verify from the preparation log that the information recorded on Form IV (or equivalent) is correct.
2. Review the results of all blank raw data and Form I (or equivalent) to ensure that there were no false negatives or false positives.
3. Verify all target compound detects found in the method blanks against the raw data. Follow the guidelines specified in Sections 4.9 and 4.10 of this procedure. After the validity of the target compounds are verified, validate the corresponding data using the criteria outlined above for Level C and Level D validation.

4.5 BLANK SPIKES AND LABORATORY CONTROL SAMPLES

Blank spike/laboratory control sample (LCS) recoveries must be within the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established for a given sample matrix. Use in-house limits if compounds are not listed in Appendix C or project limits are not specified.

Level C and Level D:

1. If the blank spike/LCS results are 0 percent, only the spiked compounds that showed low recovery in all associated samples shall be flagged as unusable "R" for nondetects and estimated "J" for detects.
2. If blank spike/LCS results are below the control limits (but above 0 percent), spiked compounds which showed low recovery in all associated samples shall be flagged as estimated "UJ" or "J."
3. If blank spike/LCS results are above the control limits, detects for only the spiked compounds which showed high recovery in all associated samples shall be flagged as estimated "J."
4. If the laboratory analyzes a blank spike duplicate/LCS duplicate (LCSD), evaluate and qualify the LCSD results using the criteria noted above.
5. If the relative percent differences (RPDs) between LCS and LCSD results are above the control limits (use the matrix spike [MS]/matrix spike duplicate [MSD] RPD control limits identified in DoD QSM Appendix B, if none are available use laboratory in-house limits), spiked compounds which showed high RPD in all associated samples shall be flagged as estimated "UJ" or "J."

Level D:

To check that the spike percent recovery was calculated and reported correctly using the following equation, recalculate one spike recovery per matrix (and any spike that would result in the qualification of a sample).

$$\%\text{Recovery} = \frac{Q_d}{Q_a} \times 100$$

Where:

Q_d = Quantity determined by analysis

Q_a = Quantity added to samples/blanks

If transcription errors are discovered on Form III (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.6 SURROGATE RECOVERY

Laboratory performance on individual samples is established by means of surrogate spiking activities. All samples are spiked with surrogate compounds prior to sample preparation. The evaluation of the results of these surrogate spikes is not necessarily straightforward. The sample itself may produce effects because of factors such as interferences and high concentrations of compounds. Since the effects of the sample matrix are frequently outside the control of the laboratory and may present relatively unique problems, the review and validation of data based on specific sample results is frequently subjective and demands analytical experience and professional judgment. The following procedures shall be followed:

Level C and Level D:

Sample and blank surrogate recoveries for PAHs must be within the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established. Use in-house limits if surrogates are not listed in Appendix C or project limits are not specified. Verify that no samples or blanks have surrogates outside the criteria from Form II (or equivalent).

1. If surrogate recovery is below the QC limits for any of the surrogates, but above or equal to 10 percent, flag associated positive results as estimated “J” and nondetects as “UJ.”
2. If any surrogate recovery is less than 10 percent, flag all nondetects as unusable “R” and detects as estimated “J.” No qualification is applied if surrogates are diluted beyond detection but note in the data validation report that surrogate evaluation could not be performed due to the high dilution factor.
3. If any surrogate recovery is above the upper QC limit, flag associated positive results as estimated “J.” No qualification of nondetects is necessary in the case of high recoveries.
4. Surrogates may be reported as “diluted out” (D); if dilution is such that the surrogate can no longer be detected. If this is the case, note in the data validation report that surrogate evaluation could not be performed due to a high dilution factor. A Full evaluation of the sample chromatogram may be necessary to determine that surrogates are truly “diluted out.”

Level D:

The reported surrogate recoveries on Form II should be verified from the raw data for a representative number of samples.

4.7 MATRIX SPIKE/MATRIX SPIKE DUPLICATE

MS/MSD data are used to determine the effect of the matrix on a method’s recovery efficiency and precision for a specific sample matrix.

No action is taken on MS/MSD data alone to qualify an entire data package. Using informed professional judgment; however, the data reviewer may use the MS/MSD results in conjunction with other QC criteria (i.e., surrogates and LCS) and determine the need for some qualification of the data.

The data reviewer should first try to determine the extent to which the results of the MS/MSD affect the associated data. This determination should be made with regard to the MS/MSD sample itself, as well as specific compounds for all samples associated with the MS/MSD.

In those instances where it can be determined that the results of the MS/MSD affect only the sample spiked, then qualification should be limited to this sample alone. It may be determined through the MS/MSD results, however, that a laboratory is having a systematic problem in the analysis of one or more compounds, which affects all associated samples.

Note: If a field blank was used for the MS/MSD, the information must be included in the data validation summary. Sample matrix effects have not been observed with field blanks therefore the recoveries and precision do not reflect the analytical impact of the site matrix.

Level C and Level D:

The laboratory must spike and analyze a MS/MSD from the specific project site as required for each matrix type and analytical batch.

1. MS/MSD data should be reported on a MS/MSD summary form similar to Form III (or equivalent).
2. Compare the percent recovery (%R) and relative percent difference (RPD) for each spiked compound with the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established. Use in-house limits if spiked compounds are not listed in Appendix C or project limits are not specified.
3. If MS/MSD results are 0 percent, only the spiked compounds that showed low recovery in the parent sample shall be flagged as unusable "R" for nondetects and estimated "J" for detects.
4. If MS/MSD results are below the control limits (but above 0 percent), spiked compounds which showed low recovery in the parent sample shall be flagged as estimated "UJ" or "J."
5. If MS/MSD results are above the control limits, detects for only the spiked compounds which showed high recovery in the parent sample shall be flagged as "J."
6. If the RPDs between MS and MSD results are greater than 30 percent, detects for only the spiked compounds which showed high RPD in the parent sample shall be flagged as estimated "J."
7. Failure of MS/MSD due to the presence of a target compound in the parent sample at greater than 2 times the spike concentration should not result in any qualifications. Note the incident in the data validation report.

Level D:

Check the raw data and recalculate one or more %Rs and RPDs, especially %Rs and RPDs that resulted in the qualification of data, using the following equations to verify that results on Form III (or equivalent) are correct.

$$\%R = \frac{(SSR - SR)}{SA} \times 100$$

$$RPD = \frac{ABS|SSR - SDR|}{(SSR + SDR)/2} \times 100$$

Where:

SA = spike added

SR = sample result

SSR = spiked sample result

SDR = spiked duplicate result

ABS = absolute value

If transcription errors are discovered on Form III (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.8 FIELD QC SAMPLES

Field QC samples discussed in this section of the procedures are equipment blanks, field blanks, field duplicates, and field triplicates.

4.8.1 Equipment Blanks and Field Blanks

Compounds detected in equipment blanks indicate the possibility of cross-contamination between samples due to improper equipment decontamination.

A field blank sample may be collected from each source of water used during each sampling event. The field blank may be analyzed to assess whether the chemical nature of the water used in decontamination may have affected the analytical results of site samples.

If PAH compounds are detected in the equipment blanks and/or field blanks, the procedure for the qualification of associated sample results is identical to the criteria outlined in Section 4.4 of this procedure.

Level C and Level D:

1. Determine which field QC samples apply to samples in the sample delivery group.

2. Ensure that units are correct when applying field QC blank qualifications. If samples are soil matrix, results must first be converted to micrograms per liter from micrograms per kilogram to make correct comparisons.
3. Because of the way in which the field blanks and equipment blanks are sampled, equipment blanks are not qualified because of field blank contamination. The affected samples are qualified, however, by either the field blank or equipment blank results, whichever has the higher contaminant concentration.
4. Equipment blanks and field blanks are only qualified with method blank results in order to account for laboratory contamination.

Level D:

Compound identification and quantification of field blank and equipment blank samples must be verified. Follow the guidelines specified in Sections 4.9 and 4.10 of this procedure.

4.8.2 Field Duplicates and Field Triplicates

Field duplicates consist of either collocated or subsampled samples. Field duplicates for ground water and surface water samples are generally considered to be collocates. Soil duplicate samples may be homogenized and subsampled in the field (or at the laboratory) to form an original and duplicate sample, or may be an additional volume of sample collected in a separate sample container to form a collocate sample. Field duplicate results are an indication of both field and laboratory precision; the results may be used to evaluate the consistency of sampling practices.

Field triplicates are collected from different, randomly selected locations to verify that an incremental sample truly represents a decision unit. Field triplicate results are more useful than field duplicates to statistically evaluate sampling precision.

Level C and Level D:

1. Check to ensure that field duplicates and/or field triplicates were collected and analyzed as specified in the project planning documents. If the sampling frequency is less than the frequency stated in the planning documents, no qualification of the associated sample results is necessary but the incident shall be discussed in the data validation report.
2. For field duplicate results, if the RPDs are greater than 50 percent for water or 100 percent for soil or as stated in the planning document if more conservative, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.
3. For field triplicate results, if the RSDs are greater than the QC limits stated in the planning document, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.

Level D:

Before comparison of duplicates and/or triplicates, the compound identification and quantification must be verified. Follow the guidelines specified in Sections 4.9 and 4.10 of this procedure.

4.9 TARGET COMPOUND IDENTIFICATION

Qualitative criteria for compound identification have been established to minimize the number of erroneous identifications of compounds. An erroneous identification can be either a false positive (reporting a compound present when it is not) or a false negative (not reporting a compound that is present).

The laboratory must report retention time window data for each compound on each detector used to analyze the samples. The retention time windows are used for qualitative identification. Retention times of reported compounds must fall within the calculated window for both detectors. Second detector confirmation must be performed. Sample chromatograms for both detectors must be provided.

Level C and Level D:

1. Review Form I and Form X (or equivalent). Check for errors.
2. Verify that the retention times of sample compounds reported on the Form X (or equivalent) fall within the calculated retention time windows for both detectors. If the qualitative criteria for both detectors were not met, all reported positive detects should be considered nondetect "U."
3. If confirmation is not performed on a second detector, qualify any reported detect as presumptive and estimated, "NJ."

Level D:

1. Verify from the raw data that the retention time of the detected compound and the retention time windows are correct.
2. Evaluate all sample chromatograms to ensure that there were no peaks present which were not reported (false negatives) or the reported detects did not meet identification criteria (false positives). Presence of a large interfering peak may result in false positives or false negatives. The reviewer should use professional judgment in evaluating the effect of interference.

4.10 COMPOUND QUANTITATION AND THE REPORTING LIMITS

The objective is to ensure that the reported quantitation results and reporting limits (i.e., LOQ, LOD, detection limit [DL]) are accurate. All soil sample results are reported on a dry weight basis.

Level C:

Specific compound quantitation is not verified for Level C validation.

Level C and Level D:

1. Verify that the reporting limits for nondetects are equal to the LODs. Verify that an annual DL study was performed or quarterly LOD/LOQ verification checks were performed in accordance with the DoD QSM. The LOD/LOQ verification check must be evaluated to determine whether the laboratory can reliably detect and identify all target analytes at a spike concentration of approximately two times but not more than four times the current reported DL. Qualify nondetects as unusable "R."

2. Check that reported nondetects and positive values have been adjusted to reflect sample dilutions (including clean-up) and for soil samples, sample moisture. When a sample is analyzed at more than one dilution, the lowest LODs are used unless a QC criterion has been exceeded. In this case, the higher LODs from the diluted analysis are used. The least technically sound data will be flagged "R" with a qualification code "D."
3. PAH results can be checked for agreement between quantitative results obtained on the two detectors. Check Form X (or equivalent) for RPDs between the two detector quantitation results. RPD should be less than or equal to 40 percent. If RPD exceeded 40 percent, the affected compound shall be qualified as estimated "J." The higher result should be reported unless overlapping peaks are causing erroneously high results, then the lower result may be reported.
4. If a sample requiring a dilution analysis due to a target compound detect exceeding the calibration linear range was not re-analyzed at a dilution, the compound exceeding calibration range shall be qualified as estimated "J."
5. If the laboratory re-analyzed a sample and submitted both sample results, the reviewer must determine which of the two analyses has better data quality. Only one analysis should be reported and the other is rejected.

Level D:

1. Compound quantification should be verified by recalculation from the raw data for a representative number of samples.
2. Verify from the standard chromatograms that the instrument sensitivity is adequate to support the LODs. Poor sensitivity may result in elevated LODs.
3. Verify from the raw data that the reported RPDs between the two detector quantitation results are calculated correctly and there are no transcription errors. The reviewer should be aware that the retention time of the target compound may have shifted due to the interference.

5. Records

A Form I that has been validated and verified, and has been determined by the data validator to accurately represent the appropriate sample results to be utilized, shall be stamped "NAVFAC PACIFIC VALIDATED." Additionally, sample result forms for which the data have been validated at Level D validation level shall be stamped or noted "Level D."

Copies of all documents generated by the data validation personnel will be stored for no less than 10 years. The original validated laboratory data shall be archived to the Federal Records Center at project completion.

6. References

Department of Defense, United States (DoD). 2005a. *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: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

———. 2005b. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B: Quality Assurance/quality Control Compendium: Minimum QA/QC Activities*. Final Version 1. DoD: DTIC ADA 426957, EPA-505-B-04-900B. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www2.epa.gov/sites/production/files/documents/qaqc_v1_0305.pdf.

———. 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2A: Optimized UFP-QAPP Worksheets*. Revision 1. March.

———. 2013. *Department of Defense Quality Systems Manual for Environmental Laboratories.* Version 5.0. Draft Final. Prepared by DoD Environmental Data Quality Workgroup and Department of Energy Consolidated Audit Program Operations Team. July.

Environmental Protection Agency, United States (EPA). 2007. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* 3rd ed., Revision 6. Office of Solid Waste. November. On-line updates at: http://www.epa.gov/epawaste/hazard/testmethods/sw846/online/index.htm.

Procedure II-A, *Data Validation*.

7. Attachments

None.

Level C and Level D Data Validation for Metals by SW-846 6000/7000

1. Purpose

This data validation procedure sets forth the standard operating procedure for performance of Level C and Level D data validation of metals data obtained under the United States (U.S.) Navy Environmental Restoration (ER) Program for Naval Facilities Engineering Command, Pacific (NAVFAC Pacific) and is consistent with protocol in the *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories* (DoD QSM) (DoD 2013). Cursory validation is addressed separately in Procedure II-A, *Data Validation*.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Responsibilities

The CTO Manager, the QA Manager or Technical Director, and the CTO QA Coordinator are responsible for ensuring that this procedure is implemented by data validation personnel.

Data validation personnel are responsible for implementing this procedure for validation of all metals data.

4. Procedure

This procedure addresses the validation of metals data obtained using U.S. Environmental Protection Agency (EPA) Method Solid Waste (SW)-846 6000/7000 (EPA 2007). The quality control (QC) criteria identified in this procedure are those specified in the analytical method and the DoD QSM (DoD 2013). Where project specific criteria are identified in the CTO work plan, they will supersede the QC criteria identified in this procedure.

- Form I: Sample Results Summary Form
- Form II: Initial and Continuing Calibration Verification Form
- Form III: Blanks Form
- Form IV: ICP Interference Check Sample Form

- Form VA: Spike Sample Recovery Form
- Form VB: Post Digest Spike Sample Recovery Form
- Form VI: Duplicates Form
- Form VII: Laboratory Control Sample Form
- Form VIII: Standard Addition Results Form
- Form IX: ICP Serial Dilutions Form
- Form X: Instrument Detection Limits Form
- Form XI: ICP Inter-element Correction Factors Form
- Form XII: ICP Linear Ranges Form
- Form XIII: Preparation Log Form
- Form XIV: Analysis Run Log Form
- Form XV: ICP-MS Internal Standards

Level C data validation consists of review of summary forms only while Level D data validation requires review of both summary forms and all associated raw data. Data review guidelines and how they apply to the different validation levels are indicated in the following text.

4.1 SAMPLE MANAGEMENT

QA/QC criteria included under sample management are sample preservation, handling, and transport; chain of custody (COC); and holding times.

4.1.1 Sample Preservation, Handling, and Transport

Level C and Level D:

Evaluate sample collection, handling, transport, and laboratory receipt from COC and laboratory receipt checklists to ensure that the samples have been properly preserved and handled.

1. Metals and Mercury - Samples must be preserved with nitric acid to a pH less than 2. If analyses for dissolved metals are requested, samples should be filtered before adding preservatives. If total metals are requested, unfiltered samples should be used. Document these occurrences in the data validation report.
2. Soil samples must be refrigerated at above freezing to 6 degrees Celsius (˚C).
3. Organic Lead samples should be collected without headspace and stored at above freezing to 6°C.
4. Based upon professional judgment, analysis of an inappropriately preserved sample by the laboratory may result in qualification of the sample results as estimated “J” or “UJ.” In extreme cases of a destructive preservative, the sample data may be qualified as unusable, “R.”
5. If the temperature of the cooler upon receipt at the laboratory was not recorded, document that the laboratory is noncompliant.

6. If the receiving laboratory transferred the samples to another laboratory for analysis, apply the same temperature criteria to both the transfer COC and the original COC.

4.1.2 Chain of Custody

Level C and Level D:

Examine the COC for legibility and check that all metal analyses requested on the COC have been performed by the laboratory. Ensure that the COC Sample Number on the laboratory Form I matches the Sample Identification on the COC. Read the laboratory case narrative for additional information.

1. Verify collect dates, sampling times, and time zones. This is critical to evaluating parameters with short holding times.
2. Any samples received for analysis that were not analyzed shall be noted in the data validation report, along with the reason(s) for failure to analyze the samples, if the reason(s) can be determined. Conversely, samples that were analyzed for metals but were not requested should also be noted.
3. Any discrepancies in sample naming between the COC and sample results form shall be noted in the data validation report with the correct sample name being identified if the correct sample name can be determined.
4. If the receiving laboratory transferred the samples to another laboratory for analysis, both the original COCs and transfer COCs shall be present. Document in the data validation report if the transfer COCs are not present.
5. Internal chain of custody is required for all samples, extracts, and digestates from receipt to disposal. Verify the internal COC forms for completeness. Document in the data validation report if the internal COC forms are not present.
7. Each individual cooler shall have an individual COC that lists only samples contained within that cooler. Document in the data validation report if multiple coolers appear on one COC.

4.1.3 Holding Times

Level C and Level D:

Holding times are determined from the time of sample collection to the time of sample analysis. Holding times are as follows:

- Metals – 6 months for soil and water
- Mercury – 28 days for both soil and water
- Organic Lead – 14 days to extraction and 40 days from extraction to analysis for soil samples; 7 days to extraction and 40 days from extraction to analysis for water samples

If holding times are exceeded, flag all results greater than the detection limit (DL) as estimated “J” and all results less than the DL as estimated “UJ.” If holding times are grossly exceeded, the reviewer may determine that the data reported as nondetects are unusable “R.” Data will not be qualified unusable “R” unless the holding time was grossly exceeded by more than a factor of 2.

4.2 CALIBRATION

Compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable quantitative data. Initial calibration demonstrates that the instrument is capable of acceptable performance at the beginning of the analysis run and of producing a linear calibration curve. Continuing calibration documents that the initial calibration is still valid and that maintenance and adjustment of the instrument on a day-to-day basis is satisfactory.

4.2.1 Initial Calibration

Level C and Level D:

Instruments must be calibrated daily prior to sample analysis and each time the instrument is set up.

1. Inductively Coupled Plasma (ICP) Analysis: A blank and at least one high standard must be used in establishing the analytical curve. If more than one standard is used, r^2 must be 0.99 or greater.
2. Graphite Furnace Atomic Absorption (GFAA) Analysis: A blank and at least three standards must be used in establishing the analytical curve. Linearity is determined using linear regression analysis. The correlation coefficient, r must be 0.995 or greater.
3. Cold Vapor Atomic Absorption (CVAA), Mercury Analysis: A blank and at least five standards must be used in establishing the analytical curve. Linearity is determined using linear regression analysis. The correlation coefficient must be 0.995 or greater.

If the correlation coefficient is below 0.995, qualify all associated detects as estimated “J” and all nondetects as “UJ.” If the correlation coefficient is significantly lower than 0.995, professional judgment may be used to reject, “R,” the analytes associated with the initial calibration.

Level D:

Recalculate the correlation coefficient for all initial calibrations. Verify from the raw data that appropriate concentration and number of standards were utilized to establish analytical curves and the associated correlation coefficients.

4.2.2 Initial and Continuing Calibration Verification (ICV and CCV)

Level C and Level D:

1. Review Form II (Part I) for ICV and CCV percent recovery (%R) values.
2. Analysis results for Method 6000 ICV and CCV must fall within the control limits of 90-110 percent recovery of the true value for all analytes.
3. Analysis results for Method 7000 ICV and CCV must fall within the control limits of 90-110 percent recovery.
4. If after a failing CCV, two additional consecutive CCVs are analyzed immediately, and both additional CCVs are within the control limits, the data is acceptable. If either of the additional CCVs is not within control limits, then the associated data will need qualification. See below for the recommended qualification guidelines.

5. Because of rounding discrepancies, let the results fall within 1 percent of the acceptance windows (e.g., 89–111 percent).
6. If the ICV or CCV %R falls outside the acceptance windows, use professional judgment to qualify all associated data. The following guidelines are recommended:
   a. If the ICV or CCV %R falls outside the acceptance windows but within the ranges of 75-89 percent or 111–125 percent, qualify results greater than the DL as estimated “J.”
   b. If the ICV or CCV %R is within the range of 111–125 percent, results less than the DL are acceptable.
   c. If the ICV or CCV %R is 75–89 percent, qualify results less than the DL as nondetected and estimated “UJ.”
   d. If the ICV or CCV %R is less than 75 percent, qualify results greater than the DL as estimated “J” and results less than the MDL as unusable “R.”
   e. If the ICV or CCV percent recovery is greater than 125 percent, qualify results greater than the DL as unusable “R”; results less than the DL are acceptable.
   f. Because no raw data is evaluated at Level C, it is unnecessary to evaluate the correlation coefficient for the initial calibrations for the graphite furnace analyses.

Note: Level C data validation does not encompass reviews of the raw data; therefore, the concentration and number of standards utilized to establish analytical curves and the associated correlation coefficients are not verified. The reviewer should note in the data validation summary that this information was not reviewed.

Level D:

1. Recalculate and verify one or more of the ICV and CCV %Rs per type of analysis using the following equation for %R. Once again, due to possible rounding discrepancies, allow the results to fall within 1 percent of the acceptance windows (e.g., 89–111 percent)

$$\%\text{Recovery} = \frac{Q_d}{Q_a} \times 100$$

Where:

Q_d = Concentration (in micrograms per liter [µg/L]) of each analyte measured in the analysis of the ICV or CCV solution.

Q_a = Concentration (in µg/L) of each analyte in the ICV or CCV source.

2. If discrepancies are discovered on any Form II, request a resubmittal from the laboratory and validate according to the criteria outlined above.

4.3 BLANKS

Method (preparation) and calibration blank analyses results are assessed to determine the existence and magnitude of laboratory contamination problems. If problems with any blank exist, all data associated with the blank must be carefully evaluated to determine whether there is a bias on the data, or if the problem is an isolated occurrence not affecting data.

4.3.1 Calibration Blanks

Level C and Level D:

1. If the blank is less than the LOQ and the samples results are greater than the DL but less than the LOQ, then qualify "U" at the result.
2. If the blank is less than the LOQ and the sample results are greater than the LOQ or nondetect, the data is acceptable.
3. If the blank is greater than the LOQ, then samples less than 5× the blank will be qualified as "U" at the concentration. Samples greater than 5× the blank are acceptable.
4. For negative blanks where the absolute value of the blank is greater than the LOQ, sample results that are less than 10x the absolute value of the negative blank qualify "J" for detect and 'UJ" for nondetect results. Results that are greater than 10× the absolute value of the negative blank are acceptable.

Ensure that units are correct when applying calibration blank qualifications. If samples are soil matrix, results must first be converted to µg/L from milligrams per kilogram to make correct comparisons.

Level D:

Verify one or more of the calibration blank results per type of analysis by comparing the Form III to the raw data. After the validity of the target analytes are verified, validate the corresponding data using the criteria outlined above for Level C and Level D validation.

4.3.2 Method (Preparation) Blanks

Level C and Level D:

At least one method blank must be prepared with each batch of samples. If a method blank was not prepared and analyzed as required, the reviewer may qualify associated sample results less than the DL as nondetected and estimated "UJ," and sample results greater than the DL as estimated "J." Professional judgment should be utilized, however, taking into account the results of other associated blanks (e.g., initial calibration blank, continuing calibration blank).

If metals are detected in the method blanks, the procedure for the qualification of associated sample results is identical to the rules outlined in Section 4.3.1 of this procedure.

Level D:

Verify out-of-control method blanks that result in the qualification of numerous analytes against the raw data. Verify the results reported on Form III. After the validity of the target analytes are verified, validate the corresponding data using the criteria outlined above for Level C and Level D validation.

4.4 ICP INTERFERENCE CHECK SAMPLE (ICP ICS)

The ICP ICS verifies the inter-element and background correction factors. An ICS must be run at the beginning of each sample analysis run.

Level C and Level D:

Review Form IV for the ICP ICS solution A and solution AB sample results and percent recovery values. Results for the ICP ICS solution AB analysis must fall within the control limits of ±20 percent of the true value. Aluminum (Al), calcium (Ca), iron (Fe), and magnesium (Mg) must be reported on the Form IV for solution A and solution AB to properly evaluate the ICP ICS. For samples with concentrations of Al, Ca, Fe, and Mg which are comparable to or greater than their respective levels in the ICS:

1. If the ICS AB recovery for an analyte is greater than 120 percent and the sample results are less than the DL, this data is acceptable for use.
2. If the ICS AB recovery for an analyte is greater than 120 percent and the sample results are greater than the DL, qualify the affected data as estimated "J."
3. If the ICS AB recovery for an analyte is between 50 percent and 79 percent and the sample results are greater than the DL, qualify the affected data as estimated "J."
4. If sample results are less than the DL and the ICS AB recovery for that analyte is within the range of 50–79 percent, the possibility of false negatives may exist. Qualify the data for these samples as nondetected and estimated "UJ."
5. If ICS AB recovery results for an analyte are less than 50 percent, qualify the affected data as unusable "R."
6. If the absolute value of the ICS A is greater than the limit of detection (LOD) and the sample result is greater than the DL but less than 10× the ICS A finding, qualify as estimated "J."
7. If the absolute value of the ICS A is greater than the LOD and the sample result is greater than 10× the ICS A finding, this data is acceptable.
8. If the positive value of the ICS A is greater than the LOD and the sample results are less than the DL, this data is acceptable for use.
9. If the absolute value of the negative ICS A is greater than the LOD and the sample results are less than the DL, this data is estimated "UJ."

Level D:

Recalculate and verify one or more ICS percent recoveries for the initial and final ICS analyses using the following equation. Verify the results reported on Form IV (or equivalent). If discrepancies are discovered, request a resubmittal from the laboratory and validate the associated data accordingly using the criteria outlined above.

$$\%\text{Recovery} = \frac{Q_d}{Q_a} \times 100$$

Where:

Q_d = Concentration (in µg/L) of each analyte measured in the analysis of the ICS solution.

Q_a = Concentration (in µg/L) of each analyte in the ICS source.

4.5 BLANK SPIKES AND LABORATORY CONTROL SAMPLES

Blank spike/laboratory control sample (LCS) recoveries must be within the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established for a given sample matrix. Use in-house limits if compounds are not listed in Appendix C or project limits are not specified.

Level C and Level D:

1. If the blank spike/LCS results are less than 50 percent, only the spiked analytes that showed low recovery in all associated samples shall be flagged as “R” for nondetects and “J” for detects.
2. If blank spike/LCS results are below the control limits (but above 50 percent), spiked analytes that showed low recovery in all associated samples shall be flagged as estimated “UJ” or “J.”
3. If blank spike/LCS results are above the control limits, detects for only the spiked analytes that showed high recovery in all associated samples shall be flagged as “J.”
4. If the laboratory analyzes a blank spike duplicate/LCS duplicate (LCSD), evaluate and qualify the LCSD results using the criteria noted above.
5. If the relative percent differences (RPDs) between LCS and LCSD results are above the control limits (use the matrix spike [MS]/matrix spike duplicate (MSD) RPD control limits identified in DoD QSM Appendix B, if none are available use laboratory in-house limits), spiked analytes which showed high RPD in all associated samples shall be flagged as estimated “UJ” or “J.”

Level D:

To check that the spike percent recovery was calculated and reported correctly using the following equation, recalculate one spike recovery per matrix (and any spike that would result in the qualification of a sample).

$$\%\text{Recovery} = \frac{Q_d}{Q_a} \times 100$$

Where:

Q_d = Quantity determined by analysis

Q_a = Quantity added to samples/blanks

If transcription errors are discovered on Form VII (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.6 MATRIX SPIKE/MATRIX SPIKE DUPLICATE AND MATRIX DUPLICATE

MS/MSD and matrix duplicate (MD) data are used to determine the effect of the matrix on a method’s recovery efficiency and precision for a specific sample matrix. MD analyses are also performed to demonstrate acceptable method precision by the laboratory at the time of analysis.

MS/MSD results should be within the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established for a given sample matrix. Use in-house limits if spiked analytes are not listed in Appendix C or project limits are not specified.

For the MD RPD, for sample results greater than 5× the LOQ, use RPD to evaluate. For sample results less than 5× the LOQ, use the difference between the MD and the sample unless project limits are specified. For difference use 1× the LOQ as the control limit for water samples and 2× the LOQ as the control limit for soil samples unless project limits are specified.

If the MS/MSD percent recovery results do not meet the control limits, further action shall be evaluated to determine the source of difference. For sample analytes greater than 50× the LOQ, a five-fold dilution test can be performed. For samples analytes less than 50× the LOQ, a post digestion spike (PDS) can be performed.

Level C and Level D:

The laboratory must spike and analyze a MS/MSD or MD from the specific project site as required for each matrix type and analytical batch.

1. MS/MSD data should be reported on a MS/MSD summary form similar to Form VA. MD data should be reported on a MD summary form similar to Form VI. PDS data should be reported on a summary form similar to Form VB. The serial dilution results should be reported on a summary form similar to Form IX.
2. If the MS/MSD results are outside of the control limits and the sample results are greater than 50× LOQ and a five-fold serial dilution test was performed and the dilution results were within 10 percent difference of the original measurement, then the data is acceptable.
3. If the MS/MSD results are outside of the control limits and the sample results are less than 50x LOQ and a PDS was performed and within 80–120 percent recovery, then the data is acceptable.
4. If the MS/MSD results are not within the control limits and the secondary actions (serial dilution test and/or PDS) are outside of the control limits or not performed, the source sample requires qualification. The following guidelines are recommended:
6. If MS/MSD results are below the control limits, spiked analytes that showed low recovery shall be flagged as estimated “UJ” or “J.”
    a. If MS/MSD results are above the control limits, detects for only the spiked analytes that showed high recovery shall be flagged as “J.”
    b. If the RPD or difference between MS and MSD or between the MD and sample are greater than 20 percent, qualify the sample as estimated “UJ” or “J.” RPD results are not affected by the serial dilution test or the PDS.
    c. Failure of MS/MSD due to the presence of a target analyte in the parent sample at greater than four times the spike concentration should not result in any qualifications. Note the incident in the data validation report.

Level D:

For the MS/MSD, check the raw data and recalculate one or more %Rs and RPDs, especially %Rs and RPDs that resulted in the qualification of data, using the following equations to verify that results on Forms VA and VB (or equivalent) are correct.

$$\%R = \frac{(SSR - SR)}{SA} \times 100$$

$$RPD = \frac{ABS|SSR - SDR|}{(SSR + SDR)/2} \times 100$$

Where:

SA = spike added
SR = sample result
SSR = spiked sample result
SDR = spiked duplicate result
ABS = absolute value

For the ICP serial dilution, recalculate one or more percent difference (%Ds) from the information supplied in the raw data and compare the results to those reported on Form IX using the following equation. If discrepancies are discovered, correct Form IX and validate the associated data accordingly using the criteria outlined above.

$$\%D = \frac{(I - S)}{I} \times 100$$

Where:

I = initial sample result
S = serial dilution result (instrument reading × 5)

If transcription errors are discovered on Forms VA or VB (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.7 FURNACE ATOMIC ABSORPTION QC

Duplicate injections and furnace analytical spikes establish the precision and accuracy of the individual analytical determinations. For analyses, graphite furnace analysis is usually performed on arsenic, lead, selenium, and thallium.

Level C and Level D:

1. Prepare and analyze the sample and one spike at 2× the limit of quantitation (LOQ). If after analysis within the calibration range the spike recovery is less than 80 percent or greater than 120 percent and the sample absorbance or concentration is greater than 50 percent of the spike amount; the sample quantitation must be performed by the Method of Standard Addition (MSA). Review Form XIV. The graphite furnace atomic absorption analytical spikes should be reported for each analyte in the column labeled %R.
2. Spike recovery must be greater than or equal to 80 percent and less than or equal to 120 percent.
    a. If the analytical spike recovery is less than 80 percent, qualify results as estimated “J” or “UJ” in all associated samples.
    b. If the analytical spike recovery is less than 10 percent, qualify nondetected results as unusable “R” and detected results as estimated “J” in all associated samples.
    c. If the analytical spike recovery is greater than 120 percent, all detected data for the specific analyte will be qualified as estimated “J,” in all associated samples.
3. If MSA is required, review Form VIII.
    a. If the MSA is required and has not been done, qualify the data as estimated “J.”
    b. If any of the samples have not been spiked at the appropriate levels, qualify the data as estimated “J.”
    c. If the MSA correlation coefficient is less than 0.995, qualify the data as estimated “J.”

Note: Level C validation does not encompass the review of raw data; therefore, for sample concentrations greater than the RL, relative standard deviation (RSD), (or coefficient of variation for duplicate injections) is not evaluated. The reviewer should note in the data validation summary that this information was not reviewed.

Level D:

1. Verify by recalculating at least one analytical spike recovery per graphite furnace analyte reported on Form XIV. Also recalculate any analytical spike recovery that resulted in qualification of an analyte during Level C validation. If any transcription errors are discovered, request a resubmittal from the laboratory and validate the associated data accordingly using the criteria outlined above.
2. Verify by recalculating all graphite furnace results reported from a MSA determination, especially if the MSA was unsuccessful and resulted in qualification of the data. If any transcription errors are discovered, request a resubmittal from the laboratory and validate the associated data accordingly using the criteria outlined above.

4.8 INDUCTIVELY COUPLED PLASMA-MASS SPECTROMETRY INTERNAL STANDARDS

The analysis of inductively coupled plasma-mass spectrometry internal standards determines the existence and magnitude of instrument drift and physical interferences. The criteria for evaluation of internal standard results apply to all analytical samples and method blanks analyzed during the run.

