

PRE-DECISIONAL



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

Draft

**Remedial Investigation Work Plan
Per- and Polyfluoroalkyl
Substances Release**

Red Hill Bulk Fuel Storage Facility

JOINT BASE PEAR HARBOR-HICKAM OAHU HI

PEARL HARBOR HI FISC SITE 30

June 2024

Distribution Statement A: Approved for public release: distribution is unlimited.

**THIS DOCUMENT CONTAINS SENSITIVE BUT UNCLASSIFIED INFORMATION WHICH IS PROHIBITED BY THE
FREEDOM OF INFORMATION ACT (FOIA):**

Citation in document	FOIA Exemption	Description
(b)(3)(A) or (b)(3)(B)	Exemption 3 (5 USC 552(b)(3)): Information exempted by other Federal statutes	<p>Information is exempted by one of the following statutes:</p> <ul style="list-style-type: none">• 10 USC § 130(e): Treatment under FOIA of certain critical infrastructure security information*• 16 USC § 470hh: The Archaeological Resources Protection Act of 1979• 16 USC § 470w-3: National Historic Preservation Act 1966 <p>*A listing of critical infrastructure determinations under 10 USC § 130(e) are provided at: https://open.defense.gov/Transparency/FOIA/FOIA-Resources/</p>
(b)(6)	Exemption 6 (5 USC 552(b)(6)): Personal information affecting an individual's privacy	Information is exempted as Personally Identifiable Information (PII) (examples: signatures, personal telephone numbers, personal email)

For more information about the Department of the Navy FOIA program:

<https://www.secnave.navy.mil/foia/Pages/default.aspx>



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

Draft

**Remedial Investigation Work Plan
Per- and Polyfluoroalkyl
Substances Release
Red Hill Bulk Fuel Storage Facility
JOINT BASE PEAR HARBOR-HICKAM OAHU HI**

PEARL HARBOR HI FISC SITE 30

June 2024

Prepared for NAVFAC Hawaii by
AECOM Technical Services Inc
1001 Bishop Street Suite 1600
Honolulu HI 96813-3698

**N62742-23-D-1802
CTO N6274223F0178**

Worksheet #1: Title and Approval Page

Draft
Work Plan/Sampling and Analysis Plan
June 2024

Remedial Investigation Work Plan
Joint Base Pearl Harbor-Hickam

Prepared for:



Department of the Navy
Naval Facilities Engineering Systems Command, Hawaii

Prepared for NAVFAC Hawaii by
AECOM Technical Services Inc
1001 Bishop Street Suite 1600
Honolulu HI 96813-3698

Prepared under:
Comprehensive Long-Term Environmental Action Navy
Contract Number N62742-23-D-1802, CTO N6274223F0178

NOTE – Will be signed upon final submission

AECOM CTO Manager:

Jeff Hart

Date

NOTE – Will be signed upon final submission

AECOM QA Program Manager:

Scott Lewis

Date

NOTE – Will be signed upon final submission

NAVFAC Hawaii RPM:

Charlotte Rangel

Date

EXECUTIVE SUMMARY

This Work Plan (WP) presents the proposed sampling and analysis program for a remedial investigation (RI) of per- and polyfluoroalkyl substances (PFAS) associated with known and potential undocumented aqueous film-forming foam (AFFF) release areas located at the Red Hill Bulk Fuel Storage Facility (RHBFSF), Joint Base Pearl Harbor-Hickam (JBPHH), Oahu, Hawaii (Figure 1). This WP has been prepared for the United States Department of the Navy under the Comprehensive Long-Term Environmental Action, Navy VI program contract number N62742-23-D-1802, contract task order N6274223F0178.

The purpose of the RI is to evaluate the nature and extent of potential PFAS impacts, and to characterize potential risks to human health and the environment associated with exposure to PFAS. Examples of common PFAS evaluated in this study include, but are not limited to, perfluorooctanoic acid and perfluorooctanesulfonic acid (PFOS). There are two general investigation areas at Red Hill: Area A and Area B (Figure 1). The investigation at Area A focuses on surface and subsurface soil, swale drainage sediment, and groundwater sampling locations near Building (Bldg.) 313 and includes areas outside and adjacent to the Adit 6 entrance where the November 2022 AFFF release incident occurred (Figure 2). The investigation at Area B includes proposed soil and groundwater sampling near the Red Hill Shaft (RHS) Water Pump House and at the western extent of the RHBFSF within the Oily Waste Disposal Facility (OWDF) located west of the Area B boundary. This WP includes a study design that will characterize the current site conditions and determine whether any further evaluation will be necessary to address PFAS at Area A and Area B (herein referred to collectively as “the Site”).

The RHBFSF is located on the island of Oahu approximately 2 miles northeast of the East Loch of Pearl Harbor, in the Koolau foothills (Figure 1). The entire RHBFSF is approximately 144 acres. Area A has an approximate rectangular area of 0.6 acre including Bldg. 313 (Pump House) and the AFFF release location around Adit 6. Area B has an approximate area of 18 acres situated around existing monitoring wells that had PFAS detections above November 2023, tap water EPA regional screening levels. The Area A and Area B lateral boundaries are shown on Figure 3.

The RHBFSF includes a complex of 20 vertical fuel storage tanks constructed beneath a minimum of 100 feet of volcanic rock, which include lower and upper access tunnels (Figure 1). Each tank is 100 feet in diameter and 250 feet high. As a part of the facility’s operations, an AFFF fire suppression system was installed between 2015 and 2018 (DON 2022b). The AFFF system was designed to provide fire protection for the lower tunnel of the RHBFSF. This fire suppression system involved the construction of Bldg. 313, that previously housed an aboveground storage tank (AST) for storing AFFF concentrate, along with the pumps and controllers for AFFF operation.

Historic features that existed in Area A include a former 5,000-barrel “slop tank” (210,000 gallons) (Facility Number [No.] S-355) that was built in the early 1960s. Tank S-355 was fed by an 8-inch-diameter oily waste line, which ran from Adit 6 (HAER 2015). A 200-gallon AFFF AST was located on the northern shoulder of Icarus Way, adjacent to the Adit 6 portal, with a 1.5-inch foam line to the former slop tank as part of the historic fire suppression system, to mitigate fires in the slop tank. Prior to the construction of Bldg. 313, the slop tank AST and AFFF AST were demolished in 2008, the associated piping was cut and plugged, the adjacent slop pump was removed, and the containment basin berms were leveled.

On 29 November 2022, approximately 1,100 gallons of AFFF concentrate (AFFF 3%-C6 solution) were released from the upgraded fire suppression system at the entrance of Adit 6 (DoD 2023d; EPA

Region 9 2023). An improperly installed valve on the tunnel's fire suppression system caused a containment standpipe to overflow with AFFF concentrate that seeped under a door, down an estimated 100-foot-long section of tunnel and out an exterior paved access road near Adit 6; affecting outside areas and potentially the underlying and adjacent soils (DOH HDB 2022).

Immediately following the release, the Navy conducted an emergency removal action which removed approximately 3,000 cubic feet of AFFF-impacted soil from areas outside of Adit 6. Prior to backfilling these excavations, PFAS confirmation sampling was conducted at the excavation boundaries (DON 2022a). PFAS were detected in confirmation soil samples but were below November 2023 EPA residential regional screening levels for soil (Figure 4); however, it is currently unknown if PFAS in surface and subsurface soil extend beyond the excavated areas. No other releases of AFFF from the fire suspension system are known to have occurred at Adit 6 or within Area A.

Area A consists of the upper lot area at the entrance to Adit 6 where the November 2022 AFFF concentrate release occurred, and the lower lot area that contains Bldg. 313 (Figure 3). Outside Adit 6 is where the excavation occurred in response to the release. The excavated areas included the crushed rock apron at the tunnel entrance, a portion of the asphalt roadway and the culvert and concrete drainage ditch to the southwest along the access road. Independently of the AFFF release, the culvert beneath the access road from the drainage ditch, and the stormwater outfall beyond the culvert were also excavated. Between the Adit 6 and Bldg. 313s is the paved road, Icarus Way, and a vegetated down slope. Area A includes three smaller access roads: one leading to Adit 6; one leading to the Bldg. 313 lower paved lot; and a temporary access road leading to basal groundwater monitoring well RHMW17. There are also vegetated areas within the northern section of Area A. Two Red Hill basal groundwater monitoring wells (RHMW06 and RHMW17) and two perched monitoring wells/piezometers (RHMW17S/RHMW17D) are also located within Area A.

Area B consists mostly of steeply sloping land populated by shrub brush and low trees. Icarus Way winds through the northern portion of the area, and the concrete-lined South Halawa Stream borders the northern portion of Area B. Icarus Way also loops back along the southern portion of Area B and is bordered to the south by military housing with portions of the area extending south of the RHBFSF fence line. The main operational feature within Area B is the RHS Pump House, which formerly provided potable water to the JBPHH Water Distribution System. The westernmost extent of the RHBFSF will also be included in this investigation to further delineate potential PFAS impacts.

Ten groundwater monitoring wells are located within the Area B boundary and at the westernmost extent of the RHBFSF: RHP01, RHP02, RHP03, RHP06, RHP07, RHP08, OWDFMW03A, OWDFMW03B, OWDFMW08A, and OWDFMW08B (Figure 3 and Figure 11). RHMW2254-01 is a sampling point in the basal aquifer and is located within the RHS Pump House. Monitoring wells RHP01, RHP02, and RHP03 are located in the northern portion of Area B, along Icarus Way. RHP07 is located inside the Red Hill tunnel, while RHP06 and RHP08 are located outside of the RHBFSF boundary near military housing. Monitoring wells OWDFMW03A, OWDFMW03B, OWDFMW08A, and OWDFMW08B are located to the west of Area B at the western extent of the RHBFSF.

There have been no known AFFF releases in Area B; however, previous sampling indicated that PFOS was present in groundwater monitoring wells at levels above November 2023 tap water EPA regional screening levels (Figure 5). Area B was recommended for further evaluation in an RI to establish the nature and extent of the PFAS detections exceeding screening criteria in soil and groundwater, and to evaluate any potential risk to human health and the environment. Additionally, the westernmost extent of the RHBFSF is also being evaluated to assess the extent of PFAS at this boundary.

The investigation will include the environmental sampling of surface and subsurface soil, drainage swale sediment (Area A only), and groundwater for the laboratory analysis of 40 PFAS listed in Worksheet #15. Five additional monitoring wells are proposed for installation in the basal aquifer across the RHBFSF: two in Area A and three in Area B. If perched groundwater is encountered during the drilling of these wells, then additional wells will be installed to monitor the perched groundwater. These wells will supplement the existing wells located at the RHBFSF.

The environmental samples collected during the PFAS RI will be shipped to a Department of Defense Environmental Laboratory Accreditation Program-accredited laboratory and analyzed for 40 PFAS using United States Environmental Protection Agency Method 1633 (EPA 2024b; DoD 2024b). The analytical data will be validated using an independent data validator, and the results will be used for assessing the lateral and vertical extents of PFAS in soil and swale sediment and serve as the basis for conducting human health and ecological risk assessments.

Data from the investigation will be used to characterize the nature and extent of PFAS in soil, swale drainage sediment and groundwater, and evaluate potential risks to human health and the environment associated with potential exposure to PFAS. A preliminary conceptual site model to identify the potential receptors and exposure pathways is presented on Figure 6 and Figure 7. Baseline human health and ecological risk assessments will quantify the potential for adverse effects for exposure to residual levels of PFAS in soil or groundwater at the Site based on conceptual site model and specific exposure assumptions. The results of the field sampling and baseline human health and ecological risk assessments will provide the basis for recommendations of any further assessment/evaluations in an RI report.

CONTENTS

Worksheet #1: Title and Approval Page	1
Executive Summary	3
Acronyms and Abbreviations	11
Worksheet #2: Work Plan/Sampling and Analysis Plan Identifying Information	15
Worksheet #3: Distribution List	19
Worksheet #4: Project Personnel Sign-Off Sheet	21
Worksheet #5: Project Organizational Chart	23
Worksheet #6: Communication Pathways	25
Worksheet #7: Personnel Responsibilities Table	27
Worksheet #8: Special Personnel Training Requirements Table	29
Worksheet #9: Project Scoping Session Participants Sheet	31
Worksheet #10: Conceptual Site Model	33
Worksheet #11: Project Quality Objectives/Systematic Planning Process Statements	53
Worksheet #12: Field Quality Control Samples	59
Worksheet #13: Secondary Data Criteria and Limitations Table	61
Worksheet #14: Summary of Project Tasks	63
Worksheet #15: Reference Limits and Evaluation Tables	83
Worksheet #16: Project Schedule/Timeline Table	91
Worksheet #17: Sampling Design and Rationale	93
Worksheet #18: Location-Specific Sampling Methods/SOP Requirements Table	101
Worksheet #19: Field Sampling Requirements Table	105
Worksheet #20: Field Quality Control Sample Summary Table	107
Worksheet #21: Project Sampling SOP References Table	109
Worksheet #22: Field Equipment Calibration, Maintenance, Testing, and Inspection Table	111
Worksheet #23: Analytical SOP References Table	113
Worksheet #24: Analytical Instrument Calibration Table	115
Worksheet #25: Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table	119
Worksheet #26: Sample Handling System	121
Worksheet #27: Sample Custody Requirements	123
Worksheet #28: Laboratory QC Samples Table	127

Worksheet #29: Project Documents and Records Table	129
Worksheet #30: Analytical Services Table	131
Worksheet #31: Planned Project Assessments Table	133
Worksheet #32: Assessment Findings and Corrective Action Responses	135
Worksheet #33: Quality Assurance Management Reports Table	137
Worksheets #34-36: Data Verification and Validation (Steps I and IIa/IIb) Process Table	139
Worksheet #37: Usability Assessment	141

APPENDIXES

- A Figures
- B Standard Operating Procedures (on CD-ROM at end of document)
- C Accident Prevention Plan
- D Analytical Data Package Requirements
- E Well Completion Diagrams and Monitoring Well Designs
- F Surface Completion
- G References
- H Response to Comments

FIGURES (INCLUDED IN APPENDIX A)

- 1 Vicinity Map
- 2 Area A Former Site Layout and Features
- 3 Current Site Layout and Features
- 4 Area A Previous Confirmation Sample/Former Decision Unit Soil Results
- 5 Baseline Groundwater Sampling Detected PFAS
- 6 Pictorial Conceptual Site Model – Area A
- 7 Pictorial Conceptual Site Model – Area B
- 8 Human Health Exposure Pathway Evaluation
- 9 Ecological Conceptual Site Model/Exposure Pathway Evaluation
- 10 Proposed Soil Sampling Locations – Area A
- 11 Proposed Soil Sampling Locations – Area B

TABLES

10-1 Results for Soil, Total PFAS Samples Collected in December 2022	44
10-2 Statistical Metrics for Comprehensive Set of Groundwater PFAS Samples Validated through December 2023	46

15-1	Project Screening Levels and Laboratory-Specific Limits for Surface Soil and Sediment	84
15-2	Project Screening Levels and Laboratory-Specific Limits for Subsurface Soil	86
15-3	Project Screening Levels and Laboratory-specific Limits for Groundwater Evaluation	88
27-1	Area Identifiers	124
27-2	Sample Type and Matrix Identifiers	125
27-3	Field QC Sample Type Identifiers	125
37-1	List of Data Qualifiers and Definitions	142
37-2	Reporting Requirements	142

ACRONYMS AND ABBREVIATIONS

%	percent
°C	degree Celsius
3:3 FTCA	3-perfluoropropyl propanoic acid
4:2 FTS	4:2 fluorotelomer sulfonic acid
5:3 FTCA	2H,2H,3H,3H-perfluorooctanoic acid
6:2 FTS	6:2 fluorotelomer sulfonic acid
AECOM	AECOM Technical Services, Inc.
AFFF	aqueous film-forming foam
APP	accident prevention plan
AST	aboveground storage tank
bgs	below ground surface
Bldg.	building
CAS	Chemical Abstracts Service
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CHT	collection, holding, and transfer
COC	chain-of-custody
CSM	conceptual site model
CTO	contract task order
DL	detection limit
DoD	Department of Defense
DOH	Department of Health, State of Hawaii
EAL	environmental action level
ELAP	Environmental Laboratory Accreditation Program
EPA	Environmental Protection Agency, United States
ER	environmental restoration
gpm	gallon per minute
GPS	Global Positioning System
HDPE	high-density polyethylene
HFPO-DA	hexafluoropropylene oxide dimer acid
ID	identification
IDW	investigation-derived waste
JP-5	Jet Propellant 5
LOD	limit of detection
LOQ	limit of quantitation
MEC	munitions and explosives of concern
MPC	measurement performance criteria
MS	matrix spike
msl	mean sea level
NAVFAC	Naval Facilities Engineering Systems Command
Navy	Department of the Navy, United States
NCTF-RH	Navy Closure Task Force-Red Hill
NEtFOSA	N-ethyl perfluorooctanesulfonamide
NFA	no further action
NFE	no further evaluation

ng/L	nanogram per liter
no.	number
NMeFOSE	N-methyl perfluorooctanesulfonamidoethanol
OWDF	Oily Waste Disposal Facility
PA	preliminary assessment
PARCC	precision, accuracy, representativeness, comparability, and completeness
PFAS	per- and polyfluoroalkyl substances
PFBA	perfluorobutanoic acid
PFBS	perfluorobutane sulfonic acid
PFDA	perfluorodecanoic acid
PFDaA	perfluorododecanoic acid
PFDoS	perfluorododecanesulfonic acid (PFDoS)
PFDS	perfluorodecanesulfonic acid
PFHpA	perfluoroheptanoic acid
PFHpS	perfluoroheptanesulfonic acid
PFHxA	perfluorohexanoic acid
PFHxS	perfluorohexane sulfonic acid
PFNA	perfluorononanoic acid
PFNS	perfluorononanesulfonic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
PFOSA	perfluorooctanesulfonamide
PFPeA	perfluoropentanoic acid
PFPeS	perfluoropentanesulfonic acid
PFTA	perfluorotetradecanoic acid
PFTeDA	perfluorotetradecanoic acid
PFTTrDA	perfluorotridecanoic acid
PFUnA	perfluoroundecanoic acid
PID	photoionization detector
PPE	personal protective equipment
ppmv	part per million by volume
PSL	project screening level
PSQ	principal study question
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
QSM	Quality Systems Manual
RHBFSF	Red Hill Bulk Fuel Storage Facility
RHS	Red Hill Shaft
RI	remedial investigation
RPD	relative percent difference
RPM	remedial project manager
RSL	regional screening level
SDS	safety data sheet
SI	site inspection

SOP	standard operating procedure
SSI	supplemental site inspection
THQ	target hazard quotient
TRL	target risk level
U.S.	United States
USCS	Unified Soil Classification System
VOC	volatile organic compound
WGS	World Geodetic System
WP	Work Plan

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

Site Name/Number: Red Hill
Operable Unit: Joint Base Pearl Harbor-Hickam
Contractor Name: AECOM Technical Services, Inc. (AECOM)
Contract Number: N62742-23-D-1802
Contract Title: Environmental Restoration Support and CERCLA Activities for PFAS Releases, Red Hill, Joint Base Pearl Harbor-Hickam, Oahu, Hawaii
Work Assignment Number (optional): Contract Task Order (CTO) N6274223F0178

1. This Work Plan (WP)/Sampling and Analysis Plan (SAP) 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: Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)

Secondary: None
3. This WP/SAP is a project-specific WP/SAP.
4. List organizational partners (stakeholders) and identify the connection with lead organization:

Organization Partner/Stakeholder	Role
Naval Facilities Engineering Systems Command, Hawaii	Lead Organization
United States Environmental Protection Agency	Territorial Regulatory Agency Support
State of Hawaii Department of Health	Regulatory Agency
AECOM Technical Services, Inc.	Lead Organization's Prime Contractor

5. Lead organization: NAVFAC Hawaii
6. If any required WP/SAP elements and required information are not applicable to the project or are provided elsewhere, then note the omitted WP/SAP elements and provide an explanation for their exclusion below:

All elements of the Uniform Federal Policy for quality assurance project plans are included in this document.