Level C and Level D:

1. Review Form XV (or equivalent) for the internal standard %R values.
2. If no internal standards were analyzed with the run, the sample data should be qualified as unusable (R).
3. If the %R is not within the 30-120 percent limit, qualify positive results as estimated “J” and nondetects as estimated “UJ.”

Level D:

Verify the internal standard %R reported on Form XV (or equivalent) from the raw data for at least one sample per sample delivery group (SDG), and verify internal standard results for samples that were qualified due to out-of-control internal standard results. If errors are discovered between the raw data and the Form XV (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.9 SAMPLE RESULT VERIFICATION

Level C:

Level C validation does not require the evaluation of raw data; sample result verification is not required. All soil sample results are reported on a dry weight basis.

Level D:

Verify by recalculating at least one ICP, GFAA, and CVAA result against the raw data for each Form I (or equivalent). Verify that the target analyte was reported from the correct run and the correct dilution factor was used. Review the laboratory preparation logs and instrument run logs to insure the accurate reporting of the data. If transcription errors are discovered, request a resubmittal from the laboratory and validate the data according the criteria outlined above.

4.10 FIELD QC SAMPLES

Field QC samples discussed in this section of the procedure are equipment blanks, field blanks, field duplicates, and field triplicates. Analytical results for field QC samples are utilized to qualify associated sample results.

4.10.1 Equipment Blanks and Field Blanks

Analytes detected in equipment blanks indicate the possibility of cross-contamination between samples due to improper equipment decontamination.

A field blank sample may be collected from each source of water used during each sampling event. The field blank may be analyzed to assess whether the chemical nature of the water used in decontamination may have affected the analytical results of site samples.

If metals are detected in the equipment blanks and/or field blanks, the procedure for the qualification of associated sample results is identical to the criteria outlined in Section 4.3.1 of this procedure.

Level C and Level D:

1. Determine which field QC samples apply to samples in the SDG.

2. Ensure that units are correct when applying field QC blank qualifications. If samples are soil matrix, results must first be converted to µg/L from micrograms per kilogram to make correct comparisons.
3. Because of the way in which the field blanks and equipment blanks are sampled, equipment blanks are not qualified because of field blank contamination. The affected samples are qualified, however, by either the field blank or equipment blank results, whichever has the higher contaminant concentration.
4. Equipment blanks and field blanks are only qualified with method blank results in order to account for laboratory contamination.

Level D:

1. Verify all target analytes found in the equipment blanks and field blanks against the raw data.
2. After the validity of the target analytes are verified, validate the corresponding data using the criteria outlined above for Level C and Level D validation.

4.10.2 Field Duplicates and Field Triplicates

Field duplicates consist of either collocated or subsampled samples. Field duplicates for ground water and surface water samples are generally considered to be collocates. Soil duplicate samples may be homogenized and subsampled in the field (or at the laboratory) to form an original and duplicate sample, or may be an additional volume of sample collected in a separate sample container to form a collocate sample. Field duplicate results are an indication of both field and laboratory precision; the results may be used to evaluate the consistency of sampling practices.

Field triplicates are collected from different, randomly selected locations to verify that an incremental sample truly represents a decision unit. Field triplicate results are more useful than field duplicates to statistically evaluate sampling precision.

Level C and Level D:

1. Check to ensure that field duplicates and/or field triplicates were collected and analyzed as specified in the project planning documents. If the sampling frequency is less than the frequency stated in the planning documents, no qualification of the associated sample results is necessary but the incident shall be discussed in the data validation report.
2. For field duplicate results, if the RPDs are greater than 50 percent for water or 100 percent for soil or as stated in the planning document if more conservative, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.
3. For field triplicate results, if the RSDs are greater than the QC limits stated in the planning document, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.

Level D:

Verify by recalculating at least two detects common between the sample and its field duplicate and/or field triplicate. If discrepancies are discovered, request a resubmittal from the laboratory.

5. Records

A Form I that has been validated and verified, and has been determined by the data validator to accurately represent the appropriate sample results to be utilized, shall be stamped "NAVFAC PACIFIC VALIDATED." Additionally, sample result forms for which the data has been validated at the Level D validation level shall be stamped or noted "Level D."

Copies of all documents generated by the data validation personnel will be stored for no less than 10 years. The original validated laboratory data shall be archived to the Federal Records Center at project completion.

6. References

Department of Defense, United States (DoD). 2005a. *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: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

———. 2005b. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B: Quality Assurance/quality Control Compendium: Minimum QA/QC Activities*. Final Version 1. DoD: DTIC ADA 426957, EPA-505-B-04-900B. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www2.epa.gov/sites/production/files/documents/qaqc_v1_0305.pdf.

———. 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2A: Optimized UFP-QAPP Worksheets*. Revision 1. March.

———. 2013. *Department of Defense Quality Systems Manual for Environmental Laboratories.* Version 5.0. Draft Final. Prepared by DoD Environmental Data Quality Workgroup and Department of Energy Consolidated Audit Program Operations Team. July.

Environmental Protection Agency, United States (EPA). 2007. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* 3rd ed., Revision 6. Office of Solid Waste. November. On-line updates at: http://www.epa.gov/epawaste/hazard/testmethods/sw846/online/index.htm.

Procedure II-A, *Data Validation*.

7. Attachments

None.

Level C and Level D Data Validation for Wet Chemistry Analyses

1. Purpose

This data validation procedure sets forth the standard operating procedure for performance of Level C and Level D data validation of wet chemistry parameters data obtained under the United States (U.S.) Navy Environmental Restoration (ER) Program for Naval Facilities Engineering Command (NAVFAC), Pacific and is consistent with protocol in the *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories* (DoD QSM) (DoD 2013). Cursory validation is addressed separately in Procedure II-A, *Data Validation*.

It covers the following parameters:

- Alkalinity (Standard Methods for the Examination of Water and Wastewater Method 2320B and U.S. Environmental Protection Agency [EPA] Method 310.1 [EPA 2007])
- Bromide, Chloride, Fluoride, Nitrate, Nitrite, Orthophosphate, and Sulfate (EPA Method Solid Waste [SW]-846 9056 and EPA Method 300.0)
- Chemical oxygen demand (EPA Method 410)
- Chloride (EPA Method 325.3)
- Chromium VI (EPA Method SW-846 7195/7196A/7197/7198/7199 and EPA method 218.6 and 218.7)
- Cyanide (EPA Method SW-846 9010B/9012A and EPA Method 335)
- Fluoride (EPA Method 340.2)
- Surfactants (M.B.A.S.) (EPA Method 425.1)
- Nitrate/Nitrite (EPA Method 353.2 and 353.3)
- Perchlorate (EPA Method 314.0)
- Phosphate (EPA Method 365.3)
- Sulfate (EPA Methods 375.3 and 375.4)
- Sulfide (EPA Method 376.1)
- Total dissolved solids (EPA Method 160.1)
- Total suspended solids (EPA Method 160.2)
- Total organic carbon (EPA Method SW-846 9060, Lloyd Kahn, and Walkley-Black)
- Total organic halides (EPA Method SW-846 Method 9020)
- Total recoverable petroleum hydrocarbons (EPA Method 418.1)
- pH (EPA Method SW-846 Method 9040 and EPA Method 150.1)
- Total hardness (Standard Methods for the Examination of Water and Wastewater Method 314A and EPA Method 130.1)

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Responsibilities

The CTO Manager, the QA Manager or Technical Director, and the CTO QA Coordinator are responsible for ensuring that this procedure is implemented by data validation personnel.

Data validation personnel are responsible for implementing this procedure for validation of all wet chemistry data.

4. Procedures

This procedure addresses the validation of wet chemistry parameters data obtained using EPA Method SW-846 7195/7196A/7197/7198/7199/9000, *Standard Methods for the Examination of Water and Wastewater*, 21st Edition, 2005, (APHA 2005) and EPA *Methods for Chemical Analysis of Water and Wastes*, revised March 1983 (EPA 1983). The quality control (QC) criteria identified in this procedure are those specified in the analytical method and the DoD QSM (DoD 2013). Where project specific criteria are identified in the CTO work plan, they will supersede the QC criteria identified in this procedure.

- Form I: Sample Results Summary Form
- Form II: Initial and Continuing Calibration Verification Form
- Form III: Blanks Form
- Form V: Spike Sample Recovery Form
- Form VI: Duplicates Form
- Form VII: Laboratory Control Sample Form
- Form XIII: Preparation Log Form
- Form XIV: Analysis Run Log Form

Level C data validation consists of review of summary forms only while Level D data validation requires review of both summary forms and all associated raw data. Data review guidelines and how they apply to the different validation levels are indicated in the following text.

4.1 SAMPLE MANAGEMENT

QA/QC criteria included under sample management are sample preservation, handling, and transport; chain of custody (COC); and holding times.

4.1.1 Sample Preservation, Handling, and Transport

Level C and Level D:

Evaluate sample collection, handling, transport, and laboratory receipt from COC and laboratory receipt checklists to ensure that the samples have been properly handled. All samples must be stored at less than 6 degrees Celsius (°C). Water samples for the following analyses should be preserved as listed below or as specified in the analytical method:

- Chemical Oxygen Demand (COD) – Sulfuric acid to pH < 2
- Cyanide – NaOH to pH > 12
- Nitrate/Nitrite – Sulfuric acid to pH < 2
- Sulfide – Zinc acetate and NaOH to pH > 9
- Total Recoverable Petroleum Hydrocarbons – Sulfuric or hydrochloric acid to pH < 2
- Total Phosphorus – Sulfuric acid to pH < 2
- Total Organic Carbon (TOC) - Sulfuric or hydrochloric acid to pH < 2
- Total Organic Halides (TOX) – Sulfuric acid to pH < 2
- Total Hardness – Nitric acid to pH < 2

1. Any sample improperly preserved or arriving at the laboratory in a broken container shall be noted in the data validation report. If there is no indication of chemical preservation, assume samples are unpreserved. Professional judgment may result in the results of an analysis of an inappropriately preserved sample by the laboratory being qualified as estimated “J” or “UJ.” In extreme cases (a preservation destructive to the analyte of interest) the sample data may be qualified as unusable, “R.”
2. If any sample arriving at the laboratory for analysis is not refrigerated or the temperature of any cooler containing samples exceeds 4 ±2°C, this shall be noted in the data validation report; however, no qualification of data will be required.
3. If the temperature of the cooler was not recorded upon its receipt at the laboratory, document that the laboratory is noncompliant.

4.1.2 Chain of Custody

Level C and Level D:

Examine the COC for legibility and check that all wet chemistry analyses requested on the COC have been performed by the laboratory. Ensure that the COC Sample Number on the laboratory Form I matches the Sample Identification on the COC. Read the laboratory case narrative for additional information.

1. Verify collect dates, sampling times, and time zones. This is critical to evaluating parameters with short holding times.
2. Any samples received for analysis that were not analyzed shall be noted in the data validation report, along with the reason(s) for failure to analyze the samples, if the reason(s) can be determined. Conversely, samples that were analyzed for wet chemistry parameters but were not requested should also be noted.
3. Any discrepancies in sample naming between the COC and sample results form shall be noted in the data validation report with the correct sample name being identified if the correct sample name can be determined.
4. If the receiving laboratory transferred the samples to another laboratory for analysis, both the original COCs and transfer COCs shall be present. Document in the data validation report if the transfer COCs are not present.
5. Internal chain of custody is required for all samples, extracts, and digestates from receipt to disposal. Verify the internal COC forms for completeness. Document in the data validation report if the internal COC forms are not present.
6. Each individual cooler shall have an individual COC that lists only samples contained within that cooler. Document in the data validation report if multiple coolers appear on one COC.

4.1.3 Holding Times

Holding times for water samples shall be those given in the most recent version of 40 Code of Federal Regulations (CFR) Part 136 or SW-846, Volume 1, Section C, if not specified in 40 CFR, art 136, or those specified in the analytical method. Holding times are determined from the time of sample collection to the time of sample analysis. Water holding times will be applied to soil/sediment samples. Current water holding times are as follows:

- Alkalinity – 14 days
- Bromide – 28 days
- COD – 28 days
- Chloride – 28 days
- Chromium (VI) – 24 hours for unpreserved water samples (14 days from lab preservation); 28 days for soil samples
- Cyanide – 14 days
- Fluoride – 28 days
- Surfactants (M.B.A.S.) – 48 hours
- Nitrate – 48 hours for water samples; 28 days for soil samples
- Nitrite – 48 hours for water samples; 28 days for soil samples
- Nitrate/Nitrite – 28 days
- Orthophosphate – 48 hours for water samples; 28 days for soil samples
- Perchlorate – 28 days

- Sulfate – 28 days
- Sulfide – 7 days
- Total Phosphorus – 28 days
- Total Dissolved Solids – 7 days
- Total Suspended Solids – 7 days
- TOC – 28 days
- TOX – 28 days (7 days if not preserved)
- Total Recoverable Petroleum Hydrocarbons – 28 days
- pH – immediate upon sampling for water samples; 28 days for soil samples
- Total Hardness – 6 months

Level C and Level D:

If holding times are exceeded, flag all results greater than the detection limit (DL) or limit of quantitation (LOQ) as estimated "J" and all results less than the DL or LOQ as estimated "UJ" and document that holding times were exceeded. If holding times are grossly exceeded, the reviewer may determine that the data reported as nondetects are unusable "R." Data will not be qualified unusable "R" unless the holding time was exceeded by more than a factor of 2.

4.2 CALIBRATION

Compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable quantitative data. Initial calibration demonstrates that the instrument is capable of acceptable performance at the beginning of the analysis run. Continuing calibration documents that the initial calibration is still valid and that maintenance and adjustment of the instrument on a day-to-day basis is satisfactory.

4.2.1 The Initial Calibration

Compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable quantitative data. Initial calibration demonstrates that the instrument is capable of acceptable performance at the beginning of the analysis run.

Level C and Level D:

A blank and at least three standards must be used in establishing the analytical curve.

If the correlation coefficient is below 0.995, qualify all associated detects as estimated "J" and all nondetects as "UJ." If the correlation coefficient is significantly lower than 0.995, professional judgment may be used to reject, "R," the analytes associated with the initial calibration.

Level D:

Recalculate the correlation coefficient for all initial calibrations. Verify from the raw data that appropriate concentration and number of standards were utilized to establish analytical curves and the associated correlation coefficients.

4.2.2 Initial Calibration Verification (ICV) and Continuing Calibration Verification (CCV)

The working calibration curve must be verified at the interval of 10 percent to ensure that the system performance has not degraded. Continuing calibration documents that the initial calibration is still valid and that maintenance and adjustment of the instrument on a day-to-day basis is satisfactory. Calibration must be verified with an independently prepared check standard.

Level C and Level D:

Review the ICV and CCV percent recovery (%R) forms. Analysis results must fall within the control limits of 90–110 percent recovery of the true value except perchlorate. Analysis results for perchlorate must fall within the control limits of 75–125 percent recovery of the true value for the ICV and 85–115 percent recovery of the true value for the CCV.

1. Due to possible rounding discrepancies, allow the results to fall within 1 percent of the acceptance windows (e.g., 89–111 percent).
2. If after a failing CCV, two additional consecutive CCVs are analyzed immediately, and both additional CCVs are within the control limits, the data is acceptable. If either of the additional CCVs is not within control limits, then the associated data will need qualification. See below for the recommended qualification guidelines.
3. If the ICV or CCV %R falls outside the acceptance windows, use professional judgment to qualify all associated data. If possible, indicate the bias in the technical review. The following guidelines are recommended:
    a. If the ICV or CCV %R falls outside the acceptance windows but within the ranges of 75–89 percent or 111–125 percent (perchlorate, 70–84 percent or 116–130 percent), qualify results greater than the DL as estimated "J."
    b. If the ICV or CCV %R is within the range of 111–125 percent (perchlorate, 116-130 percent), results less than the DL are acceptable.
    c. If the ICV or CCV %R is 75–89 percent (perchlorate, 70–84 percent), qualify results less than the DL as nondetected and estimated "UJ."
    d. If the ICV or CCV %R is less than 75 percent (perchlorate, less than 70 percent), qualify all results as unusable "R."
    e. If the ICV or CCV %R is greater than 125 percent (perchlorate, greater than 130 percent), qualify results greater than the DL as unusable "R"; results less than the DL are acceptable.

Level D:

1. Recalculate and verify one or more of the ICV and CCV %Rs per type of analysis using the following equation for %R. Once again, to correct for possible rounding discrepancies, let the results fall within 1 percent of the contract windows (e.g., 89–111 percent).

$$\%\text{Recovery} = \frac{Q_d}{Q_a} \times 100$$

Where:

Q_d = Concentration (in micrograms per liter [µg/L]) of each analyte measured in the analysis of the ICV or CCV solution.

Q_a = Concentration (in µg/L) of each analyte in the ICV or CCV source.

2. If discrepancies are discovered on any form, request a resubmittal from the laboratory and validate according to the criteria outlined above.

4.3 BLANKS

Method (preparation) and calibration blank analyses results are assessed to determine the existence and magnitude of laboratory contamination problems. If problems with any blank exist, all data associated with the blank must be carefully evaluated to determine whether there is a bias on the data, or if the problem is an isolated occurrence not affecting data.

4.3.1 Calibration Blanks

Level C and Level D:

1. If the blank is less than the LOQ and the samples results are greater than the DL but less than the LOQ, then qualify “U” at the result.
2. If the blank is less than the LOQ and the sample results are greater than the LOQ or nondetect, the data is acceptable.
3. If the blank is greater than the LOQ, then samples less than 5x the blank will be qualified as “U” at the concentration. Samples greater than 5x the blank are acceptable.
4. For negative blanks where the absolute value of the blank is greater than the LOQ, sample results that are less than 10x the absolute value of the negative blank qualify “J” for detect and ‘UJ” for nondetect results. Results that are greater than 10x the absolute value of the negative blank are acceptable.

Ensure that units are correct when applying calibration blank qualifications. If samples are soil matrix, results must first be converted to µg/L from milligrams per kilogram to make correct comparisons.

Level D:

Verify one or more of the calibration blank results per type of analysis by comparing the Form III to the raw data. After the validity of the target analytes are verified, validate the corresponding data using the criteria outlined above for Level C and Level D validation.

4.3.2 Method (Preparation) Blanks

Level C and Level D:

At least one method blank must be prepared with each batch of samples. If a method blank was not prepared and analyzed as required, the reviewer may qualify associated sample results less than the DL as nondetected and estimated “UJ,” and sample results greater than the MDL as estimated “J.”

Professional judgment should be utilized, however, taking into account the results of other associated blanks (e.g., initial calibration blank, continuing calibration blank).

If analytes of interest are detected in the method blanks, the procedure for the qualification of associated sample results is identical to the rules outlined in Section 4.3.1 of this procedure.

Level D:

Verify out-of-control method blanks that result in the qualification of numerous analytes against the raw data. Verify the results reported on Form III. After the validity of the target analytes are verified, validate the corresponding data using the criteria outlined above for Level C and Level D validation.

4.4 BLANK SPIKES AND LABORATORY CONTROL SAMPLES

Blank spike/laboratory control sample (LCS) recoveries must be within the QSM Appendix C limits specified in the DoD QSM unless project-specific control limits are established for a given sample matrix. Use in-house limits if analytes are not listed in Appendix C or project limits are not specified.

Level C and Level D:

1. If the blank spike/LCS results are less than 50 percent, only the spiked analytes that showed low recovery in all associated samples shall be flagged as “R” for nondetects and “J” for detects.
2. If blank spike/LCS results are below the control limits (but above 50 percent), spiked analytes that showed low recovery in all associated samples shall be flagged as estimated “UJ” or “J.”
3. If blank spike/LCS results are above the control limits, detects for only the spiked analytes that showed high recovery in all associated samples shall be flagged as “J.”
4. If the laboratory analyzes a blank spike duplicate/LCS duplicate (LCSD), evaluate and qualify the LCSD results using the criteria noted above.
5. If the relative percent differences (RPDs) between LCS and LCSD results are above the control limits (use the matrix spike [MS]/matrix spike duplicate [MSD] RPD control limits identified in DoD QSM Appendix B, if none are available use laboratory in-house limits), spiked compounds which showed high RPD in all associated samples shall be flagged as estimated “UJ” or “J.”

Level D:

To check that the spike %R was calculated and reported correctly using the following equation, recalculate one spike recovery per matrix (and any spike that would result in the qualification of a sample).

$$\%\text{Recovery} = \frac{Q_d}{Q_a} \times 100$$

Where:

Q_d = Quantity determined by analysis

Q_a = Quantity added to samples/blanks

If transcription errors are discovered on Form VII (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.5 MATRIX SPIKE/MATRIX SPIKE DUPLICATE AND MATRIX DUPLICATE

MS/MSD and matrix duplicate (MD) data are used to determine the effect of the matrix on a method's recovery efficiency and precision for a specific sample matrix. MD analyses are also performed to demonstrate acceptable method precision by the laboratory at the time of analysis.

If the MS/MSD and MD results do not meet the technical criteria, apply the action to the source sample only.

MS/MSD results should be within the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established for a given sample matrix. Use in-house limits if spiked analytes are not listed in Appendix C or project limits are not specified.

For the MD RPD, samples greater than 5× the LOQ use RPD to evaluate. For samples less than 5× the LOQ, use the difference between the MD and the sample unless project limits are specified. For difference use 1× the LOQ as the control limit for water samples and 2× the LOQ as the control limit for soil samples unless project limits are specified.

Level C and Level D:

1. The laboratory must spike and analyze a MS/MSD or MD from the specific project site as required for each matrix type and analytical batch.
2. MS/MSD data should be reported on a MS/MSD summary form similar to Form V. MD data should be reported on a MD summary form similar to Form VI.
3. If MS/MSD results are below the control limits, spiked analytes that showed low recovery shall be flagged as estimated "UJ" or "J."
4. If MS/MSD results are above the control limits, detects for only the spiked analytes that showed high recovery shall be flagged as "J."
5. If the RPD between MS and MSD recoveries or the RPD or difference between the MD and sample are greater than 15 percent, qualify the sample as estimated "UJ" or "J."
6. Failure of MS/MSD due to the presence of a target analyte in the parent sample at greater than four times the spike concentration should not result in any qualifications. Note the incident in the data validation report.

Level D:

Check the raw data and recalculate one or more %Rs, especially %Rs that resulted in the qualification of data, using the following equation to verify that results on Forms V and VI (or equivalent) are correct.

$$\%R = \frac{(SSR - SR)}{SA} \times 100$$

$$RPD = \frac{ABS|SSR - SDR|}{(SSR + SDR)/2} \times 100$$

Where:

SA = spike added
SR = sample result
SSR = spiked sample result
SDR = spiked duplicate result
ABS = absolute value

If transcription errors are discovered on Forms V or VI (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.6 SAMPLE RESULT VERIFICATION

Level C:

Level C validation does not require the evaluation of raw data, sample result verification is not required. All soil sample results are reported on a dry weight basis.

Level D:

The raw data should be examined to verify that the correct calculation of the sample results was reported by the laboratory. Sample preparation logs, instrument printouts, strip charts, etc. should be compared to the reported sample results recorded on the sample results summary forms. All soil sample results are reported on a dry weight basis.

1. Evaluate the raw data for any anomalies (i.e., baseline shifts, negative absorbance, omissions, legibility).
2. Verify that there are no errors in transcription or calculation. If errors are discovered, request a resubmittal from the laboratory and validate the data according the criteria outlined above.
3. Verify that results fall within the calibrated range. If the positive sample result falls outside the calibrated range, qualify the sample result "J."

4.7 FIELD QC SAMPLES

Field QC samples discussed in this section of the procedure are equipment blanks, field blanks, field duplicates, and field triplicates. Analytical results for field QC samples are utilized to qualify associated sample results.

4.7.1 Equipment Blanks and Field Blanks

Analytes detected in equipment blanks indicate the possibility of cross-contamination between samples due to improper equipment decontamination.

A field blank sample may be collected from each source of water used during each sampling event. The field blank may be analyzed to assess whether the chemical nature of the water used in decontamination may have affected the analytical results of site samples.

If analytes are detected in the equipment blanks and/or field blanks, the procedure for the qualification of associated sample results is identical to the criteria outlined in Section 4.3.1 of this procedure.

Level C and Level D:

1. Determine which field QC samples apply to samples in the sample delivery group.
2. Ensure that units are correct when applying field QC blank qualifications. If samples are soil matrix, results must first be converted to µg/L from micrograms per kilogram to make correct comparisons.
3. Because of the way in which the field blanks and equipment blanks are sampled, equipment blanks are not qualified because of field blank contamination. The affected samples are qualified, however, by either the field blank or equipment blank results, whichever has the higher contaminant concentration.
4. Equipment blanks and field blanks are only qualified with method blank results in order to account for laboratory contamination.

Level D:

1. Verify all target analytes found in the equipment blanks and field blanks against the raw data.
2. After the validity of the target analytes are verified, validate the corresponding data using the criteria outlined above for Level C and Level D validation.

4.7.2 Field Duplicates and Field Triplicates

Field duplicates consist of either collocated or subsampled samples. Field duplicates for ground water and surface water samples are generally considered to be collocates. Soil duplicate samples may be homogenized and subsampled in the field (or at the laboratory) to form an original and duplicate sample, or may be an additional volume of sample collected in a separate sample container to form a collocate sample. Field duplicate results are an indication of both field and laboratory precision; the results may be used to evaluate the consistency of sampling practices.

Field triplicates are collected from different, randomly selected locations to verify that an incremental sample truly represents a decision unit. Field triplicate results are more useful than field duplicates to statistically evaluate sampling precision.

Level C and Level D:

1. Check to ensure that field duplicates and/or field triplicates were collected and analyzed as specified in the project planning documents. If the sampling frequency is less than the frequency stated in the planning documents, no qualification of the associated sample results is necessary but the incident shall be discussed in the data validation report.

2. For field duplicate results, if the RPDs are greater than 50 percent for water or 100 percent for soil or as stated in the planning document if more conservative, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.
3. For field triplicate results, if the RSDs are greater than the QC limits stated in the planning document, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.

Level D:

Verify by recalculating at least two detects common between the sample and its field duplicate and/or field triplicate. If discrepancies are discovered, document in the data validation report.

5. Records

A Form I that has been validated and verified, and has been determined by the data validator to accurately represent the appropriate sample results to be utilized, shall be stamped "NAVFAC PACIFIC VALIDATED." Additionally, sample result forms for which the data has been validated at the Level D validation level shall be stamped or noted "Level D."

Copies of all documents generated by the data validation personnel will be stored for no less than 10 years.

6. References

American Public Health Association (APHA). 2005. *Standard Methods for the Examination of Water and Wastewater.* 21st ed. Washington. September.

Department of Defense, United States (DoD). 2005a. *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: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

———. 2005b. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B: Quality Assurance/quality Control Compendium: Minimum QA/QC Activities*. Final Version 1. DoD: DTIC ADA 426957, EPA-505-B-04-900B. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www2.epa.gov/sites/production/files/documents/qaqc_v1_0305.pdf.

———. 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2A: Optimized UFP-QAPP Worksheets*. Revision 1. March.

———. 2013. *Department of Defense Quality Systems Manual for Environmental Laboratories.* Version 5.0. Draft Final. Prepared by DoD Environmental Data Quality Workgroup and Department of Energy Consolidated Audit Program Operations Team. July.

Environmental Protection Agency, United States (EPA). 2007. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* 3rd ed., Final Update IV. Office of Solid Waste. Updates available: www.epa.gov/epaoswer/hazwaste/test/new-meth.htm.

Procedure II-A, *Data Validation*.

7. Attachments

None.

Data Quality Assessment Report

1. Purpose

This procedure describes the presentation format and information provided in the data quality assessment report (DQAR) under the United States (U.S.) Navy Environmental Restoration (ER) Program for Naval Facilities Engineering Command (NAVFAC), Pacific and is consistent with protocol in the *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories* (DoD QSM) (DoD 2013). The objective of DQAR is to summarize the validated data to the end user. This procedure also establishes the method by which a Contract task Order (CTO) Manager selects and confirms the content of the DQAR. Data validation is addressed separately in Procedure II-A, *Data Validation*.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Responsibilities

The CTO Manager, the QA Manager or Technical Director, and the CTO QA Coordinator are responsible for ensuring that this procedure is implemented by data validation personnel.

Data validation personnel (unless otherwise stated) are responsible for implementing this procedure for all DQARs.

4. Procedure

4.1 INTRODUCTION

The DQAR summarizes the QA/quality control (QC) evaluation of the data according to precision, accuracy, representativeness, completeness, comparability, and sensitivity relative to the project quality objectives (PQOs). The report provides a quantitative and qualitative assessment of the data and identifies potential sources of error, uncertainty, and bias that may affect the overall usability.

The DQAR summary report identifies the level of data validation for each sample and evaluates and summarizes the results of QA/QC data validation for the entire sampling program. Each analytical fraction has a separate section for each of the criteria. These sections interpret specific QC deviations and their effects on both individual data points and the analyses as a whole. The last section presents a summary of the precision, accuracy, representativeness, completeness, comparability, and sensitivity criteria by comparing quantitative parameters with acceptability criteria defined in the PQOs. Qualitative criteria are also summarized in this section. A DQAR example is provided as Attachment II-S-1.

4.2 PRECISION AND ACCURACY OF ENVIRONMENTAL DATA

Environmental data quality depends on sample collection procedures, analytical methods and instrumentation, documentation, and sample matrix properties. Both sampling procedures and laboratory analyses contain potential sources of uncertainty, error, and/or bias, which affect the overall quality of a measurement. Errors in sample data may result from incomplete equipment decontamination, inappropriate sampling techniques, sample heterogeneity, improper filtering, and improper preservation. The accuracy of analytical results is dependent on selecting appropriate analytical methods, maintaining equipment properly, and complying with QC requirements. The sample matrix also is an important factor in the ability to obtain precise and accurate results within a given media.

Environmental and laboratory QC samples assess the effects of sampling procedures and evaluate laboratory contamination, laboratory performance, and matrix effects. QC samples include: trip blanks, equipment blanks, field blanks, field duplicates, field triplicates, method blanks, laboratory control samples (LCSs), surrogate spikes, matrix spike/matrix spike duplicates (MS/MSDs), laboratory duplicates, and laboratory triplicates.

Before producing the DQAR, the analytical data should be validated according to the NAVFAC Pacific data validation procedures. Samples not meeting the NAVFAC ER Program validation criteria are qualified with a flag, an abbreviation indicating a deficiency with the data. The following are flags used in data validation.

J Estimated. The associated numerical value is an estimated quantity. The analyte was detected but the reported value may not be accurate or precise. The “J” qualification indicates the data fell outside the QC limits, but the exceedance was not sufficient to cause rejection of the data.

R Rejected. The data is unusable (the compound or analyte may or may not be present). Use of the “R” qualifier indicates a significant variance from functional guideline acceptance criteria. Either resampling or re-analysis is necessary to determine the presence or absence of the rejected analyte.

U Nondetected. Analyses were performed for the compound or analyte, but it was not detected. The “U” designation is also applied to suspected blank contamination. The “U” flag is used to qualify any result detected in an environmental sample at a concentration less than 10 times the value of the concentration in any associated blank for common laboratory contaminants and less than 5 times the concentration in any associated blank for all other contaminants.

UJ Estimated/Nondetected. Analyses were performed for the compound or analyte, but it was not detected and the limit of detection (LOD) is an estimated quantity due to poor accuracy or precision. This qualification is also used to flag possible false negative results in the case where low bias in the analytical system is indicated by low calibration response, surrogate, internal standard, or other spike recovery.

Once the data are reviewed and qualified according to the NAVFAC Pacific data validation procedures, the data set is then evaluated using precision, accuracy, representativeness, completeness, comparability, and sensitivity criteria that provide an evaluation of overall data usability. The following is a discussion of the precision, accuracy, representativeness, completeness, and comparability criteria as related to the PQOs.

4.2.1 Precision

Precision is a measure of the agreement or reproducibility of analytical results under a given set of conditions. It is a quantity that cannot be measured directly but is calculated from reported concentrations. Precision is expressed as the relative percent difference (RPD) or percent relative standard deviation (%RSD):

$$\text{RPD} = (\text{D1}-\text{D2})/\{1/2(\text{D1}+\text{D2})\} \times 100$$

$$\%\text{RSD} = \text{SD}/\{1/3(\text{D1}+\text{D2}+\text{D3})\} \times 100$$

Where:

D1 = the reported concentration for primary sample analyses

D2 = the reported concentrations for duplicate analyses

D3 = the reported concentrations for triplicate analyses

SD = the standard deviation for sample, duplicate and triplicate analyses

Precision is primarily assessed by calculating a RPD from the reported concentrations of the spiked compounds for each sample in the MS/MSD pair. In the absence of a MS/MSD pair, a laboratory duplicate or LCS/laboratory control sample duplicate (LCSD) pair can be analyzed as an alternative means of assessing precision. In some cases, samples from multiple sample delivery groups (SDGs) are within one QC batch and therefore are associated with the same laboratory QC samples. An additional measure of sampling precision may be obtained by collecting and analyzing field duplicate samples, which are compared using the RPD result as the evaluation criteria.

MS and MSD samples are field samples spiked by the laboratory with target analytes prior to preparation and analysis. These samples measure the overall efficiency of the analytical method in recovering target analytes from an environmental matrix. A LCS is similar to a MS/MSD sample in that the LCS is spiked with the same target analytes prior to preparation and analysis. However, the LCS is prepared using a controlled interference-free matrix instead of a field sample aliquot. Laboratory reagent water is used to prepare aqueous LCS. Non-aqueous LCSs are prepared using solid media approved by the American Society for Testing and Materials for their homogeneity. The LCS measures laboratory efficiency in recovering target analytes from either a solid or aqueous matrix in the absence of matrix interferences.

For inorganic analysis, one primary sample is analyzed and accompanied by an unspiked laboratory duplicate. The data reviewer compares the reported results of the primary analysis and the laboratory duplicate and calculates RPDs to assess laboratory precision.

Laboratory and field sampling precision are further evaluated by calculating RPDs for field sample duplicate pairs. The sampler collects two field samples at the same location and under identically controlled conditions. The laboratory then analyzes the samples under identical conditions.

If incremental sampling is performed, laboratory and field sampling precision are evaluated by calculating RSDs for laboratory triplicates and field triplicates. At the subsampling step, one sample is prepared in triplicate per batch. Laboratory triplicate data are used to determine that the samples are being reduced to sufficiently small particle sizes during the grinding process. Field triplicates are collected from different, randomly selected locations to verify that an incremental sample truly represents a decision unit. Field triplicate results are more useful than field duplicates to statistically evaluate sampling precision.

An RPD outside the numerical QC limit in either MS/MSD samples or LCS/LCSD or a %RSD outside the numerical QC limit in the laboratory triplicate indicates imprecision. Imprecision is the variance in the consistency with which the laboratory arrives at a particular reported result. Thus, the actual analyte concentration may be higher or lower than the reported result.

Possible causes of poor precision include sample matrix interference, improper sample collection or handling, inconsistent sample preparation, and poor instrument stability. In some duplicates and/or triplicates, results may be reported in the primary, duplicate, or triplicate samples at levels below the limit of quantitation (LOQ) or non-detected. Since these values are considered to be estimates, RPD exceedances from duplicates or %RSD exceedances from triplicates do not suggest a significant impact on the data quality.

4.2.2 Accuracy

Accuracy is a measure of the agreement of an experimental determination and the true value of the parameter being measured. It is used to identify bias in a given measurement system. Recoveries outside acceptable QC limits may be caused by factors such as instrumentation, analyst error, or matrix interference. Accuracy is assessed through the analysis of MS, MSD, LCS, and samples containing surrogate spikes. In some cases, samples from multiple SDGs are within one QC batch and therefore are associated with the same laboratory QC samples. Surrogate spikes are either isotopically labeled compounds or compounds that are not typically detected in the samples. Surrogate spikes are added to every blank, environmental sample, MS/MSD, and standard, for applicable organic analyses. Accuracy of inorganic analyses is determined using the percent recoveries of MS and LCS analyses.

Percent recovery (%R) is calculated using the following equation:

$$\%R = (A - B)/C \times 100$$

Where:

A = measured concentration in the spiked sample
B = measured concentration of the spike compound in the unspiked sample
C = concentration of the spike

The percent recovery of each analyte spiked in MS/MSD samples, LCS, and surrogate compounds added to environmental samples is evaluated against the acceptance criteria specified by the previously noted documents. Spike recoveries outside the acceptable QC accuracy limits provide an indication of bias, where the reported data may overestimate or underestimate the actual concentration of compounds detected or quantitation limits reported for environmental samples.

4.3 REPRESENTATIVENESS

Representativeness is a qualitative parameter that expresses the degree to which the sample data are characteristic of a population and is evaluated by reviewing the QC results of blank samples and holding times. Positive detects of compounds in the blank samples identify compounds that may have been introduced into the samples during sample collection, transport, preparation, or analysis. The various types of blanks evaluated are discussed below.

A method blank is a laboratory grade water or solid matrix that contains the method reagents and has undergone the same preparation and analysis as the environmental samples. The method blank provides a measure of the combined contamination derived from the laboratory source water, glassware, instruments, reagents, and sample preparation steps. Method blanks are prepared for each sample of a similar matrix extracted by the same method at a similar concentration level.

For inorganic analyses, initial and continuing calibration blanks consist of acidified laboratory grade water, which are injected at the beginning and at a regular frequency during each 12-hour sample analysis run. These blanks estimate residual contaminants from the previous sample or standards analysis and measure baseline shifts that commonly occur in emission and absorption spectroscopy.

Trip blanks are used to identify possible volatile organic contamination introduced into the sample during transport. A trip blank is a sample volatile organics analysis vial filled in the laboratory with reagent-grade water and preserved to a pH less than 2 with hydrochloric acid. It is transported to the site, stored with the sample containers, and returned unopened to the laboratory for analysis.

Equipment blanks consist of analyte-free water poured over or through the sample collection equipment. The water is collected in a sample container for laboratory analysis. These blanks are collected after the sampling equipment is decontaminated and measure efficiency of the decontamination procedure.

Field blanks consist of analyte-free source water stored at the sample collection site. The water is collected from each source water used during each sampling event.

If sample grinding is performed, grinding blanks, which consist of clean solid matrix (such as Ottawa sand), must be prepared (e.g., ground and subsampled) and analyzed in the same manner as a field sample. Grinding equipment must be thoroughly cleaned between the processing of samples and grinding blanks must be processed and analyzed to prevent cross-contamination.

Contaminants found in both the environmental sample and a blank sample are assumed to be laboratory artifacts if the concentration in the environmental sample is less than 10 times the blank value for common laboratory contaminants (methylene chloride, acetone, 2-butanone, and phthalate esters) or 5 times the blank value for other laboratory contaminants.

Holding times are evaluated to assure that the sample integrity is intact for accurate sample preparation and analysis. Holding times will be specific for each method and matrix analyzed. Holding time exceedances can cause loss of sample constituents due to biodegradation, precipitation, volatization, and chemical degradation.

4.4 COMPARABILITY

Comparability is a qualitative expression of the confidence with which one data set may be compared to another. It provides an assessment of the equivalence of the analytical results to data obtained from other analyses. It is important that data sets be comparable if they are used in conjunction with other data sets. The factors affecting comparability include the following: sample collection and handling techniques, matrix type, and analytical method. If these aspects of sampling and analysis are carried out according to standard analytical procedures, the data are considered comparable. Comparability can only be compared with confidence when precision, accuracy, and representativeness are known.

4.5 COMPLETENESS

Completeness is defined as the percentage of acceptable sample results compared to the total number of sample results. Completeness is evaluated to determine if an acceptable amount of usable data were obtained so that a valid scientific site assessment can be completed. Completeness equals the total number of sample results for each fraction minus the total number of rejected sample results divided by the total number of sample results multiplied by 100. The goal for completeness for target analytes in each analytical fraction should be specified in the DoD QSM (DoD 2013) or project planning document.

Percent completeness is calculated using the following equation:

$$\%C = (T - R)/T \times 100$$

Where:

$\%C$ = percent completeness

T = total number of sample results

R = total number of rejected sample results

Completeness is also determined by comparing the planned number of samples per method and matrix as specified in the project planning document, with the number determined above.

4.6 SENSITIVITY

Sensitivity is the ability of an analytical method or instrument to discriminate between measurement responses representing different concentrations. This capability is established during the planning phase to meet the data quality objectives (DQOs). It is important that calibration requirements, detection limits (DLs), and project-specific LODs and LOQs presented in the work plan are achieved and that target analytes can be detected at concentrations necessary to support the DQOs. In addition, sample results are compared to method blank and field blank results to identify potential effects of laboratory background and field procedures on sensitivity.

5. References

Department of Defense, United States (DoD). 2013. *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories.* Final version 5.0. Prepared by Department of Defense Environmental Data Quality Workgroup and the Department of Energy Consolidated Audit Program Operations Team. March.

Procedure II-A, *Data Validation*.

6. Attachments

II-S-1: Data Quality Assessment Report Example

Attachment II-S-1
Data Quality Assessment Report Example

DATA QUALITY ASSESSMENT REPORT

SITE INVESTIGATION BUILDING E-13
PEARL HARBOR, CTO XXX

12/1/03

Table of Contents

Glossary

µg/kg	microgram per kilogram
µg/L	microgram per liter
BTEX	benzene, toluene, ethylbenzene, xylenes
DL	detection limit
DQO	data quality objectives
EPA	Environmental Protection Agency, United States
IDL	instrument detection limit
LCS/LCSD	laboratory control sample/laboratory control sample duplicate
LOD	limit of detection
LOQ	limit of quantitation
mg/kg	milligram per kilogram
MS/MSD	matrix spike/matrix spike duplicate
NAS	Naval Air Station
PARCCS	Precision, Accuracy, Representativeness, Comparability, Completeness, Sensitivity
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
QA/QC	quality assurance/quality control
RPD	relative percent difference
RRF	relative response factor
RL	reporting limit
SDG	sample delivery group
%D	percent difference
%R	percent recovery
%RSD	percent relative standard deviation

1. Introduction

A remediation and closure was conducted at Building E-13 at Pearl Harbor, Oahu, Hawaii. This part of the site investigation included the collection and analyses of 141 environmental and quality control (QC) samples. The analyses were performed by the following methods:

- Polynuclear aromatic hydrocarbons (PAHs) by United States Environmental Protection Agency (EPA) SW-846 8270C-SIM
- Polychlorinated biphenyls (PCBs) by EPA SW-846 Method 8082
- Metals by EPA SW-846 Method 6010B/6020/7471A

Analytical services were provided by ZZZZ Laboratories whom performed analyses on the water and soil samples. The samples were grouped into sample delivery groups (SDGs) of up to 20 field samples received by each laboratory. The environmental samples are associated with QA/QC samples designed to document the data quality of the entire SDG or a sub-group of samples within a SDG. Table I is a cross-reference table listing each sample, analysis, SDG, collection date, laboratory sample number, and matrix. All shaded samples in Table I were reviewed under Level D validation guidelines.

One hundred percent of the analytical data were validated according to NAVFAC Pacific Level D data validation procedures. The analytical data were evaluated for quality assurance and quality control (QA/QC) based on the *Department of the Navy Environmental Restoration Program (NERP) Manual* (2006).

This data quality assessment report (DQAR) summarizes the QA/QC evaluation of the data according to precision, accuracy, representativeness, completeness, comparability, and sensitivity (PARCCS) relative to the project quality objectives (PQOs). This report provides a quantitative and qualitative assessment of the data and identifies potential sources of error, uncertainty, and bias that may affect the overall usability.

The DQAR evaluates and summarizes the results of QA/QC data validation for the entire sampling program. Each analytical fraction has a separate section for each of the PARCC criteria. These sections interpret specific QC deviations and their effects on both individual data points and the analyses as a whole. Section 6 presents a summary of the PARCC criteria by comparing quantitative parameters with acceptability criteria defined in the PQOs. Qualitative PARCC criteria are also summarized in this section.

Precision and Accuracy of Environmental Data

Environmental data quality depends on sample collection procedures, analytical methods and instrumentation, documentation, and sample matrix properties. Both sampling procedures and laboratory analyses contain potential sources of uncertainty, error, and/or bias, which affect the overall quality of a measurement. Errors in sample data may result from incomplete equipment decontamination, inappropriate sampling techniques, sample heterogeneity, improper filtering, and improper preservation. The accuracy of analytical results is dependent on selecting appropriate analytical methods, maintaining equipment properly, and complying with QC requirements. The sample matrix also is an important factor in the ability to obtain precise and accurate results within a given media.

Environmental and laboratory QA/QC samples assess the effects of sampling procedures and evaluate laboratory contamination, laboratory performance, and matrix effects. QA/QC samples include: equipment blanks, field duplicates, method blanks, laboratory control samples (LCSs), surrogate spikes, matrix spike/matrix spike duplicates (MS/MSDs), and laboratory duplicates.

Before conducting the PARCC evaluation, the analytical data were validated according to the *Department of the Navy Environmental Restoration Program (NERP) Manual* [2006]). Samples not meeting the Project Procedures Manual acceptance criteria were qualified with a flag, an abbreviation indicating a deficiency with the data. The following are flags used in data validation.

J	<u>Estimated</u>: The associated numerical value is an estimated quantity. The analyte was detected but the reported value may not be accurate or precise. The “J” qualification indicates the data fell outside the QC limits, but the exceedance was not sufficient to cause rejection of the data.
R	<u>Rejected</u>: The data is unusable (the compound or analyte may or may not be present). Use of the "R" qualifier indicates a significant variance from functional guideline acceptance criteria. Either resampling or re-analysis is necessary to determine the presence or absence of the rejected analyte.
U	<u>Nondetected</u>: Analyses were performed for the compound or analyte, but it was not detected. The "U" designation is also applied to suspected blank contamination. The "U" flag is used to qualify any result detected in an environmental sample at a concentration less than 10 times the value of the concentration in any associated blank for common laboratory contaminants and less than 5 times the concentration in any associated blank for all other contaminants.
UJ	<u>Estimated/Nondetected</u>: Analyses were performed for the compound or analyte, but it was not detected and the limit of detection (LOD) is an estimated quantity due to poor accuracy or precision. This qualification is also used to flag possible false negative results in the case where low bias in the analytical system is indicated by low calibration response, surrogate, internal standard, or other spike recovery.

Once the data are reviewed and qualified according to the *Department of the Navy Environmental Restoration Program (NERP) Manual* (2006), the data set is then evaluated using PARCCS criteria. PARCCS criteria provide an evaluation of overall data usability. The following is a discussion of PARCCS criteria as related to the PQOs.

Precision is a measure of the agreement or reproducibility of analytical results under a given set of conditions. It is a quantity that cannot be measured directly but is calculated from reported concentrations. Precision is expressed as the relative percent difference (RPD):

$$RPD = (D1 - D2)/\{1/2(D1+D2)\} \times 100$$

Where:

D1 and D2 = the reported concentrations for sample and duplicate analyses.

Precision is primarily assessed by calculating a RPD from the reported concentrations of the spiked compounds for each sample in the MS/MSD pair. In the absence of a MS/MSD pair, a laboratory duplicate or LCS/LCSD pair can be analyzed as an alternative means of assessing precision. In some cases, samples from multiple SDGs were within one QC batch and therefore are associated with the same laboratory QC samples. An additional measure of sampling precision was obtained by collecting and analyzing field duplicate samples, which were compared using the RPD result as the evaluation criteria.

MS and MSD samples are field samples spiked by the laboratory with target analytes prior to preparation and analysis. These samples measure the overall efficiency of the analytical method in recovering target analytes from an environmental matrix. A LCS is similar to a MS/MSD sample in that the LCS is spiked with the same target analytes prior to preparation and analysis. However, the LCS is prepared using a controlled interference-free matrix instead of a field sample aliquot. Laboratory reagent water is used to prepare aqueous LCS. Non-aqueous LCSs are prepared using solid media approved by the American Society for Testing and Materials (ASTM) for their homogeneity. The LCS measures laboratory efficiency in recovering target analytes from either a solid or aqueous matrix in the absence of matrix interferences.

For inorganics analysis, one primary sample is analyzed and accompanied by an unspiked laboratory duplicate. The data reviewer compares the reported results of the primary analysis and the laboratory duplicate, then calculates RPDs, which are used to assess laboratory precision.

Laboratory and field sampling precision are further evaluated by calculating RPDs for aqueous field sample duplicate pairs. The sampler collects two field samples at the same location and under identically controlled conditions. The laboratory then analyzes the samples under identical conditions.

An RPD outside the numerical QC limit in either MS/MSD samples or LCS/LCSD indicates imprecision. Imprecision is the variance in the consistency with which the laboratory arrives at a particular reported result. Thus, the actual analyte concentration may be higher or lower than the reported result.

Possible causes of poor precision include sample matrix interference, improper sample collection or handling, inconsistent sample preparation, and poor instrument stability. In some duplicate pairs, results maybe reported in either the primary or duplicate samples at levels below the limit of quantitation (LOQ) or non-detected. Since these values are considered to be estimates, RPD exceedances from these duplicate pairs do not suggest a significant impact on the data quality.

Accuracy is a measure of the agreement of an experimental determination and the true value of the parameter being measured. It is used to identify bias in a given measurement system. Recoveries outside acceptable QC limits may be caused by factors such as instrumentation, analyst error, or matrix interference. Accuracy is assessed through the analysis of MS, MSD, LCS, and samples containing surrogate spikes. In some cases, samples from multiple SDGs were within one QC batch and therefore are associated with the same laboratory QC samples. Surrogate spikes are either isotopically labeled compounds or compounds that are not typically detected in the samples. Surrogate spikes are added to every blank, environmental sample, MS/MSD, and standard, for all applicable organic analyses. Accuracy of inorganic analyses is determined using the percent recoveries of MS and LCS analyses.

%R is calculated using the following equation:

$$\%R = (A-B)/C \times 100$$

Where:

A = measured concentration in the spiked sample

B = measured concentration of the spike compound in the unspiked sample

C = concentration of the spike

The percent recovery of each analyte spiked in MS/MSD samples, LCS, and surrogate compounds added to environmental samples is evaluated against the acceptance criteria specified by the previously noted documents. Spike recoveries outside the acceptable QC accuracy limits provide an indication of bias, where the reported data may overestimate or underestimate the actual concentration of compounds detected or quantitation limits reported for environmental samples.

Representativeness is a qualitative parameter that expresses the degree to which the sample data are characteristic of a population and is evaluated by reviewing the QC results of blank samples and holding times. Positive detects of compounds in the blank samples identify compounds that may have been introduced into the samples during sample collection, transport, preparation, or analysis. The QA/QC blanks collected and analyzed are method blanks.

A method blank is a laboratory grade water or solid matrix that contains the method reagents and has undergone the same preparation and analysis as the environmental samples. The method blank provides a measure of the combined contamination derived from the laboratory source water, glassware, instruments, reagents, and sample preparation steps. Method blanks are prepared for each sample of a similar matrix extracted by the same method at a similar concentration level.

For inorganic analyses, initial and continuing calibration blanks consist of acidified laboratory grade water, which are injected at the beginning and at a regular frequency during each 12 - hour sample analysis run. These blanks estimate residual contaminants from the previous sample or standards analysis and measure baseline shifts that commonly occur in emission and absorption spectroscopy.

Trip blanks are used to identify possible volatile organic contamination introduced into the sample during transport. A trip blank is a sample bottle filled in the laboratory with reagent-grade water and preserved to a pH less than 2 with hydrochloric acid. It is transported to the site, stored with the sample containers, and returned unopened to the laboratory for analysis.

Equipment blanks consist of analyte-free water poured over or through the sample collection equipment. The water is collected in a sample container for laboratory analysis. These blanks are collected after the sampling equipment is decontaminated and measure efficiency of the decontamination procedure. Equipment blanks were collected and analyzed for all target analytes.

Field blanks consist of analyte-free source water stored at the sample collection site. The water is collected from each source water used during each sampling event. Field blanks were collected and analyzed for all target analytes.

Contaminants found in both the environmental sample and a blank sample are assumed to be laboratory artifacts if the concentration in the environmental sample is less than 10 times the blank value for common laboratory contaminants; methylene chloride, acetone, 2-butanone, and phthalate esters or 5 times the blank value for other laboratory contaminants.

Holding times are evaluated to assure that the sample integrity is intact for accurate sample preparation and analysis. Holding times will be specific for each method and matrix analyzed. Holding time exceedances can cause loss of sample constituents due to biodegradation, precipitation, volatization, and chemical degradation.

Comparability is a qualitative expression of the confidence with which one data set may be compared to another. It provides an assessment of the equivalence of the analytical results to data obtained from other analyses. It is important that data sets be comparable if they are used in conjunction with other data sets. The factors affecting comparability include the following: sample collection and handling techniques, matrix type, and analytical method. If these aspects of sampling and analysis are carried out according to standard analytical procedures, the data are considered comparable. Comparability is also dependent upon other PARCC criteria, because only when precision, accuracy, and representativeness are known can data sets be compared with confidence.

Completeness is defined as the percentage of acceptable sample results compared to the total number of sample results. Completeness is evaluated to determine if an acceptable amount of usable data were obtained so that a valid scientific site assessment can be completed. Completeness equals the total number of sample results for each fraction minus the total number of rejected sample results divided by the total number of sample results multiplied by 100. As specified in the PQOs, the goal for completeness for target analytes in each analytical fraction is 90 percent.

Percent completeness is calculated using the following equation:

$$\%C = (T - R)/T \times 100$$

Where:

$\%C$ = percent completeness

T = total number of sample results

R = total number of rejected sample results

Completeness is also determined by comparing the planned number of samples per method and matrix as specified in the project planning document, with the number determined above.

Sensitivity is the ability of an analytical method or instrument to discriminate between measurement responses representing different concentrations. This capability is established during the planning phase to meet the DQOs. It is important that calibration requirements, detection limits (DLs), and project-specific LODs and LOQs presented in the work plan are achieved and that target analytes can be detected at concentrations necessary to support the DQOs. In addition, sample results are compared to method blank and field blank results to identify potential effects of laboratory background and field procedures on sensitivity.

The following sections present a review of QC data for each analytical method.

2. Polynuclear Aromatic Hydrocarbons

A total of 58 soil samples were analyzed for PAH by EPA SW-846 Method 8270C-SIM. All PAH data were assessed to be valid with the exception of 17 of the 986 total results, which were rejected based on QC exceedances. This section discusses the QA/QC supporting documentation as defined by the PARCC criteria and evaluated based on the PQOs.

2.1 PRECISION AND ACCURACY

2.1.1 Instrument Calibration

Initial and continuing calibration results provide a means of evaluating accuracy within a particular SDG. Relative response factor (RRF), percent relative standard deviation (%RSD), and percent difference (%D) are the three major parameters used to measure the effectiveness of instrument calibration. RRF is a measure of the relative spectral response of an analyte compared to its internal standard. %RSD is an expression of the linearity of instrument response. %D is a comparison of a continuing calibration instrumental response with its initial response. %RSD and %D exceedances suggest routine instrumental anomalies, which typically impact all sample results for the affected compounds.

The relative response factors met the acceptance criteria of 0.05 in the initial and continuing calibration standards.

The relative standard deviation in the initial calibrations and/or %D between the initial calibration mean relative response factors and the continuing calibration relative response factors were within the acceptance criteria of 15 and 20 percent, respectively.

The %Ds in the initial calibration verification were within the acceptance criteria of 20 percent.

2.1.2 Surrogates

As a result of non-compliant surrogate recoveries, 17 non-detected results in sample BA368 were qualified as unusable (R). Additionally, 136 results in samples BA267, BA338, BA341, BA363, BA364, BA367, BA368, and BA369 were qualified as detected estimated (J) and non-detected estimated (UJ) due to non-compliant surrogate recoveries. The details regarding the qualification of results are provided in the data validation reports.

2.1.3 MS/MSD Samples

As a result of non-compliant MS/MSDs, five results for non-compliant RPDs and 32 results for non-compliant %Rs were qualified as detected estimated (J) and non-detected estimated (UJ). The affected compounds were 2-methylnapthalene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluorene, naphthalene, phenanthrene, and pyrene. The details regarding the qualification of results are provided in the data validation reports.

2.1.4 LCS Samples

As a result of non-compliant LCS/LCSD recoveries, 139 results were qualified as detected estimated (J) and non-detected estimated (UJ). The affected compounds were acenaphthene, benzo(a)anthracene, benzo(a)pyrene, dibenz(a,h)anthracene, fluorene, and pyrene. The details regarding the qualification of results are provided in the data validation reports.

2.1.5 Internal Standards

No data were qualified based on internal standard nonconformances. The recoveries and retention times were evaluated against the acceptance criteria.

2.1.6 Field Duplicate Samples

The field duplicate samples were evaluated for acceptable precision with RPDs for the compounds. The associated data validation narratives provided details regarding criteria exceeded. Sample data were not qualified on the basis of field duplicate precision.

2.1.7 Proficiency Testing Samples

Proficiency testing samples were not performed for the sampling event.

2.1.8 Compound Quantitation and Target Identification

Due to compound quantitation nonconformances (i.e., co-elution of peaks), 29 benzo(b)fluoranthene and benzo(k)fluoranthene detected results in several samples were qualified as detected estimated (J). The details regarding the qualification of results are provided in the data validation reports.

All target compound identifications were found to be acceptable

2.2 REPRESENTATIVENESS

2.2.1 Holding Times

The evaluation of holding times to verify compliance with the method was conducted. All holding times were met.

2.2.2 Blanks

Method blanks were analyzed to evaluate representativeness. The concentration for an individual target compounds in any of the three types of QA/QC blanks were used for data qualification.

If contaminants were detected in a blank, corrective actions were made for the chemical analytical data during data validation. The corrective action consisted of amending the laboratory reported results for organic compounds based on the following criteria. The validation qualifier codes used in the blank summary tables are described below.

- *Results Below or Above the LOQ:* If a sample result for the blank contaminant was less than the LOQ or greater than the sample LOQ and less than 5× the blank value, the sample result for the blank contaminant was amended as a non-detect at the concentration reported in the sample results.
- *No Action:* If a sample result for the blank contaminant was greater than 10× the blank value for common contaminants or 5× the blank value for other contaminants, the result was not amended.

2.2.2.1 METHOD BLANKS

As a result of method blank contamination, one benzo(a)anthracene result was qualified as non-detected (U). The details regarding the qualification of results are provided in the data validation reports.

2.3 COMPARABILITY

The laboratory used standard analytical methods for all of the analyses. In all cases, the method detection limits attained were at or below the reporting limit. Target compounds detected below the reporting limits flagged (J) by the laboratory should be considered estimated. The comparability of the data is regarded as acceptable.

2.4 COMPLETENESS

The completeness level attained for PAH field samples was 98.3 percent. This percentage was calculated as the total number of accepted sample results divided by the total number of sample results multiplied by 100.

2.5 SENSITIVITY

The calibration was evaluated for instrument sensitivity and was determined to be technically acceptable. All laboratory reporting limits met the specified requirements described in the work plan although LOD was elevated for benzo(a)anthracene for one sample due to method blank contamination.

3. Polychlorinated Biphenyls

A total of 20 soil samples were analyzed for PCB as Aroclors by EPA SW-846 Method 8082. All PCB data were assessed to be valid since none of the 140 total results were rejected based on QC exceedances. This section discusses the QA/QC supporting documentation as defined by the PARCC criteria and evaluated based on the PQOs.

3.1 PRECISION AND ACCURACY

3.1.1 Instrument Calibration

Initial and continuing calibration results provide a means of evaluating accuracy within a particular SDG. Percent relative standard deviation (%RSD) and percent difference (%D) are the two major parameters used to measure the effectiveness of instrument calibration. %RSD is an expression of the linearity of instrument response. %D is a comparison of a continuing calibration instrumental response with its initial response. %RSD and %D exceedances suggest more routine instrumental anomalies, which typically impact all sample results for the affected compounds.

Six results were qualified detected estimated (J) and non-detected estimated (UJ). The relative standard deviations in the initial calibrations and/or percent difference between the initial calibration and the continuing calibration concentrations for Aroclor 1016, Aroclor 1221, and Aroclor 1232 were outside the acceptance criteria of 20 and 15 percent, respectively. The affected samples are identified in the data validation reports.

3.1.2 Surrogates

No data were qualified based on surrogate recovery nonconformances. In cases where individual recoveries exceeded criteria, the QC exceedance was judged to have no impact on the data quality and no qualifications were made.

3.1.3 MS/MSD Samples

No data were qualified based on MS/MSD nonconformances. For those SDGs with MS/MSD results, the recoveries were evaluated against the acceptance criteria. In cases where recoveries exceeded criteria, the QC exceedance was judged to have no impact on the data quality and no qualifications were made.

3.1.4 LCS Samples

No data were qualified based on LCS nonconformances. For those SDGs with LCS results, the recoveries were evaluated against the acceptance criteria.

3.1.5 Field Duplicate Samples

The field duplicate samples were evaluated for acceptable precision with RPDs for the compounds. The associated data validation narratives provided details regarding criteria exceeded. Sample data were not qualified on the basis of field duplicate precision.

3.1.6 Proficiency Testing Samples

Proficiency testing samples were not performed for the sampling event.

3.1.7 Compound Quantitation and Target Identification

Due to compound quantitation nonconformances (i.e., %Ds between columns), one Aroclor 1260 result in sample BA245 was qualified as detected estimated (J). The details regarding the qualification of results are provided in the data validation reports.

All target compound identifications were found to be acceptable.

3.2 REPRESENTATIVENESS

3.2.1 Holding Times

The evaluation of holding times to verify compliance with the method was conducted. All holding times were met.

3.2.2 Blanks

As previously discussed in Section 2.2.2, method blanks were analyzed to evaluate representativeness.

3.2.2.1 METHOD BLANKS

No QC issues were associated with the method blanks for this analysis.

3.3 COMPARABILITY

The laboratory used standard analytical methods for all of the analyses. In all cases, the method detection limits attained were at or below the reporting limit. Target compounds detected below the reporting limits flagged (J) by the laboratory should be considered estimated. The comparability of the data is regarded as acceptable.

3.4 COMPLETENESS

The completeness level attained for PCB field samples was 100 percent. This percentage was calculated as the total number of accepted sample results divided by the total number of sample results multiplied by 100.

3.5 SENSITIVITY

The calibration was evaluated for instrument sensitivity and was determined to be technically acceptable. All laboratory LODs and LOQs met the project requirements described in the work plan.

4. Metals

A total of 48 soil samples were analyzed for metals by EPA SW-846 Method 6010B/6020/7471A. All metals data were assessed to be valid since none of the 465 total results were rejected based on QC exceedances. This section discusses the QA/QC supporting documentation as defined by the PARCC criteria and evaluated based on the PQOs.

4.1 PRECISION AND ACCURACY

4.1.1 Instrument Calibration

Initial and continuing calibration verification results provide a means of evaluating accuracy within a particular SDG. Correlation coefficient (r) and percent recovery (%R) are the two major parameters used to measure the effectiveness of instrument calibration. The correlation coefficient indicates the linearity of the calibration curve. %R is used to verify the ongoing calibration acceptability of the analytical system. The most critical of the two calibration parameters, r, has the potential to affect data accuracy across a SDG when it is outside the acceptable QC limits. %R exceedances suggest more routine instrumental anomalies, which typically impact all sample results for the affected analytes.

The correlation coefficients in the initial calibrations and/or percent recoveries in the continuing calibration verifications were within the acceptance criteria of $\geq$ 0.995 and 90-110 percent, respectively.

4.1.2 MS Samples

As a result of non-compliant MS recoveries, 21 results were qualified as detected estimated (J) and non-detected estimated (UJ). The analytes affected were barium, cadmium, and chromium. The details regarding the qualification of results are provided in the data validation reports.

4.1.3 Duplicate (DUP) Samples

No data were qualified based on duplicate nonconformances. For those SDGs with DUP results, the relative percent differences/differences were evaluated against the acceptance criteria. In cases where

RPDs or differences exceeded criteria, the QC exceedance was judged to have no impact on the data quality and no qualifications were made.

4.1.4 LCS Samples

No data were qualified based on LCS nonconformances. For those SDGs with LCS results, the recoveries were evaluated against the acceptance criteria.

4.1.5 ICP Serial Dilution

No data were qualified based on ICP serial dilution nonconformances. All recoveries were evaluated against the acceptance criteria.

4.1.6 ICP Interference Check Sample

As a result of ICP interference check sample exceedances, 16 results were qualified as detected estimated (J) and non-detected estimated (UJ). The analytes affected were arsenic, cadmium, chromium, and silver. The details regarding the qualification of results are provided in the data validation reports.

4.1.7 Field Duplicate Samples

The field duplicate samples were evaluated for acceptable precision with RPDs for the analytes. The associated data validation narratives provided details regarding criteria exceeded. Sample data were not qualified on the basis of field duplicate precision.

4.1.8 Proficiency Testing Samples

Proficiency testing samples were not performed for the sampling event.

4.1.9 Sample Result Verification

All sample results were found to be acceptable.

4.2 REPRESENTATIVENESS

4.2.1 Holding Times

The evaluation of holding times to verify compliance with the method was conducted. All holding times were met.

4.2.2 Blanks

Method blanks were analyzed to evaluate representativeness. The concentration for an individual target compounds in any of the three types of QA/QC blanks were used for data qualification.

If contaminants were detected in a blank, corrective actions were made for the chemical analytical data during data validation. The corrective action consisted of amending the laboratory reported results for organic analytes based on the following criteria. The validation qualifier codes are described below.

- *Results Below or Above the LOQ:* If a sample result for the blank contaminant was less than the LOQ or greater than the sample LOQ and less 5× the method blank value or the highest applicable calibration blank value, the sample result for the blank contaminant was amended as a non-detect at the concentration reported in the sample results.

- *No Action:* If a sample result for the blank contaminant was greater than 5× the blank value, the result was not amended.

4.2.2.1 METHOD BLANKS

No QC issues were associated with the method blanks for this analysis.

4.3 COMPARABILITY

The laboratory used standard analytical methods for all of the analyses. In all cases, the method detection limits attained were at or below the reporting limit. Target analytes detected below the reporting limits flagged (J) by the laboratory should be considered estimated. The comparability of the data is regarded as acceptable.

4.4 COMPLETENESS

The completeness level attained for metal field samples was 100 percent. This percentage was calculated as the total number of accepted sample results divided by the total number of sample results multiplied by 100.

4.5 SENSITIVITY

The calibration was evaluated for instrument sensitivity and was determined to be technically acceptable. All laboratory LODs and LOQs met the project requirements described in the work plan.

5.0 Variances in Analytical Performance

The laboratory used standard analytical methods for all of the analyses throughout the project. No systematic variances in analytical performance were noted according to the laboratory SOW.

6.0 Summary of PARCC criteria

The validation reports present the PARCC results for all SDGs. Each PARCC criterion is discussed in detail in the following sections.

6.1 PRECISION AND ACCURACY

Precision and accuracy were evaluated using data quality indicators such as MS/MSD, LCS, and surrogates. The precision and accuracy of the data set were considered acceptable after integration of qualification of estimated results as specifically noted in the data validation reports.

6.2 REPRESENTATIVENESS

All samples for each method and matrix were evaluated for holding time compliance. All samples were associated with a method blank in each individual SDG. The representativeness of the project data is considered acceptable after qualification for blank contamination.

6.3 COMPARABILITY

Sampling frequency requirements were met in obtaining duplicates and necessary field blanks. The laboratory used standard analytical methods for their analyses. The analytical results were reported in correct standard units. Holding times, sample preservation, and sample integrity were within QC criteria. The overall comparability is considered acceptable.

6.4 COMPLETENESS

Of the 1591 total analytes reported, 17 of the sample results were rejected. The completeness for all SDGs is as follows:

Parameter/Method	Total Analytes	No. of Rejects	%Completeness
PAHs	986	17	98.3
PCBs	140	0	100
Metals	465	0	100
Total	**1,591**	**17**	**98.9**

The completeness percentage based on rejected data met the 90 percent DQO goal. A less quantifiable loss of data occurred in the application of blank qualifications.

6.5 SENSITIVITY

Sensitivity was achieved by the laboratory to support the DQOs. Calibration concentrations and reporting limits met the project requirements and low level PAH contamination in the method blanks did not affect sensitivity.