Worksheet #	Required Information	Crosswalk to Related Information
A. Project Management and Objectives		
Documentation		
1	Title and Approval Page	Page 1
2	Work Plan/Sampling and Analysis Plan Identifying Information	Page 15
3	Distribution List	Page 19
4	Project Personnel Sign-Off Sheet	Page 21
Project Organization		
5	Title and Approval Page	Page 23
6	Communication Pathways	Page 25
7	Personnel Responsibilities Table	Page 27
8	Special Personnel Training Requirements Table	Page 29
Project Planning/Problem Definition		
9	Project Scoping Session Participants Sheet	Page 31
10	Conceptual Site Model	Page 33
11	Project Quality Objectives/Systematic Planning Process Statements	Page 53
12	Field Quality Control Samples	Page 59
13	Secondary Data Criteria and Limitations Table	Page 59
14	Summary of Project Tasks	Page 63
15	Reference Limits and Evaluation Tables	Page 83
16	Project Schedule/Timeline Table	Page 91
B. Measurement/Data Acquisition		
Sampling Tasks		
17	Sampling Design and Rationale	Page 91
18	Location-Specific Sampling Methods/SOP Requirements Table	Page 101
19	Field Sampling Requirements Table	Page 101
20	Field Quality Control Sample Summary Table	Page 107
21	Project Sampling SOP References Table	Page 109
22	Field Equipment Calibration, Maintenance, Testing, and Inspection Table	Page 111
Analytical Tasks		
23	Analytical SOP References Table	Page 113
24	Analytical Instrument Calibration Table	Page 115
25	Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table	Page 119
Sample Collection		
26	Sample Handling System	Page 121
27	Sample Custody Requirements	Page 123
Quality Control Samples		
28	Laboratory QC Samples Table	Page 127
Data Management Tasks		
29	Project Documents and Records Table	Page 129
30	Analytical Services Table	Page 131
C. Assessment Oversight		
31	Planned Project Assessments Table	Page 133
32	Assessment Findings and Corrective Action Responses	Page 135
33	Quality Assurance Management Reports Table	Page 137

Worksheet #	Required Information	Crosswalk to Related Information
D. Data Review		
34-36	Data Verification and Validation (Steps I and IIa/IIb) Process Table	Page 139
37	Usability Assessment	Page 141
COC	chain of custody	
QA	quality assurance	
QC	quality control	
SOP	standard operating procedure	

This document also includes the following appendixes:

1. *Appendix A:* Figures
2. *Appendix B:* Standard Operating Procedures
3. *Appendix C:* Accident Prevention Plan
4. *Appendix D:* Analytical Data Package Requirements
5. *Appendix E:* Well Completion Diagrams and Monitoring Well Designs
6. *Appendix F:* Surface Completion
7. *Appendix G:* References
8. *Appendix H:* Response to Comments

Worksheet #3: Distribution List

(b) (6)



Worksheet #4: Project Personnel Sign-Off Sheet

Listed below are key personnel who are required to read and understand the WP/SAP 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 WP/SAP to the key personnel listed below. Upon completion of review of the WP/SAP, the personnel will acknowledge that they have read the WP/SAP 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 WP/SAP 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 WP/SAP.

(b) (6)



Worksheet #5: Project Organizational Chart

(b) (6)



Worksheet #6: Communication Pathways

The communication pathways for the WP/SAP are shown below.

(b) (6)



Title: Draft RI WP

Site/Project Name: PFAS Release, RHBFSF

Site Location: JBPHH Oahu HI

Revision Number: 00
Revision Date: June 2024

(b) (6)



Worksheet #7: Personnel Responsibilities Table

Project-specific responsibilities are provided in the following table.

(b) (6)

Title: Draft RI WP

Site/Project Name: PFAS Release, RHBFSF

Site Location: JBPHH Oahu HI

Revision Number: 00
Revision Date: June 2024

(b) (6)



Title: Draft RI WP

Site/Project Name: PFAS Release, RHBFSF

Site Location: JBPHH Oahu HI

Revision Number: 00

Revision Date: June 2024

Worksheet #8: Special Personnel Training Requirements Table

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
Specialized Sampling Methods	General PFAS Sampling Guidance	AECOM	N/A ^a	Field Staff	AECOM	1001 Bishop Street Suite 1600 Honolulu, HI 96813

N/A not applicable

PFAS per- and polyfluoroalkyl substances

^a PFAS sampling training is currently provided on demand via AECOM University.

Title: Draft RI WP

Site/Project Name: PFAS Release, RHBFSF

Site Location: JBPHH Oahu HI

Revision Number: 00

Revision Date: June 2024

Worksheet #9: Project Scoping Session Participants Sheet

Project Name: PFAS Substances Release, RHBFSF

Projected Date(s) of Sampling: September 2024

Contract Task Order Manager: Watson Tanji

Date of Session: 12 April 2024

Scoping Session Purpose: To discuss the Red Hill PFAS Remedial Investigation.

Site Name: RHBFSF

Site Location: RHBFSF, JBPHH, Oahu, HI

(b) (6)



Title: Draft RI WP

Site/Project Name: PFAS Release, RHBFSF

Site Location: JBPHH Oahu HI

Revision Number: 00

Revision Date: June 2024

Project Name: PFAS Substances Release, RHBFSF

Projected Date(s) of Sampling: September 2024

Contract Task Order Manager: Watson Tanji

Date of Session: 12 April 2024

Scoping Session Purpose: To discuss the Red Hill PFAS Remedial Investigation.

Site Name: RHBFSF

Site Location: RHBFSF, JBPHH, Oahu, HI

(b) (6)

NCTF-RH

Navy Closure Task Force-Red Hill

Comments/Decisions: Presentation of Navy's slides and general discussion.

The following general topics were discussed during the scoping session: site history and background information, previous investigations (including groundwater gradient, flow direction, and modeling results), technical approach and proposed RI sampling program, sample analysis test method, project screening criteria, data availability/format, proposed monitoring wells (i.e., locations and design), and WP submission and review schedule.

Action Items:

1. The Navy will submit the draft WP, potentially providing specific QAPP worksheets early to expedite the review.
2. EPA will follow up with their QA reviewers as to which QAPP worksheets they could review early to expedite the review process.

Consensus Decisions:

1. Regulatory agencies will not provide written review comments until receipt of the draft WP, but may consider earlier review of specific worksheets.
2. The Navy will use PFAS toxicity values established by EPA and the State of Hawaii Department of Health (DOH). These toxicity values are consistent with the current DoD policy and are considered appropriate for investigations under the DoD Cleanup Program.
3. The proposed groundwater monitoring wells will target the basal aquifer. If perched groundwater is encountered, a separate well will be installed for sampling the perched groundwater, creating a well cluster.
4. The diameter of the new monitoring wells will be 4 inches.

No further scoping meetings will be needed until after submission of the draft WP.

Worksheet #10: Conceptual Site Model

10.1 OVERVIEW

This Work Plan (WP) was prepared to document the proposed sampling and analysis program for a remedial investigation (RI) of releases of PFAS-containing materials at the Red Hill Bulk Fuel Storage Facility (RHBFSF), Joint Base Pearl Harbor-Hickam (JBPHH), Oahu, Hawaii (Figure 1).

The purpose of the RI is to characterize the nature and extent of per- and polyfluoroalkyl substances (PFAS) in soil, swale drainage sediment, and groundwater outside and adjacent to Red Hill Adit 6 and Bldg. 313 (within “Area A”) and in soil and groundwater near the Red Hill Shaft (RHS) Water Pump House (within “Area B”) and Oily Waste Disposal Facility (OWDF), and to evaluate risks to human health and the environment associated with potential exposure to PFAS (Figure 1). The data collection proposed in this WP will evaluate site conditions and determine whether any further action is necessary to address PFAS at the Site (within the Area A Boundary [“Area A”] and Area B Boundary [“Area B”]).

This worksheet presents the preliminary conceptual site model (CSM) for the Site. Results of the RI field activities will be used to refine and update the CSM using the additional data and information.

10.2 SITE DESCRIPTION, HISTORY, AND ENVIRONMENTAL SETTING

10.2.1 Site Description(s) and History

The RHBFSF is located on the island of Oahu approximately 2 miles northeast of the East Loch of Pearl Harbor, in the Koolau foothills (Figure 1). The 144-acre RHBFSF is owned by the Defense Logistics Agency and formerly operated by Naval Supply Systems Command Fleet Logistics Center Pearl Harbor. This investigation focuses on the area near Building (Bldg.) 313 and adjacent to Red Hill Adit 6 (Area A), as well as near the RHS Water Pump House (Area B).

10.2.1.1 RED HILL BULK FUEL STORAGE FACILITY

The RHBFSF consists of (b) (3) (A) storage tanks constructed beneath a minimum of 100 feet of volcanic rock (Figure 1). (b) (3) (A)

(b) (3) (A) An AFFF fire suppression system was constructed at the facility and finished in 2018 (Section 10.2.1.3).

The westernmost extent of the RHBFSF includes the OWDF, which consisted of two different reclamation and disposal pits and basins and operated between 1943 and 1986. Both pits functioned similarly: oily wastewater generated from periodic cleaning of the RHBFSF underground storage tanks was pumped into the pit, where recoverable oil was skimmed from the surface. The recovered oil was transferred to holding tanks and then to trucks for transport to a fuel processing facility at Pearl Harbor. The remaining water was left to evaporate or infiltrate, and was also directed into channelized South Halawa Stream, which is located approximately 300 feet north of the pits (DON 1996b). No historical documentation of AFFF use at the OWDF has been noted.

10.2.1.2 ADIT 6 AND FORMER SLOP TANK

Prior to the construction of Bldg. 313, the footprint of the current building location contained a former 210,000-gallon “slop tank” (Facility Number [No.] S-355). Built in the early 1960s, S-355 was fed by a former 8-inch-diameter oily waste line from Adit 6 (HAER 2015) and a 200-gallon AFFF aboveground storage tank (AST) with a 1.5-inch foam line. In 2008, the slop tank and AFFF AST were

demolished, associated piping was cut and plugged, adjacent slop pump was removed, and containment basin berms were leveled. The locations of the former slop tank and supporting infrastructure are shown on Figure 2.

10.2.1.3 RED HILL FIRE SUPPRESSION SYSTEM LOCATED AT BUILDING 313 AND ADIT 6

The RHBFSF AFFF fire suppression system was installed between 2015 and 2018, as part of an upgrade mandated by the Fiscal Year 2015 National Defense Authorization Act (DON 2022b). The AFFF system was designed to provide fire protection for the lower tunnel of the RHBFSF.

This fire suppression system involved the construction of Bldg. 313, which housed an AST for storing AFFF concentrate, along with the pumps and controllers for AFFF operation (Figure 3). Water, used to mix with AFFF for firefighting purposes, was also accommodated within the system. This water was stored in two 250,000-gallon storage tanks located at the top of the hill. The AFFF fire suppression system's activation relied on flame detectors equipped with infrared sensors capable of detecting the heat associated with a fire. Simultaneous activation of any two detectors within a given zone would trigger the AFFF system in the respective zone.

Upon activation, AFFF suppressant, generated by mixing AFFF concentrate (Ansulite AFC-3MS 3% AFFF Concentrate, product code 442683) with water, would be released through sprinklers. The water would be pumped from Bldg. 313 by fire pumps, serving both the five lower tunnel AFFF zone mixing/release stations and the wet-pipe sprinkler system for the upper tunnel.

The conveyance piping for the AFFF concentrate primarily ran underground from Bldg. 313 to Adit 6, comprising 4-inch stainless steel carrier pipes surrounded by polyvinyl chloride (PVC) secondary containment pipes designed to capture any potential AFFF concentrate leakage from the piping. The location of the underground piping is shown on Figure 3.

In August 2021, during maintenance of the AFFF concentrate piping system, it was discovered that AFFF concentrate had accumulated in the 6-inch PVC secondary containment pipe (further discussion in Section 10.4.1).

The concentrate pipe system was identified for repair prior to the November 2022 AFFF Adit 6 release and is discussed in further detail throughout Section 10.2.1.4. The fire suppression system was modified but replacement was not completed prior to the release.

Within the tunnels, a containment system is used to capture the AFFF effluent after a fire suppression event. The containment system was designed to collect any dispersed agent, fuel, and water from retention sumps in the Red Hill tunnels. The contents of these sumps would then be transferred by pump to a fire suppression system retention line and deposited in an AST located outside Adit 3.

10.2.1.4 SITE FEATURES

Main features of Area A include the upper lot area at the entrance to Adit 6 where the November 2022 AFFF concentrate release occurred, and the lower lot area which contains Bldg. 313. Between the two areas is the paved road, Icarus Way, and a vegetated down slope. Area A has access roads leading to Adit 6, to the Bldg. 313 lower paved lot, and a temporary access road to basal groundwater monitoring well RHMW17. There are also vegetated areas within and north of Area A. Two Red Hill basal groundwater monitoring well locations (RHMW06 and RHMW17) are located within the Area A Boundary. Perched monitoring wells/piezometers (RHMW17S and RHMW17D) are also located within the Area A Boundary.

The monitoring well locations and site features of Area A are shown on Figure 3 and Figure 4, and described in greater detail below:

- *Excavation Areas/Former DUs:* The front apron area outside of Adit 6 is the immediate area where AFFF concentrate was released in 2022. A former concrete-lined culvert was removed as a precaution during the initial removal action. The culvert was not replaced, and the area was paved with asphalt. While impacted soils were removed and soil sample results were below EPA regional screening levels (RSLs), the AFFF concentrate pipeline runs through this section of Area A (not intersecting the culvert) and may have affected deeper subsurface soils if the PVC secondary containment failed.
- *Former Box Culvert Drainage Area/Former DUs:* This area was sampled as Former DU4A and Former DU4B. This box culvert connected the stormwater headwall/outfall north of the access road and discharged stormwater runoff to the surrounding vegetated area outside the RHBFSF fence line. Surface water runoff would have drained to this area if prior PFAS releases occurred outside Adit 6. PFAS were detected in confirmation samples from this area, but were below EPA RSLs; however, it is currently unknown if PFAS in surface and subsurface soil extend beyond the excavated areas.
- *Downsloping Areas North of Adit 6:* As shown on Figure 2, the downslope area north of Adit 6 formerly contained the 5,000-barrel-capacity (210,000-gallon) Slop Tank, the former 200-gallon AFFF tank and associated pipelines. The location is marked by the former tank's footprint and also contains a down slope vegetated area north of the former 200-gallon AFFF tank. In the mid to late 1960s, various fluids were piped to the former slop tank, including aviation gasoline, Jet Propellant 5, and oily waste (see Section 10.2.8.1 for additional details). The water from the tank 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). Stormwater runoff from the former AFFF tank area presumably would flow to this area. The former AFFF AST had a 1.5-inch-diameter AFFF pipeline that led from the tank to the Former Slop Tank fire suppression system. An 8-inch-diameter oily waste line also ran through this area from Adit 6 to the Former Slop Tank. Potential surface and subsurface releases from the former AFFF tank and former AFFF pipeline may have occurred. The unpaved area at the base of the slope, immediately south of Bldg. 313, can receive stormwater runoff and erosion from uphill areas, and runoff from paved areas around Bldg. 313. This unsurfaced low-lying area could have PFAS present in soil if prior surface releases of AFFF occurred at Bldg. 313 or from upgradient areas.
- *Surge Rock/Drainage Area:* Uphill potential PFAS-affected surface materials could be mobilized via stormwater runoff and ultimately discharge to this area from the lower drainage swale, near the northern boundary of Area A. The surge rock area was installed as a temporary access road for Red Hill monitoring wells. No surface soil is present in this area.
- *Bldg. 313:* Bldg. 313 is (b) (3) (A) It also contains the repaired AFFF concentrate pipeline (b) (3) (A). Prior to the construction of Bldg. 313, a former 5,000-barrel-capacity (210,000-gallon) "slop tank," (i.e., Former Slop Tank) and containment basin constructed in the early 1960s was located within the footprint of Bldg. 313. The slop tank was fed by an 8-inch-diameter oily waste line from Adit 6 and was equipped with a fire suppression system fed by a 1.5-inch-diameter AFFF line that was connected to an AFFF AST. No release of AFFF is known to have occurred at Bldg. 313.

- *Lower Drainage Swale:* Surface water runoff drains into this concrete drainage swale located in the lower lot south and southeast of Bldg. 313. Sediments in the drainage potentially contain PFAS from surface erosion and runoff. Sediments were observed in this area during a recent site visit (Section 10.2.8.5).

No known AFFF release occurred in Area B, but sampling showed perfluorooctanesulfonic acid (PFOS) present in Area B groundwater monitoring wells. Area B consists mostly of steeply sloping land populated by shrub brush and low trees. Icarus Way winds through the northern portion of the area, and the concrete-lined South Halawa Stream borders the northern portion of Area B. The southern portion of Area B is bordered by military housing and the RHBFSF boundary. The westernmost extent of the RHBFSF corresponds to the location of OWDF, located west of Area B. The main operational feature within Area B is the RHS Pump House, which formerly provided potable water to the JBPHH Water Distribution System. Ten groundwater monitoring wells planned for sampling are located within the Area B boundary: RHP01, RHP02, RHP03, RHP06, RHP07, RHP08, OWDFMW03A, OWDFMW03B, OWDFMW08A, and OWDFMW08B (Figure 3 and Figure 11). RHMW2254-01 is a sampling point directly into the basal aquifer, located within the RHS Pump House. Monitoring wells RHP01, RHP02, and RHP03 are located in the northern portion along Area B, along Icarus Way; RHP07 is located in the Red Hill tunnel; RHP06 and RHP08 are located outside of the RHBFSF boundary located near military housing; and OWDFMW03A, OWDFMW03B, OWDFMW08A, and OWDFMW08B are located at the westernmost extent of RHBFSF, within the OWDF. These are cluster wells in which the “A” designation indicates the well is screened in the deeper underlying basal drinking water aquifer (OWDFMW03A and OWDFMW08A), and the “B” designator indicates the well is screened in the underlying shallower perched water aquifer.