Table 1: Validation Sample Table, SDG 42300

Client ID #	Lab ID #	QC Type	Matrix	Date Collected	Mercury (7470A)	PAH (8270C-SIM)	PCBs (8082)
BA268	AP55206		soil	7-30-03	X		
BA269	AP55207		soil	7-30-03	X		
BA270	AP55208		soil	7-30-03	X		
BA271	AP55209		soil	7-30-03	X		
BA272	AP55210		soil	7-30-03	X		
BA273	AP55211		soil	7-30-03	X		
BA274	AP55212		soil	7-30-03	X		
BA275	AP55213		soil	7-30-03	X		
BA276	AP55214		soil	7-30-03	X		
BA277	AP55215		soil	7-30-03	X		
BA278	AP55216		soil	7-31-03	X		
BA279	AP55217		soil	7-31-03	X		
BA280	AP55218		soil	7-31-03	X		
BA281	AP55219		soil	7-31-03	X		
BA282	AP55220		soil	7-31-03	X		
BA283	AP55221		soil	7-31-03	X		
BA284	AP55222		soil	7-31-03	X		
BA285	AP55223		soil	7-31-03	X		
BA286	AP55224		soil	7-31-03	X		
BA287	AP55225		soil	7-31-03	X		
BA245	AP54789		soil	7-25-03			X
BA246	AP54790		soil	7-25-03			X
BA247	AP54791		soil	7-25-03			X
BA248	AP54792		soil	7-25-03			X
BA249	AP54793		soil	7-25-03			X
BA250	AP54794		soil	7-25-03			X
BA251	AP54795		soil	7-25-03			X
BA252	AP54796		soil	7-25-03			X
BA253	AP54797		soil	7-25-03			X
BA254	AP54798		soil	7-25-03			X
BA255	AP54799		soil	7-25-03			X
BA256	AP54800		soil	7-25-03			X
BA257	AP54801		soil	7-25-03			X
BA258	AP54802		soil	7-25-03			X
BA259	AP54803		soil	7-25-03			X
BA260	AP54804		soil	7-25-03			X
BA261	AP54805		soil	7-25-03			X
BA262	AP54806		soil	7-25-03			X
BA263	AP54807		soil	7-25-03			X
BA264	AP54808		soil	7-25-03			X
BA265	AP54809		soil	7-26-03		X	
BA265DL	AP54809DL	DL	soil	7-26-03		X	

Client ID #	Lab ID #	QC Type	Matrix	Date Collected	Mercury (7470A)	PAH (8270C-SIM)	PCBs (8082)
BA266	AP54810		soil	7-26-03		X	
BA266DL	AP54810DL	DL	soil	7-26-03		X	
BA266DL2	AP54810DL2	DL2	soil	7-26-03		X	
BA267	AP54811		soil	7-26-03		X	
BA245MS	AP54789MS	MS	soil	7-25-03			X

Level C and Level D Data Validation for GC/FID/ECD Volatile Organics and Fixed Gases in Soil Gas/Vapor by EPA Method TO-03 and ASTM D1946

1. Purpose

This data validation procedure sets forth the standard operating procedure for performance of Level C and Level D data validation of volatile organic and fixed gases data obtained under the United States (U.S.) Navy Environmental Restoration (ER) Program for Naval Facilities Engineering Command (NAVFAC), Pacific and is consistent with protocol in the *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories* (DoD QSM) (DoD 2013). Level B validation is addressed separately in Procedure II-A, *Data Validation*.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Responsibilities

The CTO Manager, the QA Manager or Technical Director, and the CTO QA Coordinator are responsible for ensuring that this procedure is implemented by data validation personnel.

Data validation personnel are responsible for implementing this procedure for validation of all gas chromatography with flame ionization detection or electron capture detection (GC/FID/ECD) volatile and fixed gases data.

4. Procedure

This procedure addresses the validation of volatile organic and fixed gases data obtained using U.S. Environmental Protection Agency (EPA) Method TO-03 (EPA 1999) and American Society for Testing and Materials (ASTM) D1946 (ASTM 2011). The quality control (QC) criteria identified in this procedure are those specified in the analytical method and the DoD QSM (DoD 2013). Where project specific criteria are identified in the CTO work plan, they will supersede the QC criteria identified in this procedure.

- Form I: Sample Results Summary Form

- Form II: Surrogate Recovery Summary Form
- Form III: Matrix Spike/Matrix Spike Duplicate or Blank Spike/Blank Spike Duplicate Recovery Summary Form
- Form IV: Method Blank Summary Form
- Form VI: Initial Calibration Summary Form
- Form VII: Continuing Calibration Summary Form
- Form VIII: Analytical Sequence Form

Level C data validation consists of review of summary forms only while Level D data validation requires review of both summary forms and all associated raw data. Data review guidelines and how they apply to the different validation levels are indicated in the following text.

4.1 SAMPLE MANAGEMENT

QA/QC criteria included under sample management are sample preservation, handling, and transport; chain of custody (COC); and holding times.

4.1.1 Sample Preservation, Handling, and Transport

Level C and Level D:

1. Evaluate sample collection, handling, transport, and laboratory receipt from chain of custody and laboratory receipt checklists to ensure that the samples have been properly preserved and handled.
2. The chain-of custody, laboratory traffic reports, and sample preparation logs will be reviewed to verify that tedlar bags and sorbent tubes were properly filled and canisters were properly pressurized and handled. Improper pressurization or analysis of an inappropriately pressurized sample by the laboratory may require that all results be reported as estimated (J) or unusable (R).

4.1.2 Chain of Custody

Level C and Level D:

Examine the COC form for legibility and check that all volatile and fixed gas analyses requested on the COC have been performed by the laboratory. Ensure that the COC Sample Number on the laboratory sample results form (Form I [or equivalent]) matches the Sample Identification on the COC. Read the laboratory case narrative for additional information.

1. Any samples received for analysis that were not analyzed shall be noted in the data validation report, along with the reason(s) for failure to analyze the samples, if the reason(s) can be determined. Conversely, samples that were analyzed for volatiles and fixed gases but were not requested should also be noted.
2. Any discrepancies in sample naming between the COC and Form I (or equivalent) form shall be noted in the data validation report with the correct sample name being identified if the correct sample name can be determined.

3. If the receiving laboratory transferred the samples to another laboratory for analysis, both the original COCs and transfer COCs shall be present. Document in the data validation report if the transfer COCs are not present.
4. Internal COC is required for all samples, extracts, and digestates from receipt to disposal. Verify the internal COC forms for completeness. Document in the data validation report if the internal COC forms are not present.

4.1.3 Holding Times

Level C and Level D:

Holding times for volatile organics and fixed gases are measured from the time of collection (as shown on the COC) to the time of sample analysis (as shown on the sample results form and instrument performance check summary form [Forms I and V (or equivalent)]). If canisters and sorbent tubes were used to collect the samples, all samples must be analyzed within 30 days of sample collection. If tedlar bags were used to collect the samples, all samples must be analyzed within 72 hours of sample collection.

1. If holding times are exceeded, flag positive results as estimated “J” and limits of detection (LODs) (nondetects) as estimated “UJ,” and document that holding times were exceeded.
2. If holding times are exceeded by more than a factor of 2 (e.g., air sample in a canister has a holding time of more than 60 days), detects will be qualified as estimated “J” and nondetects as unusable “R.”

4.2 INSTRUMENT PERFORMANCE

The objective is to ensure that the instrument condition is adequate for proper identification and quantification of the compounds of interest. The chromatographic resolution and the sensitivity should be evaluated from the chromatograms.

Level C:

Instrument performance is not evaluated for Level C validation.

Level D:

Evaluate blank, standard, sample, and QC chromatograms to ensure that the chromatographic resolution and the sensitivity are adequate. Any shift in baseline, negative peaks, or peak tailing/splitting shall be discussed in the data validation report. If the data quality has been affected by poor instrument performance, the data should be qualified using the reviewer’s professional judgment.

4.3 CALIBRATION

Compliance requirements for satisfactory instrument calibration are established to ensure that an instrument is capable of producing acceptable quantitative data. Initial calibration demonstrates that an instrument is capable of acceptable performance at the beginning of a sequence, and continuing calibration checks document satisfactory maintenance and adjustment of the instrument on a day-to-day basis.

4.3.1 Initial Calibration

The GC system can be calibrated using the external standard technique or internal standard technique. Because of the difficulty in selecting suitable internal standards, the external standard technique will often be the method of choice.

At the beginning of the analysis sequence, calibration standards must be run at three concentration levels for each parameter of interest to establish the calibration curve and expected retention time windows for the compounds of interest. One of the standards should be at a concentration at or just above the limit of quantitation (LOQ), and the other concentrations should correspond to the expected range of concentrations found in real samples or should define the working range of the detector.

Level C and Level D:

For the initial calibration (at least three-points), the relative standard deviation (RSD) of the calibration factor (CF) for each target compound must be less than or equal to 20 percent. Verify the RSDs from the initial calibration summary forms. Alternatively, a linear curve may be used with a coefficient of determination (r^2); r^2 equal to or greater than 0.990. A second order calibration curve may also be used after evaluating the laboratory's acceptance criteria. If the initial calibration criteria are not met, flag all associated quantitative results as estimated “J” for detects and estimated “UJ” for nondetects.

Level D:

Verify the percent RSDs (%RSDs), r^2, or laboratory established measure of linearity for the initial calibration from the raw data. Verify the CF for each target compound from the raw data on the low-point calibration standard and one additional calibration standard. If errors are discovered, request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.3.2 Initial Calibration Verification

The initial calibration curve must be verified with a standard that has been purchased or prepared from an independent source each time initial calibration is performed. A standard from the same manufacturer but independently prepared from different source materials may also be used as an independent source. This initial calibration verification (ICV) must contain all of the method target compounds.

Level C and Level D:

1. Verify the ICV was analyzed following the initial calibration and contained all method target compounds.
2. If any target analyte has a percent difference (%D) greater than 20 percent, flag detects for the affected compounds as estimated “J” and nondetects as estimated “UJ” in all samples associated with the initial calibration.

Level D:

Verify from the raw data that there were no calculation or transcription errors by recalculating a percentage of the ICV calculations.

4.3.3 Continuing Calibration

The working calibration curve or CF must be verified by the injection of a continuing calibration standard. A continuing calibration standard must also be analyzed after every 10 samples and at the end of the analysis sequence to ensure that system performance has not degraded. The initial calibration standard chosen for the continuing calibration standard shall be the mid-level standard or the standard with a contaminant concentration level that is potentially the most representative of contaminant concentrations in the next 10 samples.

Level C and Level D:

Verify the %Ds from the continuing calibration summary forms. The %D between the CF from the continuing calibration and the average CF from the initial calibration must be less than 20 percent. Alternatively, if a linear, (first-order) calibration curve is utilized in the initial calibration, the %D of the calculated amount and the true amount for each compound must be less than or equal to 20 percent. If the continuing calibration criteria are not met for both columns, qualify all associated results as estimated “J” for detects and estimated “UJ” for nondetects.

Level D:

Verify the %Ds from the raw data.

4.4 BLANKS

Method blank analytical results are assessed to determine the existence and magnitude of contamination problems. If problems with any method blank exist, all associated data must be carefully evaluated to determine whether there is any bias on the data, or if the problem is an isolated occurrence not affecting other data. No contaminants should be present in the method blank(s). The method blank should be analyzed on each GC system used to analyze site samples.

1. The reviewer should identify samples associated with each method blank using Form IV (or equivalent). Verify that method blank analysis has been reported per matrix and concentration level for each set of samples. Each sample must have an associated method blank. Qualify positive results in samples with no method blank as unusable “R.” Nondetects do not require qualification.
2. If the method blank was not analyzed on a GC used to analyze site samples, note the deficiency in the data validation report. Professional judgment shall be used for subsequent qualification of the data.
3. Compare the results of each method blank with the associated sample results. The reviewer should note that the blank analyses may not involve the same volumes or dilution factors as the associated samples. These factors must be taken into consideration when applying the 5× criteria discussed below, such that a comparison of the total amount of contamination is actually made.
4. If a compound is found in the blank, but not in the associated sample, no action is taken.
5. Any compound, detected in both the sample and the associated blank shall be qualified when the sample concentration is less than the LOQ and the blank concentration is less than, greater than, or equal to the LOQ. Care should be taken to factor in the percent moisture

when comparing detects in the sample and the method blank. The applicable review qualifier(s) are summarized in Table II-W-1.

Table II-W-1: Blank Qualifications

Sample Result	Sample Value	Reviewer Qualifier(s)
Less than LOQ and blank result is <, > or = LOQ	Leave as reported	U
≥LOQ, blank result is <LOQ	Leave as reported	None
≥LOQ, blank result is >LOQ and sample result <blank result	Leave as reported	Use professional judgment
≥LOQ, blank result is >LOQ and sample result ≥blank result	Leave as reported	Use professional judgment
≥LOQ and blank result is = LOQ	Leave as reported	Use professional judgment

6. In the case wherein both the sample concentration and the blank concentration are greater than or equal to the LOQ, previously approved criteria as identified in the project planning documents may be applied to qualify associated sample results. Otherwise, qualify sample results as non-detect “U” when the sample concentration is less than or equal to 5 times the blank concentration (5× rule).
7. Instances of contamination can be attributable to the dilution process. These occurrences are difficult to determine; however, the reviewers should qualify the sample data as nondetects, “U,” when the reviewer determines the contamination to be from a source other than the sample.
8. In the event of gross contamination (i.e., saturated peaks) in the blanks, the associated samples must be evaluated for gross contamination. If gross contamination exists in the samples, the affected compounds should be qualified as unusable, “R.”

Level D:

1. Verify from the preparation log that the information recorded on Form IV (or equivalent) is correct.
2. Review the results of all blank raw data and Form I (or equivalent) to ensure that there were no false negatives or false positives.
3. Verify all target compound detects found in the method blanks against the raw data. Follow the guidelines specified in Sections 4.9 and 4.10 of this procedure. After the validity of the target compounds are verified, validate the corresponding data using the criteria outlined above for Level C and Level D validation.

4.5 BLANK SPIKES AND LABORATORY CONTROL SAMPLES

Blank spikes or laboratory control samples (LCSs) are not required by Method TO-03 and ASTM D1946. However, if the laboratory analyzes blank spikes or LCSs, these procedures shall be followed:

Level C and Level D:

1. Blank spike/LCS recoveries must be within project-specific control limits. Use in-house limits if there are no project-specific limits.
2. If the blank spike/LCS results are 0 percent, only the spiked compounds that showed low recovery in all associated samples shall be flagged as unusable "R" for nondetects and estimated "J" for detects.
3. If blank spike/LCS results are below the control limits (but above 0 percent), spiked compounds which showed low recovery in all associated samples shall be flagged as estimated "UJ" or "J."
4. If blank spike/LCS results are above the control limits, detects for only the spiked compounds which showed high recovery in all associated samples shall be flagged as estimated "J."
5. If the laboratory analyzes a blank spike duplicate/LCS duplicate (LCSD), evaluate and qualify the LCSD results using the criteria noted above.
6. If the relative percent differences (RPDs) between LCS and LCSD results are above the control limits (use the matrix spike [MS]/matrix spike duplicate [MSD] RPD control limits identified in DoD QSM Appendix B [DoD 2013], if none are available use laboratory in-house limits), spiked compounds which showed high RPD in all associated samples shall be flagged as estimated "UJ" or "J."

Level D:

To verify that the spike percent recovery was calculated and reported correctly using the following equation, recalculate one spike recovery per matrix (and any spike that would result in the qualification of a sample).

$$\%\text{Recovery} = \frac{Q_d}{Q_a} \times 100$$

Where:

Q_d = Quantity determined by analysis

Q_a = Quantity added to samples/blanks

If transcription errors are discovered on Form III (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.6 SURROGATE RECOVERY

Surrogates are not required by Method TO-03 and ASTM D1946. However, if the laboratory spiked samples with surrogate compounds, these procedures shall be followed:

Level C and Level D:

Sample and blank surrogate recoveries for herbicides must be within the QC limits specified in the DoD QSM Appendix C (DoD 2013) unless project-specific control limits are established. Use in-house limits if surrogates are not listed in Appendix C or project limits are not specified. Verify that no samples or blanks have surrogates outside the criteria from Form II (or equivalent).

1. Sample and blank surrogate recoveries must be within project-specific control limits. Use in-house limits if there are no project-specific limits. Verify that no samples or blanks have surrogates outside the criteria from Form II (or equivalent).
2. If any surrogate recovery is below the QC limits for either one of the surrogates, but above or equal to 10 percent, flag associated positive results as estimated “J” and nondetects as “UJ.”
3. If any surrogate recovery is less than 10 percent, flag all nondetects as unusable “R” and detects as estimated “J.” No qualification is done if surrogates are diluted beyond detection but note in the data validation report that surrogate evaluation could not be performed due to the high dilution factor.
4. If any surrogate recovery is above the upper QC limit, flag associated positive results as estimated “J.” No qualification of nondetects is necessary in the case of high recoveries.
5. Surrogates may be reported as “diluted out” (D); if dilution is such that the surrogate can no longer be detected. If this is the case, note in the data validation report that surrogate evaluation could not be performed due to a high dilution factor. A full evaluation of the sample chromatogram may be necessary to determine that surrogates are truly “diluted out.”

Level D:

The reported surrogate recoveries on Form II should be verified from the raw data for a representative number of samples.

4.7 MATRIX SPIKE/MATRIX SPIKE DUPLICATE AND MATRIX DUPLICATE

MS/MSDs are not required by Method TO-03 and ASTM D1946.

Matrix duplicate (MD) data are used to determine the effect of the matrix on a method’s recovery efficiency and precision for a specific sample matrix. MD analyses are also performed to demonstrate acceptable method precision by the laboratory at the time of analysis.

Level C and Level D:

The laboratory must spike and analyze a MS/MSD from the specific project site as required for each matrix type and analytical batch.

1. MD data should be reported on a summary form similar to Form III (or equivalent).
2. Compare the RPD for each spiked compound with project-specific control limits. Use in-house limits if there are no project-specific limits.

3. If the sample results are greater than 5× the LOQ and the RPDs between sample and duplicate results are greater than the control limits, detects for only the spiked compounds which showed high RPD in the parent sample shall be flagged as estimated "J."

Level D:

Check the raw data and recalculate one or more RPDs, especially RPDs that resulted in the qualification of data, using the following equations to verify that results on Form III (or equivalent) are correct.

$$\text{RPD} = \frac{\text{ABS}|\text{SR} - \text{DR}|}{(\text{SR} + \text{DR})/2} \times 100$$

Where:

SR = sample result

DR = duplicate result

ABS = absolute value

If transcription errors are discovered on Form III (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.8 FIELD QC SAMPLES

Field QC samples discussed in this section of the procedures are ambient blanks, field blanks, and field duplicates.

4.8.1 Ambient Blanks and Field Blanks

An ambient blank is collected in the same type of container used for an environmental sample, kept with the sample containers before sample collection and opened at the site and exposed to the ambient conditions. Ambient levels of site contaminants are determined by the analysis of ambient blanks.

A field blank is a sample collected in the field from a certified air source. Compounds detected in field blanks indicate the possibility of cross-contamination between samples due to improper equipment decontamination.

If target compounds are detected in the ambient blanks and/or field blanks, the procedure for the qualification of associated sample results is identical to the criteria outlined in Section 4.4 of this procedure.

Level C and Level D:

1. Determine which field QC samples apply to samples in the sample delivery group.
2. Because of the way in which the field blanks and equipment blanks are sampled, equipment blanks are not qualified because of field blank contamination. The affected samples are qualified, however, by either the field blank or equipment blank results, whichever has the higher contaminant concentration.

3. Ambient blanks and field blanks are only qualified with method blank results in order to account for laboratory contamination.

Level D:

Compound identification and quantification of field blank and equipment blank samples must be verified. Follow the guidelines specified in Sections 4.9 and 4.10 of this procedure.

4.8.2 Field Duplicates

Field duplicates are samples collected in the field simultaneously. Field duplicates should be collected in separate sample containers at the same location and depth. Field duplicate results are an indication of both field and laboratory precision; the results may be used to evaluate the consistency of sampling practices.

Level C and Level D:

1. Check to ensure that field duplicates were collected and analyzed as specified in the project planning documents. If the sampling frequency is less than the frequency stated in the planning documents, no qualification of the associated sample results is necessary but the incident shall be discussed in the data validation report.
2. For field duplicate results, if the RPDs are greater than 100 percent or as stated in the planning document if more conservative, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.

Level D:

Before comparison of duplicates, the compound identification and quantification must be verified. Follow the guidelines specified in Sections 4.9 and 4.10 of this procedure.

4.9 TARGET COMPOUND IDENTIFICATION

Qualitative criteria for compound identification have been established to minimize the number of erroneous identifications of compounds. An erroneous identification can be either a false positive (reporting a compound present when it is not) or a false negative (not reporting a compound that is present).

The laboratory must report retention (RT) time window data for each compound on each column used to analyze the samples. The RT windows are used for qualitative identification. RTs of reported compounds must fall within the calculated window for both chromatographic columns. Second column confirmation must be performed for all GC work. Sample chromatograms for both columns must be provided.

Level C:

Target compound identification is not evaluated for Level C validation since it requires the interpretation of raw data.

Level D:

1. Verify from the raw data that the RT of the detected compound and the RT windows are correct.
2. Evaluate all sample chromatograms to ensure that there were no peaks present which were not reported (false negatives) or the reported detects did not meet identification criteria (false positives). Presence of a large interfering peak may result in false positives or false negatives. The reviewer should use professional judgment in evaluating the effect of interference.

4.10 COMPOUND QUANTITATION AND REPORTING LIMITS

The objective is to ensure that the reported quantitation results and reporting limits (i.e., LOQ, LOD, detection limit [DL]) are accurate. All soil sample results are reported on a dry weight basis.

Level C:

Specific compound quantitation is not verified for Level C validation.

Level C and Level D:

1. Verify that the RLs for nondetects are equal to the LODs. Verify that an annual DL study was performed or quarterly LOD/LOQ verification checks were performed in accordance with the DoD QSM (DoD 2013). The LOD/LOQ verification check must be evaluated to determine whether the laboratory can reliably detect and identify all target analytes at a spike concentration of approximately two times but not more than four times the current reported DL. Qualify nondetects as unusable "R."
2. Check that reported nondetects and positive values have been adjusted to reflect sample dilutions. When a sample is analyzed at more than one dilution, the lowest LODs are used unless a QC criterion has been exceeded. In this case, the higher LODs from the diluted analysis are used. The least technically sound data will be flagged "R" with a qualification code "D."
3. Verify that no results exceed the highest calibration standard without being diluted. If a result has exceeded the highest calibration standard, verify that a dilution was performed. If not, qualify the detected compound that required dilution as "J" and document the event in the data validation report.

Level D:

Compound quantification should be verified by recalculation from the raw data for a representative number of samples.

5. Records

A Form I that has been validated and verified, and has been determined by the data validator to accurately represent the appropriate sample results to be utilized, shall be stamped "NAVFAC PACIFIC VALIDATED." Additionally, sample result forms for which the data has been validated at the Level D validation level shall be stamped or noted "Level D."

Copies of all documents generated by the data validation personnel will be stored for no less than 10 years. The original validated laboratory data shall be archived to the Federal Records Center at project completion.

6. References

ASTM International (ASTM). 2011. *Standard Practice for Analysis of Reformed Gas by Gas Chromatography*. D1946-90(2011). West Conshohocken, PA.

Department of Defense, United States (DoD). 2005a. *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: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

———. 2005b. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B: Quality Assurance/quality Control Compendium: Minimum QA/QC Activities*. Final Version 1. DoD: DTIC ADA 426957, EPA-505-B-04-900B. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www2.epa.gov/sites/production/files/documents/qaqc_v1_0305.pdf.

———. 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2A: Optimized UFP-QAPP Worksheets*. Revision 1. March.

———. 2013. *Department of Defense Quality Systems Manual for Environmental Laboratories.* Version 5.0. Draft Final. Prepared by DoD Environmental Data Quality Workgroup and Department of Energy Consolidated Audit Program Operations Team. July.

Environmental Protection Agency, United States (EPA). 1999. *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air.* 2nd ed. EPA-625/R-96-010b. Center for Environmental Research Information. January.

———. 2007. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* 3rd ed., Revision 6. Office of Solid Waste. November. On-line updates at: http://www.epa.gov/epawaste/hazard/testmethods/sw846/online/index.htm.

Procedure II-A, *Data Validation*.

7. Attachments

None.

Level C and Level D Data Validation for GC/MS Volatile Organics and Fixed Gases in Soil Gas/Vapor by EPA Methods TO-14, TO-15, and TO-17

1. Purpose

This data validation procedure sets forth the standard operating procedure for performance of Level C and Level D data validation of volatile organic and fixed gases data obtained under the United States (U.S.) Navy Environmental Restoration (ER) Program for Naval Facilities Engineering Command (NAVFAC), Pacific and is consistent with protocol in the *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories* (DoD QSM) (DoD 2013). Cursory validation is addressed separately in Procedure II-A, *Data Validation*.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Responsibilities

The CTO Manager, the QA Manager or Technical Director, and the CTO QA Coordinator are responsible for ensuring that this procedure is implemented by data validation personnel.

Data validation personnel are responsible for implementing this procedure for validation of all gas chromatography/mass spectrometry (GC/MS) volatile and fixed gases data.

4. Procedure

This procedure addresses the validation of volatile organic and fixed gases data obtained using U.S. Environmental Protection Agency (EPA) Methods TO-15, TO-16, and TO-17 (EPA 1999). The quality control (QC) criteria identified in this procedure are those specified in the analytical method and the DoD QSM (DoD 2013). Where project specific criteria are identified in the CTO work plan, they will supersede the QC criteria identified in this procedure.

- Form I: Sample Results Summary Form
- Form II: Surrogate Recovery Summary Form

- Form III: Matrix Spike/Matrix Spike Duplicate or Blank Spike/Blank Spike Duplicate Recovery Summary Form
- Form IV: Method Blank Summary Form
- Form V: Instrument Performance Check Summary Form
- Form VI: Initial Calibration Summary Form
- Form VII: Continuing Calibration Summary Form
- Form VIII: Internal Standard Summary Form

Level C data validation consists of review of summary forms only, whereas Level D data validation requires review of both summary forms and all associated raw data. Data review guidelines and how they apply to the different validation levels are indicated in the following text.

4.1 SAMPLE MANAGEMENT

QA/QC criteria included under sample management are sample preservation, handling, and transport, chain of custody (COC), and holding times.

4.1.1 Sample Preservation, Handling, and Transport

Level C and Level D:

Evaluate sample collection, handling, transport, and laboratory receipt from chain of custody and laboratory receipt checklists to ensure that the samples have been properly preserved and handled.

1. The COC, laboratory traffic reports, and sample preparation logs will be reviewed to verify that tedlar bags and sorbent tubes were properly filled and canisters were properly pressurized and handled. Improper pressurization or analysis of an inappropriately pressurized sample by the laboratory may require that all results be reported as estimated (J) or unusable (R).
2. Sorbent tubes should be properly stored at <4 degrees Celsius in the field prior to use and in the laboratory prior to analysis. Document in the data validation report if storage temperature was not met.

4.1.2 Chain of Custody

Level C and Level D:

Examine the COC form for legibility and check that all volatile and fixed gas analyses requested on the COC have been performed by the laboratory. Ensure that the COC Sample Number on the laboratory sample results form (Form I [or equivalent]) matches the Sample Identification on the COC. Read the laboratory case narrative for additional information.

1. Any samples received for analysis that were not analyzed shall be noted in the data validation report, along with the reason(s) for failure to analyze the samples, if the reason(s) can be determined. Conversely, samples that were analyzed for volatiles and fixed gases but were not requested should also be noted.

2. Any discrepancies in sample naming between the COC and sample results form shall be noted in the data validation report with the correct sample name being identified if the correct sample name can be determined.
3. If the receiving laboratory transferred the samples to another laboratory for analysis, both the original COCs and transfer COCs shall be present. Document in the data validation report if the transfer COCs are not present.
4. Internal COC is required for all samples, extracts, and digestates from receipt to disposal. Verify the internal COC forms for completeness. Document in the data validation report if the internal COC forms are not present.

4.1.3 Holding Times

Level C and Level D:

Holding times for volatile organics and fixed gases are measured from the time of collection (as shown on the COC) to the time of sample analysis (as shown on the sample results form and instrument performance check summary form [Forms I and V (or equivalent)]). If canisters and sorbent tubes were used to collect the samples, all samples must be analyzed within 30 days of sample collection. If tedlar bags were used to collect the samples, all samples must be analyzed within 72 hours of sample collection.

1. If the holding time is exceeded, flag all associated positive results as estimated “J” and all associated limits of detection (LODs) (nondetects) as estimated “UJ,” and document that holding times were exceeded.
2. If holding times are grossly exceeded by greater than a factor of 2.0 (e.g., air sample in a canister has a holding time of more than 60 days), detects will be qualified as estimated "J" and nondetects as unusable “R.”

4.2 GC/MS INSTRUMENT PERFORMANCE CHECK

Level C and Level D:

GC/MS instrument performance checks (formerly referred to as tuning) are performed to ensure mass resolution, identification, and to some degree, sensitivity. These criteria are not sample specific. Conformance is determined using standard reference materials; therefore, these criteria should be met in all circumstances.

The analysis of the instrument performance check solution must be performed at the beginning of each 12-hour (24-hour for TO-15 and TO-17) period during which samples or standards are analyzed. The instrument performance check, bromofluorobenzene (BFB) for volatile analysis, must meet the ion abundance criteria given in Table II-X-1 and Table II-X-2.

Table II-X-1: Ion Abundance Criteria – BFB (TO-14)

m/z	Ion Abundance Criteria
50	15.0–40.0% of m/z 95
75	30.0–60.0% of m/z 95
95	Base peak, 100% relative abundance
96	5.0–9.0% of m/z 95

m/z	Ion Abundance Criteria
173	Less than 2.0% of m/z 174
174	Greater than 50.0% of m/z 95
175	5.0–9.0% of m/z 174
176	Greater than 95.0% but less than 101.0% of m/z 174
177	5.0–9.0% of m/z 176

%	percent
m/z	mass-to-charge ratio

Table II-X-2: Ion Abundance Criteria – BFB (TO-15 and TO-17)

m/z	Ion Abundance Criteria
50	8.0–40.0% of m/z 95
75	30.0–66.0% of m/z 95
95	Base peak, 100% relative abundance
96	5.0–9.0% of m/z 95
173	Less than 2.0% of m/z 174
174	50.0–120% of m/z 95
175	4.0–9.0% of m/z 174
176	93.0–101% of m/z 174
177	5.0–9.0% of m/z 176

Check that all sample runs are associated with an injection. Make certain that a BFB performance check is present for each 12-hour or 24-hour period samples are analyzed (Form V [or equivalent]). Verify that all samples were analyzed within 12 hours or 24 hours of BFB injection.

If ion abundance criteria are not met, professional judgment may be applied to determine to what extent the data may be utilized. The most important factors to consider are the empirical results that are relatively insensitive to location on the chromatographic profile and type of instrumentation; therefore, the critical ion abundance criteria for BFB are the mass-to-charge ratio (m/z) 95/96, 174/175, 174/176, and 176/177 ratios. The relative abundance of m/z 50 and 75 are of lesser importance. Use professional judgment when samples are analyzed beyond the 12-hour or 24-hour time limit.

Decisions to use analytical data associated with BFB instrument performance checks not meeting requirements should be noted in the data validation report.

Level D:

Verify by recalculating from the quantitation reports, mass spectra, and chromatograms that the mass assignment is correct and that the mass listing is normalized to the specified m/z. If transcription errors are discovered on the Form V (or equivalent), request a resubmittal from the laboratory. Validate the data using the criteria outlined above.

4.3 CALIBRATION

Compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable qualitative and quantitative data for compounds on the target compound list.

4.3.1 Initial Calibration

Initial calibration demonstrates that the instrument is capable of acceptable performance in the beginning of the analytical run and of producing an acceptable calibration curve.

Level C and Level D:

1. Evaluate the average relative response factors (RRFs) for all target compounds by checking Form VI (or equivalent).
2. Check Form VI (or equivalent) and evaluate the percent relative standard deviation (%RSD) for all target compounds. If any target compound has a %RSD of greater than 30 percent, flag detects for the affected compounds as "J" and nondetects as "UJ" in the associated samples that correspond to that initial calibration.

Level D:

1. Verify the files reported on Form VI (or equivalent) against the quantitation reports, mass spectra, and chromatograms. If the files do not match, the RRFs reported are likely to be from another initial calibration and will have to be changed. Request a resubmittal from the laboratory.
2. Recalculate the average RRFs and %RSDs reported on Form VI (or equivalent) for one compound per internal standard, (preferably compounds which were identified in the samples) on the low-point calibration standard and one additional calibration standard. If errors are discovered, request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.3.2 Initial Calibration Verification

The initial calibration curve must be verified with a standard that has been purchased or prepared from an independent source each time initial calibration is performed. A standard from the same manufacturer but independently prepared from different source materials may also be used as an independent source. This initial calibration verification (ICV) must contain all of the method target compounds.

Level C and Level D:

1. Verify the ICV was analyzed following the initial calibration and contained all method target compounds.
2. If any target compound has a percent difference (%D) greater than 30 percent, flag detects for the affected compounds as estimated "J" and nondetects as estimated "UJ" in all samples associated with the initial calibration.

Level D:

Verify from the raw data that there were no calculation or transcription errors by recalculating a percentage of the ICV calculations.

4.3.3 Continuing Calibration

Compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable qualitative and quantitative data. Continuing calibration establishes the 12-hour or 24-hour relative response factors on which the quantitations are based and checks satisfactory performance of the instrument on a day-to-day basis.

Level C and Level D:

1. Continuing calibration standards containing both target compounds and system monitoring compounds must be analyzed every 12 hours or 24 hours during operation. Evaluate the continuing RRFs on Form VII (or equivalent).
2. Ensure that the average RRFs reported on Form VII (or equivalent) correspond to the average RRFs reported on Form VI (or equivalent) for the corresponding initial calibration.
3. If any target compound has a %D between the initial calibration average RRF and continuing calibration RRFs outside 30 percent, flag all detects as "J" and all nondetects as "UJ" in all associated samples that correspond to that continuing calibration.

Level D:

1. Verify the file reported on Form VII (or equivalent) against the raw data for the continuing calibration. If the file does not match, the RRFs reported are likely to be from another continuing calibration and will have to be changed. Request a resubmittal from the laboratory.
2. Recalculate the reported RRFs and %Ds reported on Form VII (or equivalent) for one compound per internal standard. If errors are discovered, request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.4 BLANKS

4.4.1 Method Blanks

Method blank analytical results are assessed to determine the existence and magnitude of contamination problems. If problems with any method blank exist, all associated data must be carefully evaluated to determine whether there is any bias associated with the data, or if the problem is an isolated occurrence not affecting other data. Results may not be corrected by subtracting any blank values.

Level C and Level D:

1. The reviewer should identify samples associated with each method blank using Form IV (or equivalent). Verify that method blank analysis has been reported per matrix and concentration level for each 12-hour or 24-hour time period on each GC/MS system used to analyze volatile and fixed gas samples. Each sample must have an associated method blank. Qualify positive results in samples with no method blank as unusable "R." Nondetects do not require qualification.