10.2.2 Surrounding Area and Land Use

The overall RHBFSF is zoned by the City and County of Honolulu as a mix of F1-Federal, Military, and P-1 Restricted Preservation districts. It is bordered on the east and northeast by preservation lands; on the north by Halawa Correctional Facility, private businesses, and the State of Hawaii Department of Agriculture Animal Quarantine Station; on the southwest by the U.S. Army-owned Island Palm Communities; on the south and southeast by residential neighborhoods; and Moanalua Valley, respectively.

Access to Area A and Area B is from Halawa Valley Street, through the Red Hill Main Gate, and via Icarus Way. Access is limited by Naval Supply Systems Command Fleet Logistics Center Pearl Harbor and Navy Closure Task Force-Red Hill personnel and JBPHH security personnel patrol the surrounding areas.

10.2.3 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 in Honolulu, and air temperatures on 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 Koolau 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 feet mean sea level (msl) near the ridge line of the

Koolau Range, is 139 and 137 inches, respectively (i.e., 0.4 inch per day) (USGS 2017b; 2017a). In lower North Halawa Valley at approximately 180 feet 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).

10.2.4 Topography and Surface Water Drainage Patterns

10.2.4.1 GENERAL AREA TOPOGRAPHY AND SURFACE WATER DRAINAGE PATTERNS

Four major geomorphic provinces define the island of Oahu: two volcanic mountain ranges (Waianae and Koolau), the Schofield Plateau, and the coastal plains that form the northwest and south margins of the island (Stearns and Vaksvik 1935). The Koolau volcano is a shield, or dome, volcano; the windward half of which collapsed due to catastrophic mass wasting (Walker 1990). The pali (cliff line) on the east side of the range defines the predominantly stream-eroded, back-collapsed scarp.

In the south-central part of the range, the leeward flank of the shield volcano is eroded into a series of parallel ridges and stream-carved valleys extending generally perpendicular from the Koolau crest. Red Hill is one such leeward ridge that descends 5 miles from the Koolau crest at approximately 2,200 feet msl southwest to the coastal plain. The surface elevation of Red Hill in the tank farm area is approximately 420–560 feet msl. The ridge's northwest and southeast flanks drop steeply to South Halawa Valley to where the Site is located and Moanalua Valley, where valley floor elevations in the tank farm area are approximately 200 feet msl and 100–160 feet msl, respectively. North Halawa Valley lies north of South Halawa Valley and a low inter-valley ridge, which is the site of Halawa Quarry.

10.2.4.2 TOPOGRAPHY AND SURFACE WATER DRAINAGE PATTERNS

Area A is situated on sloping terrain at approximately 240–480 feet above msl and east of the channelized portion of South Halawa Stream (Figure 3). Area A is located on the north-facing slope of the southern wall of South Halawa Valley. (b) (3) (A) across the street from Bldg. 313, east of Icarus Way. The northern perimeter of Area A is located approximately 150 feet south of South Halawa Stream. Starting at the Halawa Correctional Facility, the stream is concrete-lined and channelized, flowing into the valley. The higher elevations between the southern perimeter of Area A and the Halawa Stream consist of steeply sloping land covered by scrub brush and low trees.

Area B is located southwest of Area A, mostly within the RHBFSF property boundary, and sits between 140 and 300 feet msl. (b) (3) (A) (Figure 3). The concrete-lined South Halawa Stream runs through and borders the northern portion of Area B. The southern portion of Area B is bound by military housing. Area B is predominately characterized by steeply north-sloping land covered by scrub brush and low trees, south of Icarus way and the South Halawa Stream.

10.2.5 Geology and Soils

Soils in the vicinity of the Site are mapped as Helemano-Wahiawa association consisting of well-drained, moderately fine textured and fine textured soils. The surface of the basaltic flows has been weathered to form reddish-brown clayey silt, which is the basis for the local name of “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 and consist of clays and clayey gravels to a depth of 10 feet below ground surface (bgs). Along the slopes, the basaltic bedrock is covered with 10–30 feet of Koolau 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 fractured basalts are encountered at depth.

Basalt originating from the Koolau Volcanic Series lavas represents the bedrock and primary material for the basal aquifer beneath and around the Site. The units exposed in South Halawa Valley are flows of primarily a'a lava of the Tertiary Koolau basalt (Izuka 1992). A'a flows typically consist of a relatively low-permeability central core, bounded by spiny, fragmented margins called "clinker." Spaces in the clinker margin of the a'a flows allow efficient lateral transmission of basal groundwater, while the massive basalt cores inhibit vertical flow (Lau and Mink 1995).

Fractures and vesicles throughout the entirety of most lava flows allow additional potential avenues for groundwater flow (Stearns and Macdonald 1946). Localized portions of the basalt in South Halawa Valley are composed of thicker, massive a'a flows, which inhibit the downward flow of groundwater. These massive flows commonly contain a significantly lower proportion of the fractures and vesicles that are characteristic of most of the other basalt formations in Hawaii. These massive basalt flows are the primary target of Halawa Valley quarries (Wentworth 1951). These qualities, which make the material suitable for mining and processing into cement and building material, may also make the massive flow material relatively impermeable to groundwater transmission.

Basalt material in the basal aquifer is overlain in some areas by tuffs and welded tuffs of the Honolulu Volcanic Series. The tuffs in the RHBFSF vicinity are formed by lithification of air-deposited volcanic ash originating from nearby Aliamanu, Salt Lake, and Makalapa Craters of the Honolulu Volcanic Series.

Sediments in Halawa Valley and Moanalua Valley are mainly alluvial. The older alluvium in some deep Oahu valleys is deposited in thicknesses of 100 feet or more above the bedrock basalt. In Halawa Valley near the Site, some of the alluvium has been transported and deposited by South Halawa Stream. Alluvium may also merge with underlying layers of saprolite (the product of heavily weathered basalt), blurring the boundary between substrata of volcanic and sedimentary origin. It has been observed that areas in Halawa Valley where basalt bedrock is overlain by alluvium and supplementing weathered bedrock represent zones of ineffective infiltration to the basal aquifer. Most of the rainfall percolating in these areas is typically absorbed into the younger overlying alluvial layers.

10.2.6 Groundwater Hydrogeology

Generally, groundwater in Hawaii exists in two principal aquifer types: basal and caprock. However, caprock groundwater has not been identified at the Site. A third type, perched groundwater, also occurs in limited formations throughout the region, including at the Site. Discussion of the basal and perched groundwater is as follows:

Perched Groundwater: Perched groundwater occurs when groundwater is isolated above the regional water table (e.g., basal groundwater aquifer) by a layer of low-permeability material (e.g., dense clays or lithified fine tuff). Perched groundwater in Hawaiian environments is typically limited in horizontal and vertical extent (Wentworth 1951). Shallow perched water-bearing zones have been reported at several locations in the Halawa-Red Hill-Moanalua area during well drilling or excavation activities. Perched groundwater is also encountered farther away at the Former Oily Waste Disposal Facility site, located approximately 0.25 mile west of Area A and only 500 feet west of Area B.

The shallow perched groundwater identified during the installation of the monitoring wells in the general vicinity of Area A (or within 500 feet of RHMW17) are summarized below:

- RHMW04
 - *Approximate perched aquifer elevation:* 183–228 feet msl
 - *Approximate distance and direction from RHMW17:* 700 feet east northeast
- RHMW08
 - *Approximate perched aquifer elevation:* 214–217 feet msl and 193–198 feet msl
 - *Approximate distance and direction from RHMW17:* 2,350 feet southwest
- RHMW13
 - *Approximate perched aquifer elevation:* 229–237 feet msl and 108–120 feet msl
 - *Approximate distance and direction from RHMW17:* 490 feet northeast
- RHMW17
 - *Approximate perched aquifer elevation:* 200–205 feet msl and 80–85 feet msl
 - Within the proposed site boundary

The shallow perched groundwater identified during the installation of the monitoring wells within Area B (or within 500 feet of RHMW2254-01) are summarized below:

- RHP01
 - *Approximate perched aquifer elevation:* 110–142 feet msl
 - Within the proposed site boundary
- RHP02
 - *Approximate perched aquifer elevation:* 115–129 feet msl
 - Within the proposed site boundary
- RHP03
 - *Approximate perched aquifer elevation:* 43–78 feet msl and 106–127 feet msl
 - Within the proposed site boundary
- RHP05
 - *Approximate perched aquifer elevation:* 84–112 feet msl and 205–214 feet msl
 - *Approximate distance and direction from RHMW2254-01:* 374 feet southwest (outside of the site boundary)
- RHP06
 - *Approximate perched aquifer elevation:* 210–269 feet msl
 - Within the proposed site boundary

- RHP07
 - *Approximate perched aquifer elevation:* 85–100 feet msl
 - Within the proposed site boundary
- RHP08
 - *Approximate perched aquifer elevation:* 137–182 feet msl and 220–265 feet msl
 - Within the proposed site boundary
- OWDFMW03B
 - *Approximate perched aquifer elevation:* 79–89 feet msl
 - Outside the proposed site boundary
- OWDFMW08B
 - *Approximate perched aquifer elevation:* 99–103 feet msl
 - Outside the proposed site boundary

Elevated Heads: Elevated head conditions were observed during the drilling of monitoring well RHMW11 with continuous saturation within the saprolite (perched conditions not observed) (DON 2018). Similar but distinguishable conditions were observed during the drilling and installation of monitoring well RHMW14 on the South Halawa Valley floor, RHMW16, and at the Former Oily Waste Disposal Facility.

Basal Aquifer: The basal aquifer exists as a lens of fresh water floating on and displacing seawater within the pore spaces, fractures, and voids of the basalt that forms the underlying mass of each Hawaiian island. Basal groundwater potentiometric elevations typically slope downward in the seaward direction. Thus, in the vicinity of Red Hill, the overall regional flow of basal groundwater is expected to be from higher mountain elevations (mauka) toward Pearl Harbor (makai). The potential exists for variances in the localized flow directions from the overall regional flow pattern due to the heterogeneity and anisotropic conditions of the basalt.

Basal groundwater elevations in the southern Oahu region range from 0 foot msl near the shoreline to elevations ranging between 20 and 30 feet msl in the vicinity of the southern Oahu Schofield water region boundary (USAF 2007; Nichols, Shade, and Hunt Jr. 1996). Regional basal aquifer groundwater ranges from unconfined to completely confined. Potentiometric heads in the Red Hill area vary between approximately 16 and 20 feet msl, which are consistent with the heads observed in existing wells at Area A and Area B.

State of Hawaii Aquifer Classification: DOH has adopted a regional aquifer classification by Mink and Lau (1990) to determine the permissible uses for groundwater in the different areas of Hawaii. This classification is used to determine the EALs used for screening potential risk related to soil and groundwater chemicals of concern detected at a site (DOH 2017a). This use of aquifer classification criteria and groundwater designations is patterned after the EPA Groundwater Protection guidelines (EPA 1988).

Per Mink and Lau (1990), the RHBFSF lies above an aquifer designated as the Waimalu System, part of the larger Pearl Harbor aquifer sector. Mink and Lau classify the region beneath the RHBFSF as an unconfined basal aquifer contained in horizontally extensive flank basalt lava flows of the Koolau Range. This aquifer is given a Status Code of 11111, which indicates a fresh water source (i.e., with a chloride content below 250 milligrams per liter) currently in use, which serves as an irreplaceable source of drinking-quality water.

The regional basal aquifer beneath the RHBFSF is also included in the Oahu Sole Source Aquifer (also known as the Southern Oahu Basal Aquifer) and was designated as a sole source aquifer in 1987 under Section 1424I of the Safe Drinking Water Act (52 Federal Register 45496). Sole source aquifers are those that are the sole or principal drinking water source for an area.

A former municipal drinking water supply well is located in the RHBFSF (Navy Supply Well No. 2254-01 [RHS]) (Figure 1). This is not a true well, but a horizontal water supply shaft (i.e., water development tunnel or infiltration gallery) known in Hawaii as a ‘Maui’-type shaft, from which water is pumped.

10.2.7 Vegetation and Wildlife

The RHBFSF is inhabited by non-native vegetation, including koa haole scrub, disturbed habitat, and some 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 to be of very low quality and is primarily used by introduced, common urban species such as mongoose and wild pigs.

The on-site 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). No subsequent threatened or endangered species surveys are known to have been conducted after 1995 at the facility and no threatened or endangered species are known or expected to be present on-site (DON 2005).

10.2.8 Previous Investigations and Removal Actions

10.2.8.1 DEMOLITION OF JET PROPELLANT 5 SLOP TANK AT ADIT 6 (2008)

A former 5,000-barrel “slop tank,” constructed in the early 1960s that was located near the footprint of Bldg. 313, was fed by an 8-inch-diameter oily waste line from Adit 6. The location and layout of slop tank No. S-355, and the adjacent slop tank pump, are depicted on Figure 3. In 2008, the slop tank was demolished, associated piping was cut and plugged, and the adjacent slop pump removed (Shaw 2009). Surface soil samples (0.5 foot bgs) were collected but were not analyzed for PFAS (Shaw 2009).

10.2.8.2 AFFF RELEASE AND RESPONSE ACTIONS AT ADIT 6 (NOVEMBER 2022)

AFFF Release Incident: On 29 November 2022, approximately 1,100 gallons of AFFF concentrate (AFFF 3%-C6 solution) were released from the fire suppression system at the entrance of Adit 6 within the RHBFSF (DoD 2023d; EPA Region 9 2023). An improperly installed valve on the fire suppression system in the tunnel caused a containment standpipe to overflow with AFFF concentrate and accumulate on the facility floor. Subsequently, it seeped under a door and flowed onto a paved access road, affecting both the pavement and the adjacent soil on the edge of the road outside Adit 6. The immediate impact

spanned an estimated 100-foot-long section inside the tunnel entrance and the surrounding areas outside Adit 6. Outside areas affected by the AFFF release included a crushed rock apron, an asphalt roadway, a stormwater conveyance system leading to Halawa Stream, and presumably the underlying and neighboring soils (DOH HDB 2022). Efforts taken to address the issue included emptying the system and subjecting it to a pressure test. AFFF concentrate was found in the containment pipe 3 weeks after the system was placed back into service. This prompted the decision to disable the system, which depressurized the underground piping and effectively stopped the leak. No other releases of AFFF from the fire suspension system are known to have occurred at Area A. Immediately following the release, measures were taken to prevent the migration of the AFFF concentrate, described in greater detail below.

The fire suppression system was disabled following the 29 November 2022, AFFF release. The system was not refilled with AFFF concentrate and remains inactive. (b) (3) (A)

the United States (U.S.) Department of the Navy (Navy) conducted repairs to the inactive AFFF pipeline leading from the Pump House to the Adit 6 tunnel so that it could be activated in case the AFFF fire suppression system was needed during defueling operations.

Response and Removal Actions at Adit 6: On 29 November 2022, the Navy removed approximately 3,000 cubic feet of soil. Excavated areas outside Adit 6 included the asphalt apron at the tunnel entrance, and the concrete drainage ditch to the southwest along the access road. Prior to excavation of the culvert beneath the access road from the drainage ditch, and the stormwater outfall beyond the culvert (Figure 4), the Navy installed an expandable bellows plug in front of the storm drain as a preventative measure. The culvert and stormwater outfall structures were removed independently of the AFFF release response; however, the areas are included due to their proximity to the release.

Geotextile fabric and plastic sheets were placed in the excavated areas near the entrance to Adit 6 to isolate potential PFAS impacts. Instead of installing a new culvert, the inlet was concreted to retain earthen materials in the excavated areas. Following excavation, the areas were refilled with clean material such as imported soil or gravel. An asphalt surface was applied to minimize stormwater infiltration.

Within Adit 6, absorbent pads were placed to extract as much AFFF as possible prior to cleaning activities that occurred from 3–9 January 2023. To prevent the migration of any residual concentrate that might be present to subsurface soils, the interior walls and concrete floor were sealed with epoxy. A permeability test on the Adit 6 floor was conducted on 26 January 2023, and access to Adit 6 was reinstated on 30 January 2023. Results indicated that the epoxy did not allow water to infiltrate the floor. All AFFF concentrate was removed from RHBFSF on 23 April 2024. To date the fire suppression system has remained deactivated and AFFF concentrate is not currently stored or used at the RHBFSF.

Confirmation Sampling: Prior to backfilling of the excavation areas, confirmation sampling was conducted at the excavation boundaries in accordance with the Sampling and Analysis Plan reviewed by the U.S. Environmental Protection Agency (EPA) and approved by the DOH (DON 2022a). Between 2 December and 15 December 2022, multi-increment soil samples were collected from excavation areas outside of Adit 6 and analyzed for PFAS using Draft EPA Method 1633 and for 2-(2-butoxyethoxy)ethanol using EPA Method 8015. The former decision units (DUs) used for the confirmation sampling program and detected PFAS results are presented on Figure 4. Further discussion of the sampling and analysis conducted is presented in Section 10.2.8.3.

Confirmation sample results were compared against applicable EPA residential RSLs and DOH interim PFAS soil environmental action levels (EALs) (EPA 2022; DOH 2021). Several PFAS, including 6:2 fluorotelomer sulfonic acid (6:2 FTS), perfluoroheptanoic acid, perfluorohexanoic acid (PFHxA), and perfluorooctanoic acid (PFOA), were found in soil confirmation samples above their respective DOH EALs, though none exceeded their respective EPA RSLs.

Confirmation samples detected several PFAS that currently have no available EPA RSLs, including 6:2 FTS. 6:2 FTS had the highest concentration in the soil samples collected from the release area. The highest concentration of 6:2 FTS detected in confirmation samples was 150 micrograms per kilogram, collected from the soil area situated between the road, storm culvert, and apron (Formerly DU 2) (Section 10.4.2.1), see Figure 4.

10.2.8.3 SAMPLING AND ANALYSIS AT ADIT 6

Samples were collected and characterized for potential PFAS and concentrate solvent 2-(2-butoxyethoxy)ethanol in the beginning of December 2022, immediately following the AFFF release. The sampling and analysis was described in the *PFAS-Specific Sampling and Analysis Plan, Red Hill Bulk Fuel Storage Facility, Adit 6, Joint Base Pearl Harbor-Hickam, Hawaii* (DON 2022a). The analyzed media included investigation-derived waste (soil excavated at the spill location), site soils (after excavation [i.e., multi increment confirmation samples]), and groundwater samples (DON 2023c). Groundwater sampling and analysis was conducted on a weekly basis from December 2022 through May 2023 (DON 2023e; 2023d; 2023h; 2023a; 2023i). Groundwater sampling and analysis changed to a monthly basis in June 2023 and continued through December 2023 (DON 2023g; 2023f; 2023b; 2023k). Additionally, a sample of the released product was analyzed for non-target PFAS and an extended list of PFAS using alternative methods. This was done to identify other potential PFAS not included in the draft EPA Method 1633 analyte list (e.g., 6:2 FTS, 8:2 FTS). The non-target analysis allowed for identification of unknown compounds from a mass spectra library search; the analysis was qualitative in nature. The non-target analysis of the AFFF product detected several 6:2 FTS derivatives or precursors.

Excavation Soil Sampling and Analysis

Soil samples collected in December 2022 from former DUs 1, 2, 3, 4A, 4B, 5, 6, 7, and 8 detected the presence of 26 of the 40 PFAS reported (DON 2023d), shown on Figure 4. Six of these compounds were detected at concentrations exceeding DOH EALs used during the compliance sampling. No PFAS detections in the confirmation samples exceeded the EPA RSLs. 6:2 FTS was the PFAS detected in soil with the greatest concentration at 150 micrograms per kilogram.

Analyses of 2-(2-butoxyethoxy)ethanol, a solvent component of the AFFF concentrate released in 2022, was detected in two of the 12 samples analyzed (including sample replicates); one sample exceeded the EPA RSL for residential soil. The maximum concentration for each detected compound is presented in Table 10-1.

Table 10-1: Results for Soil, Total PFAS Samples Collected in December 2022

PFAS	2023 Nov. EPA Residential Soil (THQ 0.1) ^b	Maximum Concentration (µg/kg)	Location of Maximum Detected Concentration	Maximum Concentration Exceeds RSLs
2H,2H,3H,3H-Perfluorooctanoic acid (5:3 FTCA)	NA	1.60	DU4A	No
3-Perfluoropropyl propanoic acid (3:3 FTCA)	NA	0.087 J	DU4A	No
4:2 Fluorotelomer sulfonic acid (4:2 FTS)	NA	1.00 J	DU2	No
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	NA	150 J	DU2	No
N-Ethyl perfluorooctanesulfonamide (NEtFOSA)	NA	0.0350 J	DU4A	No
N-Methyl perfluorooctanesulfonamidoethanol (NMeFOSE)	NA	0.730	DU2	No
Perfluorobutanesulfonic acid (PFBS)	1900	0.0240 J	DU7	No
Perfluorobutanoic acid (PFBA)	7800	5.80	DU2	No
Perfluorodecanesulfonic acid (PFDS)	NA	0.160	DU4A	No
Perfluorodecanoic acid (PFDA)	NA	0.150	DU2	No
Perfluorododecanesulfonic acid (PFDoS)	NA	0.140 J	DU2, DU4A	No
Perfluorododecanoic acid (PFDoA)	320	0.096	DU4A	No
Perfluoroheptanesulfonic acid (PFHpS)	NA	0.0170 J	DU4A	No
Perfluoroheptanoic acid (PFHpA)	NA	1.50	DU4A	No
Perfluorohexanesulfonic acid (PFHxS)	130	0.210	DU7	No
Perfluorohexanoic acid (PFHxA)	3200	17.0	DU2	No
Perfluorononanesulfonic acid (PFNS)	NA	0.0940	DU4A	No
Perfluorononanoic acid (PFNA)	19	0.0540	DU4A	No
Perfluorooctanesulfonamide (PFOSA)	NA	0.0280 J	DU4A	No
Perfluorooctanesulfonic acid (PFOS)	13	5.40	DU4A	No
Perfluorooctanoic acid (PFOA)	19	1.20	DU2	No
Perfluoropentanesulfonic acid (PFPeS)	NA	0.0230 J	DU7	No
Perfluoropentanoic acid (PFPeA)	NA	5.60	DU4A	No
Perfluorotetradecanoic acid (PFTeDA)	6300	0.0370 J	DU4B	No
Perfluorotridecanoic acid (PFTTrDA)	NA	0.075	DU4A	No
Perfluoroundecanoic acid (PFUnA)	1900	0.180	DU4B	No
2-(2-butoxyethoxy)ethanol ^a	190	210	DU3	Yes

Note: All concentrations are reported in µg/kg.

µg/kg microgram per kilogram

J estimated concentration

NA not applicable

THQ target hazard quotient

^a Solvent component of the AFFF concentrate.^b EPA RSLs table values for residential soil and tap water using a THQ of 0.1 and target cancer risk of 1E-06 (EPA 2023).

During the confirmation sampling, synthetic precipitation leaching procedure (SPLP) was performed on soil samples and the leachate was analyzed for PFAS; these SPLP results are summarized in the *Aqueous Film Forming Foam Soil and Groundwater Investigation and Monitoring Monthly Report, January 2023* (DON 2023e). SPLP, used in conjunction with draft EPA Method 1633, identified the presence of 17 out of the 40 analytes targeted. The four analytes detected in the greatest concentration (above 100 parts per trillion or 100 nanograms per liter [ng/L]) in the analyzed leachate samples included 6:2 FTS, perfluoropentanoic acid (PFPeA), PFHxA, and perfluorobutanoic acid (PFBA). Analysis of the SPLP extracts shows that residual PFAS found in site soils are potentially leachable and are likely mobile with water. Note that using SPLP to indicate leaching for PFAS is not yet standardized.

Regular Groundwater Sampling and Analyses

Groundwater samples were collected from 10 wells (HDMW2253-03, RHMW02, RHMW03, RHMW04, RHMW06, RHMW10, RHMW12A, RHMW16, RHMW17, and RHMW2254-01) and two piezometers (RHMW17D and RHMW17S) (Figure 5). Samples were analyzed for PFAS using draft EPA Method 1633 (DON 2023j). A total of 421 groundwater samples have been collected and reported through the end of December 2023 (379 normal samples and 42 duplicates). Over the course of the groundwater monitoring, 25 of the 40 PFAS have been detected in groundwater samples. PFAS concentrations in groundwater were detected at levels that did not exceed EPA RSLs. A summary of the maximum detected groundwater concentration for the target PFAS for samples collected through the December 2023 monitoring is presented in Table 10-2.

Baseline PFAS Sampling Event

Baseline groundwater samples were collected from 21 non-routine wells located near and around the RHBFSF in September 2023. Samples were analyzed for PFAS using draft EPA Method 1633 (DON 2023m). The wells sampled included RHMW01, RHMW01R, RHMW05, RHMW07, RHMW08, RHMW09, RHMW19, RHMW20, NMW24, NMW25, RHP01, RHP02, RHP03, RHP04A, RHP04B, RHP04C, RHP05, RHP06, RHP07, RHP08, and NMW32 (Figure 5). Four multilevel wells (RHMW11, RHMW13, RHMW14, and RHMW15) were not sampled because they have or contain sampling equipment or materials that potentially contain PFAS.

Ten out of 40 PFAS analytes were reported above the analytical limit of quantitation (LOQ) in the samples collected. Analytical results from four wells (RHP01, RHP02, RHP07 and NMW32) showed concentrations of PFOS above the DOH EAL of 4.0 ng/L, with values ranging from 9.0 ng/L to 16.0 ng/L. In addition to the EAL exceedances, concentrations in RHP03 and RHP06 exceeded the EPA tap water RSL of 4 ng/L for PFOS. PFOS was the only analyte identified above screening criteria.

A preliminary review of the analytical results from the non-routine wells with PFOS detections was conducted. Each analysis profile included a significant or dominant branched PFOS isomer peak immediately before the linear isomer peak in the analysis chromatograph. Branched isomers are produced by the electrochemical manufacturing process used by legacy AFFF and not by the modern fluorotelomer process used to manufacture the 6:2 fluorotelomer thioether amido sulfonate in the known Adit 6, November 2022, AFFF release (Section 10.4.2.1).

In the AFFF product test results from the November 2022 release at Adit 6, 6:2 FTS is the dominant target analyte, but the 6:2 FTS was non-detect above the LOQ in all non-routine well groundwater results where PFOS exceeded screening criteria (RHP01, RHP02, RHP03, RHP06, and RHP07). Based on this information and the presence of branched PFOS isomers in the cases where PFOS exceeded screening criteria, the PFOS detections in the non-routine wells are not suspected to be related to the AFFF concentrate released in November 2022 at the Site (i.e., the PFAS detected are likely to be from different sources).

Table 10-2: Statistical Metrics for Comprehensive Set of Groundwater PFAS Samples Validated through December 2023

Parameter	November 2023 EPA Tap Water ^a (THQ 0.1)	DOH Groundwater EALs (Table A) PFAS	Maximum Detected Concentration (ng/L)	Samples Exceeding RSL or EAL Level	Location of Maximum Detected Concentration	Sample Count with Detected Concentrations
2H,2H,3H,3H-Perfluorooctanoic acid (5:3 FTCA)	NA	NA	0.83 J	No	RHMW17	1/421
4:2 Fluorotelomer sulfonic acid (4:2 FTS)	NA	NA	0.53 J	No	RHMW10	1/421
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	NA	1,500	269	No	RHMW17	137/421
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	NA	NA	0.31 J	No	RHMW10	1/421
Perfluoro-3-methoxypropanoic acid (PFMPA)	NA	NA	0.53 J	No	RHMW10	4/421
Perfluoro-4-methoxybutanoic acid (PFMBA)	NA	NA	0.11 J	No	RHMW10	1/421
Perfluorobutanesulfonic acid (PFBS)	600	2,000	4.3	No	RHMW17S	62/421
Perfluorobutanoic acid (PFBA)	1,800	1,500	66.5	No	RHMW02	89/421
Perfluorodecanoic acid (PFDA)	NA	7.7	0.79 J	No	RHMW10	17/421
Perfluorododecanesulfonic acid (PFDoS)	NA	NA	0.16 J	NA	RHMW12A	1/421
Perfluorododecanoic acid (PFDoA)	100	26.0	1.10 J	No	RHMW03	8/421
Perfluoroheptanesulfonic acid (PFHpS)	NA	38.0	7.1 J	No	RHMW17D	4/421
Perfluoroheptanoic acid (PFHpA)	NA	77	4.9	No	RHMW06	153/421
Perfluorohexanesulfonic acid (PFHxS)	39	10	1.6 J	No	RHMW2254-01	54/421
Perfluorohexanoic acid (PFHxA)	990	1,000	7.7	No	RHMW12A	192/421
Perfluorononanesulfonic acid (PFNS)	NA	NA	0.17 J	No	RHMW17J	1/421
Perfluorononanoic acid (PFNA)	5.9	1.0	2.2	No	RHMW10	35/421
Perfluorooctanesulfonamide (PFOSA)	NA	46.0	1.2	No	RHMW03	19/421
Perfluorooctanesulfonic acid (PFOS)	4	4.0	2.8 J	No	RHMW12A	71/421
Perfluorooctanoic acid (PFOA)	6	4.0	1.8	No	RHMW2254-01	95/421
Perfluoropentanesulfonic acid (PFPeS)	NA	620	0.23 J	No	RHMW2254-01	9/421
Perfluoropentanoic acid (PFPeA)	NA	1,500	60.9 J	No	RHMW02	190/421
Perfluorotetradecanoic acid (PFTeDA)	2,000	260	0.23 J	No	RHMW17D	1/421
Perfluorotridecanoic acid (PFTTrDA)	NA	26	0.48 J	No	RHMW10	2/421
Perfluoroundecanoic acid (PFUnA)	600	19.0	0.99	No	RHMW10	7/421

Note: All concentrations are reported in ng/L.

J estimated concentration

NA not applicable

^a EPA RSLs table values for resident soil and tap water using a THQ of 0.1 and target cancer risk of 1E-06 (EPA 2023).

10.2.8.4 PREVIOUS INVESTIGATIONS AT OWDF

Site investigations at the OWDF began after a 1983 *Initial Assessment Study* (NEESA 1983) identified the area as one that potentially posed a threat to human health or the environment. Following preliminary investigations, an RI (DON 1996b; 2000) and Removal Action (DON 1996a) were conducted, and the site received NFA status from the DOH in 2005 (DOH 2005). As part of the Red Hill AOC (EPA Region 9 and DOH 2015), the basal groundwater beneath and around Red Hill is undergoing long-term groundwater monitoring, which includes sampling of wells at OWDF. These ongoing investigations at Red Hill include investigation and remediation of contamination, modeling of regional groundwater flow and contaminant fate and transport, and expansion and monitoring of the groundwater monitoring well network.

No historical documentation of AFFF use was noted in historical documents reviewed (DON 1996b) (DON 2021) related to the OWDF.

10.2.8.5 COLLECTION, HOLDING, AND TRANSFER TANK

The Collection, Holding, and Transfer (CHT) Tank is an approximately 15-foot by 8-foot by 7-foot aboveground cement tank that sits outside Adit 3. 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 offsite. However, petroleum was inadvertently pumped into the CHT Tank during the 20 November 2021, Jet Propellant 5 (JP-5) release. The CHT Tank then overflowed during rain events in December 2021 and January 2022, impacting the surrounding area with light non-aqueous phase liquid and petroleum-contaminated storm water.

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.

10.2.8.6 FORMER HOLDING TANK AND LEACH TANK

The Former Holding Tank and connected Leach Tank were a pair of underground 8-foot-tall, 7-foot-diameter cylindrical cement tanks located outside Adit 3 approximately 250 feet northwest of the CHT Tank. 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 20 November 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 11–13 January 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 feet bgs. During 9–17 March 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 total petroleum hydrocarbons and related chemical constituents were observed in soil and perched groundwater above DOH EALs (DON 2022c; 2023I).

The Navy followed up with two removal actions:

- Between 13–25 May 2022, the Navy excavated and removed the Holding Tank, Leach Tank, adjacent piping, and contaminated soil.
- Between 29 August and 3 October 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 feet bgs.
- The Navy has proposed an Environmental Hazard Evaluation 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.

10.3 SITE RECONNAISSANCE

A site reconnaissance was conducted at Area A on 20 October 2023, with Navy personnel to:

- Document current site conditions (surface cover, building/tank footprints, remediation footprint, and potential sampling areas).
- Identify features and characteristics to assist in the development of field sample collection methodologies and requirements.
- Identify other site conditions (potential health/safety concerns, overhead, and subsurface utilities).

Current Area A conditions noted during the site reconnaissance include the following:

- Area A is partially developed with paved roads, an entrance to Adit 6, Bldg. 313, and pavement footprints similar to previous footprints dating back to at least 2000. Bldg. 313 was constructed in 2015 over the former slop tank footprint. Fencing along the perimeter of Area A exists.
- The immediate vicinity north, east, and south of Area A consists of vegetated areas with asphalt-paved roads. The Halawa Correctional Facility is located to the northwest.
- The location of the former AFFF AST pad is outside of Adit 6 at the top of the sloped embankment to Bldg. 313.
- The terrain gradually slopes downward to the north and west.
- The asphalt pavement over excavated areas is visibly newer than surrounding paved areas. These include areas outside of Adit 6, along the former drainage swale following the road, and pavement crossing the road where the Former Box Culvert Drainage Area was located.
- Installation of a new pipeline (b) (3) (A) in progress in case the use of an AFFF fire suppression system is mandated by regulatory agencies for defueling.
- A drainage swale runs around Bldg. 313 starting on the south side of the building and runs to the discharge point north of the building. Sediment accumulation was observed in the drainage swale.
- Surge rock gravel at the end of the drainage swale was observed. The surge rock provided a drivable surface connecting Bldg. 313 to RHMW17 and drainage for the swale during storm events.

- Two nearby monitoring wells (RHMW17 and RHMW06) were observed at the east and west ends of the Site.
- Staged (b) (3) (A) was observed north and west of Bldg. 313.

Other site conditions noted during the site reconnaissance include the following:

- Subsurface utilities that traverse Area A are present, as evidenced by (b) (3) (A).
- The northern portion of Area A has a perimeter fence around most of it. The areas outside of the fence line perimeter are densely vegetated with grass and trees; vegetation clearance will be needed prior to the fieldwork.
- The AFFF pipeline section was in the process of being replaced/repared in case the use of the AFFF fire suppression system were mandated by regulators during defueling activities. The defueling Fire Suppression Plan proposes use of alternative dry chemical (sodium bicarbonate) fire extinguishers, the existing water sprinkling system, and Federal Fire response (DoD 2023a).

No site reconnaissance was conducted at Area B.

10.4 PRELIMINARY EXPOSURE ASSESSMENT

The CSMs for Area A and Area B summarize the known information and existing conditions at the Site; integrate known and suspected PFAS, and potential sources of those PFAS; identify potential receptors; and evaluate how and where potential receptors may be exposed to PFAS. The preliminary CSMs were developed using historical information and the environmental setting (Section 10.2) and previous investigations (Section 10.2.7). A visual representation of the Area A CSM is presented on Figure 6 and a visual representation of the Area B CSM is presented on Figure 7. The preliminary CSM exposure diagram for the entire Site is presented on Figure 8 and Figure 9.

10.4.1 PFAS Release Mechanisms

A known AFFF release incident occurred on 29 November 2022, and PFAS contained in the AFFF were released to the environment. During this event, there was an unintentional discharge of approximately 1,100 gallons of AFFF liquid concentrate, which occurred at the Adit 6 tunnel at the RHBFSF.

While no other documented releases of AFFF to the environment have been recorded at the Site, there were recurrent issues with the installed AFFF suppression system, prompting the need for system modifications and/or repairs (DoD 2023d). It is unknown whether any additional releases may have occurred and affected site surface or subsurface soils as a result of these system issues. However, the former slop tank was used to separate fuels from approximately 1963 to the mid to late 1960s. Water was emptied into South Halawa Stream, and the fuel was trucked offsite for disposal (Earl and Wright 1962). The former 200-gallon AFFF had piping to the slop tank fire suppression system. In addition, in August 2021, during maintenance of the AFFF concentrate piping system that runs underground from Bldg. 313 to Adit 6, it was discovered that AFFF concentrate had accumulated in the 6-inch-diameter PVC containment pipe surrounding the underground section of the 4-inch diameter steel concentrate pipe. The AFFF concentrate was observed in the vertical section of containment pipe near where the piping penetrates the floor in the eastern corner of Bldg. 313.

10.4.1.1 PFAS AND ENVIRONMENTAL MEDIA

The specific PFAS included for this investigation consist of the individual PFAS listed in the analytical laboratory test method(s) currently available as well as Navy guidance. Presently, this list consists of 40 PFAS, per EPA Method 1633. However, only 11 PFAS currently have toxicity values for deriving regulatory screening criteria (e.g., current RSLs). These PFAS include hexafluoropropylene oxide dimer acid, perfluorobutanesulfonic acid (PFBS), perfluorobutanoic acid (PFBA), perfluorohexane sulfonic acid (PFHxS), PFHxA, perfluorononanoic acid (PFNA), PFOS, PFOA, perfluorododecanoic acid (PFDA), perfluorotetradecanoic acid, perfluoroundecanoic acid, and perfluorooctadecanoic acid.

10.4.2 Fate and Transport Considerations

10.4.2.1 AQUEOUS FILM-FORMING FOAM AND PER- AND POLYFLUOROALKYL SUBSTANCES

PFAS are a large, complex class of synthetic organic compounds (ITRC 2018). Discussions here are in broad terms referring to the 40 PFAS being tested for during this investigation. In general, PFAS have the same basic tail/head chemical structure where the tail is a chain of two or more fluorinated carbon atoms (e.g., $-\text{[CF}_2\text{]}_6\text{CF}_3$ or $-\text{[CH}_2\text{]}_2\text{[CF}_2\text{]}_7\text{CF}_3$) and the head is a functional group at the end of the fluorocarbon chain (e.g., carboxylate $[-\text{CO}_2^-]$, sulfonate $[-\text{SO}_3^-]$, N-alkyl sulfonamides $[-\text{SO}_2\text{NR}_2]$, or alcohol $[-\text{OH}]$). In simplified terms, the tail and head impart the chemical and physical properties of the molecule. Like other surfactants, the (fluorocarbon) tail is considered hydrophobic (and oleophobic), while the head functional group is hydrophilic and polar (e.g., will participate in electrostatic interactions and will increase water solubility).