2. Compare the results of each method blank with the associated sample results. The reviewer should note that the blank analyses may not involve the same volumes or dilution factors as the associated samples. These factors must be taken into consideration when applying the criteria discussed below, such that a comparison of the total amount of contamination is actually made.
3. If a compound is found in the blank, but not in the associated sample, no action is taken.
4. Any compound, other than those listed in Table II-X-3, detected in both the sample and the associated blank shall be qualified when the sample concentration is less than the limit of quantitation (LOQ) and the blank concentration is less than, greater than, or equal to the LOQ. Compounds listed in Table II-X-3 shall be qualified when the sample concentration is less than two times (2×) the LOQ and the blank concentration is less than, greater than, or equal to 2× LOQ. Care should be taken to factor in the percent moisture when comparing detects in the sample and the method blank. The applicable review qualifier(s) are summarized in Table II-X-4.

Table II-X-3: Common Laboratory Contaminants

1. Methylene chloride
2. Acetone
3. 2-Butanone

Table II-X-4: Blank Qualifications

Sample Result	Sample Value	Reviewer Qualifier(s)
Less than LOQ* and blank result is <, > or = LOQ*	Leave as reported	U
≥LOQ*, blank result is <LOQ*	Leave as reported	None
≥LOQ*, blank result is >LOQ* and sample result <blank result	Leave as reported	Use professional judgment
≥LOQ*, blank result is >LOQ* and sample result ≥blank result	Leave as reported	Use professional judgment
≥LOQ* and blank result is = LOQ*	Leave as reported	Use professional judgment

*2× LOQ for common laboratory contaminants

5. In the case wherein both the sample concentration and the blank concentration are greater than or equal to the LOQ, previously approved criteria as identified in the project planning documents may be applied to qualify associated sample results. Otherwise, qualify sample results as non-detect “U” when the sample concentration is less than or equal to 10 times the blank concentration (10× rule) for the compounds listed in Table II-X-3 and tentatively identified compounds (TICs). For all other compounds, qualify sample results as non-detect “U” when the sample concentration is less than or equal to 5 times the blank concentration (5× rule).
6. If gross contamination exists in the blanks (i.e., saturated peaks by GC/MS), all compounds affected shall be flagged as unusable “R” due to interference in all samples affected and this shall be noted in the data validation comments.
7. If target compounds other than common laboratory contaminants are found at low levels in the blank(s), it may be indicative of a problem at the laboratory and shall be noted in the data validation report.

8. Additionally, there may be instances where little or no contamination was present in the associated blanks, but qualification of the sample was deemed necessary. Contamination introduced through dilution is one example. Although it is not always possible to determine, instances of this occurring can be detected when contaminants are found in the diluted sample result, but are absent in the undiluted sample result. It may be impossible to verify this source of contamination; however, if the reviewer determines that the contamination is from a source other than the sample, the data should be qualified. The sample value shall be reported as a nondetect and the reason shall be documented in the data validation report. Qualification of the data will be performed as given in Table II-X-4.

Level D:

1. Verify all target compound and TIC detects found in the method blanks against the raw data.
2. Verify that the target compound detects have valid spectra, as defined in Section 4.10 and the tentative identity of any TICs against the raw data, as defined in Section 4.12. If the spectra are not valid or the tentative identity is in error, request for a corrected Form I for the method blank from the laboratory.
3. Verify detected concentrations of target compounds and TICs from the raw data, as defined in Section 4.11. After the validity of the target compounds and TICs is verified, validate the corresponding data using the criteria outlined above.

4.4.2 Canister Blanks

All canisters must be clean and free of any contaminants before sample collection. Each sample must have an associated canister blank. Verify that canister blank analysis has been reported per canister. Canister blank analysis results are assessed to determine the existence and magnitude of contamination problems. The reviewer should refer to the COC to identify samples associated with each canister blank.

1. If target compounds are detected in the canister blanks, the procedure for the qualification of associated sample results is identical to the criteria outlined in Section 4.4.1 of this procedure.
4. The reviewer, using professional judgment, may qualify detected result in samples with no associated canister blank data as estimated (J).

4.5 BLANK SPIKES AND LABORATORY CONTROL SAMPLES

Blank spikes or laboratory control samples (LCSs) are not required by Methods TO-14, TO-15, and TO-17 (EPA 1999). However, if the laboratory analyzes blank spikes or LCSs, these procedures shall be followed:

Level C and Level D:

1. Blank spike/LCS recoveries must be within project-specific control limits. Use in-house limits if there are no project-specific limits.
2. If the blank spike/LCS results are 0 percent, only the spiked compounds that showed low recovery in all associated samples shall be flagged as unusable "R" for nondetects and estimated "J" for detects.

3. If blank spike/LCS results are below the control limits (but above 0 percent), spiked compounds which showed low recovery in all associated samples shall be flagged as estimated "UJ" or "J."
4. If blank spike/LCS results are above the control limits, detects for only the spiked compounds which showed high recovery in all associated samples shall be flagged as estimated "J."
5. If the laboratory analyzes a blank spike duplicate/LCS duplicate (LCSD), evaluate and qualify the LCSD results using the criteria noted above.
6. If the relative percent differences (RPDs) between LCS and LCSD results are above the control limits (use the matrix spike [MS]/matrix spike duplicate [MSD] RPD control limits identified in DoD QSM Appendix B [DoD 2013], if none are available use laboratory in-house limits), spiked compounds which showed high RPD in all associated samples shall be flagged as estimated "UJ" or "J."

Level D:

To check that the spike percent recovery was calculated and reported correctly using the following equation, recalculate one or more spike recoveries per matrix (and any spike that would result in the qualification of a sample).

$$\%\text{Recovery} = \frac{Q_D}{Q_A} \times 100$$

Where:

Q_D = Quantity determined by analysis

Q_A = Quantity added to samples/blanks

If transcription errors are discovered on Form III (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.6 SYSTEM MONITORING COMPOUNDS (SURROGATE SPIKES)

Surrogates are not required by Methods TO-14, TO-15, and TO-17 (EPA 1999). However, if the laboratory spiked samples with surrogate compounds, these procedures shall be followed:

Level C and Level D:

1. Sample and blank surrogate recoveries must be within project-specific control limits. Use in-house limits if there are no project-specific limits. Verify that no samples or blanks have surrogates outside the criteria from Form II (or equivalent).
2. If any surrogate recovery is below the QC limits for either one of the surrogates, but above or equal to 10 percent, flag associated positive results as estimated "J" and nondetects as "UJ."
3. If any surrogate recovery is less than 10 percent, flag all nondetects as unusable "R" and detects as estimated "J." No qualification is done if surrogates are diluted beyond detection

but note in the data validation report that surrogate evaluation could not be performed due to the high dilution factor.

4. If any surrogate recovery is above the upper QC limit, flag associated positive results as estimated "J." No qualification of nondetects is necessary in the case of high recoveries.
5. Surrogates may be reported as "diluted out" (D), if dilution is such that the surrogate can no longer be detected. If this is the case, note in the data validation report that surrogate evaluation could not be performed due to a high dilution factor. A full evaluation of the sample chromatogram and quantitation report may be necessary to determine that surrogates are truly "diluted out."

Level D:

To verify that the surrogate percent recovery was calculated and reported correctly using the following equation, recalculate all surrogate recoveries per matrix (and any surrogate that would result in the qualification of a sample).

$$\%\text{Recovery} = \frac{Q_D}{Q_A} \times 100$$

Where:

Q_D = Quantity determined by analysis

Q_A = Quantity added to samples/blanks

If transcription errors are discovered on Form II (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.7 MATRIX SPIKE/MATRIX SPIKE DUPLICATE AND MATRIX DUPLICATE

MS/MSDs are not required by Methods TO-14, TO-15, and TO-17.

Matrix duplicate (MD) data are used to determine the effect of the matrix on a method's recovery efficiency and precision for a specific sample matrix. MD analyses are also performed to demonstrate acceptable method precision by the laboratory at the time of analysis.

Level C and Level D:

1. MD data should be reported on a summary form similar to Form III (or equivalent).
2. Compare the RPD for each spiked compound with project-specific control limits. Use in-house limits if there are no project-specific limits.
3. If the sample results are greater than 5× the LOQ and the RPDs between sample and duplicate results are greater than the control limits, detects for only the spiked compounds which showed high RPD in the parent sample shall be flagged as estimated "J."

Level D:

Check the raw data and recalculate one or more RPDs, especially RPDs that resulted in the qualification of data, using the following equations to verify that results on Form III (or equivalent) are correct.

$$\text{RPD} = \frac{\text{ABS}|\text{SR} - \text{DR}|}{(\text{SR} + \text{DR})/2} \times 100$$

Where:

SR = sample result

DR = spiked duplicate result

ABS = absolute value

If transcription errors are discovered on Form III (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.8 FIELD QC SAMPLES

Field QC samples discussed in this section of this procedure are ambient blanks, field blanks, and field duplicates.

4.8.1 Ambient Blanks and Field Blanks

An ambient blank is collected in the same type of container used for an environmental sample, kept with the sample containers before sample collection and opened at the site and exposed to the ambient conditions. Ambient levels of site contaminants are determined by the analysis of ambient blanks.

A field blank is a sample collected in the field from a certified air source. Compounds detected in field blanks indicate the possibility of cross-contamination between samples due to improper equipment decontamination.

If target compounds are detected in the ambient blanks and/or field blanks, the procedure for the qualification of associated sample results is identical to the criteria outlined in Section 4.4.1 of this procedure.

Level C and Level D:

1. Determine which field QC samples apply to samples in the sample delivery group (SDG).
2. Because of the way in which the field blanks and equipment blanks are sampled, equipment blanks are not qualified because of field blank contamination. The affected samples are qualified, however, by either the field blank or equipment blank results, whichever has the higher contaminant concentration.
3. Ambient blanks and field blanks are only qualified with method blank results in order to account for laboratory contamination.

Level D:

1. Verify all target compound and TIC detects found in the ambient blanks and field blanks against the raw data.
2. Verify that the target compound detects have valid spectra, as defined in Section 4.10 and the tentative identity of any TICs against the raw data, as defined in Section 4.12. If the spectra are not valid, or if the tentative identity is in error, request for a corrected Form I (or equivalent) for the equipment blank or field blank from the laboratory.
3. Verify detected concentrations of target compounds and TICs from the raw data, as defined in Section 4.11. After the validity of the target compounds and TICs is verified, validate the corresponding data using the criteria outlined above.

4.8.2 Field Duplicates

Field duplicates are samples collected in the field simultaneously. Field duplicates should be collected in separate sample containers at the same location and depth. Field duplicate results are an indication of both field and laboratory precision; the results may be used to evaluate the consistency of sampling practices.

Level C and Level D:

1. Check to ensure that field duplicates were collected and analyzed as specified in the project planning documents. If the sampling frequency is less than the frequency stated in the planning documents, no qualification of the associated sample results is necessary but the incident shall be discussed in the data validation report.
2. For field duplicate results, if the RPDs are greater than 100 percent or as stated in the planning document if more conservative, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.

Level D:

1. Verify all target compound and TIC detects found in the field duplicates against the raw data.
2. Verify that the target compound detects have valid spectra, as defined in Section 4.10 and the tentative identity of any TICs against the raw data, as defined in Section 4.12. If the spectra are not valid, or if the tentative identity is in error, request for a corrected Form I for the field duplicates from the laboratory.
3. Verify detected concentrations of target compounds and TICs from the raw data, as defined in Section 4.11. After the validity of the target compounds and TICs is verified, validate the corresponding data using the criteria outlined above.

4.9 INTERNAL STANDARDS PERFORMANCE

Internal standards performance criteria ensure that GC/MS sensitivity and response are stable during every analytical run.

Level C and Level D:

1. If an internal standards area count for a sample is outside –50 percent or +100 percent of the area for the initial calibration midpoint standard:
   a. Positive results for compounds quantitated using an internal standards area count greater than 100 percent should be qualified as estimated "J." Nondetected compounds should not be qualified.
   b. Compounds quantitated using an internal standards area count less than 50 percent should be qualified as estimated "J" for detects and estimated "UJ" for nondetects.
   c. If extremely low area counts are reported (less than 20 percent of the area for associated standards), detected compounds should be qualified as estimated "J" and nondetected target compounds should then be qualified as unusable "R."
2. If an internal standards retention time varies by more than 20 seconds from the retention time of the initial calibration midpoint standard, the nondetected target compounds should be qualified as unusable "R" at Level C validation. A Level D validation examination of the raw data should be recommended to the CTO Manager. The chromatographic profile for that sample must be examined to determine if any false positives or negatives exist. For shifts of a large magnitude, the reviewer may consider partial or total rejection of the data for that sample fraction. Positive results should be qualified as "NJ" if the mass spectral criteria are met.

Level D:

Verify the internal standard areas reported on Form VIII (or equivalent) from the raw data for at least one sample per SDG, and verify internal standard areas for samples that were qualified due to out-of-control internal standard areas. If errors are discovered between the raw data and the Form VIII (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.10 TARGET COMPOUND IDENTIFICATION

The objective of the criteria for GC/MS qualitative analysis is to minimize the number of erroneous identifications of target compounds. An erroneous identification can either be false positive (reporting a compound present when it is not) or a false negative (not reporting a compound that is present).

The identification criteria can be applied more easily in detecting false positives than false negatives. More information is available for false positives due to the requirement for submittal of data supporting positive identifications. However, negatives, or nondetected compounds represent an absence of data and are therefore more difficult to assess. One example of detecting false negatives is the not reporting of a target compound that is reported as a TIC.

Level C:

Target compound identification is not evaluated for Level C validation since it requires the interpretation of mass spectral raw data.

Level D:

The following criteria should be followed when evaluating raw data.

1. The relative retention times (RRTs) must be within ± 0.06 RRT units of the standard RRT.
2. Mass spectra of the sample compound and a current laboratory-generated standard (i.e., the mass spectrum from the associated calibration standard) must match according to the following criteria:
    a. All ions present in the standard mass spectrum at a relative intensity greater than 10 percent must be present in the sample spectrum.
    b. The relative intensities of these ions must agree within ± 20 percent between the standard and sample spectra. (Example: For an ion with an abundance of 50 percent in the standard spectrum, the corresponding sample ion abundance must be between 30 percent and 70 percent.)
    c. Ions present at greater than 10 percent in the sample mass spectrum, but not present in the standard spectrum, must be considered and accounted for.
    d. The application of qualitative criteria for GC/MS analysis of target compounds requires professional judgment. It is up to the reviewer's discretion to obtain additional information from the laboratory and CTO Manager. If it is determined that incorrect identifications were made, all such data should be qualified as not detected "U" or unusable "R."
    e. Professional judgment must be used to qualify the data if it is determined that cross-contamination has occurred. Any changes made to the reported compounds or concerns regarding target compound identifications should be clearly indicated in the data validation report.

4.11 COMPOUND QUANTITATION AND REPORTING LIMITS

The objective is to ensure that the reported quantitation results and reporting limits (i.e., LOQ, LOD, decision level [DL]) are accurate. All soil sample results are reported on a dry weight basis.

Level C and Level D:

1. Verify that the reporting limits for nondetects are equal to the LODs. Verify that an annual DL study was performed or quarterly LOD/LOQ verification checks were performed in accordance with the DoD QSM (DoD 2013). The LOD verification check must be evaluated to determine whether the laboratory can reliably detect and identify all target analytes at a spike concentration of approximately two times but not more than four times the current reported DL. Qualify nondetects as unusable "R."
2. Check that reported nondetects and positive values have been adjusted to reflect sample dilutions. When a sample is analyzed at more than one dilution, the lowest LODs are used unless a QC criterion has been exceeded. In this case, the higher LODs from the diluted analysis are used. The least technically sound data will be flagged "R" with a qualification code "D."
3. Verify that no results exceed the highest calibration standard without being diluted. If a result has exceeded the highest calibration standard, verify that a dilution was performed. If

not, qualify the detected compound that required dilution as "J" and document the event in the data validation report.

Level D:

The compound quantitation must be evaluated for all detects by evaluating the raw data. Compound concentrations must be calculated based on the internal standards associated with that compound, as listed in the following equation. Quantitation must be based on the quantitation ion (m/z) specified in the analytical method for both the internal standards and target compounds. The compound quantitation must be based on the RRF from the appropriate ICAL standard.

Air

$$\mu g/m^3 = \frac{A_x \times I_s \times D_f \times MW \times Dw}{A_{is} \times ARRF \times Gas}$$

Where:

$\mu g/m^3$ = microgram per cubic meter

A_x = area of characteristic ion for compound being measured

I_s = amount of internal standard added (parts per billion)

D_f = dilution factor

MW = molecular weight of compound

Dw = density of water (1.44 gram/milliliter)

A_{is} = area of characteristic ion for the internal standard

Gas = gas constant at $25^{o}C$ (24.45 mole/liter)

ARRF = average relative response factor for compound being measured

If discrepancies are discovered in the quantitation, request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

4.12 TENTATIVELY IDENTIFIED COMPOUNDS

For each sample, the laboratory must conduct a mass spectral search of the spectral library and report the possible identity for up to 30 of the largest volatile fraction peaks that are not system monitoring compounds (surrogates), internal standards, or target compounds, but which have area or height greater than 10 percent of the area or height of the nearest internal standard. TIC results are reported for each sample on the Form I or equivalent.

Level C and Level D:

1. All TIC results should be qualified "NJ," tentatively identified with approximated concentrations.
2. The reviewer should be aware of common laboratory artifacts and their sources such as siloxane compounds, which indicate capillary column degradation, and CO2 which indicates a possible air leak in the system. These may be qualified as unusable "R."

3. If a target compound is identified as a TIC by non-target library search procedures, the reviewer should request that the laboratory recalculate the result using the proper quantitation ion.
4. TIC results that are not above the 10× level in the blank should be qualified as unusable, "R." (Dilutions and sample size must be taken into account when comparing the amounts present in blanks and samples.)
5. The reviewer may elect to report all similar compounds as a total (e.g., all alkanes may be summarized and reported as total hydrocarbons).

Level D:

Check each TIC for each sample using the following criteria.

1. Major ions (greater than 10 percent relative intensity) in the reference spectrum should be present in the sample spectrum.
2. The relative intensities of the major ions should agree within ± 20 percent between the sample and the reference spectra.
3. Molecular ions present in the reference spectrum should be present in the sample spectrum.
4. Ions present in the sample spectrum but not in the reference spectrum should be reviewed for possible background contamination, interference, or co-elution of additional TIC or target compounds.
5. When the above criteria are not met, but in the technical judgment of the data reviewer or mass spectral interpretation specialist, the identification is correct, the data validator may report the identification.
6. Since TIC library searches often yield several candidate compounds having a close matching score, all reasonable choices must be considered. The reviewer may use judgment to change the reported tentative identity.

5. Records

A Form I or equivalent that has been validated and verified, and has been determined by the data validator to accurately represent the appropriate sample results to be utilized, shall be stamped "NAVFAC PACIFIC VALIDATED." Additionally, sample result forms for which the data has been validated at the Level D validation level shall be stamped or noted "Level D."

Copies of all documents generated by the data validation personnel will be stored for no less than 10 years. The original validated laboratory data shall be archived to the Federal Records Center at project completion.

6. References

Department of Defense, United States (DoD). 2005a. *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: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

———. 2005b. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B: Quality Assurance/quality Control Compendium: Minimum QA/QC Activities*. Final Version 1. DoD: DTIC ADA 426957, EPA-505-B-04-900B. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www2.epa.gov/sites/production/files/documents/qaqc_v1_0305.pdf.

———. 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2A: Optimized UFP-QAPP Worksheets*. Revision 1. March.

———. 2013. *Department of Defense Quality Systems Manual for Environmental Laboratories.* Version 5.0. Draft Final. Prepared by DoD Environmental Data Quality Workgroup and Department of Energy Consolidated Audit Program Operations Team. July.

Environmental Protection Agency, United States (EPA). 1999. *Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air.* 2nd ed. EPA-625/R-96-010b. Center for Environmental Research Information. January.

———. 2007. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* 3rd ed., Revision 6. Office of Solid Waste. November. On-line updates at: http://www.epa.gov/epawaste/hazard/testmethods/sw846/online/index.htm.

Procedure II-A, *Data Validation*.

7. Attachments

None.

Laboratory QC Samples (Water, Soil)

1. Purpose

This section sets forth the standard operating procedure for identifying the number and type of laboratory quality control (QC) samples that will be analyzed during each contract task order (CTO) associated with the United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific. Laboratory QC analyses serve as a check on the precision and accuracy of analytical methods and instrumentation, and the potential contamination that might occur during laboratory sample preparation and analyses. Laboratory QC analyses include blank, surrogate, blank spike, laboratory control sample (LCS), and matrix spike (MS)/matrix spike duplicate (MSD) analyses. These laboratory QC analyses are discussed in general below.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 PRECISION

Precision is the degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves. Precision is usually expressed as a standard deviation, variance, or range, in either absolute or relative terms. Examples of QC measures for precision include laboratory duplicates, laboratory triplicates, and matrix spike/matrix spike duplicates.

3.2 ACCURACY

Accuracy is the degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias), components which are due to sampling and analytical operations. Examples of QC measures for accuracy include performance evaluation samples, matrix spikes, LCSs, and equipment blanks.

3.3 MATRIX

A specific type of medium (e.g., surface water, drinking water), in which the analyte of interest may be contained. Medium is a substance (e.g., air, water, soil), which serves as a carrier of the analytes of interest (EPA 2010).

3.4 METHOD BLANK

An analyte-free matrix (water, soil, etc.) subjected to the entire analytical process to demonstrate that the analytical system itself does not introduce contamination.

3.5 MATRIX SPIKE

A sample prepared by adding a known concentration of a target analyte to an aliquot of a specific homogenized environmental sample for which an independent estimate of the target analyte concentration is available. The MS is accompanied by an independent analysis of the unspiked aliquot of the environmental sample. Spiked samples are used to determine the effect of the matrix on a method's recovery efficiency.

3.6 LABORATORY CONTROL SAMPLES AND BLANK SPIKES

A sample of known composition prepared using reagent-free water or an inert solid that is spiked with analytes of interest at the midpoint of the calibration curve or at the level of concern. It is analyzed using the sample preparation, reagents, and analytical methods employed for regular samples.

3.7 SURROGATES

A pure substance with properties that mimic the analyte of interest (organics only). Surrogates are typically brominated, fluorinated, or isotopically labeled compounds unlikely to be found in environmental samples. These analytes are added to samples to evaluate analytical efficiency by measuring recovery.

3.8 INTERNAL STANDARDS

A pure substance added to both samples and laboratory standards at a known concentration with the purpose of providing a basis of comparison in the quantitation of analytes of interest. Internal standards are primarily used to increase the accuracy and precision of analytical methods where the primary source of variability is in sample preparation or sample injection on instrument.

4. Responsibilities

The prime contractor's QA Manager or Technical Director, as well as QC coordinators are responsible for ensuring that sample analytical activities during all CTOs are in compliance with this procedure.

The CTO QC Coordinators and the Laboratory Manager are responsible for identifying instances of non-compliance with this procedure and ensuring that future laboratory analytical activities are in compliance with it.

5. Procedures

Laboratory QC checks include all types of samples specified in the requested analytical methods, such as the analysis of laboratory blank, duplicate, and MS samples. QC requirements are specified in each analytical method and in Appendix B, *Quality Control Requirements*, and Appendix C, *Laboratory Control Sample (LCS) Control Limits and Requirements*, of the *Department of Defense Quality Systems Manual for Environmental Laboratories* Version 5.0 (or most current version)

(DoD QSM). Types of QC samples are discussed in general below. Detailed discussion and minimum QA/QC requirements are presented in the DoD QSM (DoD 2013).

A comprehensive discussion of the minimum number of laboratory QC samples can be found in the *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B, Quality Assurance/Quality Control Compendium: Minimum QA/QC Activities* (DoD 2005b). However, additional QA/QC samples may be necessary based on the project quality objectives. Information pertaining to laboratory QC samples shall be documented in Worksheet 28 Laboratory QC Samples Table of the project UFP QAPP-style planning document.

5.1 LABORATORY BLANKS

Laboratory blank samples are analyzed to assess the degree to which laboratory contamination by reagent or method preparation may have affected sample analytical results. At a minimum, one laboratory blank will be analyzed per matrix per analytical method for each batch of at most 20 samples. In evaluating the blank results, all blank data are reviewed to identify any compounds detected in the blanks. The laboratory shall be contacted to discuss detection of analytes in blank samples only in the event of unusual contamination, but not for common laboratory contaminants at low levels. The following compounds are considered to be common laboratory contaminants: acetone, methylene chloride, 2-butanone, and common phthalate esters. The data for samples analyzed during the same time period as the blank are then evaluated to identify the presence of any contaminants found in the blanks. The presence of the blank contaminants found in associated samples is then evaluated to avoid potential misinterpretation of actual sample constituents. Briefly, as discussed in the data validation procedures, any analyte detected above the LOQ in both the sample and the associated blank is qualified as not detected if the sample concentration is less than five times the blank concentration (5× rule). For common laboratory contaminants (methylene chloride, acetone, 2-butanone, and common phthalate esters), a 10× rule applies.

5.2 LABORATORY REPLICATES (DUPLICATES AND TRIPLICATES)

Replicates are analyzed to evaluate the reproducibility, or precision, of the analytical procedures for a given sample. A replicate is two (duplicates) or three (triplicates) representative portions taken from one homogeneous sample by the laboratory and analyzed in the same laboratory (DoD 2005a). One duplicate sample is analyzed for each batch of twenty samples analyzed in a given matrix. Lab triplicates are assigned by the field team and identified on the chain of custody. The identification of a sample for lab triplicate analysis is typically selected from one of the field triplicates to allow for the evaluation of total study error of the sampling and analysis process. Duplicate analyses are normally performed on sample portions analyzed for inorganic constituents. For organic analyses, duplicate analyses are performed on MS samples (Section 5.5 of this procedure).

5.3 SURROGATES

Surrogate compounds must be added to all samples, standards, and blanks for all organic chromatography methods except when the matrix precludes its use or when a surrogate is not available. Poor surrogate recovery may indicate a problem with the sample composition and shall be reported to the client whose sample produced the poor recovery. Surrogate compounds to be included for organic analysis are specified in each analytical method.

5.4 LABORATORY CONTROL SAMPLES AND BLANK SPIKES

LCSs are used to demonstrate that the laboratory process for sample preparation and analysis is under control.

Analytes selected for spiking of LCSs are usually the same compounds used to spike MS/MSD samples and are representative target compounds. Control limits for LCS recoveries are provided in Appendix C of DoD QSM. If no control limits for LCS recoveries are listed in Appendix C of the DoD QSM for a given analyte, the laboratory's in-house derived control limits should be used.

For wet chemistry methods, a single spike of an appropriate control for each method may be used for LCS analyses (i.e., cyanide, a control standard of sodium cyanide from a source other than that used for calibration may be spiked into water samples and analyzed with the water samples). LCSs should be analyzed at a frequency of one per batch of at most twenty samples analyzed of similar matrix.

5.5 MATRIX SPIKES/MATRIX SPIKE DUPLICATES

MS analyses are conducted by the laboratory to assess the accuracy of specific analytical methods and to provide information on the effect of the sample matrix on the analytical methodology. Spike analyses are performed by adding compounds of known concentration to a sample, an unspiked portion of which has previously been analyzed or is concurrently analyzed. The spiked analytes are representative target compounds for each analytical method performed. The spiked sample results are evaluated with the original sample results to evaluate any effects the matrix has on the analysis. One MS is analyzed for each batch of at most 20 samples of similar matrix. Since MS samples only provide information about the specific sample matrix used for the spike, MS analyses should be performed for each type of matrix collected.

For the MSD, a separate aliquot of the sample is separately spiked and analyzed. As discussed in Section 5.2, results of MSD analyses are expressed as a relative percent difference, which is calculated by dividing the difference in concentration between the MSD and the MS sample analyses by the arithmetic mean of their concentrations. One MSD analysis is required for at most each 20 samples of similar matrix.

Acceptance criteria for both the MS and the MSD are based on historic laboratory performance and are laboratory-specific. As a general rule, the acceptance criteria should be no more stringent than the LCS acceptance criteria.

It is important to note that the UFP QAPP Part 2B, QA/QC Compendium: Minimum QA/QC Activities (DoD 2005b) states that for organic analysis, MS and MSDs are not considered a minimum QC activity as long as surrogate spikes properly mimic the analytes of concern and can identify matrix effects. Project quality objectives should be evaluated to determine if organic MS/MSDs are useful for individual projects.

6. Records

Records of QC samples analyzed during ER Program CTO activities will be maintained on laboratory bench sheets, raw data sheets, in the laboratory computerized data system, and on QC summary forms, as requested. Analytical laboratories maintain records in accordance with their quality assurance manual (QAM) as part of performing environmental analytical work under DoD.

Records shall be maintained in accordance with the analytical laboratory subcontract agreement specifications or the laboratory-specific QAM, whichever is more stringent.

7. Health and Safety

Applicable to laboratory personnel only.

8. References

Department of Defense, United States (DoD). 2005a. *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: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

———. 2005b. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B: Quality Assurance/quality Control Compendium: Minimum QA/QC Activities*. Final Version 1. DoD: DTIC ADA 426957, EPA-505-B-04-900B. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/swerffrr/pdf/-qaqc_v1_0305.pdf.

———. 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2A: Optimized UFP-QAPP Worksheets*. Revision 1. March.

———. 2013. *Department of Defense Quality Systems Manual for Environmental Laboratories.* Version 5.0. Final. Prepared by DoD Environmental Data Quality Workgroup and Department of Energy Consolidated Audit Program Operations Team. July.

Environmental Protection Agency, United States (EPA). 2010. Environmental Monitoring and Assessment Program: QA Glossary. November 8. On-line updates available at: http://www.epa.gov/emfjulte/html/pubs/docs/resdocs/qa_terms.html#mm. Accessed 2015.

Procedure I-A-7, *Analytical Data Validation Planning and Coordination.*

9. Attachments

None.

Field QC Samples (Water, Soil)

1. Purpose

This standard operating procedure describes the number and types of field quality control (QC) samples that will be collected during United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific site field work.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the Contract Task Order (CTO) Manager and the Quality Assurance (QA) Manager or Technical Director, as well as QC coordinators responsible for compliance with the procedure. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 TRIP BLANK

Trip blanks are samples that originate from organic-free water (e.g., ASTM Type II water, high performance liquid chromatography grade water, etc.) prepared by the laboratory, shipped to the sampling site, and returned to the laboratory with samples to be analyzed for volatile organic compounds (VOCs). Trip blanks are analyzed to assess whether contamination was introduced during sample shipment (DoD 2005a). Trip blanks are prepared using the same sample container (typically a 40 ml VOA vial) as that used to collect field samples.

3.2 EQUIPMENT BLANK SAMPLES

An equipment blank (i.e., “decontamination rinsate,” or “equipment rinsate”) sample consists of a sample of water free of measurable contaminants poured over or through decontaminated field sampling equipment that is considered ready to collect or process an additional sample. Equipment blanks are to be collected from non-dedicated sampling equipment to assess the adequacy of the decontamination process.

3.3 FIELD BLANKS

A blank used to provide information about contaminants that may be introduced during sample collection, storage, and transport. It can also be a clean sample carried to the sampling site, exposed to sampling conditions, transported to the laboratory, and treated as an environmental sample.

3.4 FIELD DUPLICATE

A generic term for two field samples taken at the same time in approximately the same location is referred to as a field duplicate. The location of the duplicate (distance and direction from primary sample) should be specified in the project planning documents. They are intended to represent the same population and are taken through all steps of the analytical procedure in an identical manner and provide precision information for the data collection activity. There are two categories of field duplicate samples defined by the collection method: co-located field duplicates and subsample field duplicates. Co-located field duplicates are two or more independent samples collected from side-by-side locations at the same point in time and space so as to be considered identical. Co-located samples are collected from adjacent locations or liners (e.g., laterally or vertically, in separate containers), or water samples collected from the same well at the same time that have not been homogenized. Subsample field duplicates samples are obtained from one sample collection at one sample location.

3.5 FIELD REPLICATES

Two or more field replicates are used with incremental sampling approaches to statistically evaluate the sampling precision or error for each decision unit (DU). The location of the replicates (distance and direction from primary sample) and the number of DUs with replicates should be specified in the project planning documents. Increments for replicate samples are collected from completely separate locations (i.e., separate systematic random or stratified random grid). Triplicate samples (i.e., primary incremental sample plus two replicates) are required for incremental sampling and are more useful than just duplicates for statistical evaluation. The replicate samples are collected, prepared, and analyzed in the same manner as carried out for the primary sample.

3.6 TEMPERATURE INDICATORS (BLANKS)

A temperature indicator sample is often referred to as a temperature blank, but it is not analyzed nor does it measure introduced contamination. It may be a small sample bottle or VOA vial filled with distilled water that is placed in each shipping container to evaluate if samples were adequately cooled during sample shipment.

3.7 SOURCE WATER

Source water is water free from measurable contaminants that is used as the final decontamination rinse water.

4. Responsibilities

The prime contractor CTO Manager and QA Manager or Technical Director are responsible for ensuring that field QC samples are collected and analyzed according to this procedure. The CTO Manager is responsible for ensuring that all personnel involved in sampling or testing shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QC Coordinator is responsible for determining the QC sample requirements.

The Laboratory Manager is responsible for ensuring that field QC samples are analyzed according to the specifications of the project statement of work and the analytical methods used.

The Field Manager is responsible for ensuring that all project field staff follow these procedures.

Field sampling personnel are responsible for the implementation of this procedure.

5. Procedures

Field QC checks may include submission of trip blank, equipment blank, field blank, duplicate, triplicate, and temperature indicator (blank) samples to the laboratory. Types of field QC samples are discussed in general below. Table III-B-1 identifies the minimum frequency at which field QC samples should be collected, with the actual frequency to be determined by the individual project needs. For additional information on field QC frequency, see the State of Hawaii Department of Health 2009 *Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan*.

A comprehensive discussion of the minimum types and numbers of field QC samples can be found in the *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B, Quality Assurance/Quality Control Compendium: Minimum QA/QC Activities* (DoD 2005).

Table III-B-1: Field QC Samples per Sampling Event

	Minimum QC Sample Frequency	
Type of Sample	Metals	Organic
Trip blank (for volatiles only)	N/A	1/analytical method/cooler
Equipment blank	5%	5%
Field blank	1/decontamination water source/event [a]/for all analytes	
Field replicates [b]	10%	10%
Temperature Indicator (blank)	1/shipping container	

%	percent
N/A	not applicable

[a] A sampling event is considered to be from the time sampling personnel arrive at a site until they leave for more than a week. The use of controlled-lot source water makes one sample per lot, rather than per event, an option.

[b] To the extent practical, field replicates should be collected from the same locations as the samples designated for a laboratory matrix spike/matrix spike duplicate (organic analysis) where applicable, or from the sample used as a laboratory duplicate (inorganic analysis).

5.1 TRIP BLANKS

The laboratory prepares trip blanks using organic-free water, and then sends them to the field. The laboratory shall place trip blanks in sample coolers prior to transport to the site so that they accompany the samples throughout the sample collection/handling/transport process. Once prepared, trip blanks should not be opened until they reach the laboratory. One set of two 40-milliliter vials per volatile analysis forms a trip blank and accompanies each cooler containing samples to be analyzed for volatiles. Trip blanks are only analyzed for volatiles. Results of trip blank analyses are used to assess whether samples have been contaminated by volatiles during sample handling and transport to the laboratory.

Trip blanks are not typically associated with tissue samples; however, project-specific quality objectives shall determine if trip blanks for tissue samples are required.

5.2 EQUIPMENT BLANK SAMPLES

Collect equipment blank samples by pumping the source water over and/or through the decontaminated sampling equipment. Collect this runoff water into the sample containers directly or with the use of a funnel, if necessary. The source water may be pumped or poured by tipping the jug of water upside down over the equipment. Results of equipment blank samples are used to evaluate whether equipment decontamination was effective.

At a minimum, equipment blank samples should be collected at a rate of 5 percent of the total samples planned for collection for each sampling technique used. This rate may be adjusted depending on the nature of the investigation (site inspection, remedial investigation, remedial site evaluation, long-term monitoring) and the associated project quality objectives (PQOs). Equipment blank samples will be analyzed for the same parameters as the samples collected with that particular equipment. If analytes pertinent to the project are found in the equipment blanks, the frequency of equipment blank samples may be increased after decontamination procedures have been modified to further evaluate the effectiveness of the decontamination procedure.

When disposable or dedicated sampling equipment is used, equipment blank samples do not need to be collected.

Sampling devices (e.g., gloved hands, dip nets, or traps) used for collection of tissue samples are generally non-intrusive into the organisms collected, so equipment blank samples will not be collected as long as the devices have been properly cleaned following Procedure I-F, *Equipment Decontamination*, and appear clean.

5.3 FIELD BLANKS

Field blanks, consisting of samples of the source water used as the final decontamination rinse water, will be collected on site by field personnel by pouring the source water into sample containers and then analyzed to assess whether contaminants may have been introduced during sample collection, storage, and transport.

The final decontamination rinse water source (the field blank source water) and equipment blank source water should all be from the same purified water source. Tap water used for steam cleaning augers or used in the initial decontamination buckets need not be collected and analyzed as a field blank since augers typically do not touch the actual samples and the final decontamination rinse water should be from a purified source.

Field blanks should be collected at a minimum frequency of one per sampling event per each source of water. A sampling event is considered to be from the time sampling personnel arrive at a site until they leave for more than a week. Field blanks will be analyzed for the same parameters as the samples collected during the period that the water sources are being used for decontamination. Additional field blanks may be required based on PQOs.

5.4 FIELD DUPLICATES

Field duplicates consist of either co-located or subsampled samples. Field duplicates for ground water and surface water samples are generally considered to be co-located samples. Soil duplicate samples may be homogenized and subsampled in the field (or at the laboratory) to form an original and duplicate sample, or may be an additional volume of sample collected in a separate sample container to form a co-located sample.

The interpretation of co-located duplicate data may be more complex than subsample duplicate data because of the number of variables associated with the results of this type of duplicate sample. Duplicate soil samples for VOC analysis shall always be co-located (i.e., not homogenized or otherwise processed or subsampled). Duplicates will be analyzed for the same analytical parameters as their associated original sample. Collection of both co-located and subsampled versions of the same sample may be performed to aid in approximating sampling and analysis error.

Field duplicates for biological tissue samples will consist of subsamples of the original sample. Twice the required volume of organisms for one sample will be collected and placed into one food-grade, self-sealing bag. The sample will later be homogenized in the laboratory and subsampled, producing an original and a duplicate sample. Tissue duplicate samples will be analyzed for the same analytical parameters as their associated original samples.

5.5 FIELD REPLICATES

Field replicates are completely separate incremental replicate samples (collected from a set of systematic random or stratified random locations within the DU that are different from those used for the primary incremental samples). A different random starting location is determined for each replicate collected in the selected DU. Field replicates are typically collected in sets of three (the primary sample and two replicate samples) to produce a triplicate.

Replicate sample increments are collected from the same sampling grid established through the DU for the primary incremental sample, though at different systematic random locations than initially used. The replicate increments should not be collected from the same points or co-located with those used for the primary incremental sample. Replicate samples are sent to the laboratory as “blind” samples, meaning the laboratory does not know they represent replicate samples of the primary incremental sample.

5.6 TEMPERATURE INDICATORS (BLANKS)

Temperature indicators (blanks) may be prepared in the lab or field by filling a small sample bottle or VOA vial with distilled water and sealing the container. One temperature indicator sample should be placed in each sample cooler or shipping container. Upon arrival at the laboratory, the temperature of the bottle is measured to determine if samples were adequately cooled during the shipment.

6. Records

Records of QC samples analyzed during ER Program CTO activities will be maintained on laboratory bench sheets, raw data sheets, in the laboratory computerized data system, and on QC summary forms, as requested. Analytical laboratories maintain records in accordance with their quality assurance manual (QAM) as part of performing environmental analytical work under DoD. Records shall be maintained in accordance with the analytical laboratory subcontract agreement specifications or the laboratory-specific QAM, whichever is more stringent.

7. Health and Safety

Field personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

Department of Defense, United States (DoD). 2005a. *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: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

———. 2005b. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B: Quality Assurance/quality Control Compendium: Minimum QA/QC Activities*. Final Version 1. DoD: DTIC ADA 426957, EPA-505-B-04-900B. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/swerffrr/pdf/-qaqc_v1_0305.pdf.

———. 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2A: Optimized UFP-QAPP Worksheets*. Revision 1. March.

———. 2013. *Department of Defense Quality Systems Manual for Environmental Laboratories.* Version 5.0. Draft Final. Prepared by DoD Environmental Data Quality Workgroup and Department of Energy Consolidated Audit Program Operations Team. July.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual.* EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-F, *Equipment Decontamination*.

Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*.

9. Attachments

None.

Logbooks

1. Purpose

This standard operating procedure describes the activities and responsibilities pertaining to the identification, use, and control of logbooks and associated field data records for use by United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan Appendix A. Section 1.4 *Field Documentation SOPs* (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the Contract Task Order (CTO) Manager and the Quality Assurance Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 LOGBOOK

A logbook is a bound field notebook with consecutively numbered, water-repellent pages that is clearly identified with the name of the relevant activity, the person assigned responsibility for maintenance of the logbook, and the beginning and ending dates of the entries.

3.2 DATA FORM

A data form is a predetermined format used for recording field data that may become, by reference, a part of the logbook (e.g., soil boring logs, trenching logs, surface soil sampling logs, groundwater sample logs, and well construction logs are data forms).

4. Responsibilities

The prime contractor CTO Manager or delegate is responsible for determining which team members shall record information in field logbooks and for obtaining and maintaining control of the required logbooks. The CTO Manager shall review the field logbook on at least a monthly basis. The CTO Manager or designee is responsible for reviewing logbook entries to determine compliance with this procedure and to ensure that the entries meet the project requirements.

A knowledgeable individual such as the Field Manager, CTO Manager, or quality control (QC) Supervisor shall perform a technical review of each logbook at a frequency commensurate with the level of activity (weekly is suggested, or, at a minimum, monthly). Document these reviews by the dated signature of the reviewer on the last page or page immediately following the material reviewed.

The Field Manager is responsible for ensuring that all project field staff follow these procedures and that the logbook is completed properly and daily. The Field Manager is also responsible for submitting copies to the CTO Manager, who is responsible for filing them and submitting a copy to the Navy (if required by the CTO Statement of Work).

The logbook user is responsible for recording pertinent data into the logbook to satisfy project requirements and for attesting to the accuracy of the entries by dated signature. The logbook user is also responsible for safeguarding the logbook while having custody of it.

Field personnel are responsible for the implementation of this procedure.

All NAVFAC Pacific ER Program field personnel are responsible for complying with Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

5. Procedure

The field logbook serves as the primary record of field activities. Make entries chronologically and in sufficient detail to allow the writer or a knowledgeable reviewer to reconstruct the applicable events. Store the logbook in a clean location and use it only when outer gloves used for personal protective equipment (PPE) have been removed.

Individual data forms may be generated to provide systematic data collection documentation. Entries on these forms shall meet the same requirements as entries in the logbook and shall be referenced in the applicable logbook entry. Individual data forms shall reference the applicable logbook and page number. At a minimum, include names of all samples collected in the logbook even if they are recorded elsewhere.

Enter field descriptions and observations into the logbook, as described in Attachment III-D-1, using indelible black ink.

Typical information to be entered includes the following:

- Dates (month/day/year) and times (military) of all onsite activities and entries made in logbooks/forms
- Site name, and description
- Site location by longitude and latitude, if known
- Weather conditions, including estimated temperature and relative humidity
- Fieldwork documentation, including site entry and exit times
- Descriptions of, and rationale for, approved deviations from the work plan or field sampling plan
- Field instrumentation readings
- Names, job functions, and organizational affiliations of personnel on-site

- Photograph references
- Site sketches and diagrams made on-site
- Identification and description of sample morphology, collection locations and sample numbers as described in Procedure I-A-8, *Sample Naming*
- Sample collection information, including dates (month/day/year) and times (military) of sample collections, sample collection methods and devices, station location numbers, sample collection depths/heights, sample preservation information, sample pH (if applicable), analysis requested (analytical groups), etc., as well as chain-of-custody (COC) information such as sample identification numbers cross-referenced to COC sample numbers
- Sample naming convention
- Field QC sample information
- Site observations, field descriptions, equipment used, and field activities accomplished to reconstruct field operations
- Meeting information
- Important times and dates of telephone conversations, correspondence, or deliverables
- Field calculations
- PPE level
- Calibration records
- Contractor and subcontractor information (address, names of personnel, job functions, organizational affiliations, contract number, contract name, and work assignment number)
- Equipment decontamination procedures and effectiveness
- Laboratories receiving samples and shipping information, such as carrier, shipment time, number of sample containers shipped, and analyses requested
- User signatures

The logbook shall reference data maintained in other logs, forms, etc. Correct entry errors by drawing a single line through the incorrect entry, then initialing and dating this change. Enter an explanation for the correction if the correction is more than for a mistake.

At least at the end of each day, the person making the entry shall sign or initial each entry or group of entries.

Enter logbook page numbers on each page to facilitate identification of photocopies.

If a person’s initials are used for identification, or if uncommon acronyms are used, identify these on a page at the beginning of the logbook.

At least weekly and preferably daily, the preparer shall photocopy (or scan) and retain the pages completed during that session for backup. This will prevent loss of a large amount of information if the logbook is lost.

6. Records

Retain the field logbook as a permanent project record. If a particular CTO requires submittal of photocopies of logbooks, perform this as required.

7. Health and Safety

Store the logbook in a clean location to keep it clean and use it only when outer gloves used for PPE have been removed.

8. References

Department of Defense, United States (DoD). 2005a. *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: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Procedure I-A-8, *Sample Naming.*

9. Attachments

Attachment III-D-1: Description of Logbook Entries

Attachment III-D-1
Description of Logbook Entries

Logbook entries shall be consistent with Section A.1.4 *Field Documentation SOPs* of the UFP-QAPP Manual (DoD 2005) and contain the following information, as applicable, for each activity recorded. Some of these details may be entered on data forms, as described previously.

Name of Activity	For example, Asbestos Bulk Sampling, Charcoal Canister Sampling, Aquifer Testing.
Task Team Members and Equipment	Name all members on the field team involved in the specified activity. List equipment used by serial number or other unique identification, including calibration information.
Activity Location	Indicate location of sampling area as indicated in the field sampling plan.
Weather	Indicate general weather and precipitation conditions.
Level of PPE	Record the level of PPE (e.g., Level D).
Methods	Indicate method or procedure number employed for the activity.
Sample Numbers	Indicate the unique numbers associated with the physical samples. Identify QC samples.
Sample Type and Volume	Indicate the medium, container type, preservative, and the volume for each sample.
Time and Date	Record the time and date when the activity was performed (e.g., 0830/08/OCT/89). Use the 24-hour clock for recording the time and two digits for recording the day of the month and the year.
Analyses	Indicate the appropriate code for analyses to be performed on each sample, as specified in the WP.
Field Measurements	Indicate measurements and field instrument readings taken during the activity.
Chain of Custody and Distribution	Indicate chain-of-custody for each sample collected and indicate to whom the samples are transferred and the destination.
References	If appropriate, indicate references to other logs or forms, drawings, or photographs employed in the activity.
Narrative (including time and location)	Create a factual, chronological record of the team’s activities throughout the day including the time and location of each activity. Include descriptions of general problems encountered and their resolution. Provide the names and affiliations of non-field team personnel who visit the site, request changes in activity, impact the work schedule, request information, or observe team activities. Record any visual or other observations relevant to the activity, the contamination source, or the sample itself. It should be emphasized that logbook entries are for recording data and chronologies of events. The logbook author must include observations and descriptive notations, taking care to be objective and recording no opinions or subjective comments unless appropriate.
Recorded by	Include the signature of the individual responsible for the entries contained in the logbook and referenced forms.
Checked by	Include the signature of the individual who performs the review of the completed entries.

Record Keeping, Sample Labeling, and Chain-Of-Custody

1. Purpose

The purpose of this standard operating procedure is to establish standard protocols for all United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific field personnel for use in maintaining field and sampling activity records, writing sample logs, labeling samples, ensuring that proper sample custody procedures are used, and completing chain-of-custody/analytical request forms.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 LOGBOOK

A logbook is a bound field notebook with consecutively numbered, water-repellent pages that is clearly identified with the name of the relevant activity, the person responsible for maintenance of the logbook, and the beginning and ending dates of the entries.

3.2 CHAIN-OF-CUSTODY

Chain-of-custody (COC) is documentation of the process of custody control. Custody control includes possession of a sample from the time of its collection in the field to its receipt by the analytical laboratory, and through analysis and storage prior to disposal.

4. Responsibilities

The prime contractor CTO Manager is responsible for determining which team members shall record information in the field logbook and for checking sample logbooks and COC forms to ensure compliance with these procedures. The CTO Manager shall review COC forms on a monthly basis at a minimum.

The prime contractor CTO Manager and QA Manager or Technical Director are responsible for evaluating project compliance with the Project Procedures Manual. The QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Laboratory Project Manager or Sample Control Department Manager is responsible for reporting any sample documentation or COC problems to the CTO Manager or CTO Laboratory Coordinator within 24 hours of sample receipt.

The Field Manager is responsible for ensuring that all field personnel follow these procedures. The CTO Laboratory Coordinator is responsible for verifying that the COC/analytical request forms have been completed properly and match the sampling and analytical plan. The CTO Manager or CTO Laboratory Coordinator is responsible for notifying the laboratory, data managers, and data validators in writing if analytical request changes are required as a corrective action. These small changes are different from change orders, which involve changes to the scope of the subcontract with the laboratory and must be made in accordance with a respective contract (e.g., Comprehensive Long-Term Environmental Action Navy, remedial action contract).

NAVFAC Pacific ER Program field personnel are responsible for following these procedures while conducting sampling activities. Field personnel are responsible for recording pertinent data into the logbook to satisfy project requirements and for attesting to the accuracy of the entries by dated signature. All NAVFAC Pacific ER Program field personnel are responsible for complying with Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

5. Procedures

This procedure provides standards for documenting field activities, labeling the samples, documenting sample custody, and completing COC/analytical request forms. The standards presented in this section shall be followed to ensure that samples collected are maintained for their intended purpose and that the conditions encountered during field activities are documented.

5.1 RECORD KEEPING

The field logbook serves as the primary record of field activities. Make entries chronologically and in sufficient detail to allow the writer or a knowledgeable reviewer to reconstruct each day’s events. Field logs such as soil boring logs and groundwater sampling logs will also be used. These procedures are described in Procedure III-D, *Logbooks*.

5.2 SAMPLE LABELING

Affix a sample label with adhesive backing to each individual sample container with the exception of pre-tared containers. Record the following information with a waterproof marker (ballpoint pen for containers for volatile analyses) on each label:

- Project name or number (optional)
- COC sample number
- Date and time of collection
- Sampler's initials
- Matrix (optional)
- Sample preservatives (if applicable)

- Analysis to be performed on sample (This shall be identified by the method number or name identified in the subcontract with the laboratory)
- Indicate if sample is to be used as the matrix spike (MS)/matrix spike duplicate (MSD) or laboratory triplicate sample

With the exception of sample containers with pre-tared labels, place clear tape over each label (preferably prior to sampling) to prevent the labels from tearing off, falling off, or being smeared, and to prevent loss of information on the label.

These labels may be obtained from the analytical laboratory or printed from a computer file onto adhesive labels.

For volatile soil organic analyses (VOA), labels are not to be affixed to vials that are pre-tared by the laboratory. Instead, on each of the VOA vials in the sample set (typically three per sample), mark the sample COC Sample identification (ID) on the vial in ballpoint pen. Then wrap the vials together in bubble wrap and place one sample label on the bubble wrap and cover with tape. It is imperative that the COC Sample ID be clearly marked on each vial as this will help prevent laboratory error if the vials are inadvertently separated after removal from the bubble wrap.

5.3 CUSTODY PROCEDURES

For samples intended for chemical analysis, sample custody procedures shall be followed through collection, transfer, analysis, and disposal to ensure that the integrity of the samples is maintained. Maintain custody of samples in accordance with the U.S. Environmental Protection Agency (EPA) COC guidelines prescribed in U.S. Environmental Protection Agency (EPA) *NEIC Policies and Procedures*, National Enforcement Investigations Center, Denver, Colorado, revised August 1991 (EPA 1978); EPA *RCRA Ground Water Monitoring Technical Enforcement Guidance Document* (TEGD), *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA OSWER Directive 9355 3-01) (EPA 1988, Appendix 2 of the *Technical Guidance Manual for Solid Waste Water Quality Assessment Test (SWAT) Proposals and Reports* (Cal/EPA 1988), and *Test Methods for Evaluating Solid Waste* (EPA 2007). A description of sample custody procedures is provided below.

5.3.1 Sample Collection Custody Procedures

According to the EPA guidelines, a sample is considered to be in custody if one of the following conditions is met:

- It is in one’s actual physical possession or view
- It is in one’s physical possession and has not been tampered with (i.e., it is under lock or official seal)
- It is retained in a secured area with restricted access
- It is placed in a container and secured with an official seal such that the sample cannot be reached without breaking the seal

Place custody seals on sample containers (on bubble wrap for pre-tared containers) immediately after sample collection and on shipping coolers if the cooler is to be removed from the sampler's custody.

Place custody seals in such a manner that they must be broken to open the containers or coolers. Label the custody seals with the following information:

- Sampler's name or initials
- Date and time that the sample/cooler was sealed

These seals are designed to enable detection of sample tampering. An example of a custody seal is shown in Attachment III-E-1.

Field personnel shall also log individual samples onto COC forms (carbon copy or computer generated) when a sample is collected or just prior to shipping. These forms may also serve as the request for analyses. Procedures for completing these forms are discussed in Section 5.4, indicating sample identification number, matrix, date and time of collection, number of containers, analytical methods to be performed on the sample, and preservatives added (if any). The samplers will also sign the COC form signifying that they were the personnel who collected the samples. The COC form shall accompany the samples from the field to the laboratory. When a cooler is ready for shipment to the analytical laboratory, the person delivering the samples for transport will sign and indicate the date and time on the accompanying COC form. One copy of the COC form will be retained by the sampler and the remaining copies of the COC form shall be placed inside a self-sealing bag and taped to the inside of the cooler. Each cooler must be associated with a unique COC form. Whenever a transfer of custody takes place, both parties shall sign and date the accompanying carbon copy COC forms, and the individual relinquishing the samples shall retain a copy of each form. One exception is when the samples are shipped; the delivery service personnel will not sign or receive a copy because they do not open the coolers. The laboratory shall attach copies of the completed COC forms to the reports containing the results of the analytical tests. An example COC form is provided in Attachment III-E-2.

5.3.2 Laboratory Custody Procedures

The following custody procedures are to be followed by an independent laboratory receiving samples for chemical analysis; the procedures in their Naval Facilities Engineering and Expeditionary Warfare Center-evaluated Laboratory Quality Assurance Plan must follow these same procedures. A designated sample custodian shall take custody of all samples upon their arrival at the analytical laboratory. The custodian shall inspect all sample labels and COC forms to ensure that the information is consistent, and that each is properly completed. The custodian will also measure the temperature of the temperature blank in the coolers upon arrival using either a National Institute for Standards and Technology calibrated thermometer or an infra-red temperature gun. The custodian shall note the condition of the samples including:

- If the samples show signs of damage or tampering
- If the containers are broken or leaking
- If headspace is present in sample vials
- Proper preservation of samples (made by pH measurement, except volatile organic compounds (VOCs) and purgeable total petroleum hydrocarbons (TPH) and temperature). The pH of VOC and purgeable TPH samples will be checked by the laboratory analyst after the sample aliquot has been removed from the vial for analysis.

- If any sample holding times have been exceeded

All of the above information shall be documented on a sample receipt sheet by the custodian.

Discrepancies or improper preservation shall be noted by the laboratory as an out-of-control event and shall be documented on an out-of-control form with corrective action taken. The out-of-control form shall be signed and dated by the sample control custodian and any other persons responsible for corrective action. An example of an out-of-control form is included as Attachment III-E-4.

The custodian shall then assign a unique laboratory number to each sample and distribute the samples to secured storage areas maintained at 4 degrees Celsius (soil samples for VOC analysis are to be stored in a frozen state until analysis). The unique laboratory number for each sample, the COC sample number, the client name, date and time received, analysis due date, and storage shall also be manually logged onto a sample receipt record and later entered into the laboratory's computerized data management system. The custodian shall sign the shipping bill and maintain a copy.

Laboratory personnel shall be responsible for the care and custody of samples from the time of their receipt at the laboratory through their exhaustion or disposal. Samples should be logged in and out on internal laboratory COC forms each time they are removed from storage for extraction or analysis.

5.4 COMPLETING COC/ANALYTICAL REQUEST FORMS

COC form/analytical request form completion procedures are crucial in properly transferring the custody and responsibility of samples from field personnel to the laboratory. This form is important for accurately and concisely requesting analyses for each sample; it is essentially a release order from the analysis subcontract.

Attachment III-E-2 is an example of a generic COC/analytical request form that may be used by field personnel. Multiple copies may be tailored to each project so that much of the information described below need not be handwritten each time. Attachment III-E-3 is an example of a completed site-specific COC/analytical request form, with box numbers identified and discussed in text below.

Box 1 *Project Manager:* This name shall be the name that will appear on the report. Do not write the name of the Project Coordinator or point of contact for the project instead of the CTO manager.

Project Name: Write the project name as it is to appear on the report.

Project Number: Write the project number as it is to appear on the report. It shall include the project number and task number. Also include the laboratory subcontract number.

Box 2 *Bill to:* List the name and address of the person/company to bill only if it is not in the subcontract with the laboratory.

Box 3 *Sample Disposal Instructions:* These instructions will be stated in the Master Service Agreement or each CTO statement of work with each laboratory.

Shipment Method: State the method of shipment (e.g., hand carry; air courier via FED EX, AIR BORNE, or DHL).

Comment: This area shall be used by the field team to communicate observations, potential hazards, or limitations that may have occurred in the field or additional information regarding analysis (e.g., a specific metals list, samples expected to contain high analyte concentrations).

Box 4 *Cooler Number:* This will be written on the inside or outside of the cooler and shall be included on the COC. Some laboratories attach this number to the trip blank identification, which helps track volatile organic analysis samples. If a number is not on the cooler, field personnel shall assign a number, write it on the cooler, and write it on the COC.

QC Level: Enter the reporting/QC requirements (e.g., Full Data Package, Summary Data Package).

Turn around time (TAT): TAT will be determined by a sample delivery group (SDG), which may be formed over a 14-day period, not to exceed 20 samples. Once the SDG has been completed, standard TAT is 21 calendar days from receipt of the last sample in the SDG. Entering NORMAL or STANDARD in this field will be acceptable. If quicker TAT is required, it shall be in the subcontract with the laboratory and reiterated on each COC to remind the laboratory.

Box 5 *Type of containers:* Write the type of container used (e.g., 1 liter glass amber, for a given parameter in that column).

Preservatives: Field personnel must indicate on the COC the correct preservative used for the analysis requested. Indicate the pH of the sample (if tested) in case there are buffering conditions found in the sample matrix.

Box 6 *COC sample number:* This is typically a five-character alpha-numeric identifier used by the contractor to identify samples. The use of this identifier is important since the labs are restricted to the number of characters they are able to use. See Procedure I-A-8, *Sample Naming*.

Description (sample identification): This name will be determined by the location and description of the sample, as described in Procedure I-A-8, *Sample Naming*. This sample identification should not be submitted to the laboratory, but should be left blank. If a computer COC version is used, the sample identification can be input, but printed with this block black. A cross-referenced list of COC Sample Number and sample identification must be maintained separately.

Identify if sample requires laboratory subsampling.

Date Collected: Record the collection date to track the holding time of the sample. Note: For trip blanks, record the date it was placed in company with samples.

Time Collected: When collecting samples, record the time the sample is first collected. Use of the 24-hour military clock will avoid a.m. or p.m. designations (e.g., 1815 instead of 6:15 p.m.). Record local time; the laboratory is responsible for calculating holding times to local time.

Lab Identification: This is for laboratory use only.

Box 7 *Matrix and QC:* Identify the matrix (e.g., water, soil, air, tissue, fresh water sediment, marine sediment, or product). If a sample is expected to contain high analyte concentrations (e.g., a tank bottom sludge or distinct product layer), notify the laboratory in the comment section. Mark an "X" for the sample(s) that have extra volume for laboratory QC matrix spike/matrix spike duplicate (MS/MSD) or laboratory triplicate purposes. The sample provided for MS/MSD purposes is usually a field duplicate.

Box 8 *Analytical Parameters:* Enter the parameter by descriptor and the method number desired (e.g. benzene, toluene, ethylbenzene, and xylenes 8260B, polynuclear aromatic hydrocarbons 8270C, etc.). Whenever practicable, list the parameters as they appear in the laboratory subcontract to maintain consistency and avoid confusion.

If the COC does not have a specific box for number of sample containers, use the boxes below the analytical parameter, to indicate the number of containers collected for each parameter.

Box 9 *Sampler's Signature:* The person who collected samples must sign here.

Relinquished By: The person who turned over the custody of the samples to a second party other than an express mail carrier, such as FEDEX, must sign here.

Received By: Typically, a representative of the receiving laboratory signs here. Or, a field crew member who delivered the samples in person from the field to the laboratory might sign here. A courier, such as Federal Express, does not sign here because they do not open the coolers. It must also be used by the prime contracting laboratory when samples are to be sent to a subcontractor.

Relinquished By: In the case of subcontracting, the primary laboratory will sign the Relinquished By space and fill out an additional COC to accompany the samples being subcontracted.

Received By (Laboratory): This space is for the final destination (e.g., at a subcontracted laboratory).

Box 10 *Lab Number and Questions:* This box is to be filled in by the laboratory only.

Box 11 *Control Number:* This number is the "COC" followed by the first contractor identification number in that cooler, or contained on that COC. This control number must be unique (i.e., never used twice). Record the date the COC is completed. It should be the same date the samples are collected.

Box 12 *Total No. of Containers/row:* Sum the number of containers in that row.

Box 13 *Total No. of Containers/column:* Sum the number of containers in that column. Because COC forms contain different formats depending on who produced the form, not all of the information listed in items 1 to 13 may be recorded; however, as much of this information as possible shall be included.

COC forms tailored to each CTO can be drafted and printed onto multi-ply forms. This eliminates the need to rewrite the analytical methods column headers each time. It also eliminates the need to write the project manager, name, and number; QC Level; TAT; and the same general comments each time.

Complete one COC form per cooler. Whenever possible, place all volatile organic analyte vials into one cooler in order to reduce the number of trip blanks. Complete all sections and be sure to sign and date the COC form. One copy of the COC form must remain with the field personnel.

6. Records

The COC/analytical request form shall be faxed or e-mailed to the CTO Laboratory Coordinator for verification of accuracy. Following the completion of sampling activities, the sample logbook and COC forms will be transmitted to the CTO Manager for storage in project files. The data validators shall receive a copy also. The original COC/analytical request form shall be submitted by the laboratory along with the data delivered. Any changes to the analytical requests that are required shall be made in writing to the laboratory. A copy of this written change shall be sent to the data validators and placed in the project files. The reason for the change shall be included in the project files so that recurring problems can be easily identified.

7. Health and Safety

Not applicable.

8. References

California Environmental Protection Agency (Cal/EPA). 1988. *Technical Guidance Manual, Solid Waste Water Quality Assessment Test (SWAT) Proposals and Reports.* Solid Waste Disposal Program, Hydrogeology Section, Land Disposal Branch, Division of Water Quality, State Water Resources Control Board. August.

Department of Defense, United States (DoD). 2005a. 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: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

———. 2005b. Uniform Federal Policy for Quality Assurance Project Plans, Part 2B: Quality Assurance/quality Control Compendium: Minimum QA/QC Activities. Final Version 1. DoD: DTIC ADA 426957, EPA-505-B-04-900B. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/swerffrr/pdf/-qaqc_v1_0305.pdf.

———. 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2A: Optimized UFP-QAPP Worksheets*. Revision 1. March.

———. 2013. *Department of Defense Quality Systems Manual for Environmental Laboratories.* Version 5.0. Draft Final. Prepared by DoD Environmental Data Quality Workgroup and Department of Energy Consolidated Audit Program Operations Team. July.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Environmental Protection Agency, United States (EPA). 1978. *NEIC Policies and Procedures.* EPA-330/9-78-001-R. Revised August 1991. National Enforcement Investigation Center. Denver. May.

———. 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA.* Interim Final. EPA/540/G-89/004. Office of Emergency and Remedial Response. October.

———. 2007. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* 3rd ed., Revision 6. Office of Solid Waste. November. On-line updates at: http://www.epa.gov/epawaste/hazard/testmethods/sw846/online/index.htm.