PFAS are manufactured chemical compounds that have been in wide use in numerous commercial and consumer products and materials since their development in the 1930s due to their unique chemical properties. They became a key component in AFFF, an effective fire suppressant that has been used routinely since the 1960s for extinguishing Class B fires (flammable or combustible liquids) at airports, refineries, and bulk storage terminals. AFFF meeting military specifications appeared in 1973. Although PFAS are found in many industrial and commercial products and materials, AFFF use is considered the primary source of PFAS in military installations.

PFAS are not currently regulated under the Resource Conservation and Recovery Act, Clean Water Act, and Clean Air Act. PFAS were recognized as an emerging concern in the early 2000s primarily with the detection of PFOA and PFOS in human blood, and nationwide PFAS detections in public water supply systems that could potentially pose unacceptable risks to human health and the environment. EPA recently (April 2024) designated PFOA and PFOS, including their salts and structural isomers, as Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) hazardous substances. The rationale for the new designation is based on evidence indicating that PFOA and PFOS released into the environment may present risks to public health or the environment.

PFAS are resistant to degradation. Once in the environment, PFAS are persistent and can travel great distances in air as aerosols, and can dissolve in surface water and groundwater. Some PFAS are known to bioaccumulate in plants and animals, can be disseminated throughout the food chain, including crops and livestock, and may eventually pose a threat to human health.

Potential PFAS presence in surface water and groundwater will depend on their proximity to the PFAS source and the volume of the release. Affected surface waters and groundwater can potentially discharge PFAS to the ocean. If PFAS enter the ocean, PFAS anions can form strong ion pairs with some cations or bind tightly to organic material, which can result in PFAS “salting-out” of water that has relatively

high amounts of dissolved solids (ITRC 2018). During transport in water, the partitioning rates of PFAS to soils and sediments will depend on environmental conditions.

The potential release mechanisms for PFAS at the Site are most likely associated with AFFF, which include incidental leaks, accidental spills, and releases that may have occurred during equipment testing/training. Historically, water was allowed to settle out of the former slop tank and was emptied into Halawa Stream; remaining waste was loaded into a truck for offsite disposal (Earl and Wright 1962). However, there has not been a known release of AFFF from the fire suppression system at Area A, prior to the November 2022 AFFF Adit 6 release. Soil from the November 2022 AFFF release area was excavated and confirmation soil samples showed detections of PFAS, but all detections were below EPA RSLs for PFAS that have them available. PFAS without screening criteria were also detected. Residual AFFF remains in the excavation footprints, which were capped with asphalt. It is unknown if other AFFF releases occurred from the fire suppression systems at Area A (i.e., from the AFFF tanks, piping, and pumping system located in and around Bldg. 313 and Adit 6 areas) or from the AFFF system associated with the former slop tank, prior to the November 2022 incident. After release, surface erosion and stormwater runoff to storm culverts and streams and leaching to groundwater are the expected principal transport mechanisms for the PFAS.

There is no known source for PFAS at Area B, nor are there any known releases of AFFF.

10.4.3 Potential Receptors and Exposure Pathways

The exposure pathway evaluation identified potentially complete current and future exposure pathways for human and ecological receptors at the Site. The preliminary CSMs exposure pathway evaluation is a dynamic model that was developed based on the Site's physical features and history, and will be updated as new information and data becomes available. A summary of the current CSMs and a description of site exposure pathways by human and ecological receptors are presented on Figure 8 and Figure 9 and briefly discussed below. Pictorial CSMs are presented on Figure 6 and Figure 7 for Area A and Area B, respectively.

Four human receptors are identified for potential exposure to PFAS at the Site: residents (hypothetical), occupational workers, construction workers, and trespassers/hunters.

At present, there is no residential use on the Site. However, hypothetical residential receptors are considered to provide conservative potential exposure estimates. Though the Site is located on a military installation, portions of the Site outside fence lines could potentially be accessed by trespassers hunting for pigs or by off-trail recreational users walking along Halawa Stream, and the boundary of Area B intercepts the adjacent military housing. Other visitors to the Site are assumed to have similar activities as occupational workers.

On-site occupational workers are people who work at the Site and larger RHBFSF. They are anticipated to spend their workday within the Site and surrounding grounds outside the tunnels. Construction workers also work at the RHBFSF and are assumed to work in excavations as part of construction or maintenance activities or in utility trenches. These work activities would expose construction workers to chemicals associated with subsurface soils.

Potential exposure pathways for human receptors at the Site are limited to direct contact (incidental ingestion and dermal contact) with affected soil and inhalation of dust generated from the surface soil. Incidental ingestion, dermal contact, and inhalation of particulates of subsurface soil are also considered potentially complete pathways for future construction workers, as well as all future

occupational workers, trespassers (adult/adolescent), and hypothetical residents (adult/child). While there are no current complete subsurface soil exposures, all receptors could be exposed if subsurface soils are brought to the surface during excavations for site development. Construction workers conducting intrusive activities could also be exposed to subsurface soil within excavations.

Basal groundwater beneath RHBFSF and the Site is a drinking water source. Since the November 2021 fuel release, the Navy's RHS has been off line. The groundwater beneath RHBFSF is not currently serving as drinking water source. Offsite residents who use the RHS water supply as their tap water source could be exposed to chemicals in tap water via direct ingestion and dermal contact (the RHS has not been used as a drinking water source since December 2021). Tap water at the RHBFSF was formerly supplied from the JBPHH water distribution system. Therefore, occupational workers, construction workers, and visitors who use tap water at the Facility could potentially be exposed to chemicals via ingestion. The only dermal exposure to water at the Site is from potential hand washing, as bathing is not a realistic scenario for on-site receptors; therefore, dermal exposure is considered an insignificant pathway.

Perched groundwater is not a current or potential drinking water source and is therefore an incomplete pathway and is considered too deep (approximately 30 feet bgs) for potential exposures to construction workers. Migration of potentially lower-quality perched groundwater to the basal drinking water aquifer is possible. A preliminary exposure pathway evaluation, identifying human receptors and potential PFAS exposure pathways for the Site, is presented on Figure 6 for Area A and Figure 7 for Area B.

Various ecological receptors including soil invertebrates, terrestrial plants, and herbivorous/omnivorous birds and mammals were considered, as shown in the Site CSM (Figure 9). Invertebrates and terrestrial plants can be exposed to affected surface through direct contact. Due to the vegetation and pavement cover, and anticipated range of birds known or suspected to occur at the Site and surrounding area, it is unlikely that birds are in direct contact with the soil for extended periods of time; therefore, direct contact is considered insignificant compared to other pathways. However, there is potential for pigs to wallow in vegetated areas at the Site; therefore, direct contact with soil is considered potentially complete for surface soils. Mammals and birds may be exposed to PFAS through direct ingestion of site soils and through bioaccumulation of PFAS from ingestion of site plants and animal tissues previously exposed to PFAS.

Receptors potentially exposed to PFAS through water sources from the Site are considered insignificant or incomplete for ecological receptors potentially found offsite at Halawa Stream. Groundwater occurs 80 feet beneath the stream beds and does not discharge to South Halawa Stream. Further, Halawa Stream is impaired by nutrient inputs, pathogens, turbidity, and exotic species due to urban runoff, storm sewers, and other sources of disturbance (DON 2007); the stream is not anticipated to support aquatic life.

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

The project quality objectives (PQOs) were developed based on the *Guidance on Systematic Planning Using the Data Quality Objectives Process (EPA QA/G-4)* (EPA 2006) and the Naval Facilities Engineering Systems Command, Pacific Environmental Restoration Program Procedure I-A-1, *Development of Data Quality Objectives* (DON 2015). The data quality objectives (DQOs) are presented below.

11.1 STEP 1 – STATE THE PROBLEM

This Site was identified as having a known release of AFFF concentrate. Based on the Site's history, other undocumented releases of AFFF may have occurred from either the fire suppression system (e.g., the AFFF concentrate pipe (b) (3) (A)) or from the former slop tank's associated former 200-gallon AFFF AST. Soil and groundwater samples will be collected and analyzed for PFAS. PFAS were selected based on the storage of AFFF in tanks as part of a fire suppression system. The primary objective of the sampling is to characterize the nature and extent of PFAS in the soil, sediment, and groundwater at concentrations above project screening levels (PSLs) and to determine whether further evaluation is warranted based on risk associated with potential exposure to the PFAS.

The data currently available are insufficient to adequately determine the nature and extent of PFAS at the Site. Additional data are needed to refine the extent of PFAS PSL exceedances, refine the preliminary CSM, and evaluate the potential risks to human health and the environment at the Site.

11.2 STEP 2 – IDENTIFY THE STUDY GOALS

The second step of the DQO process identifies 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. For this project, the principal study questions (PSQs) are as follows:

- *PSQ #1:* Are PFAS detected at the Site in soil, swale drainage sediment (Area A only), or groundwater at concentrations exceeding PSLs?
- *PSQ #2:* Has the extent of PFAS in soil, swale drainage sediment (Area A only), and groundwater with concentrations exceeding PSLs been delineated?
- *PSQ #3:* Does exposure to PFAS in soil, swale drainage sediment (Area A only), or groundwater present unacceptable risks to human health or the environment?

11.3 STEP 3 – IDENTIFY THE INFORMATION INPUTS TO THE DECISION

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

Previous data collected from the Site are insufficient to evaluate the nature and extent of site PFAS associated with historical activities and the November 2022 AFFF release at the Site. Therefore, additional information is required to evaluate the nature and extent of PFAS, determine the risk presented by site media potentially affected by AFFF releases, and decide if further evaluation is warranted. Environmental samples (soil, swale drainage sediment [Area A only], and groundwater)

will be collected at the Site for laboratory analysis of PFAS. Primary decision inputs will include the following:

- PSLs for PFAS in soil, swale drainage sediment (Area A only), and groundwater. This data input consists of the PFAS that exceed PSLs that may pose potential adverse effects from exposure to impacted soil, drainage swale sediment (Area A only), or groundwater. All PSLs were derived from the EPA RSLs and Department of Defense (DoD) and CERCLA guidance. The following inputs are used for development of the PSLs.
 - EPA RSL table values for resident soil and tap water using a target hazard quotient (THQ) of 0.1 and target cancer risk of 1E-06 (EPA 2023).
 - “PFAS 101 Regional Screening Levels Used in DoD Cleanups” (DoD 2024c).
- PFAS concentrations in surface soil (0–0.5 foot bgs) and subsurface soil (0.5–18 feet bgs) samples collected from locations at Area A and Area B during the RI. Soil analytical results from the sampling locations will be used to delineate the vertical and horizontal extent of PFAS in soil at Area A and Area B and used in baseline human health and ecological risk assessments, if needed.
- PFAS concentrations in swale drainage sediment samples collected from locations behind Bldg. 313. Swale drainage sediment analytical results will be used to delineate the lateral extent of PFAS currently in the drainage swale and contribute to the development of the baseline human health and ecological risk assessments, if needed. There are no surface water bodies within the Site.
- PFAS concentrations in perched (if encountered) and basal groundwater samples collected from within Area A and Area B. Analytical results will be used to evaluate the presence and concentration of PFAS in groundwater and help develop a baseline human health risk assessment.
- PFAS concentrations in basal groundwater samples collected from non-routine wells and new groundwater monitoring wells. Analytical results will be used to evaluate the presence and concentration of PFAS in groundwater and help develop a baseline human health risk assessment.
- Location coordinates and depths, if applicable, of samples collected from Area A and Area B. Field observations and field-recorded Unified Soil Classification System soil and lithologic descriptions (ASTM 2011). These data inputs will assist in refinement of the CSM and aid in delineation goals.
- PFAS analytical results collected from response and compliance activities. This includes prior weekly and monthly groundwater monitoring programs and soil confirmation sampling.
- Results of human health and ecological risk assessments; *2023 DoD Memorandum: Investigating Per- and Polyfluoroalkyl Substances within the DoD* (DoD 2023c) identifies the PFAS non-carcinogenic reference doses and oral cancer slope factors for human health risk assessment. *Recommended Ecological Screening Values for Per- and Polyfluoroalkyl Substances* identifies applicable screening values for ecological risk assessments (DON 2023n). The human health and ecological risk assessments will determine if PFAS concentrations in soil, swale drainage sediment, and groundwater present unacceptable risks to human health or the environment.

11.4 STEP 4 – DEFINE THE BOUNDARIES OF THE STUDY

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.

In Area A, the horizontal site boundaries consist of an approximate rectangular area of about 0.6 acre centered on the Bldg. 313 Pump House. The lateral site boundaries were designed to encompass the areas previously or potentially affected by AFFF release(s) on-site. These areas include Adit 6 and the apron, the culverts and outflows, the former AFFF AST area, Bldg. 313, the lower concrete drainage swales, and the buffer areas extending to vegetated areas past the fence line. Areas outside of the proposed lateral study area are not anticipated to have PFAS present due to by historical site activities. The Area A horizontal RI boundaries are shown on Figure 3.

The Area B horizontal site boundaries consist of an area of approximately 18 acres around wells from the baseline sampling that had PFOS detections along with wells located to the west that did not have PFOS detections. The Area B horizontal boundaries are shown on Figure 3. In addition to Area B, the boundaries of the study extend to the westernmost fence line at the RHBFSF to delineate PFAS at the westernmost boundary (Figure 11).

The vertical boundary of the RI extends from the ground surface to basal groundwater, at approximately 235 feet bgs near Area A. However, subsurface soil sampling will be limited to within the first 20 feet bgs. Perched and basal groundwater will be sampled from the two existing piezometers on-site (RHMW17S and RHMW17D) and the two existing monitoring wells (RHMW06 and RHMW17) along with the two proposed basal monitoring wells. The vertical boundary of the RI also extends from the ground surface to basal groundwater, at approximately 250 feet bgs near Area B. Perched groundwater will be sampled from OWDFMW03B and OWDFMW08B. Basal groundwater will be sampled from the following wells: RHP01, RHP02, RHP03, RHP06, RHP07, RHP08, RHMW2254-01, OWDFMW03A, and OWDFMW08A, along with the three proposed basal monitoring wells.

After review of the soil analytical data and field investigation findings, the horizontal or vertical boundaries may be adjusted, if necessary, based on the identification of PFAS and the need to further evaluate the extent of contamination.

The temporal boundary for this investigation is limited to the period of time necessary to complete the RI field activities and data evaluation.

11.5 STEP 5 – DEVELOP THE ANALYTIC APPROACH

The objective of Step 5 in the PQO process is to develop decision rules that will guide the analytical approach for the study results and to determine what conclusions are to be derived from the data. The analytical approach comprises a series of if-then statements. The following approach has been developed to address the PSQ. Potential outcomes are as follows:

- *PSQ #1:* Are PFAS detected at the Site in soil, swale drainage sediment (Area A only), or groundwater at concentrations exceeding PSLs?
 - If PFAS are not detected at concentrations exceeding PSLs, then recommend no further evaluation.
 - If PFAS are detected at concentrations exceeding PSLs, then proceed to PSQ #2.

- *PSQ #2:* Has the extent of PFAS in soil, swale drainage sediment (Area A only), and groundwater with concentrations exceeding PSLs been delineated?
 - If the extent of PFAS is not horizontally and vertically delineated to the RI PSLs in soil and groundwater, then additional soil or groundwater sampling may be considered by the project team. If the CSM has changed based on the data collected, a WP addendum or field change request will be completed to document the approach, rationale, and updated CSM for additional sampling locations.
 - If the extent of PFAS data is horizontally and vertically delineated to the PSLs, then additional sampling is not required. Proceed to PSQ #3.
- *PSQ #3:* Does exposure to PFAS in soil, swale drainage sediment (Area A only), or groundwater present unacceptable risks to human health or the environment?
 - If exposure to PFAS does not present unacceptable risks to human health or the environment, then recommend no further evaluation.
 - If exposure to PFAS does present unacceptable risks to human health or the environment, then recommend further evaluation and actions.

11.6 STEP 6 – SPECIFY PERFORMANCE OR ACCEPTANCE CRITERIA

The following objectives are used to identify the potential sources of study error and describe how these potential errors will be minimized throughout the investigation:

- Identify potential sources of study error (i.e., sampling [laboratory and field] error or measurement [analytical] error).
- Establish and identify methods to reduce the potential sources of error.
- Establish how decision errors will be managed during the project.

11.6.1 Potential Sources of Error

Potential decision errors could occur because of sampling design error, measurement error, or a combination of the two (known as total study error). A sampling error (field or laboratory) occurs when a sampling design or its implementation does not represent the range of heterogeneity at the Site. A measurement error occurs due to performance variance from laboratory instrumentation, analytical methods, or operator error. The EPA identifies the combination of all these errors as “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 represents the chemical characteristics of the Site.

11.6.2 Managing Decision Error

The investigation will use the following methods to minimize decision errors:

- Evaluate all the available historical data to determine historical site use, select appropriate sampling locations, and define site characteristics.
- Apply standardized field sampling methodologies (as discussed in Worksheets #17 and #18). Sampling activities will be performed in accordance with the *Project Procedures Manual, U.S. Navy Environmental Restoration Program, NAVFAC Pacific* (DON 2015).

- Apply specialized field sampling methodologies developed for sampling these PFAS to minimize potential introduction of chemicals of concern from outside sources (see Field Sampling Protocols for Sampling at PFAS-impacted sites [Worksheets #14 and #21]). Sampling activities for PFAS will be performed in accordance with the *Navy PFAS Interim Guidance* (DON 2020a) and those outlined in *Environmental Data Quality Workgroup (EDQW) PFAS Sampling Factsheet Rev 1.2 July 2017* (DoD 2017).
- Use applicable analytical methods (as discussed in Worksheets #23, #24, and #25) for sample analysis by a competent analytical laboratory evaluated by the DoD Environmental Laboratory Accreditation Program (ELAP) to reduce measurement errors, follow guidelines set by *Establishing a Consistent Methodology for the Analysis of Per- and Polyfluoroalkyl Substances in Matrices Other than Drinking Water* (DoD 2023b).
- 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.

11.6.3 Identifying and Managing Measurement Error

Sampling errors, and therefore decision errors, will be minimized during the field investigation by applying specialized field-sampling methodologies developed for sampling PFAS to minimize cross-contamination with outside sources (as discussed in Worksheet #17). Applicable standardized field sampling methodologies are discussed in Worksheets #18, #20, #21, and #22.

The field sample collection will be carefully managed in accordance with the *Final Project Procedures Manual, U.S. Navy Environmental Restoration Program, NAVFAC Pacific* (Worksheet #21) (DON 2015), which details the standard operating procedures applicable to this RI. Field sampling errors for surface and subsurface soil sampling will be evaluated by reviewing field duplicate sample results and their relative percent differences.