Procedure I-A-8, *Sample Naming.*

Procedure III-D, *Logbooks.*

9. Attachments

Attachment III-E-1, Chain-of-Custody Seal

Attachment III-E-2, Generic Chain-of-Custody/Analytical Request Form

Attachment III-E-3, Sample Completed Chain-of-Custody

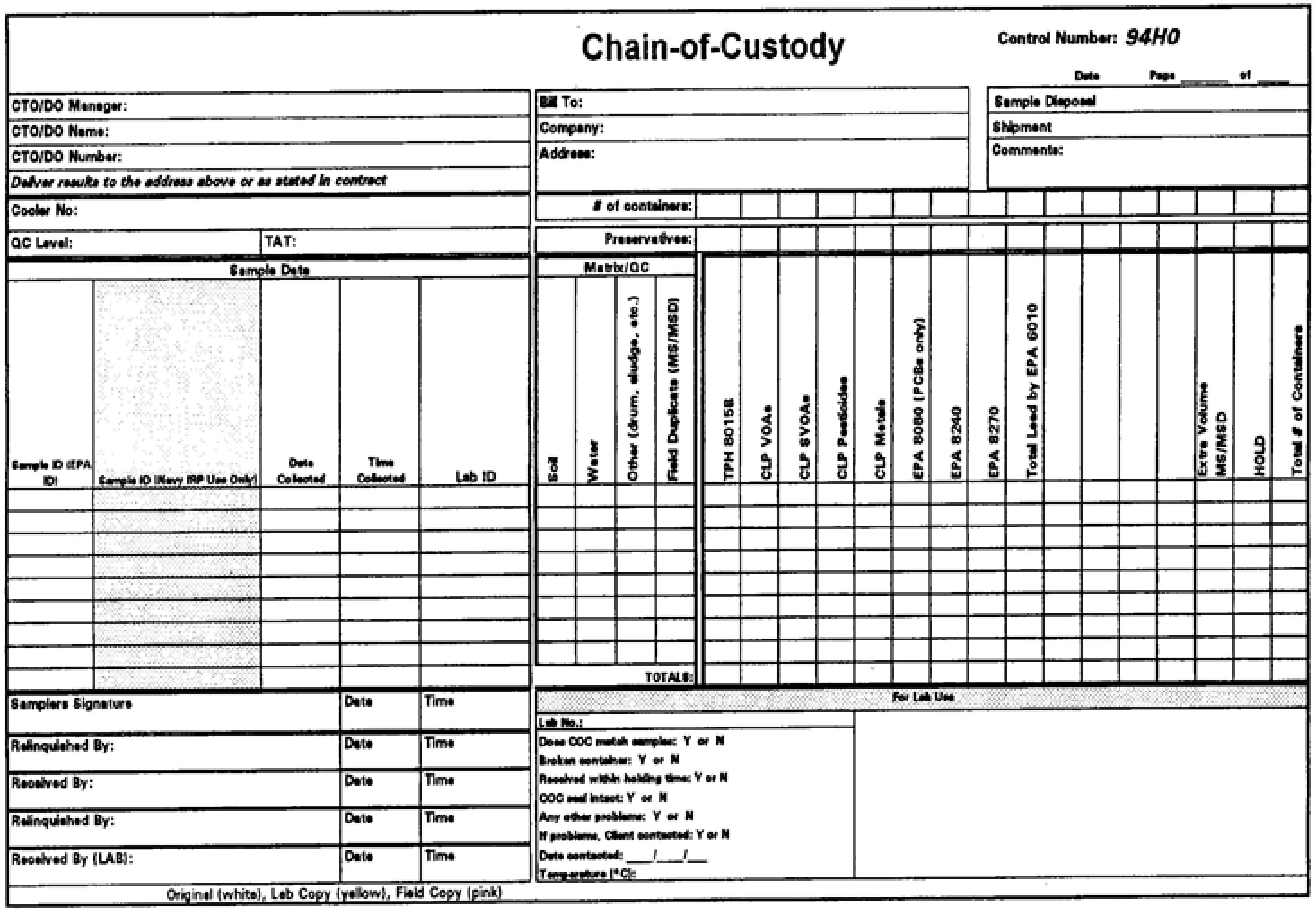
Attachment III-E-4, Sample Out-of-Control Form

Attachment III-E-1
Chain-of-Custody Seal

CHAIN-OF-CUSTODY SEAL

CUSTODY SEAL	
Company Name (808) XXX-XXXX	
Sampler's Name/Initials:___________________	Date: _____________ Time: _____________

Attachment III-E-2
Generic Chain-of-Custody/Analytical Request Form



Chain-of-Custody

Control Number: *94H0*

Date Page ____ of ____

CTO/DO Manager:	Bill To:	Sample Disposal
CTO/DO Name:	Company:	Shipment
CTO/DO Number:	Address:	Comments:
Deliver results to the address above or as stated in contract		
Cooler No:	# of containers:	
QC Level: TAT:	Preservatives:	

Sample ID (EPA ID)	Sample ID (Navy IRP Use Only)	Date Collected	Time Collected	Lab ID	Soil	Water	Other (drum, sludge, etc.)	Field Duplicate (MS/MSD)	TPH 8015B	CLP VOAs	CLP SVOAs	CLP Pesticides	CLP Metals	EPA 8080 (PCBs only)	EPA 8240	EPA 8270	Total Lead by EPA 6010					Extra Volume MS/MSD	HOLD	Total # of Containers
								TOTALS:																

Samplers Signature	Date	Time
Relinquished By:	Date	Time
Received By:	Date	Time
Relinquished By:	Date	Time
Received By (LAB):	Date	Time

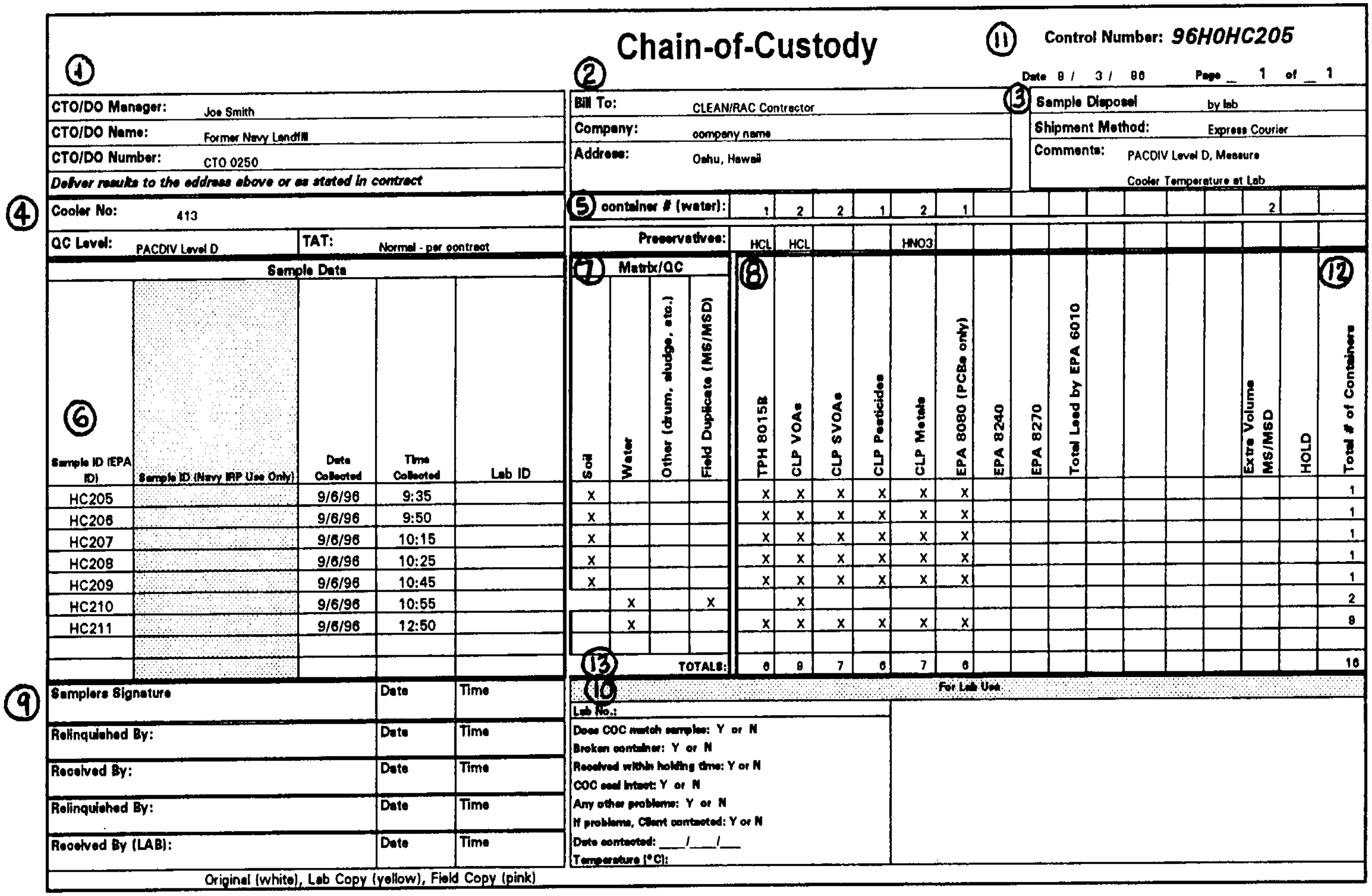
For Lab Use

Lab No.:
Does COC match samples: Y or N
Broken container: Y or N
Received within holding time: Y or N
COC seal intact: Y or N
Any other problems: Y or N
If problems, Client contacted: Y or N
Date contacted: ___/___/___
Temperature (°C):

Original (white), Lab Copy (yellow), Field Copy (pink)

Generic Chain-of-Custody/Analytical Request Form

Attachment III-E-3
Sample Completed Chain-of-Custody



Chain-of-Custody

⑪ **Control Number:** *96H0HC205*

Date 9 / 3 / 96 **Page** 1 **of** 1

①

CTO/DO Manager: Joe Smith
CTO/DO Name: Former Navy Landfill
CTO/DO Number: CTO 0250
Deliver results to the address above or as stated in contract

②

Bill To: CLEAN/RAC Contractor
Company: company name
Address: Oahu, Hawaii

③

Sample Disposal by lab
Shipment Method: Express Courier
Comments: PACDIV Level D, Measure Cooler Temperature at Lab

④

Cooler No: 413
QC Level: PACDIV Level D **TAT:** Normal - per contract

⑤ **container # (water):**

Preservatives:

⑥ **Sample Data** ⑦ **Matrix/QC** ⑧ ⑫

				container # (water):					1	2	2	1	2	1								2		
				Preservatives:					HCL	HCL			HNO3											
Sample ID (EPA ID)	**Sample ID (Navy IRP Use Only)**	**Date Collected**	**Time Collected**	**Lab ID**	**Soil**	**Water**	**Other (drum, sludge, etc.)**	**Field Duplicate (MS/MSD)**	**TPH 8015B**	**CLP VOAs**	**CLP SVOAs**	**CLP Pesticides**	**CLP Metals**	**EPA 8080 (PCBs only)**	**EPA 8240**	**EPA 8270**	**Total Lead by EPA 6010**					**Extra Volume MS/MSD**	**HOLD**	**Total # of Containers**
HC205		9/6/96	9:35		X				X	X	X	X	X	X										1
HC206		9/6/96	9:50		X				X	X	X	X	X	X										1
HC207		9/6/96	10:15		X				X	X	X	X	X	X										1
HC208		9/6/96	10:25		X				X	X	X	X	X	X										1
HC209		9/6/96	10:45		X				X	X	X	X	X	X										1
HC210		9/6/96	10:55			X		X		X														2
HC211		9/6/96	12:50			X			X	X	X	X	X	X										9
					⑬			**TOTALS:**	6	9	7	6	7	6										16

⑨

Samplers Signature	**Date**	**Time**
Relinquished By:	**Date**	**Time**
Received By:	**Date**	**Time**
Relinquished By:	**Date**	**Time**
Received By (LAB):	**Date**	**Time**

Original (white), Lab Copy (yellow), Field Copy (pink)

⑩ **For Lab Use**

Lab No.:
Does COC match samples: Y or N
Broken container: Y or N
Received within holding time: Y or N
COC seal intact: Y or N
Any other problems: Y or N
If problems, Client contacted: Y or N
Date contacted: ___/___/___
Temperature (°C):

Sample Completed Chain-of-Custody

Attachment III-E-4
Sample Out-of-Control Form

OUT OF CONTROL FORM	Status	Date	Initial
	Noted OOC		
	Submit for CA*		
	Resubmit for CA*		
	Completed		

Date Recognized:	By:
Dated Occurred:	Matrix
Parameter (Test Code):	Method:
Analyst:	Supervisor:
1. Type of Event (Check all that apply)	2. Corrective Action (CA)* (Check all that apply)

	Calibration Corr. Coefficient <0.995		Repeat calibration
	%RSD>20%		Made new standards
	Blank >MDL		Reran analysis
	Does not meet criteria:		Sample(s) redigested and rerun
	Spike		Sample(s) reextracted and rerun
	Duplicate		Recalculated
	LCS		Cleaned system
	Calibration Verification		Ran standard additions
	Standard Additions		Notified
	MS/MSD		Other (please explain)
	BS/BSD		
	Surrogate Recovery		
	Calculations Error		

Samples Affected (List by Accession AND Sample No.)

☐ Holding Times Missed	
☐ Other (Please explain	Comments:

3. Results of Corrective Action
☐ Return to Control (indicated with)
☐ Corrective Actions Not Successful - DATA IS TO BE FLAGGED with _____________.

Analyst:	Date:
Supervisor:	Date:
QA Department:	Date:

Sample Handling, Storage, and Shipping

1. Purpose

This standard operating procedure sets forth the methods for use by the United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel engaged in handling, storing, and transporting samples.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

None.

4. Responsibilities

The prime contractor CTO Manager and the Laboratory Project Manager are responsible for identifying instances of non-compliance with this procedure and ensuring that future sample transport activities are in compliance with this procedure.

The Field Manager is responsible for ensuring that all samples are shipped according to this procedure.

Field personnel are responsible for the implementation of this procedure.

The QA Manager or Technical Director is responsible for ensuring that sample handling, storage, and transport activities conducted during all CTOs are in compliance with this procedure.

All field personnel are responsible for complying with Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

5. Procedures

5.1 HANDLING AND STORAGE

Immediately following collection, label all samples according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*. In addition, when more than one volatile organic analyte

(VOA) vial is used to collect one sample, the chain-of-custody (COC) identification (ID) will be written on the VOA vials (even pre-tared vials) with a ball point pen for that sample. The lids of the containers shall not be sealed with duct tape, but should be covered with custody seals (except pre-tared containers which should have the custody seal placed on the outside of the protective bubble wrap). Wrap glass sample containers on the sides, tops, and bottoms with bubble wrap or other appropriate padding to prevent breakage during transport. When collecting three VOA vials per sample, it is acceptable to wrap all three vials together and store in one plastic bag. Store all glass containers for water samples in an upright position, never stacked or placed on their sides. Samples will be maintained as close to 4 degrees Celsius (°C) as possible from the time of collection through transport to the analytical laboratory, using refrigerators and/or freezers when appropriate. Place all containers into self-sealing bags and into an insulated cooler with wet ice while still in the field. Samples should occupy the lower portion of the cooler, while the ice should occupy the upper portion. Place an absorbent material (e.g., proper absorbent cloth material) on the bottom of the cooler to contain liquids in case of spillage. Ship samples as soon after collection as possible to allow the laboratory to meet holding times for analyses. Check with the laboratory for operating/sample receipt hours prior to all traditional and non-traditional holidays to ensure sample shipment will be received. When not shipping samples directly upon field collection, store samples in a refrigerator or freezer (never freeze water samples) until shipped to the laboratory.

5.2 PACKING

Each cooler must contain a temperature blank (small plastic bottle with sterile water) to confirm cooler temperature upon receipt at the laboratory. Water samples can be used as such, but it is best to include a designated temperature blank bottle, typically supplied by the laboratory with the coolers.

One trip blank must be included in each cooler containing samples for volatile analysis (e.g., volatile organic compounds, total petroleum hydrocarbons-gasoline range organics.

Cooler must be lined completely in ice at the bottom and all four sides. After confirming all project samples are accounted for and labeled correctly, place samples in cooler. Record sample IDs on cooler-specific COC(s). Pack glass containers for water samples in an upright position, never stacked or placed on their sides. Fill all empty space between sample containers with bubble wrap or other appropriate material (not Styrofoam). Place a layer of ice on top of samples and fill all empty space between ice and cooler lid with bubble wrap or other appropriate material.

Place laboratory copies of completed COC(s), and soil permit if applicable, into resealable bag and tape to underside of cooler lid.

5.3 SHIPPING

Follow all appropriate U.S. Department of Transportation regulations (e.g., 49 Code of Federal Regulations [CFR], Parts 171-179) for shipment of air, soil, water, and other samples. Elements of these procedures are summarized below.

5.3.1 Hazardous Materials Shipment

Field personnel must state whether any sample is suspected to be a hazardous material. A sample should be assumed to be hazardous unless enough evidence exists to indicate it is non-hazardous. If not suspected to be hazardous, shipments may be made as described in the Section 5.3.3 for non-hazardous materials. If hazardous, follow the procedures summarized below.

Any substance or material that is capable of posing an unreasonable risk to life, health, or property when transported is classified as hazardous. Perform hazardous materials identification by checking the list of dangerous goods for that particular mode of transportation. If not on that list, materials can be classified by checking the Hazardous Materials Table (49 CFR 172.102 including Appendix A) or by determining if the material meets the definition of any hazard class or division (49 CFR Part 173), as listed in Attachment III-F-2.

All persons shipping hazardous materials must be properly trained in the appropriate regulations, as required by HM-126F, Training for Safe Transportation of Hazardous Materials (49 CFR HM-126F Subpart H). The training covers loading, unloading, handling, storing, and transporting of hazardous materials, as well as emergency preparedness in the case of accidents. Carriers, such as commercial couriers, must also be trained. Modes of shipment include air, highway, rail, and water.

When shipping hazardous materials, including bulk chemicals or samples suspected of being hazardous, the proper shipping papers (49 CFR 172 Subpart C), package marking (49 CFR 172 Subpart D), labeling (49 CFR 172 Subpart E), placarding (49 CFR 172 Subpart F, generally for carriers), and packaging must be used. Attachment III-F-1 shows an example of proper package markings. Refer to a copy of 49 CFR each time hazardous materials/potentially hazardous samples are shipped.

According to Section 2.7 of the International Air Transport Association Dangerous Goods Regulations publication, very small quantities of certain dangerous goods may be transported without certain marking and documentation requirements as described in 49 CFR Part 172. However, other labeling and packing requirements must still be followed. Attachment III-F-2 shows the volume or weight for different classes of substances. A “Dangerous Goods in Excepted Quantities” label must be completed and attached to the associated shipping cooler (Attachment III-F-3). Certain dangerous goods are not allowed on certain airlines in any quantity.

As stated in item 4 of Attachment III-F-4, the Hazardous Materials Regulations do not apply to hydrochloric acid (HCl), nitric acid (HNO_3), sulfuric acid (H_2SO_4), and sodium hydroxide (NaOH) added to water samples if their pH or percentage by weight criteria are met. Hazardous Materials Regulations also do not apply to methanol (MeOH) for soil samples if the percentage by weight criterion is met. These samples may be shipped as non-hazardous materials as discussed below.

5.3.2 Non-hazardous Materials Shipment

If the samples are suspected to be non-hazardous based on previous site sample results, field screening results, or visual observations, if applicable, then samples may be shipped as non-hazardous.

If preservatives (HCl, HNO_3, H_2SO_4, NaOH, or MeOH) are used, ensure their individual pH or percentage by weight criteria, as shown in item 4 of Attachment III-F-4, are met to continue shipping as non-hazardous samples.

When a cooler is ready for shipment to the laboratory, place the receiving laboratory address on the top of the cooler, place chain-of-custody seals on the coolers as discussed in Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*, place soil permit labels on top if applicable, and seal the cooler with waterproof tape.

5.3.3 Shipments from Outside the Continental United States

Shipment of sample coolers to the continental U.S. from locations outside the continental U.S. is controlled by the U.S. Department of Agriculture (USDA) and is subject to their inspection and regulation. A "USDA Soil Import Permit" is required to prove that the receiving analytical laboratory is certified by the USDA to receive and properly dispose of soil. In addition, all sample coolers must be inspected by a USDA representative, affixed with a label indicating that the coolers contain environmental samples, and accompanied by shipping forms stamped by the USDA inspector prior to shipment. In addition, the U.S. Customs Service must clear samples shipped from U.S. territorial possessions or foreign countries upon entry into the U.S. As long as the commercial invoice is properly completed (see below), shipments typically pass through U.S. Customs Service without the need to open coolers for inspection.

In Hawaii, soil sample shipments are typically brought to the courier at the airport where the courier contacts a USDA representative to make an inspection. Alternatively, the contractor may enter into an agreement with the USDA to ship soil samples. In this way, the USDA does not need to inspect each soil sample shipment. If the contractor maintains a Domestic Soil Permit, place the permit label and the soil origination label (Attachment III-F-9) on the top of the cooler. Place a copy of the receiving laboratory's soil permit with the COC inside the cooler. Confirm custody seals were placed on each container (Section 5.1) to ensure proper chain-of-custody control in the event coolers are opened for inspection.

In Guam, shipments can be dropped off directly to the Federal Express branch or to the courier at the airport. Alternatively, the courier can pick up shipments at each site provided that arrangements have been made regarding pickup time and location. USDA inspections occur outside of Guam. The laboratory's soil permit shall be placed with the COC inside the cooler, and the soil origination label (see Attachment III-F-9) should be placed on top of the cooler.

The USDA does not need to inspect water sample shipments.

Completion and use of proper paperwork will, in most cases, minimize or eliminate the need for the USDA and U.S. Customs Service to inspect the contents. Attachment III-F-5 shows an example of how paperwork may be placed on the outside of coolers for non-hazardous materials. For hazardous materials, refer to Section 5.3.1.

In summary, tape the paperwork listed below to the outside of the coolers to assist sample shipments. If a shipment is made up of multiple pieces (e.g., more than one cooler), the paperwork need only be attached to one cooler, provided that the courier agrees. All other coolers in the shipment need only be taped and have address and COC seals affixed.

1. **Courier Shipping Form & Commercial Invoice**. See Attachment III-F-6, and Attachment III-F-7 for examples of the information to be included on the commercial invoice for soil and water. Place the courier shipping form and commercial invoice inside a clear, plastic, adhesive-backed pouch that adheres to the package (typically supplied by the courier) and place it on the cooler lid as shown in Attachment III-F-5.
2. **Soil Import Permit (soil only)**. See Attachment III-F-8 and Attachment III-F-9 for examples of the soil import permit and soil samples restricted entry labels. The laboratory shall supply these documents prior to mobilization. The USDA in Hawaii often <u>does</u> stop

shipments of soil without these documents. Staple together the 2 inch × 2 inch USDA label (described below), and soil import permit, and place them inside a clear plastic pouch. The courier typically supplies the clear, plastic, adhesive-backed pouches that adhere to the package.

Placing one restricted entry label as shown in Attachment III-F-5 (covered with clear packing tape) and one stapled to the actual permit is suggested.

The USDA does not control water samples, so the requirements for soil listed above do not apply.

3. **Chain-of-Custody Seals**. The laboratory should supply the seals. CTO personnel must sign and date these. At least two seals should be placed in such a manner that they stick to both the cooler lid and body. Placing the seals over the tape (as shown in Attachment III-F-5), then covering it with clear packing tape is suggested. This prevents the seal from coming loose and enables detection of tampering.
4. **Address Label**. Affix a label stating the destination (laboratory address) of each cooler.
5. **Special Requirements for Hazardous Materials**. See Section 5.3.1.

Upon receipt of sample coolers at the laboratory, the sample custodian shall inspect the sample containers as discussed in Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*. The samples shall then be either immediately extracted and/or analyzed, or stored in a refrigerated storage area until they are removed for extraction and/or analysis. Whenever the samples are not being extracted or analyzed, they shall be returned to refrigerated storage.

6. Records

Maintain records as required by implementing these procedures.

7. Health and Safety

Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2012) and site-specific health and safety plan.

8. References

Department of Defense, United States (DoD). 2005a. *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: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

———. 2005b. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B: Quality Assurance/quality Control Compendium: Minimum QA/QC Activities*. Final Version 1. DoD: DTIC ADA 426957, EPA-505-B-04-900B. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/swerffrr/pdf/-qaqc_v1_0305.pdf.

———. 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2A: Optimized UFP-QAPP Worksheets*. Revision 1. March.

———. 2013. *Department of Defense Quality Systems Manual for Environmental Laboratories.* Version 5.0. Draft Final. Prepared by DoD Environmental Data Quality Workgroup and Department of Energy Consolidated Audit Program Operations Team. July.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual.* EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody.*

9. Attachments

Attachment III-F-1: Example Hazardous Materials Package Marking

Attachment III-F-2: Packing Groups

Attachment III-F-3: Label for Dangerous Goods in Excepted Quantities

Attachment III-F-4: SW-846 Preservative Exception

Attachment III-F-5: Non-Hazardous Material Cooler Marking Figure for Shipment From Outside The Continental United States

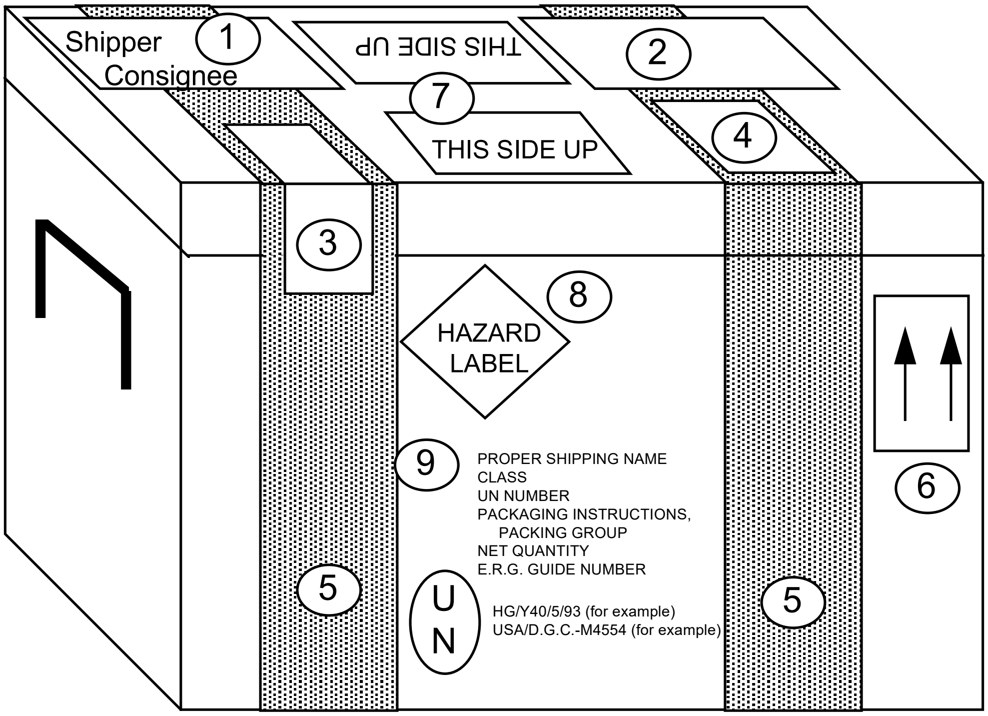
Attachment III-F-6: Commercial Invoice – Soil

Attachment III-F-7: Commercial Invoice – Water

Attachment III-F-8: Soil Import Permit

Attachment III-F-9: Soil Samples Restricted Entry Labels

Attachment III-F-1
Example Hazardous Material Package Marking



① **AIR BILL/COMMERCIAL INVOICE**

② **USDA PERMIT (Letter to Laboratory from USDA)**

③ **CUSTODY SEAL**

④ **USDA 2" X 2" SOIL IMPORT PERMIT**

⑤ **WATERPROOF STRAPPING TAPE**

⑥ **DIRECTION ARROWS STICKER - TWO REQUIRED**

⑦ **THIS SIDE UP STICKERS**

⑧ **HAZARD LABEL**

⑨ **HAZARDOUS MATERIAL INFORMATION**

⑩ **PACKAGE SPECIFICATIONS**

Attachment III-F-2
Packing Groups

PACKING GROUP OF THE SUBSTANCE	**PACKING GROUP 1**		**PACKING GROUP II**		**PACKING GROUP III**	
CLASS or DIVISION of PRIMARY or SUBSIDIARY RISK	Packagings		Packagings		Packagings	
	Inner	Outer	Inner	Outer	Inner	Outer
1: Explosives	---------------------------- Forbidden (Note A) ----------------------------------					
2.1: Flammable Gas	---------------------------- Forbidden (Note B) ----------------------------------					
2.2: Non-Flammable, non-toxic gas	---------------------------- See Notes A and B ----------------------------------					
2.3: Toxic gas	---------------------------- Forbidden (Note A) ----------------------------------					
3. Flammable liquid	30 mL	300 mL	30 mL	500 mL	30 mL	1 L
4.1 Self-reactive substances	Forbidden		Forbidden		Forbidden	
4.1: Other flammable solids	Forbidden		30 g	500 g	30 g	1 kg
4.2: Pyrophoric substances	Forbidden		Not Applicable		Not Applicable	
4.2 Spontaneously combustible substances	Not Applicable		30 g	500 g	30 g	1 kg
4.3: Water reactive substances	Forbidden		30 g or 30 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
5.1: Oxidizers	Forbidden		30 g or 30 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
5.2: Organic peroxides (Note C)	See Note A		30 g or 30 mL	500 g or 250 mL	Not Applicable	
6.1: Poisons - Inhalation toxicity	Forbidden		1 g or 1 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
6.1: Poisons - oral toxicity	1 g or 1 mL	300 g or 300 mL	1 g or 1 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
6.1: Poisons - dermal toxicity	1 g or 1 mL	300 g or 300 mL	1 g or 1 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
6.2: Infectious substances	---------------------------- Forbidden (Note A) ----------------------------------					
7: Radioactive material (Note D)	---------------------------- Forbidden (Note A) ----------------------------------					
8: Corrosive materials	Forbidden		30 g or 30 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
9: Magnetized materials	---------------------------- Forbidden (Note A) ----------------------------------					
9: Other miscellaneous materials (Note E)	Forbidden		30 g or 30 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L

Note A: *Packing groups are not used for this class or division.*
Note B: *For inner packagings, the quantity contained in receptacle with a water capacity of 30 mL. For outer packagings, the sum of the water capacities of all the inner packagings contained must not exceed 1 L.*
Note C: *Applies only to Organic Peroxides when contained in a chemical kit, first aid kit or polyester resin kit.*
Note D: *See 6.1.4.1, 6.1.4.2 and 6.2.1.1 through 6.2.1.7, radioactive material in excepted packages.*
Note E: *For substances in Class 9 for which no packing group is indicated in the List of Dangerous Goods, Packing Group II quantities must be used.*

Attachment III-F-3
Label for Dangerous Goods in Excepted Quantities

DANGEROUS GOODS IN EXCEPTED QUANTITIES

This package contains dangerous goods in excepted small quantities and is in all respects in compliance with the applicable international and national government regulations and the IATA Dangerous Goods Regulations.

____
Signature of Shipper

________________________ ______________________
Title Date

____

____
Name and address of Shipper

This package contains substance(s) in Class(es) (check applicable box(es))

Class:	2	3	4	5	6	8	9
	○	○	○	○	○	○	○

and the applicable UN Numbers are:

Attachment III-F-4
SW-846 Preservative Exception

Measurement	Vol. Req. (mL)	Container[2]	Preservative [3,4]	Holding Time[5]
MBAS	250	P,G	Cool, 4ºC	48 Hours
NTA	50	P,G	Cool, 4ºC	24 Hours

1. More specific instructions for preservation and sampling are found with each procedure as detailed in this manual. A general discussion on sampling water and industrial wastewater may be found in ASTM, Part 31, p. 72-82 (1976) Method D-3370.

2. Plastic (P) or Glass (G). For metals, polyethylene with a polypropylene cap (no liner) is preferred.

3. Sample preservation should be performed immediately upon sample collection. For composite samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then samples may be preserved by maintaining at 4ºC until compositing and sample splitting is completed.

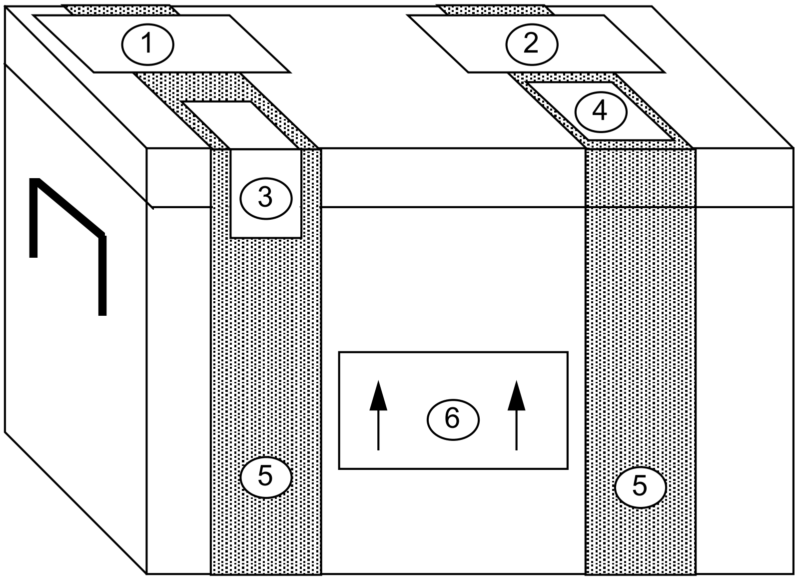
4. When any sample is to be shipped by common carrier or sent through the United States Mail, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172). The person offering such material for transportation is responsible for ensuring such compliance. for the preservation requirements of Table 1, the Office of Hazardous Materials, Materials Transportation Bureau, Department of Transportation has determined that the Hazardous Materials regulations do not apply to the following materials: Hydrochloric acid (HCl) in water solutions at concentration of 0.04% by weight or less (pH about 1.96 or greater); Nitric acid (HNO_3) in water solutions at concentrations of 0.15% by weight or less (pH about 1.62 or greater); Sulfuric acid (H_2SO_4) in water solutions at concentrations of 0.35% by weight or less (pH about 1.15 or greater); Sodium hydroxide (NaOH) in water solutions at concentrations of 0.080% by weight or less (pH about 12.30 or less).

5. Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of sample under study are stable for the longer time, and has received a variance from the Regional Administrator. Some samples may not be stable for the maximum time period given in the table. A permittee, or monitoring laboratory, is obligated to hold the sample for a shorter time if knowledge exists to show this is necessary to maintain sample stability.

6. Should only be used in the presence of residual chlorine.

Attachment III-F-5

Non-Hazardous Material Cooler Marking Figure for Shipment from outside the Continental United States



① **AIR BILL/COMMERCIAL INVOICE**
② **USDA PERMIT (Letter to Laboratory from USDA)**
③ **CUSTODY SEAL**
④ **USDA 2" X 2" SOIL IMPORT PERMIT**
⑤ **WATERPROOF STRAPPING TAPE**
⑥ **DIRECTION ARROWS STICKER - TWO REQUIRED**

Attachment III-F-6
Commercial Invoice – Soil

DATE OF EXPORTATION
1/1/94

EXPORT REFERENCES (i.e., order no., invoice no., etc.)
<CTO #>

SHIPPER/EXPORTER (complete name and address)
Joe Smith
Ogden
c/o <hotel name>
<hotel address>

CONSIGNEE
Sample Receipt
<Lab Name>
<Lab Address>

COUNTRY OF EXPORT
Guam, USA

COUNTRY OF ORIGIN OF GOODS
Guam, USA

COUNTRY OF ULTIMATE DESTINATION
USA

IMPORTER - IF OTHER THAN CONSIGNEE

INTERNATIONAL AIR WAYBILL NO.

(NOTE: All shipments must be accompanied by a Federal Express International Air Waybill)

MARKS/NOS	NO. OF PKGS	TYPE OF PACKAGING	FULL DESCRIPTION OF GOODS	QTY	UNIT OF MEASURE	WEIGHT	UNIT VALUE	TOTAL VALUE
	3	coolers	Soil samples for labora analysis only				$1.00	$3.00

TOTAL NO. OF PKGS.	TOTAL WEIGHT	TOTAL INVOICE VALUE
3		$3.00

Check one
☐ F.O.B.
☐ C&F
☐ C.I.F.

THESE COMMODITIES ARE LICENSED FOR THE ULTIMATE DESTINATION SHOWN.

DIVERSION CONTRARY TO UNITED STATES LAW IS PROHIBITED.

I DECLARE ALL THE INFORMATION CONTAINED IN THIS INVOICE TO BE TRUE AND CORRECT

SIGNATURE OF SHIPPER/EXPORTER (Type name and title and sign)

Name/Title: Joe Smith, Ogden
Signature: Joe Smith
Date: 1/1/94

Attachment III-F-7
Commercial Invoice – Water

DATE OF EXPORTATION 1/1/94	EXPORT REFERENCES (i.e., order no., invoice no., etc.) <CTO #>
SHIPPER/EXPORTER (complete name and address) Joe Smith Ogden c/o <hotel name> <hotel address>	CONSIGNEE Sample Rece <Lab Name> <Lab Address>
COUNTRY OF EXPORT Guam, USA	IMPORTER - IF OTHER THAN CONSIGNEE
COUNTRY OF ORIGIN OF GOODS Guam, USA	
COUNTRY OF ULTIMATE DESTINATION USA	

INTERNATIONAL AIR WAYBILL NO.		(NOTE: All shipments must be accompanied by a Federal Express International Air Waybill)

MARKS/NOS	NO. OF PKGS	TYPE OF PACKAGING	FULL DESCRIPTION OF GOODS	QTY	UNIT OF MEASURE	WEIGHT	UNIT VALUE	TOTAL VALUE
	3	coolers	Water samples for labo analysis only				$1.00	$3.00
	TOTAL NO. OF PKGS.					TOTAL WEIGHT		TOTAL INVOICE VALUE
	3							$3.00

Check one
☐ F.O.B.
☐ C&F
☐ C.I.F.

THESE COMMODITIES ARE LICENSED FOR THE ULTIMATE DESTINATION SHOWN.

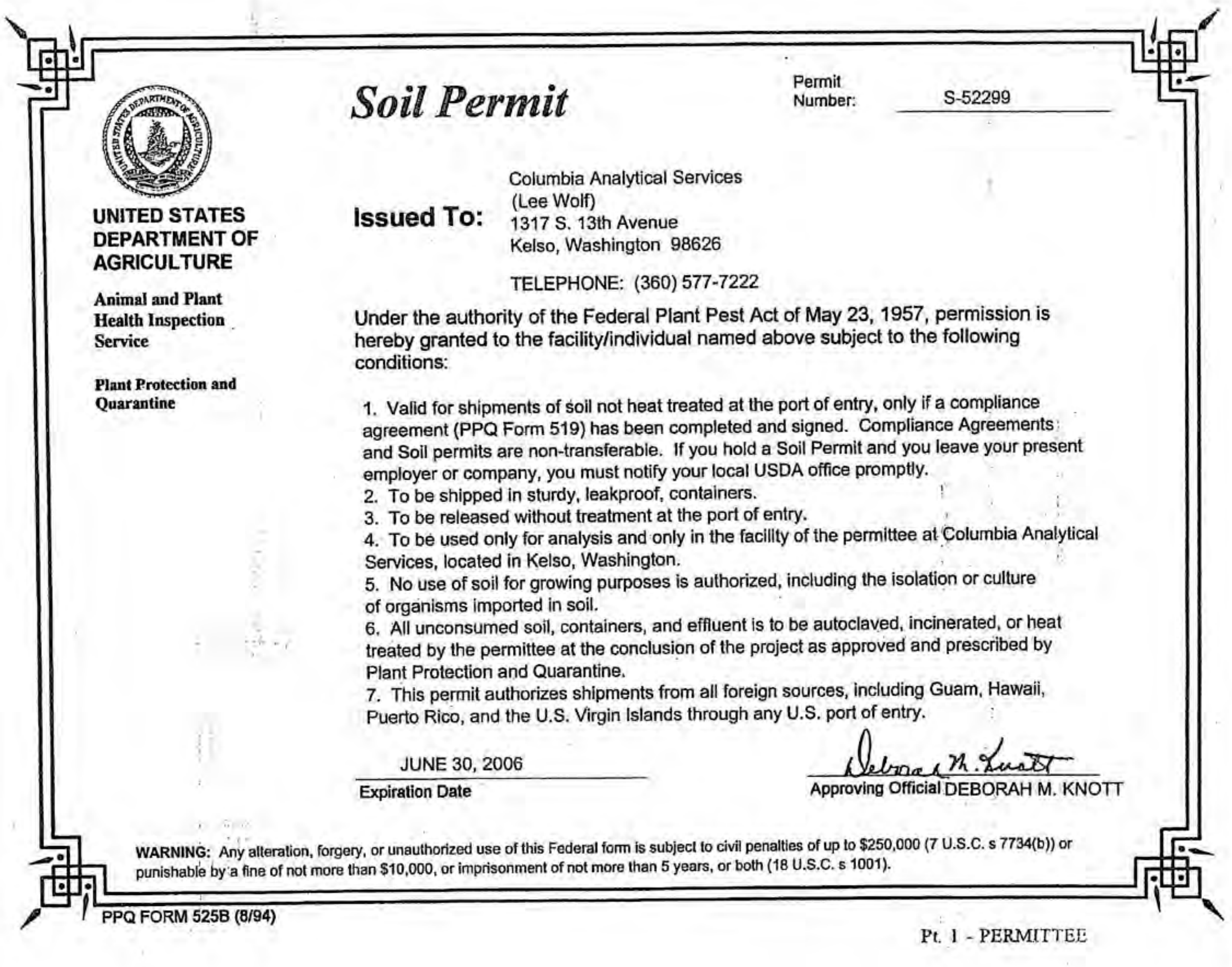
DIVERSION CONTRARY TO UNITED STATES LAW IS PROHIBITED.

I DECLARE ALL THE INFORMATION CONTAINED IN THIS INVOICE TO BE TRUE AND CORRECT

SIGNATURE OF SHIPPER/EXPORTER (Type name and title and sign)

Name/Title	Signature	Date
Joe Smith, Ogden	Joe Smith	1/1/94

Attachment III-F-8
Soil Import Permit



Soil Permit

Permit Number: S-52299

UNITED STATES DEPARTMENT OF AGRICULTURE

Animal and Plant Health Inspection Service

Plant Protection and Quarantine

Issued To:
Columbia Analytical Services
(Lee Wolf)
1317 S. 13th Avenue
Kelso, Washington 98626

TELEPHONE: (360) 577-7222

Under the authority of the Federal Plant Pest Act of May 23, 1957, permission is hereby granted to the facility/individual named above subject to the following conditions:

1. Valid for shipments of soil not heat treated at the port of entry, only if a compliance agreement (PPQ Form 519) has been completed and signed. Compliance Agreements and Soil permits are non-transferable. If you hold a Soil Permit and you leave your present employer or company, you must notify your local USDA office promptly.
2. To be shipped in sturdy, leakproof, containers.
3. To be released without treatment at the port of entry.
4. To be used only for analysis and only in the facility of the permittee at Columbia Analytical Services, located in Kelso, Washington.
5. No use of soil for growing purposes is authorized, including the isolation or culture of organisms imported in soil.
6. All unconsumed soil, containers, and effluent is to be autoclaved, incinerated, or heat treated by the permittee at the conclusion of the project as approved and prescribed by Plant Protection and Quarantine.
7. This permit authorizes shipments from all foreign sources, including Guam, Hawaii, Puerto Rico, and the U.S. Virgin Islands through any U.S. port of entry.

JUNE 30, 2006
Expiration Date

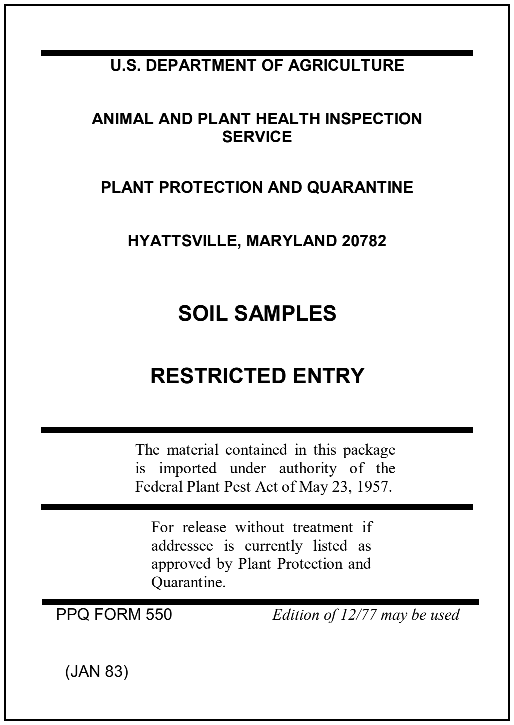
Deborah M. Knott
Approving Official DEBORAH M. KNOTT

WARNING: Any alteration, forgery, or unauthorized use of this Federal form is subject to civil penalties of up to $250,000 (7 U.S.C. s 7734(b)) or punishable by a fine of not more than $10,000, or imprisonment of not more than 5 years, or both (18 U.S.C. s 1001).

PPQ FORM 525B (8/94)

Pt. 1 - PERMITTEE

Attachment III-F-9
Soil Samples Restricted Entry Label and Soil Origin Label



U.S. DEPARTMENT OF AGRICULTURE

ANIMAL AND PLANT HEALTH INSPECTION SERVICE

PLANT PROTECTION AND QUARANTINE

HYATTSVILLE, MARYLAND 20782

SOIL SAMPLES

RESTRICTED ENTRY

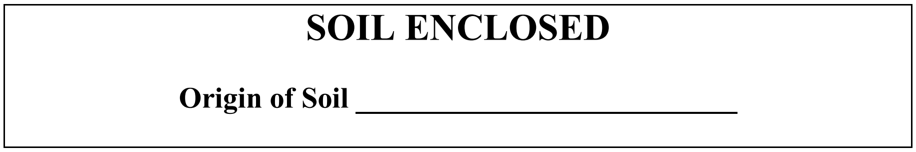
The material contained in this package is imported under authority of the Federal Plant Pest Act of May 23, 1957.

For release without treatment if addressee is currently listed as approved by Plant Protection and Quarantine.

PPQ FORM 550 *Edition of 12/77 may be used*

(JAN 83)

Soil Samples Restricted Entry Label



SOIL ENCLOSED

Origin of Soil ___________________________

Soil Origin Label

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.

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Any misuse or unauthorized disclosure of this information may result in both criminal and civil penalties.

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.

R. E. HARMEYER
CAPT, CEC, U.S. Navy
By direction

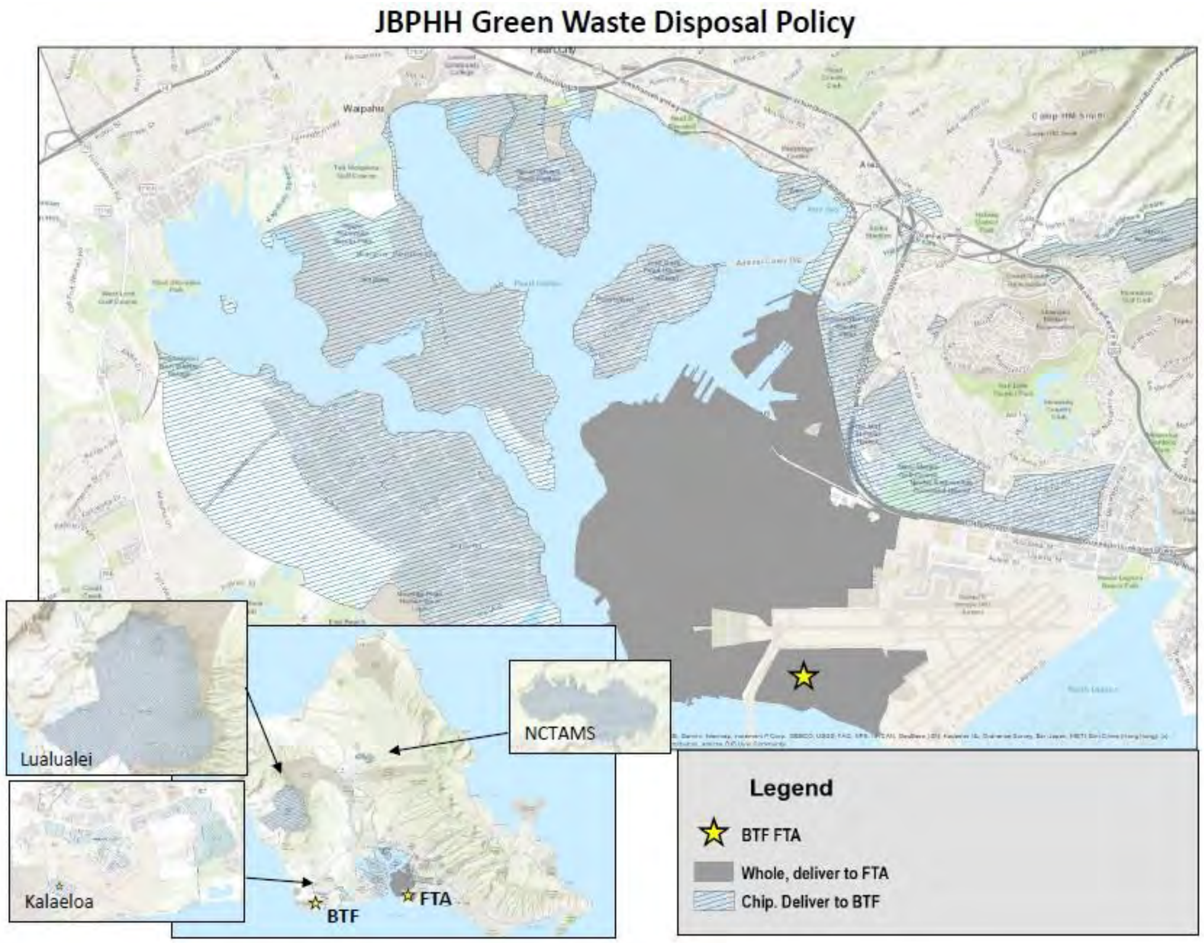
<u>FOR INQUIRIES REGARDING GREEN WASTE POLICY/WAIVER APPLICATION, CONTACT:</u>

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

<u>FIRE TRAINING AREA (FTA) AND BIO-SOLID TREATMENT FACILITY (BTF) CONTACTS:</u>

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)

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Any misuse or unauthorized disclosure of this information may result in both criminal and civil penalties.

Appendix F:
EDMS Requirements

DATA DELIVERABLES REQUIREMENTS

The final report package shall include amended and additional pages requested during data review and validation. To support the data review and validation by AECOM Technical Services, Inc. or third-party, the laboratory shall be required to submit a final report electronically with the following directly into the Red Hill Environmental Data Management System (EDMS) online database:[1]

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

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[1] https://synectics.net/

Data from the laboratory.

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

Data from the laboratory.

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

Data from the laboratory.

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

Data from the laboratory.

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

Data from the laboratory.

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

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

Data Type Descriptions

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

Appendix G:
References

REFERENCES

Bechtel, Bechtel Corporation. 1949. *Subj: Report on Engineering Survey of U. S. Navy Petroleum Facilities at Pearl Harbor*. From: Bechtel Corporation, Contract NOy 16535; To: Officer in Charge, Contract No. 16535. 12 May. San Francisco, CA.

CNRH, Commander Navy Region Hawaii (CNRH). 2020. *Red Hill Fuel Storage Facility (RHFSF) Response Plan*. August.

DLNR, Department of Land and Natural Resources, State of Hawaii (DLNR). 2015. *Endangered Species Recovery Committee Hawaiian Hoary Bat Guidance Document*. Division of Forestry and Wildlife. July. https://dlnr.hawaii.gov/wildlife/files/2013/09/Item-3_Hawaiian-Hoary-Bat-White-Paper-Guidance-Document1.pdf.

DoD and DOE, 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.

———. 2023. *Department of Defense and Department of Energy Quality Systems Manual for Environmental Laboratories Version 6.0*. Prepared by DoD Environmental Data Quality Workgroup and DOE Consolidated Audit Program Data Quality Workgroup.

DoD, 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.

———. 2019. *General Data Validation Guidelines*. Revision 1. Environmental Data Quality Workgroup. September.

DOH, Department of Health, State of Hawaii (DOH). 2005. *Subject: Request for No Further Action Determination for the Red Hill Oily Waste Disposal Facility*. Letter from: M. K. Miyasaka, Hawaii DOH Hazard Evaluation and Emergency Response Office, to: D. Ige, Naval Facilities Engineering Command, Pacific. April 11.

———. 2017a. *Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater, Hawai'i Edition. Volume 1: User's Guide.* Environmental Management Division. Fall 2017.

———. 2017b. *Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan*. Interim Final. Honolulu, HI: Hazard Evaluation and Emergency Response Office. September.

———. 2021. *Emergency Order Re: Emergency Change-In-Service and Defueling of 20 Underground Storage Tanks, Red Hill Bulk Fuel Storage Facility. December 6*. Docket No. 21-UST-EA-02. From: DOH Solid And Hazardous Waste Branch Underground Storage Tank Section. To: The United States Department of the Navy, c/o Rear Admiral Timothy Kott, Commander Navy Region Hawaii.

———. 2022. *Emergency Order. Re: Emergency Change-In-Service, Defueling, and Closure of 20 Underground Storage Tanks, Surge Tanks, and Associated Piping, Red Hill Bulk Fuel Storage Facility*. Docket No. 22-UST-EA-01. From: K. S. Ho, DOH Deputy Director for Environmental Health. To: United States Department of the Navy, c/o Rear Admiral T. J. Kott, Commander, Navy Region Hawaii. https://health.hawaii.gov/about/files/2022/05/DOH-Emergency-Order-Final-May-6-2022.pdf.

———. 2023. *Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan*. Interim Final. Honolulu, HI: Hazard Evaluation and Emergency Response Office. Latest Update: July 2023.

DON, Department of the Navy (DON). 1992. *Work Plan (WP), Red Hill Oily Waste Disposal Pit Remedial Investigation/Feasibility (RI/FS), Naval Supply Center Pearl Harbor, Oʻahu, Hawaiʻi*. Prepared by ERC Environmental and Energy Services Company, Inc. (ERCE), Honolulu, HI. Pearl Harbor, HI: Naval Facilities Engineering Command, Pacific. January.

———. 1996a. *Final Remediation Verification Report, Closure and Removal of Red Hill Stilling Basin, Fleet and Industrial Supply Center - Pearl Harbor, Red Hill, Hawaii*. Prepared by OHM Remediation Services Corp., Pleasanton, CA. Pearl Harbor, HI: Naval Facilities Engineering Command, Pacific. February.

———. 1996b. *Phase I Remedial Investigation Report, Red Hill Oily Waste Disposal Facility, Fleet and Industrial Supply Center, Pearl Harbor, Oahu, Hawaii, Volume I, Technical Report*. Prepared by Ogden Environmental and Energy Services Co., Inc., Honolulu, HI. Pearl Harbor, HI: Naval Facilities Engineering Command, Pacific. January.

———. 1999. *Initial Phase II Site Characterization Report, Fleet Industrial Supply Center Bulk Fuel Storage Facility at Red Hill*. Prepared by Ogden Environmental and Energy Services Co., Inc., Honolulu, HI. Pearl Harbor, HI: Naval Facilities Engineering Command, Pacific. March.

———. 2000. *Remedial Investigation Phase II, Red Hill Oily Waste Disposal Facility, Halawa, Oahu, Hawaii*. Prepared by Earth Tech, Inc., Honolulu, HI. Volume I, Technical Report. Pearl Harbor, HI: Naval Facilities Engineering Command, Pacific. September.

———. 2001. *Subj: Petroleum Contamination at Navy's Installation Restoration (IR) Sites*. Letter from: M. Z. Waki, Environmental Engineering Department, Naval Facilities Engineering Command, Pacific; to: L. Mitani, Environmental Protection Agency Region IX, Federal Facilities Cleanup Office; and K. Kawaoka, Hawaii Department of Health, Hazard Evaluation and Emergency Response Office. 5090.A14, Ser ENV1821/ 1130 and 1131. May 17.

———. 2002. *Red Hill Bulk Fuel Storage Facility Investigation Report (Final) for Fleet Industrial Supply Center (FISC), Oahu, Hawaii*. Prepared by AMEC Earth&Environmental, Inc., Huntsville, AL. Pearl Harbor, HI: Naval Facilities Engineering Command, Pacific. August.

———. 2005. *Red Hill Bulk Fuel Storage Facility Work Plan, Pearl Harbor, Hawaii*. Prepared by The Environmental Company, Inc. (TEC), Honolulu, HI; and AMEC Earth&Environmental, Inc., Honolulu, HI. Pearl Harbor, HI: Naval Facilities Engineering Command, Pacific. June.

———. 2007. *Red Hill Bulk Fuel Storage Facility Final Technical Report, Pearl Harbor, Hawaii*. Prepared by TEC, Inc. Pearl Harbor, HI: Naval Facilities Engineering Command, Pacific. August.

———. 2008a. *Red Hill Bulk Fuel Storage Facility Final Groundwater Protection Plan, Pearl Harbor, Hawaii*. Prepared by TEC Inc. Includes December 2009 Revisions to the Red Hill Groundwater Protection Plan. Pearl Harbor, HI: Naval Facilities Engineering Command, Pacific. January.

———. 2008b. *Tank 17 Removal Action Report, Red Hill Fuel Storage Facility, Pearl Harbor, Oahu, Hawaii*. Prepared by TEC Inc., Honolulu, HI. Pearl Harbor, HI: Commander, Navy Region Hawaii, Environmental Department, Code N45. September.

———. 2014a. *Interim Update, Red Hill Bulk Fuel Storage Facility Final Groundwater Protection Plan, Pearl Harbor, Hawaii. (January 2008)*. Pearl Harbor, HI: Naval Facilities Engineering Command, Pacific. August.

———. 2014b. *Tank 5 Initial Release Response Report, Red Hill Bulk Fuel Storage Facility, JBPHH, Oahu, Hawaii*. Prepared by Commander Navy Region Hawaii Environmental Department, Code N45, JBPHH HI. April.

———. 2015. *Final Project Procedures Manual, U.S. Navy Environmental Restoration Program, NAVFAC Pacific*. JBPHH HI: Naval Facilities Engineering Command, Pacific. May.

———. 2016. *3.2 Tank Upgrade Alternatives (TUA), Scope of Work Outline Final Submission, Red Hill Fuel Storage Facility, NAVSUP FLC Pearl Harbor, HI (PRL), Joint Base Pearl Harbor-Hickam*. 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. Prepared by Enterprise Engineering, Inc., Freeport, ME. JBPHH HI: Naval Facilities Engineering Command, Pacific. September.

———. 2017a. *Groundwater Model Evaluation 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; September 8, 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. *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.

———. 2018a. *Seismic Profiling to Map Hydrostratigraphy in the Red Hill Area, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i; March 30, 2018, Revision 00*. Prepared by Lee Liberty and James St. Claire, Boise State University, Boise, ID, for AECOM Technical Services, Inc., Honolulu, HI. Boise State University Technical Report BSU CGISS 18-01. Prepared for Defense Logistics Agency Energy, Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI.

———. 2018b. *Technical Memorandum, Testing and Verification of Packer Integrity at RHMW11, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i; February 9, 2018*. JBPHH HI: Naval Facilities Engineering Command, Hawaii. February.

———. 2019. *Conceptual Site Model, 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; June 30, 2019, 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.

———. 2020. *Groundwater Flow Model Report, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i; March 25, 2020, 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.

———. 2021a. *Initial Release Response Report, Pipeline Breach in Tunnel Red Hill Bulk Fuel Storage Facility JBPHH O'ahu Hawai'i*. Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Hawaii. September.

———. 2021b. *Navy Memorandum Re History of Releases and Suspected Release Events at the Red Hill Bulk Fuel Storage Facility*. Hawaii Department of Health Case No. 19-UST-EA-01 In the Matter of Contested Case Hearing Re: Red Hill Permit Application. March 5.

———. 2021c. *Subject: Red Hill Bulk Fuel Storage Facility Request for Information – Addendum, DOH Facility ID No. 9-102271, DOH Release ID No. 210012*. Letter from: J. G. Meyer, Navy Region Hawaii; to: Roxanne Kwan, Hawaii DOH Solid and Hazardous Waste Branch. 5090, SerN45/053. October 1.

———. 2022a. *Initial Release Response Report, Fire Suppression Drain Line, 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 HEER Incident Release Case No. 20211120-2330. JBPHH HI: Naval Facilities Engineering Systems Command, Hawaii. Revised March 7.

———. 2022b. *Meeting Summary, RHMW17 Field Observations, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam (JBPHH), O'ahu, Hawai'i; January 27*.

———. 2022c. *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. July 7.

———. 2022d. *Quarterly Release Response Report, 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 Nos. 140010, 210012; DOH HEER Release Incident Case Nos. 20210507-0852, 20211120-2330. JBPHH HI: Naval Facilities Engineering Systems Command, Hawaii. December 21.

———. 2022e. *Red Hill Bulk Fuel Storage Facility Tank Closure Plan*. Office of the Secretary of the Navy. November 1.

———. 2022f. *Technical Memorandum, Holding Tank and Leach Tank Characterization, November 2021 Pipeline Release, Red Hill Bulk Fuel Storage Facility JBPHH, O'ahu, Hawai'i February 2022*. Prepared for NAVFAC Hawaii by AECOM Technical Services, Inc. DOH Facility ID No.

9-102271; DOH Release ID No 20211120_2330. JBPHH HI: Naval Facilities Engineering Systems Command, Hawaii. February.

———. 2023a. *Contaminant Fate and Transport Model Technical Memorandum, Red Hill Bulk Fuel Storage Facility. JBPHH, Oʻahu, Hawaiʻi*. Prepared for NAVFAC Hawaii by AECOM Technical Services Inc. June 26.

———. 2023b. *Final Second Quarter 2023 - Quarterly Groundwater Monitoring Report, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Oʻahu, HI*. Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Hawaii. August 22.

———. 2023c. *Final Technical Memorandum, Phase 2 Holding Tank and Leach Tank Characterization, November 2021 Pipeline Release, Red Hill Bulk Fuel Storage Facility JBPHH, Oʻahu, Hawaiʻi*. Prepared for NAVFAC Hawaii by AECOM Technical Services, Inc. DOH Facility ID No. 9-102271; DOH Release ID No 20211120_2330. JBPHH HI: Naval Facilities Engineering Systems Command, Hawaii. July 13.

———. 2023d. *Groundwater Flow Model Technical Memorandum, Red Hill Bulk Fuel Storage Facility. JBPHH, Oʻahu, Hawaiʻi*. Prepared for NAVFAC Hawaii by AECOM Technical Services Inc. May 17.

———. 2023e. *In-Progress Draft Remedial Investigation Work Plan Per- and Polyfluoroalkyl Substance Release at Building 313 Red Hill Bulk Fuel Storage Facility (Worksheets 10, 11, 15, and 17) Joint Base Pearl Harbor-Hickam Oahu HI*. Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Hawaii. January.

———. 2023f. *Quarterly Release Response Report, Red Hill Bulk Fuel Storage Facility, JBPHH, Oʻahu, Hawaiʻi*. Prepared for NAVFAC Hawaii by AECOM Technical Services, Inc. DOH Facility ID No. 9-102271; DOH UST Release ID Nos. 140010, 210012; DOH HEER Release Incident Case Nos. 20210507-0852, 20211120-2330. JBPHH HI: Naval Facilities Engineering Systems Command, Hawaii. June 20.

———. 2023g. *Site Characterization Report, November 2021 JP-5 Release in Adit 3, Operable Unit 1, Red Hill Bulk Fuel Storage Facility, JBPHH, Oʻahu, Hawaiʻi*. Working Draft. JBPHH HI: Naval Facilities Engineering Systems Command, Hawaii. March.

———. 2023h. *Vadose Zone Model Technical Memorandum, Red Hill Bulk Fuel Storage Facility. JBPHH, Oʻahu, Hawaiʻi*. Prepared for NAVFAC Hawaii by AECOM Technical Services Inc. May 17.

———. 2024a. *Accident Prevention Plan Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam Oʻahu HI*. Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. April.

———. 2024b. *Quarterly Release Response Report, Red Hill Bulk Fuel Storage Facility, JBPHH, Oʻahu, Hawaiʻi*. Prepared for NAVFAC Hawaii by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Hawaii. March 15.

———. 2024c. *Site Characterization Plan Addendum, Collection, Holding, and Transfer Tank Overflow Site Characterization, November 2021 Release, Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam, Oʻahu, Hawaiʻi*. Naval Facilities Engineering Systems Command Hawaii. March.

Earl and Wright. 1962. *Manual of Operations for Aviation Fuel Systems Constructed Under Contract NBy-25540 for the Conversion of POL Facilities, Naval Supply Center, Pearl Harbor, Hawaii*. Prepared by Earl and Wright, Consulting Engineers, San Francisco, California. July 15.

EPA, Environmental Protection Agency, United States (EPA). 2002. *Guidance for Quality Assurance Project Plans*. EPA QA/G-5. EPA/240/R-02/009. Washington, DC: Office of Environmental Information. December.

———. 2006. *Guidance on Systematic Planning Using the Data Quality Objectives Process*. EPA QA/G-4. EPA/240/B-06/001. Washington, DC: Office of Environmental Information. February.

EPA Region 9 and DOH, 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.

EPA Region 9, Environmental Protection Agency, United States, Region 9 (EPA Region 9). 2023. *Red Hill Bulk Fuel Storage Facility Defueling, Closure, and Joint Base Pearl Harbor-Hickam Drinking Water System 2023 Consent Order*. EPA DKT NO. RCRA 7003-R9-2023-001; EPA DKT NO. PWS-AO-2023-001. June 2.

HAER, Historic American Engineering Record (HAER). 2015. *U.S. Naval Base, Pearl Harbor, Red Hill Underground Fuel Storage System: Photographs, Written Historical and Descriptive Data*. HAER HI-123. Washington, DC: National Park Service.

Hunt Jr., C. D. 1996. *Geohydrology of the Island of Oahu, Hawaii*. Professional Paper 1412-B. Regional Aquifer-System Analysis—Oahu, Hawaii. U.S. Geological Survey.

Izuka, S. K. 1992. *Geology and Stream Infiltration of North Halawa Valley, Oahu, Hawaii*. Prepared in cooperation with the State of Hawaii Department of Transportation. Honolulu, HI. Water-Resources Investigations Report 91-4197. U.S. Geological Survey.

Izuka, S. K., J. A. Engott, K. Rotzoll, M. Bassiouni, A. G. Johnson, L. D. Miller, and A. Mair. 2018. *Volcanic Aquifers of Hawaiʻi—Hydrogeology, Water Budgets, and Conceptual Models*. Ver. 2.0, March 2018. Scientific Investigations Report 2015–5164. Water Availability and Use Science Program. U.S. Geological Survey.

Macdonald, G. A. 1941. *Geology of the Red Hill and Waimalu Areas, Oahu, in Relation to the Underground Fuel Storage Project of the U.S. Navy*. February 21, 1941 Report Attachment to Letter from H. T. Stearns, U.S. Geological Survey Geologist in Charge, Hawaiian Ground-Water Investigations, to: Capt. H. F. Bruns, Public Works Office, Pearl Harbor, February 26, 1941. Honolulu, HI: U.S. Geological Survey.

Macdonald, G. A., A. T. Abbott, and F. L. Peterson. 1983. *Volcanoes in the Sea: The Geology of Hawaii*. 2nd ed. Honolulu, HI: University of Hawaii Press.

Oki, D. S. 2005. *Numerical Simulation of the Effects of Low-Permeability Valley-Fill Barriers and the Redistribution of Ground-Water Withdrawals in the Pearl Harbor Area, Oahu, Hawaii*. Scientific Investigations Report 2005-5253. U.S. Geological Survey.

Oki, D. S., S. B. Gingerich, and R. L. Whitehead. 1999. "Hawaii." In *Ground Water Atlas of the United States: Segment 13 - Alaska, Hawaii, Puerto Rico and the U.S. Virgin Islands*. HA 730-N. U.S. Geological Survey.

Pankiwskyj, K. A. 1972. "Geology of the Salt Lake Area, Oahu, Hawaii." *Pacific Science* 26 (2): 242–53.

PGE, Pacific Geotechnical Engineers, Inc. (PGE). 2013. *Final Letter Report, Geotechnical Consultation, During DLA MILCON Planning Documentation, FY15 DLA MILCON [P-205/1551], Red Hill Fire Protection & Ventilation System, Joint Base Pearl Harbor-Hickam, Red Hill Fuel Storage Facility*. September 20.

———. 2015. *0 to 35% Design, FY15 DLA MILCON P-205, Red Hill Fire Suppression and Ventilation System, Joint Base Pearl Harbor-Hickam, Red Hill Fuel Storage Facility, Hawaii*. PGE Job No. 3773-008.

Shaw, Shaw Environmental, Inc. (Shaw). 2005. *Cleaning and Abandonment of Cross Country Pipelines, PRL 03-13, Pearl Harbor, Hawaii*. Technical Report. Revision 0. Air Force Center for Environmental Excellence. January.

———. 2009. *Technical Report: Demolish JP-5 Slop Tank at the Red Hill Fuel Facility Fleet and Industrial Supply Center Pearl Harbor, Hawaii*. Rev. 0. Brooks City-Base, TX: Air Force Center for Engineering and the Environment. April.

Sohn, Y. K., and K. H. Park. 2005. "Composite Tuff Ring/Cone Complexes in Jeju Island, Korea: Possible Consequences of Substrate Collapse and Vent Migration." *Journal of Volcanology and Geothermal Research* 141:157–75.

Stearns, H. T. 1943. *Print of Log of Red Hill Shaft Water Development Tunnel*. Letter from: H. T. Stearns, USGS Senior Geologist, to: O. E. Meizner, Geologist in Charge, USGS Division of Ground Water. Provided as Attachment to Stearns April 12, 1941 Report: A Maui-Type Well for the U. S. Navy at Red Hill, Oahu.

Stearns, H. T., and K. N. Vaksvik. 1935. *Geology and Groundwater Resources of the Island of Oahu, Hawaii*. Bulletin 1. Prepared in cooperation with the Geological Survey. Honolulu: Hawaii (Terr.) Department of Public Lands, Division of Hydrography.

USDA SCS, United States Department of Agriculture, Soil Conservation Service (USDA SCS). 1972. *Soil Survey of Islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii*. In cooperation with the University of Hawaii Agricultural Experiment Station. Washington, DC. August. https://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=HI.

USGS, United States Geological Survey (USGS). 2017a. *National Water Information System - Moanalua Precipitation Gauge*. https://nwis.waterdata.usgs.gov/nwis/inventory/?site_no=212359157502601&agency_cd=USGS. Accessed October 2017.

———. 2017b. *National Water Information System - North Halawa Valley Precipitation Gauge*. https://nwis.waterdata.usgs.gov/nwis/inventory/?site_no=212428157511201&agency_cd=USGS. Accessed October 2017.

———. 2017c. *USGS 212304157542201 771.9 N Halawa Rain Gage Nr Honolulu, Oahu, HI*. https://waterdata.usgs.gov/nwis/dv?cb_00045=on&format=html&site_no=212304157542201&referred_module=sw&period=&begin_date=2005-01-01&end_date=2017-07-07. Accessed July 2017.

———. 2017d. *USGS 212346157533701 772.1 N Halawa Rain Gage Nr Aiea, Oahu, HI*. https://waterdata.usgs.gov/nwis/dv?cb_00045=on&format=html&site_no=212346157533701&referred_module=sw&period=&begin_date=2005-01-01&end_date=2017-07-06. Accessed July 2017.

USINDOPACOM, U.S. Indo-Pacific Command. 2024. "Joint Task Force Red Hill." March 18, 2024. https://www.pacom.mil/JTF-Red-Hill/.

Walker, G. P. L. 1990. "Geology and Volcanology of the Hawaiian Islands." *Pacific Science* 44 (4): 315–47.

Wentworth, C. K. 1938. *Geology and Ground Water Resources of the Palolo-Waialae District*. Honolulu, HI: Board of Water Supply.

———. 1951. *Geology and Groundwater Resources of the Honolulu-Pearl Harbor Area, Oahu, Hawaii*. Honolulu, HI: City and County of Honolulu, Board of Water Supply.

Wentworth, C. K., and G. A. Macdonald. 1953. *Structures and Forms of Basaltic Rocks in Hawaii*. Geological Survey Bulletin 994. U.S. Geological Survey.

White, J. D. L., and P. S. Ross. 2011. "Maar-Diatreme Volcanoes: A Review." *Journal of Volcanology and Geothermal Research* 201:1–29.