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/quality control data; and calibrating, maintaining, testing, and inspecting laboratory equipment (see Worksheets #23, #24, and #25).

An analytical laboratory accredited by the 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 (DoD and DOE 2023).

Spikes, blanks, and duplicates will be required to identify and control potential laboratory error. Analytical results will be evaluated by comparing relative percent differences between field duplicates, laboratory duplicate samples, and the results of spikes and blanks.

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 through 6 to develop a resource-effective design for collecting and measuring environmental data. The principal objectives of the sampling and analysis program are to characterize the nature and extent of PFAS concentrations greater than the project screening criteria in evaluated site media. The sampling design for this RI 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 objectives are to evaluate where PFAS concentrations exceed the PSLs presented in Worksheet #15 and to delineate the extent of PFAS at the Site. If PFAS exceedances of PSLs are identified and PFAS impacts are adequately delineated, then analytical results will be incorporated into human health and ecological risk assessments for the exposure pathways identified in the CSM.

It is believed that an adequate number of primary samples and new and existing well locations are planned to satisfy the data needs, achieve the project objectives, and enable informed management decisions. Samples are based on the current and historical land use and site information, as well as the results from the prior soil confirmation sampling and PFAS groundwater monitoring. Existing monitoring wells along with up to two new monitoring well clusters (a paired perched and basal monitoring well at each location) within Area A will be utilized in the sample design to collect both perched and basal groundwater samples. Existing monitoring wells and three new monitoring well clusters (a paired perched and basal monitoring well at each location) within Area B will be utilized to collect both perched and basal groundwater samples. An understanding of the current site conditions and consideration of potential PFAS impacts discussed in Worksheet #10 were used to select appropriate sampling locations that will evaluate the nature and extent of PFAS, define site characteristics, and refine the CSM during the RI.

Worksheet #12 specifies the measurement performance criteria for soil sample analytical data, and Worksheet #15 specifies the PFAS and corresponding screening levels for the analytical data. A summary of project tasks is included in Worksheet #14. Samples will be collected in accordance with the standard operating procedures (DON 2015) described in Worksheets #18 and #21, and analyzed using EPA methods listed in Worksheet #19. The analytical laboratory will have current DoD ELAP accreditation. Data verification and validation will be performed, as described in Worksheets #34-36. The quality of data collected during the RI 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	MPC
Field duplicate	PFAS	10% of primary samples collected per matrix per analytical method	Precision	RPD ≤50% water ^{c,d} RPD ≤100% soil/sediment (judgmental) ^{c,d}
Field blank	PFAS	Once per source of decontamination water per sampling event	Adequacy of the decontamination water quality	≤1/2 of LOQ or ≤1/10th of screening level ^d
Equipment rinsate	PFAS	5% of primary samples collected per matrix per analytical method	Adequacy of the decontamination process	≤1/2 of LOQ or ≤1/10th of screening level ^d

% percent

DQI data quality indicator

LOQ limit of quantitation

MPC measurement performance criteria

RPD relative percent difference

^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) and Per Section II, *Data Validation Procedures* (DON 2015).

^d Data Validation Guidelines Module 6: Data Validation Procedure for Per- and Polyfluoroalkyl Substances Analysis by QSM Table B-24 (DoD 2022).

Worksheet #13: Secondary Data Criteria and Limitations Table

Secondary Data	Data Source	Data Generator	How Data Will Be Used	Limitations on Data Use
Historical Data	Historic American Engineering Record. 2015. <i>U.S. Naval Base, Pearl Harbor, Red Hill Underground Fuel Storage System: Photographs, Written Historical and Descriptive Data</i> . HAER HI-123. Washington, DC: National Park Service.	Historic American Engineering Record	Historical data and photographs will be used to provide site history and information about potential unknown PFAS releases.	Information is limited to the current Area A.
	Department of the Navy. Subj: Supplement to the Command Investigation into the 6 May 2021 and 20 November 2021 Incidents at Red Hill Bulk Fuel Storage Facility. Letter 5830 from: RADM J. P. Waters III; to: Vice Chief of Naval Operations. Encl: (1) Final Report. April 15.	Naval Facilities Engineering Systems Command Pacific	Information about the installation of the AFFF system in the lower tunnel of RHBFSF will be used. Data includes the construction of the AFFF conveyance system, including Bldg. 313, type of AFFF concentrate used, how the system works.	TBD.
	Shaw Environmental, Inc. 2009. <i>Technical Report: Demolish JP-5 Slop Tank at the Red Hill Fuel Facility Fleet and Industrial Supply Center Pearl Harbor, Hawaii</i> . Rev. 0. Brooks City-Base, TX: Air Force Center for Engineering and the Environment. April.	Shaw Environmental, Inc.	Soil sampling during this investigation showed no historical release from the JP-5 Slop Tank near Adit 6. Soil samples were not analyzed for PFAS.	Samples not analyzed for PFAS.
Release Report	Department of the Navy. 2023. "Joint Task Force – Red Hill Announces AFFF Investigation Findings and Publishes Video Footage." Press Release. Headquarters, Joint Task Force-Red Hill Public Affairs Office Ford Island Conference Center Joint Base Pearl Harbor-Hickam. May 5, 2023.	Naval Facilities Engineering Systems Command Pacific	Report providing information on the 2022 AFFF release at Adit 6. Provides information regarding the extent of the release and areas affected.	TBD.
	Environmental Protection Agency, United States, Region 9. 2023. <i>Aqueous Film Forming Foam Investigation Report Red Hill Bulk Fuel Storage Facility</i> . Honolulu, HI: EPA Region 9. August.	United States Environmental Protection Agency	Report providing information on the 2022 AFFF release at Adit 6. Provides information regarding the extent of the release and areas affected.	TBD.
	Department of Health, State of Hawaii, Hansen's Disease Branch. 2022. <i>Release Notification: Navy Red Hill Aqueous Film Forming Foam (AFFF) Release</i> . Case Number: 20221129-1438.	State of Hawaii Department of Health, Hansen's Disease Branch	Report provides background information on areas affected by the 2022 AFFF release. Highlights efforts taken to inhibit the migration of AFFF.	Only provides qualitative data.
Sampling and Analysis Plan	Department of the Navy. 2022. <i>PFAS-Specific Sampling and Analysis Plan, Red Hill Bulk Fuel Storage Facility, Adit 6, Joint Base Pearl Harbor-Hickam, Hawaii</i> . Revision 1. Prepared for: Red Hill OIC. December 7. JBPHH HI: Naval Facilities Engineering Systems Command Pacific. December	Naval Facilities Engineering Systems Command Pacific	Data will be used to provide baselines levels of PFAS in media after excavation of affected materials and prior to backfilling.	Data limited to specific sampled areas.
Groundwater Investigation and Monthly Report	Department of the Navy. 2023. <i>Aqueous Film-Forming Foam Soil and Groundwater Investigation and Monitoring Monthly Report December 2022 Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam O'ahu HI</i> . Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. January 7.	Naval Facilities Engineering Systems Command Pacific	Data will provide information regarding PFAS levels in media underneath the excavated areas as well as the nearby groundwater.	Sampling limited to near Bldg. 313.
Monthly Groundwater Monitoring Report	Department of Navy. 2023. <i>Aqueous Film-Forming Foam Soil and Groundwater Investigation and Monitoring Monthly Report January 2023 Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam O'ahu HI</i> . Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. February 7.	Naval Facilities Engineering Systems Command Pacific	Data provides quantitative measure of PFAS analytes in groundwater on a weekly basis.	Limited to PFAS in groundwater at certain wells.
	Department of Navy. 2023. <i>Aqueous Film-Forming Foam Soil and Groundwater Investigation and Monitoring Monthly Report February 2023 Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam Oahu HI</i> . Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. March 7.			

Title: Draft RI WP

Site/Project Name: PFAS Release, RHBFSF

Site Location: JBPHH Oahu HI

Revision Number: 00

Revision Date: June 2024

Secondary Data	Data Source	Data Generator	How Data Will Be Used	Limitations on Data Use
Monthly Groundwater Monitoring Report (cont'd)	Department of Navy. 2023. <i>Aqueous Film-Forming Foam Soil and Groundwater Investigation and Monitoring Monthly Report March 2023 Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam Oahu HI</i> . Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. April 7.	Naval Facilities Engineering Systems Command Pacific	Data provides quantitative measure of PFAS analytes in groundwater on a weekly basis.	Limited to PFAS in groundwater at certain wells.
	Department of Navy. 2023. <i>Aqueous Film-Forming Foam Soil and Groundwater Investigation and Monitoring Monthly Report April 2023 Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam Oahu HI</i> . Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. May 7.			
	Department of Navy. 2023. <i>Aqueous Film-Forming Foam Soil and Groundwater Investigation and Monitoring Monthly Report May 2023 Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam Oahu HI</i> . Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. June 7.			
	Department of Navy. 2023. <i>Aqueous Film-Forming Foam Soil and Groundwater Investigation and Monitoring Monthly Report June 2023 Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam Oahu HI</i> . Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. July 7.		Data used to support information input of PFAS concentrations in groundwater on a monthly basis. Identified PFAS analytes to focus on for further investigation.	Limited to the groundwater wells sampled.
	Department of Navy. 2023. <i>Aqueous Film-Forming Foam Soil and Groundwater Investigation and Monitoring Monthly Report July 2023 Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam Oahu HI</i> . Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. August 7.			
	Department of Navy. 2023. <i>Aqueous Film-Forming Foam Soil and Groundwater Investigation and Monitoring Monthly Report August 2023 Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam Oahu HI</i> . Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. September 7.			
	Department of Navy. 2023. <i>Aqueous Film-Forming Foam Soil and Groundwater Investigation and Monitoring Monthly Report September 2023 Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam Oahu HI</i> . Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. October 6.			
	Department of Navy. 2023. <i>Aqueous Film-Forming Foam Soil and Groundwater Investigation and Monitoring Monthly Report October 2023 Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam Oahu HI</i> . Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. November 7.			
	Department of Navy. 2023. <i>Per- and Polyfluoroalkyl Substances Delineation Non-Routine Wells Groundwater Investigation Report September 2023 Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam Oahu HI</i> . Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. November 27.			
	Department of Navy. 2023. <i>Per- and Polyfluoroalkyl Substances Delineation Non-Routine Wells Groundwater Investigation Report September 2023 Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam Oahu HI</i> . Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. November 27.		Data provides additional baseline information for PFAS and PFOS presence in groundwater from both routine and non-routine groundwater wells.	TBD.
Investigation Findings	Department of Defense. 2023. "Joint Task Force – Red Hill Announces AFFF Investigation Findings and Publishes Video Footage." Press Release. Headquarters, Joint Task Force-Red Hill Public Affairs Office Ford Island Conference Center Joint Base Pearl Harbor-Hickam. May 5, 2023.	Department of Defense	Findings from this investigation provide information inputs to the decision of modifying the AFFF system. Provides background information for the 2022 release.	TBD

JP-5 Jet Propellant 5
TBD to be determined

Worksheet #14: Summary of Project Tasks

This worksheet describes the various tasks for the RI, including field sampling procedures and chemical analyses for the field sampling program presented in Worksheet #17. The objectives for collecting data are presented in Worksheet #11. The following field activities are proposed to satisfy the project quality objectives for the RI:

- Drilling for soil sampling
- Additional monitoring well installation for groundwater sampling
- Groundwater sampling
- Sediment sampling

Unless otherwise noted, project tasks will be conducted in accordance with the *Project Procedures Manual, U.S. Navy Environmental Restoration Program, NAVFAC Pacific* (DON 2015) and PFAS sampling guidance (Appendix B).

14.1 PRE-WORK MEETING

Before mobilization, AECOM personnel will meet or coordinate with the U.S. Department of the Navy (Navy) to address the following issues:

- Planned field activities
- Site-specific safety issues
- Schedule of field operations
- Logistics, including area access
- Investigation-derived waste (IDW) management

14.2 SITE SURVEYS AND PREPARATION

Field team personnel will identify and locate soil and storm drain sediment sampling locations and groundwater monitoring well locations at the Site. Proposed soil and sediment sampling locations are provided on Figure 10, and proposed soil sampling, monitoring well, and groundwater sampling locations are shown on Figure 11. Each area for sampling or well installation will be marked and visually inspected for obstructions and potential health and safety hazards. The field team will also prepare a location for temporary storage of IDW following discussion with the Navy RPM.

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

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

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

Overgrown vegetation concealing designated sampling, or well installation locations, or impeding travel paths may be cut back using manually operated vegetation trimming tools (e.g., machete), as necessary, to clear a path and open sufficient space for sample collection or drilling activities.

14.3 SITE PREPARATION

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

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

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

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

After the work is completed, the drilling locations will be restored to their roughly original pre-construction condition.

14.4 DIRECT PUSH TECHNOLOGY AND HOLLOW STEM AUGURING DRILLING FOR SOIL SAMPLING

Properly maintained drilling equipment and support vehicles will be mobilized to the site after passing inspection and being mechanically certified by a qualified mechanic familiar with the equipment. In addition, the drill rig and accessory equipment should be evaluated, and all PFAS-bearing parts replaced with PFAS-free parts.

Discrete surface and subsurface soil samples are to be collected at the Site via a direct push drill rig or a hollow stem auger (HSA); the locations of these proposed soil sampling locations are illustrated in Figure 10. A HSA will be used for sample collection if the direct push method is unable to advance in compacted material; if bedrock material is encountered, (refusal twice after relocating within the cleared area) the last sample will be collected from the deepest soil encountered before bedrock. Surface and subsurface soil collection will be conducted in accordance with Procedure I-B-1, *Soil Sampling* (DON 2015), Procedure III-A, *Laboratory QC Samples (Water, Soil)*, and Procedure III-B, *Field QC Samples (Water, Soil)*. The field geologist will identify the types of soil collected using Procedure I-E, *Soil and Rock Classification* (DON 2015).

At each surface soil location samples will be collected from 0–0.5 foot bgs. Up to five depths will be collected at the soil sampling locations from the depths of: 0–0.5 foot bgs, 2–3 feet bgs, 5–6 feet bgs, 11–12 feet bgs, and 17–18 feet bgs, or if refusal is met prior to 18 feet bgs, then the greatest depth encountered prior to refusal will be sampled. Discrete sampling intervals will be collected between 3 to 6 inches, within the 1-foot target interval. At the previous excavation areas, samples of the native soil will be collected from beneath the existing fill. If direct push technology is utilized, it will be completed in accordance with Procedure I-H, *Direct Push Sampling Techniques* (DON 2015).

14.5 MONITORING WELL DRILLING AND INSTALLATION PROCEDURES

Properly maintained drilling equipment and support vehicles will be mobilized to the site after passing inspection and being mechanically certified by a qualified mechanic familiar with the equipment. In addition, the drill rig and accessory equipment should be evaluated, and all PFAS-bearing parts replaced with PFAS-free parts.

Two basal groundwater monitoring wells are to be installed in Area A, and three basal groundwater monitoring wells are to be installed in Area B; proposed locations are illustrated in Figure 10 (Area A) and Figure 11 (Area B). If perched groundwater is encountered during the drilling of these wells, then a well will be installed to monitor the perched zone and the location of the basal monitoring well will be relocated nearby (within 15 feet) and installed as part of a well pair. The combination of a basal groundwater monitoring well and a perched groundwater monitoring well will result in a groundwater monitoring well cluster at that location. The presence or absence of perched groundwater will determine the ultimate number of wells to be installed at each location. If no perched groundwater conditions are encountered, then only five wells will be installed across the Site. However, if perched groundwater conditions are encountered, then up to ten monitoring wells could be installed across the Site.

Basalt bedrock is anticipated to be encountered at shallow depths within the Site. At each well location, both a pilot borehole (for detailed lithologic logging) and an percussion hammer drilling borehole (for monitoring well installation) will be advanced.

Procedures for monitoring well drilling and installation are described below:

1. Drilling for Well Installation
2. Video Logging
3. True Vertical Depth Analysis
4. Evaluation of Groundwater Conditions
5. Drilling for Lithological Investigation and Soil Sampling
6. Conductor Casing
7. Well Design and Completion
8. Well Development
9. Initial Groundwater Sampling
10. Borehole, Corehole, and Well Abandonment

The project procedures cited below are from the NAVFAC Pacific Environmental Restoration Program (DON 2015) (see Worksheet #21).

14.5.1 Drilling for Well Installation

A pilot borehole will be initiated by drilling through unconsolidated materials (which could include soil such as valley fill, saprolite, tuff, or other materials) using a hollow-stem auger, bucket auger, or air rotary methods until competent bedrock is encountered. Soil will be collected at specific intervals using split-spoon samplers (if using hollow-stem auger method) or directly from drill cuttings (if using bucket-auger or air-rotary methods). Logged soil cuttings will be screened for volatile organic compounds (VOCs) using a PID. Logging and screening will take place for soil from the depths of 10, 15, and 20 feet bgs. Below 20 feet bgs, soil cuttings will be collected at intervals of no greater than 10 feet. Soil logging will end when bedrock is encountered. A conductor casing may be installed in accordance with Work Plan Section 14.5.5 if evidence of contamination is observed or to maintain the integrity of the borehole at the surface through unconsolidated material.

Below the top of bedrock, well boreholes will typically be advanced using air-rotary or percussion air-hammer drilling methods. Drill cuttings and fluids will be collected from the discharge for lithologic description and screening for VOCs. In cases where air drilling methods are not effective, alternative drilling methods such as mud rotary may be used. A drilling log will be maintained to document the penetration rate, lithology, drilling additives, hammer oil rate of application, and volume and rate of water added to the borehole.

For intervals where the borehole is unstable or shows evidence of perched water, the affected interval may be grouted and redrilled.

Following drilling, any excess drilled footage more than 8 feet below the target depth will be backfilled with uncoated bentonite pellets or sand. The monitoring well will then be installed, and the annular seal will be emplaced as expeditiously as practicable.

14.5.2 Video Logging

In addition to lithologic logging completed by the field geologist, portions of the borehole will be logged using downhole video logging techniques before well installation begins. Logging will be conducted in accordance with Procedure III-D, *Logbooks* (DON 2015). Borehole video logging may be conducted in the vadose zone if hole stability and impacts to drilling logistics are judged acceptable. Video logging may not be performed if there are concerns with hole stability. Logging tools may include optical televiewer, caliper, natural gamma ray, induction resistivity, downhole camera, or other instruments. Below the basal aquifer groundwater level, logging tools may include acoustic televiewer, optical televiewer, caliper, natural gamma ray, induction resistivity, temperature, specific conductivity, electromagnetic flowmeter, downhole camera, or other instruments. The data will be used to obtain additional information on the local hydrogeology and geochemistry.

14.5.3 True Vertical Deviation Analysis

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

14.5.4 Evaluation of Groundwater Conditions

14.5.4.1 UNCONFINED CONDITIONS

After drilling to a depth of approximately 7 feet below mean sea level (msl), the static water level will be evaluated by removing groundwater from the borehole by air injection (blowing) or bailing the borehole clear and measuring recovery of the water level using a pressure transducer or water level meter. Groundwater discharged from the borehole during the evacuation process will be captured for screening with a PID. If the estimated water level stabilizes within the range of approximately 16–20 feet above msl, then the borehole has been drilled into groundwater under unconfined conditions and the well can be installed according to Section 14.5.6.

14.5.4.2 CONFINED GROUNDWATER

If confined conditions are suspected in the basal aquifer, drilling will advance to approximately 7 feet below msl, the basal aquifer water level will be evaluated by blowing or bailing the borehole clear and measuring recovery of the water level using a pressure transducer. If the estimated water level is outside the range of 16–20 feet above msl, the test will be repeated. If the water level is confirmed to be outside this range, a confined or elevated head condition may be present, and the proposed well screen interval may need to be adjusted to ensure that the well is in good hydraulic communication with the basal aquifer.

If confined conditions are confirmed, drilling will advance until the water level in the borehole stabilizes at approximately 16–20 feet above msl and the rate of water recovery in the borehole is above 0.5 gallon per minute (gpm) after the borehole is cleared with air, bailing, or other acceptable methods. Water level recovery data will be evaluated further to recommend an appropriate revised well screen depth interval.

Water level data and results of headspace PID readings will be provided to the regulatory agencies in an electronic spreadsheet format on a weekly basis.

14.5.4.3 PERCHED GROUNDWATER

Drill cuttings will be monitored during drilling for signs of groundwater infiltration into the borehole. If inflow of groundwater to the borehole is suspected above the basal aquifer, the borehole will be cleared with compressed air, bailing, or other acceptable methods, and a headspace sample will be collected from the discharged water to evaluate the presence of contamination. Groundwater in the borehole will be cleared, and observations will be conducted at the start of each day at approximately 40-foot intervals while drilling. If water is present in the hole at the end of the day and the borehole is apparently stable, a pressure transducer will be deployed to record water levels overnight. The drilling log will record water loss totalizer readings and average gallons of water per foot for each core run or drilling rod.

Water levels will be measured in the well borehole at the beginning and end of each day during drilling and a transducer will be deployed to record water levels overnight. A headspace test will be tested each morning on groundwater retrieved from the borehole using a bailer. The drilling log will record totalizer readings and an average gallons of water added to the borehole per foot of drilling will be determined.

Similar testing and evaluation will be conducted at a depth equal to approximately 30 feet above msl. If groundwater inflow is detected from perched interval(s), a borehole video inspection may be conducted (Section 14.5.2). Procedures for evaluating the headspace tests and required actions and notifications are described in Section 14.6.

If there is no evidence of contamination in the perched groundwater and efforts to stop the inflow of perched groundwater are unsuccessful, a well will be set in the perched zone, and the basal groundwater well will be redrilled nearby, resulting in a well cluster at this location. Information regarding perched groundwater well installation can be found in Section 14.6. More information on identification of perched aquifers, well construction, and logging can be found in *Monitoring Well Installation Work Plan, Red Hill Bulk Fuel Storage Facility* (DON 2024a).

14.5.4.4 DRILLING FOR LITHOLOGICAL INVESTIGATION

Pilot borehole drilling will be advanced to the same target depth as the well borehole. The pilot borehole will be advanced through unconsolidated materials using hollow-stem auger. Soil will be collected for logging using split-spoon samplers or directly from the drill cuttings. Logged soil cuttings will be screened for VOCs using a PID. Logging and screening will take place at intervals of no greater than 5 feet. Soil logging will end when bedrock is encountered. The auger may be left in place during drilling as a temporary surface casing to stabilize the unconsolidated interval.

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

The rock cores will be inspected and logged to characterize the lithology and evaluate potential pathways for migration of PFAS. The entire pilot borehole will be logged by the field geologist

(according to the procedures described below). A summary rock core chart will be used in the field to log the information. In general, each log will note rock-quality designation; rock color; texture; strength; degree and angle of fracturing; shape, size, and volume of voids; weathering; and secondary staining and mineralization. Additionally, details of basalt flow and intraflow structures (e.g., aʻā clinker flow-top breccias [clinker sub-types], inflated pāhoehoe lobes, massive aʻā dense core interiors) will be included in logging of the rock cores.

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

Evaluation of perched groundwater and contamination during pilot borehole drilling is described in Section 14.5.4.3. When the pilot borehole is drilled prior to the well borehole, drilling will pause at a depth corresponding to an elevation of 30 feet msl, and the presence of inflow to the borehole will be evaluated by bailing or pumping down the water level and measuring water level recovery with a pressure transducer or water level meter and conducting headspace tests on bailed groundwater with a PID to evaluate for VOCs. If no VOCs are detected in the perched groundwater, drilling may proceed to the target depth.

Geophysical logging and video surveys may be conducted in the pilot borehole (Section 14.5.2). After logging, the pilot borehole will be backfilled to approximately 25 feet above msl with sand, and a 5-foot seal of bentonite chips or uncoated pellets will be emplaced using a tremie pipe. Above approximately 30 feet msl, the pilot borehole will be backfilled with neat cement, cement-bentonite grout, or sand cement slurry in accordance with DLNR standards (2004) for hole abandonment. If the required grout volume is more than 150 percent of the calculated borehole volume due to voids in the formation, then gravel, bentonite chips, or uncoated bentonite pellets can be used to fill up to a 10-foot vertical interval of the pilot borehole.

14.5.5 Conductor Casing

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

If conductor casing is required due to contaminated soil or contaminated perched groundwater (as described in Section 14.6) in the well borehole that has been advanced to a depth corresponding to 30 feet msl, the well borehole may be reamed or over-drilled and a conductor casing installed to seal the interval of contaminated perched groundwater. Alternatively, the well borehole may be abandoned in accordance with DLNR standards (2004) and re-drilled near the same location to a larger diameter to accommodate the surface casing.

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

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

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

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

14.5.6 Well Design and Completion

14.5.6.1 WELL DESIGN

Proposed wells will be installed as single-screen monitoring wells screened across or below the approximate elevation of the regional basal aquifer (water table conditions), or other depths (e.g., confined conditions or deeper intervals farther below the potentiometric elevation). In some cases, wells may also be completed in perched aquifers or elevated-head conditions. Perched aquifers are expected to be less than 10 feet thick; therefore, perched wells will be screened from a minimum of 5 feet above the perched water table to the underlying aquitard, with a minimum total of 10 feet of well screen. Wells screened at deeper intervals may be used to monitor for evidence of plume diving, evaluate vertical gradients, evaluate groundwater chemistry deeper in the aquifer, and gather lithologic data at deeper depths within the aquifer to further refine the CSM.

Typical monitoring well designs for both perched and basal groundwater monitoring wells are shown in Appendix E.

14.5.6.2 WELL CONSTRUCTION

The field manager or field geologist will oversee all monitoring well construction activities. The driller will install monitoring wells in conformance with DLNR standards (2004) and Procedure I-C-1, *Monitoring Well Installation and Abandonment* (DON 2015). Monitoring well completion for both basal and perched groundwater monitoring wells (unless specified) will include (but not be limited to) the following:

- *Casing and screen:* The typical well design uses 4-inch-diameter PVC or stainless steel well casing and a 0.02-inch slotted screen. All well designs will be in accordance with the DLNR well construction standards (2004) with a minimum of 1.5-inch-thick annular well seals. To ensure the casing is centered in the borehole, centralizers will be installed at the top and bottom

of the screened sections and placed at 30- to 40-foot intervals on the blank casing. Centralizers will be aligned from the top to the bottom of the casing so that they do not interfere with the insertion and removal of a tremie pipe. Devices used to affix centralizers to the casing will not puncture the casing or contaminate the groundwater with which they come in contact. No PVC solvent or cement may be used. Manufacturer-supplied O-rings will be installed on all threaded PVC joints.

- *Annular materials:* During installation of annular materials, the casing and screen will be suspended under tension above the bottom of the borehole. Annular materials will be installed via tremie pipe if the annular space is less than 2 inches.
- *Sand filter pack:* #3 Monterey silica sand will be installed from the bottom of the borehole to approximately 5 feet above the monitoring well screen. The filter pack will be surged midway and following placement. The depth to top of the filter pack will be monitored during surging. Additional material will be added if settling occurs.
- *Bentonite seals:* If the top of sand is below water, a 5-foot thick seal of uncoated PFAS-free bentonite pellets will be emplaced via tremie pipe and allowed to hydrate. If top of sand is above water level, a 5-foot thick seal of bentonite granules or chips will be emplaced via tremie pipe in two lifts and allowed to hydrate.
- *Cement seals:* Neat cement, cement-bentonite grout, or sand cement slurry will be installed in stages or lifts to limit potential for well casing damage from heat of hydration and excessive hydrostatic pressure. Gravel, bentonite chips, or uncoated bentonite pellets can be used over short intervals to raise the top of the annular materials if the presence of voids or other features would otherwise consume excessive grout.
- *Design variances:* Other designs, well diameters, materials, and screen types and slot sizes may be considered where conditions require modification of the typical design. Stainless steel well casing and screens may be used in place of PVC.

14.5.6.3 CEMENT GROUT

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

- *Neat cement grout:* Neat cement for grouting will be mixed at a ratio of one 94-pound sack of Portland Type I cement to no more than 6 gallons of potable water.
- *Cement-bentonite grout:* The grout mixture will 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.
- *Sand-cement slurry:* Sand-cement for grouting will be mixed at a ratio of no more than one part sand to one part Portland Type I cement, by weight, and no more than 6 gallons of potable water per sack of cement.

Excess grout and rinse fluids will be minimized and reused to the extent possible.

14.5.7 Surface Completion

Each monitoring well, either basal or perched zones, will be completed in accordance with Procedure I-C-1, *Monitoring Well Installation and Abandonment*, and Procedure I-C-2, *Monitoring Well Development* (DON 2015). Aboveground completion and flush-mount vault completion diagrams can be found in Appendix F.

14.5.7.1 ABOVEGROUND COMPLETIONS

Selected monitoring wells will be completed aboveground with a monument-style steel protective casing fitted with a locking, tamper-proof lid that covers the steel protective casing and wellhead. The lock will be recessed and covered for added protection, and permanent labels will be applied both inside and outside the casing via painting, marking, or engraving on the protective casing or surface completion. All steel protective casing cuts should be made from the downhole or shoe portion of the casing, to ensure a minimum of 5 continuous feet of casing before a connection or joint at the surface. Cement or grout will then be brought to the surface or ground level. The steel casing will be set in concrete at the wellhead for strength and security and to provide a continuous cement surface seal. The steel protective casing will be filled with cement grout extending to a level of 6 inches below the top of the PVC or stainless steel well casing.

14.5.7.2 FLUSH-MOUNT VAULTS

Depending on the specific conditions surrounding a well, some wells may require a flush-mount traffic-rated steel cover. The covers will be corrosion resistant, leak resistant, and lockable. The concrete pad surrounding traffic-rated covers will be raised 0.25 inch above the road surface in paved areas, and 1.5 inches aboveground surface in unpaved areas. Cement or grout will then be brought to the surface or ground level. The vaults will have an H-20 load rating and bolt-down, gasketed covers with recessed padlocks.

14.5.8 Well Development

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

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

14.6 CONTAMINATION SCENARIOS, NOTIFICATIONS, AND RESPONSE ACTIONS

Four scenarios are identified to address anticipated conditions encountered during drilling of both basal and perched groundwater monitoring wells, and notifications and response actions associated with each. The contamination scenarios are in anticipation of potential non-target chemicals of concern including VOCs. PID readings can be collected from borehole headspace, rock cores, or drill cuttings. The four anticipated scenarios consist of the following:

- *Scenario 1:* No contamination is observed and PID readings are less than 10 ppmv.
- *Scenario 2:* No contamination is observed and PID readings are greater than 10 ppmv but less than 50 ppmv.
- *Scenario 3:* Moderate levels of contamination are observed and PID readings are greater than 10 ppmv but less than 50 ppmv.
- *Scenario 4:* Contamination is observed or PID readings exceed 50 ppmv.

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

14.6.1.1 SCENARIO 1: NO CONTAMINATION OBSERVED, PID READING LESS THAN 10 PPMV

In this scenario:

- Drilling efforts will continue.
- The Navy will notify the regulatory agencies weekly via email regarding progress and observations and provide tabulated data.
- Field screening and sampling procedures will continue to the basal aquifer.
- If inflow is greater than 5 gpm, attempts will be made to seal the hole by grouting, and conductor casing may be required.

14.6.1.2 SCENARIO 2: NO CONTAMINATION OBSERVED, PID READING BETWEEN 10 PPMV AND 50 PPMV

In this scenario:

- Drilling efforts will continue.
- The Navy will notify the regulatory agencies weekly via email regarding progress and observations and provide tabulated data.
- Field screening and sampling procedures will continue to the basal aquifer.
- If inflow is greater than 5 gpm after grouting attempts, conductor casing will be used to isolate perched water.

14.6.1.3 SCENARIO 3: MODERATE LEVELS OF CONTAMINATION OBSERVED

Moderate levels of contamination are observed (e.g., with evidence of olfactory or visual oily staining or sheen on rock core or drill cuttings) and PID readings are greater than 10 ppmv but less than 50 ppmv. In this scenario:

- Drilling efforts will continue.
- The Navy will notify the regulatory agencies via email within 24 hours after contamination is encountered.

- Soil or groundwater sampling will be conducted. The Navy will provide sampling results (validated or unvalidated) 45 days after shipping or 7 days after receipt, whichever comes first. The Navy agrees to provide unvalidated data if validated results are not received in the requested timeframes, with the understanding that unvalidated data presents opportunity for misuse, if publicly reported, or generates responses on non-validated results. Validated results include explanations if the respective unvalidated result is changed. The Navy will also continue to submit validated results within 30 days of receipt via EDMS.
- Conductor casing will be used to isolate contaminated soil and contaminated perched water with inflow greater than 5 gpm.

14.6.1.4 SCENARIO 4: CONTAMINATION OBSERVED OR PID READING GREATER THAN 50 PPMV

Contamination is defined as PID readings greater than 50 ppmv, strong olfactory and visual oily staining, or sheen/observation of mobile fuel product. In this scenario:

- Drilling will be discontinued, borehole will be stabilized, and the Navy COR will be immediately contacted for collaboration.
- Upon discovery of oily staining or sheen/observation of mobile fuel product, the Navy will verbally notify Navy leadership and the regulatory agencies within 24 hours of discovery and before advancing the boring further for collaboration to determine the next steps.
- Soil and groundwater sampling will occur. The Navy will provide sampling results (validated or unvalidated) 45 days after shipping or 7 days after receipt, whichever comes first. The Navy agrees to provide unvalidated data if validated results are not received in the requested timeframes, with the understanding that unvalidated data presents opportunity for misuse, if publicly reported, or generates responses on non-validated results. Validated results include explanations if the respective unvalidated result is changed. The Navy will also continue to submit validated results within 30 days of receipt via EDMS.
- The Navy will provide the regulatory agencies with written confirmation of the results and a description of how drilling will proceed (e.g., with borehole abandonment or completion of the well with conductor casing) within 30 days of the discovery of the impacted soil, sent with proof of delivery.

14.7 ENVIRONMENTAL MEDIA SAMPLING

14.7.1 Surface Soil and Subsurface Soil Sampling

To evaluate the extent of PFAS in soil at the Site, surface and subsurface soil samples will be collected from specific locations at Area A and Area B. Discrete soil sampling locations at Area A will be judgmentally selected. For Area B, discrete soil samples will be taken in proximity to the existing monitoring wells. Soil boreholes will also be drilled at judgmentally selected locations. Soil samples will be collected from each borehole at several intervals (e.g., surface soil represented by 0 to 0.5 foot bgs, and discrete 3- to 6-inch interval subsurface soil samples from within the 1-foot target depth intervals of 2 to 3, 5 to 6, 11 to 12, and 17 to 18 feet bgs). However, if refusal is encountered during drilling, the deepest interval collected from the borehole will be the 1-foot target depth interval before refusal. More information on the soil sampling design is provided in Worksheet #17. The proposed soil borehole locations for both Area A and Area B can be seen on Figure 10 and Figure 11.

Proposed areas to be sampled in Area A correspond to the following site features:

- Adit 6 Asphalt Apron: subsurface sampling
- Corner Apron and former Concrete Lined Storm Water Culvert: subsurface sampling
- Area between road, culvert inlet and culvert outlet: surface/subsurface sampling
- Surge Rock Drainage Area: subsurface sampling
- Former Box Culvert Drainage Area: subsurface sampling
- Downsloping Area North of Adit 6: surface/subsurface sampling
- Bldg. 313 Pump House, Piping area and Former Slop Tank: surface/subsurface sampling
- Sloped Area between Road and Bldg. 313: surface/subsurface sampling
- Lower Drainage Swale: surface soil/sediment sampling
- Downslope of Road: surface soil/sediment sampling

In Area B, surface and subsurface soil sampling are proposed to be conducted around the following existing groundwater monitoring wells:

- RHP01
- RHP02
- RHP03
- RHP06
- RHP08

Soil sampling will also be conducted along Icarus way to the northern boundary of the RHBFSF and along the southern boundary of the RHBFSF. Additional surface and subsurface soil sampling are proposed to be conducted at the western extent of the RHBFSF located west of the Area B boundary. Soil sampling locations can be seen on Figure 11.

Soil sampling will be conducted in accordance with Procedure I-B-1, *Soil Sampling* (DON 2015) and in accordance with the general PFAS sampling guidance (Appendix B). Soil sampling will be conducted using stainless-steel or non-PFAS-containing disposable hand trowels to acquire a grab sample of surface soil and subsurface soil from the target depth intervals.

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 sampling log along with other pertinent information as outlined in Procedure I-E, *Soil and Rock Classification* (DON 2015). Collected soil samples will be transferred directly into laboratory-supplied, pre-cleaned, high-density polyethylene (HDPE) containers that will then be sealed, labeled, and placed in an insulated cooler with ice, pending shipment to the designated analytical laboratory.

14.7.2 Sediment Sampling

Sediment grab samples will be collected from the material found in the concrete drainage swale located south and southeast of Bldg. 313 in Area A. Sampling locations will be judgmentally chosen based on thickness of sediment accumulation. Swale drainage sediment sampling will be conducted in accordance with Procedure I-B-1, *Soil Sampling* (DON 2015) and in accordance with the general PFAS sampling guidance (Appendix B). Sediment sampling will be conducted using stainless-steel or non PFAS-containing disposable hand trowels/scoops to acquire a grab sample of sediment from the drainage swale.

14.7.3 Groundwater Sampling

Groundwater samples representing water within the saturated zone will be collected from the following monitoring wells in Area A:

- RHMW06
- RHMW17 (basal) and RHMW17S (perched)
- Two proposed perched monitoring wells (if encountered)
- Two proposed basal monitoring wells

Additionally, the following monitoring wells or sampling points within RHBFSF Area B, will also be sampled during this investigation:

- RHMW2254-01
- RHP01
- RHP02
- RHP03
- RHP06
- RHP07
- RHP08
- OWDFMW03A
- OWDFMW03B
- OWDFMW08A
- OWDFMW08B
- Three proposed perched monitoring wells (if encountered)
- Three proposed basal monitoring wells

Proposed groundwater monitoring well installation locations can be seen on Figure 11. Groundwater monitoring wells will be sampled in accordance with Procedure I-C-3, *Monitoring Well Sampling* (DON 2015) and in accordance with the general PFAS sampling guidance (Appendix B). The wells will be gauged with a Teflon-free interface probe to measure the depth to groundwater and depth to the bottom of each well.

Use of a sampling pump (PFAS-free design) and the low-flow (micro-purge) sampling technique is the preferred sampling method for groundwater monitoring wells. Bailing may be used for groundwater sampling of monitoring wells if pumping proves to be impractical; however, bailing will still require that sufficient purging be performed to achieve stabilization of the water quality parameters. If bailing is the method of groundwater sampling, then PFAS-free bailers will be used. Field filtration of all groundwater samples will be avoided.

Prior to sampling, all monitoring wells will be purged and the groundwater quality parameters of temperature, pH, conductivity, DO, ORP, and turbidity will be monitored during purging with a minimum of five sequential readings. Parameters should stabilize as follows:

- pH stabilizes to within ± 0.1 pH units for three successive readings.
- Temperature stabilizes to within ± 1 degree Celsius.
- Conductivity stabilizes to within ± 3 percent.
- Oxidation reduction potential stabilizes to within ± 10 millivolts.
- Dissolved oxygen (DO) concentration stabilizes to within ± 0.3 mg/L.
- Groundwater is clear to the unaided eye in areas where the local groundwater is known to be clear and the turbidity readings are below 10 NTUs.
- Turbidity stabilizes to within ± 10 percent at readings higher than 10 NTUs in areas of known turbid groundwater.

Once these parameters have stabilized as listed above, and in accordance with Procedure I-C-3, representative groundwater samples will be collected into laboratory-supplied HDPE containers using the submersible bladder pump at low flow rates of less than 0.3 liter per minute or using a Teflon-free bailer. The water quality meter will be calibrated daily in the field using factory prepared standards and following manufacturer instructions. Calibration records will be recorded in the field logbook. A representative groundwater sample will be collected from each well sampled.

14.8 EQUIPMENT DECONTAMINATION AND OTHER QUALITY CONTROL PROCEDURES

Decontamination of non-disposable equipment will be conducted between each soil sampling location. The decontamination procedure will generally consist of the following steps:

- Disassemble non-disposable equipment, if possible.
- Wash with a non-phosphate detergent (Alconox, Liquinox, or other non PFAS-containing suitable detergent), potable water solution, and a PFAS-free plastic brush.
- Rinse in a bath with potable water.
- Spray with laboratory-grade isopropyl alcohol.
- Triple rinse in a bath with deionized or distilled water, provided and certified PFAS-free by the laboratory.
- Spray with deionized or distilled water, provided and certified PFAS-free by the laboratory.

14.9 PER- AND POLYFLUOROALKYL SUBSTANCES SAMPLING PROCEDURES

To the extent practicable, field personnel will take the following additional measures during the sampling process to avoid sample cross contamination during sample collection:

- Will not use Post-It Notes or waterproof field notebooks/pens at any time during sample handling or mobilization/demobilization.
- Will wear only old, well-laundered (with at least six washings since purchase) clothing.
- Will not wear water-resistant clothing prior to or during sample collection.
- Will not wear Coated Tyvek suits during sample handling.
- Will wear powder-free nitrile gloves at all times while collecting and handling samples.
- Will thoroughly wash hands after handling fast food, carryout food, or snacks.
- Will not be in possession of pre-wrapped food or snacks during sampling.
- Will not use blue ice to cool samples or be used in sample coolers.
- Will not use products containing Teflon during sample handling or mobilization, and demobilization. This includes tubing and sample container lids.
- Will only use PFAS-free unlined sample containers.
- Will use PFAS-free, laboratory-certified water for field and equipment blanks, or alternatively tested source water.

14.10 SAMPLE LABELING, HANDLING, AND SHIPPING

All environmental samples (soil, surface water, spring water, and groundwater) will be collected into laboratory-supplied, pre-cleaned containers that will then be sealed and labeled according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody Procedures* (DON 2015). See Worksheet #27 for sample identification (ID) information.

Once appropriately labeled, the samples will be placed in insulated 72-hour coolers with wet ice, pending shipment to the designated analytical laboratory. The samples will be maintained in a chilled state on ice or in a sample refrigerator until ready for shipping to the laboratory.

When it is time for shipping to the laboratory, the samples will be carefully packaged into 72-hour coolers with sufficient padding and wet ice for the transit to the continental United States. Samples will be documented on chain-of-custody (COC) forms in accordance with Procedure III-F, *Sample Handling, Storage and Shipping* (DON 2015). The samples will be shipped by express carrier to the laboratory where they will be inspected (arrival temperature, sample count, labeling, and physical conditioning assessment), logged, and processed for analysis in accordance with laboratory SOPs. Sample shipping and COC documentation will be maintained in the project folder and used for sample tracking.

14.11 INVESTIGATION-DERIVED WASTE MANAGEMENT AND DISPOSAL

The following types of IDW are anticipated to be generated during the RI:

- Drill cuttings brought to the surface by drilling.
- Purge and development water from groundwater sampling activities as well as well installation activities.

- Fluids generated during decontamination of non-consumable downhole equipment (e.g., sampling equipment, drilling equipment).
- Miscellaneous IDW anticipated to be composed of spent disposable personal protective equipment (PPE) and groundwater sampling tubing.

Drill cuttings, equipment decontamination fluids, and purge water will be contained in the appropriate receptacle. IDW containers that could be used include 55-gallon drums, 20-cubic yard roll-off bins and 500- to 1,000-gallon poly tanks or 20,000-gallon frac tanks. IDW will be disposed of, as appropriate, based on analytical results as specified in Procedure I-A-6, *IDW Management* (DON 2015). Disposable PPE and sampling equipment that is not contaminated will be collected in plastic trash bags and disposed of as municipal solid waste offsite. Any visibly impacted or contaminated items will be segregated for characterization and proper disposal.

Unless otherwise indicated, IDW will be marshaled from the sampling locations to the Navy-approved waste accumulation point staging areas at RHBFSF for temporary storage. IDW drums will be placed on wooden pallets (solid IDW) or spill containment pallets (liquid IDW) and covered with tarps for protection from the weather. All IDW will be managed in accordance with Procedure I-A-6, *IDW Management* (DON 2015).

IDW will be disposed of within a reasonable time after completing the field activities. Liquid IDW containing PFOS or PFOA individually, or in combination at concentrations exceeding the EPA lifetime health advisory level, or PFOS, PFOA, PFBS, PFBA, PFHxA, PFHxS, PFNA, and HFPO-DA exceeding EPA's RSLs will require treatment or offsite disposal. The disposal options for IDW will be in accordance with the Assistant Secretary of Defense Memorandum *Guidance on Destruction or Disposal of Materials Containing Per- and Polyfluoroalkyl Substances in the United States* (EPA 2024a).

The IDW inventory and analytical data obtained during the investigation will be evaluated to select appropriate disposal methods and to verify compliance with the DoD and Navy PFAS disposal policy. The evaluation will include review of Resource Conservation and Recovery Act and Toxic Substances Control Act regulations, and discussions with facilities authorized to receive CERCLA wastes.

14.12 DATA EVALUATION (TIER 1)

The analytical results will be evaluated in comparison with the project screening levels (PSLs). For this RI, EPA residential soil and tap water RSLs have been identified for soil and groundwater, respectively (EPA 2023), as well as the Navy Emerging Chemicals Workgroup Issue Paper-recommended ecological screening values (DON 2024b). If screening criteria become available for other PFAS, they will be incorporated into the data screening. For this RI, tap water RSLs will apply to all groundwater samples. Residential soil RSLs and ecological screening values will apply to surface soil and swale drainage sediment samples. Subsurface soil will apply to residential soil RSLs. The PSLs are summarized on the following tables:

- *Table 15-1:* Project Screening Levels and Laboratory-Specific Limits for Surface Soil and Sediment
- *Table 15-2:* Project Screening Levels and Laboratory-Specific Limits for Subsurface Soil
- *Table 15-3:* Project Screening Levels and Laboratory-specific Limits for Groundwater Evaluation

14.13 DATA GENERATION

Data generated during this investigation will include the following:

- Laboratory analytical results for 40 PFAS in soil, swale drainage sediment, and groundwater. The selected laboratory is currently DoD ELAP accredited for all preparation and analytical methods associated with analysis of the RI analyses identified in this WP.
- Physical characteristics of soils and rock cores recorded on borehole 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.
- Geologic logs with lithologic descriptions, PID screening results and other observations taken in accordance with Procedure I-E, *Soil and Rock Classification* (DON 2015).
- Monitoring well construction logs.
- Borehole video logging data from basal aquifer wells prior to casing operations.
- Survey data consisting of land coordinates for sample locations provided by a licensed land surveyor, including northing and easting coordinates and ground surface and wellhead elevations.
- Gyroscopic survey data (true vertical depth) for all newly installed monitoring wells.
- Data recorded on monitoring well development and groundwater sampling logs, that will include groundwater quality parameters data (temperature, conductivity, turbidity, ORP, and DO) and static water level.

The selected laboratory will maintain current DoD ELAP, accredited through the duration of the project for all preparation and analytical methods associated with analysis of the PFAS identified in this document.

14.13.1 Data Management Tasks

All analytical data, field notes, data sheets, and other data necessary to support the project will be maintained in an AECOM Technical Services, Inc. (AECOM) electronic database. 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.

14.13.1.1 DOCUMENTATION AND RECORDS

All field observations and measurements will be recorded in a field notebook and project-specific field data sheets. GPS locations and/or survey coordinates will be recorded for all sample locations. COC forms, air bills, and sample logs will be prepared and retained for each sample. See Worksheet #21 for a list of documentation SOPs. All data will be included in the investigation report.

14.13.1.2 FIELD AND LABORATORY DATA DOCUMENT AND RECORDS GENERATION

Sample collection documents and records will be produced by the project sampling team during field activities. Analytical data reports will be delivered on Contract Laboratory Program-like forms, along with case narrative, table of contents, and raw data. Data assessment documents and records will be produced by the data validators and will include validated data, validation reports, and a data quality analysis report. Validation data will consist of Contract Laboratory Program-like forms with associated

qualifiers and qualification codes. Validation reports will include a case narrative describing discrepancies or anomalies in both the data and the validated data.

Other project assessment documents consisting of any field audit reports and/or corrective action forms will be generated as detailed in Worksheets #31 through #33. The RI report will contain all field and laboratory documentation and records generated during the investigation, in addition to recommendations and conclusions.

The analytical laboratory will verify, reduce, and report data as specified in their DoD ELAP-evaluated laboratory quality assurance (QA) plan. Reported data will be provided as electronic data deliverables. The laboratory deliverables will be consistent with Appendix A of the *DoD DOE Consolidated QSM for Environmental Laboratories*, Version 6.0 (DoD and DOE 2023).

The laboratory will submit reports and EDDs directly input into the Red Hill Environmental Data Management System (EDMS). The data will be parsed through internal verification and validation checks. Internal verification and validation checks are performed to identify data entries that exceed the specific QC criteria. If QC criteria are not met or if errors are identified due to an incorrect or incomplete laboratory submittal, the data package will be returned to the laboratory for correction and resubmittal.

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 appropriate QA/QC level will be evaluated. Analytical data will be submitted to the EDMS by the laboratory and will be available for the data validation firm by download.

Copies of all analytical data packages will be printed and archived in the administrative record at the designated Iron Mountain facility at the close of the project. Laboratory data record retention will be 5 years consistent with the DoD Quality Systems Manual (QSM) (DoD and DOE 2023).

14.13.1.3 DATA MANAGEMENT

All analytical data, field notes, data sheets, and other data necessary to support the project will be maintained in an AECOM electronic database. 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.

All documents produced for the project will be kept in a secured facility for the life of the project. Upon closure of the project, laboratory documents will be archived with the project report in the administrative record on file at NAVFAC Hawaii. Hard copies of the analytical data will be archived at NAVFAC Hawaii's direction.

14.13.2 Quality Control Tasks

Standard operating procedures and the PFAS sampling guidance in Appendix B will be strictly adhered to during sample collection, packaging, and shipping tasks. The QC samples will be analyzed for the same analytical groups as the primary samples. The QC requirements in the DoD QSM will also be followed, specifically the requirements concerning PFAS using liquid chromatography tandem mass spectrometry with isotope dilution or internal standard quantitation in media other than drinking water (DoD and DOE 2023; EPA 2024b; DoD 2024b).

14.13.2.1 ASSESSMENT/AUDIT TASKS

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

14.13.3 Data Reporting

The analytical laboratory will verify, reduce, and report data as specified in their DoD ELAP-evaluated laboratory QA plan. Reported data will be provided as hard copy and electronic data deliverables (EDDs). The laboratory deliverables will be consistent with Appendix A 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).

The laboratory will submit reports and EDDs directly input into the Red Hill Environmental Data Management System (EDMS) following required specifications. The database will be parsed through internal verification and validation checks. Internal verification and validation checks are performed to identify data entries that exceed the specified QC criteria. If QC criteria are not met or if errors are identified due to an incorrect or incomplete laboratory submittal, the data package will be returned to the laboratory for correction and resubmittal.

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.

14.13.4 Data Validation

All analytical laboratory data results will be validated by a third-party data validation firm. Third-party data validation will consist of standard, Stage 2B validation (90 percent) and full, Stage 4 validation (10 percent). The first 10 percent of project field data (PFAS) generated by the laboratory will be validated at full validation to establish a baseline, ensuring the laboratory has complied with the requirements outlined in both the analytical methods and the DoD QSM Version 6.0 (DoD and DOE 2023; DoD 2024b), and in accordance with flagging conventions outlined in the DoD *General Data Validation Guidelines* (DoD 2019a) and *Data Validation Guidelines Module 6: Data Validation Procedure for Per- and Polyfluoroalkyl Substances Analysis* by current QSM Table B-24 (DoD 2022).

The project chemist will review the analytical data before it is validated to address time-critical issues such as re-extraction, matrix interference, and holding times. The findings of the validation will be submitted to EDMS in a Data Validation Report, and the analytical results and qualifiers will be updated accordingly in the database. The project chemist will review the validated analytical data to ensure proper reporting and database entry prior to releasing the data for general users.

Worksheet #15: Reference Limits and Evaluation Tables

This worksheet presents a detailed list of PFAS and corresponding screening levels for surface soil, subsurface soil, sediment, and groundwater. The collected samples will be sent to and analyzed by a DoD ELAP-accredited laboratory, 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) and in accordance with DoD Memorandum, *Establishing a Consistent Methodology for the Analysis of Per- and Polyfluoroalkyl Substances in Matrices Other than Drinking Water* (DoD 2023e) and follow on *DoD Environmental Data Quality Workgroup Memorandum, EPA Method 1633 Clarification Update, February 29, 2024* (DoD 2024a). An explanation of the PSLs chosen and the analyte lists are presented below.

Soil and groundwater screening levels are identified in the Assistant Secretary of Defense Memorandum, *Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program* (DoD 2023c) and subsequent online updates (DoD 2023c). Additionally, surface soil and swale sediment screening levels were developed to relevant ecological screening values (DON 2024b). Soil and groundwater PSLs are identified as:

- EPA residential soil and tap water RSLs, respectively (EPA 2023). The selected RSLs are derived using a THQ of 0.1 and a target cancer risk of 1E-06 (EPA 2023).
- Navy Emerging Chemicals Workgroup Issue Paper recommended ecological screening values (DON 2024b).

It is noted that the November 2023 RSL update (DoD 2024c) contained four additional PFAS (perfluoroundecanoic acid, perfluorododecanoic acid, perfluorotetradecanoic acid, and perfluorooctadecanoic acid) not identified in the August 2023 Defense Memorandum (DoD 2023b). Three of these PFAS are included as target analytes in the EPA Method 1633. The RSLs are listed for these PFAS to generate limit of detection goals for these PFAS, but not yet used as PSLs. Similarly, the DOH has developed PFAS screening levels for some PFAS listed in Worksheet #15 (DOH 2023). The DOH Interim Soil and Water EALs for PFAS (Table A-2 soil action levels [potentially affected groundwater is a current or potential drinking water resource; surface water body is located within 150 meters of release site]) were used to establish project limit of detection and LOQ goals, but the DOH EALs are not used as PSLs at this time. Additionally, EPA Method 1633 includes some PFAS without currently available screening levels. These will be reported, and sensitivity of detection limit and LOQ for these analytes will be comparable to estimates listed in the test method.

Based on limitations of the analytical instrumentation, the standard method quantitation limit may exceed the screening criteria for some PFAS. In such cases, analytes not detected in samples would be treated as a non-detect exceedance. The usability of non-detect data of analytes with laboratory reporting limits above the PSLs will be evaluated in a data quality assessment report and the risk assessment sections of the RI report. PFAS without currently available screening values will be used to update the CSM. These analytes will not be further evaluated, and uncertainty associated with PFAS without screening criteria will be discussed in the risk assessment sections of the RI report. Any further site-specific evaluation conducted during the RI Phase will be consistent and in accordance with the Assistant Secretary of Defense Memorandum: *Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program* (DoD 2023c) and *PFAS 101 Regional Screening Levels Used in DoD Cleanups* (DoD 2024c). The evaluation of state standards will be performed during the feasibility study phase, consistent with CERCLA.

The PSLs for selected PFAS are provided in Table 15-1 to Table 15-3 for soil, sediment, and groundwater, respectively. Of the 40 PFAS analytes presented, only some have EPA RSLs available for use as screening levels accepted by all stakeholders.

Table 15-1: Project Screening Levels and Laboratory-Specific Limits for Surface Soil and Sediment

Matrix: Solid – Surface Soil and Swale Sediment

Analytical Group: PFAS

Analyte	Abbreviation	CAS No.	EPA RSL ^a	Eco SL	DOH EALs ^b	PSL	PSL Reference	Project LOQ Goal	Project LOD Goal	Lab-Specific Limits		
										LOQ	LOD	DL
Perfluorobutanoic acid	PFBA	375-22-4	7800	2980	190	7800	EPA RSL	62	19	TBD	TBD	TBD
Perfluoropentanoic acid	PFPeA	2706-90-3	—	—	5.9	—	—	1.9	0.6	TBD	TBD	TBD
Perfluorohexanoic acid	PFHxA	307-24-4	3200	6200	0.93	3200	EPA RSL	2.1	0.6	TBD	TBD	TBD
Perfluoroheptanoic acid	PFHpA	375-85-9	—	1000	0.55	—	—	0.2	0.1	TBD	TBD	TBD
Perfluorooctanoic acid	PFOA	335-67-1	19	3840	0.12	19	EPA RSL	0.12	0.03	TBD	TBD	TBD
Perfluorononanoic acid	PFNA	375-95-1	19	24.2	1.8	19	EPA RSL	0.7	0.2	TBD	TBD	TBD
Perfluorodecanoic acid	PFDA	335-76-2	—	67.7	0.92	—	—	0.31	0.09	TBD	TBD	TBD
Perfluoroundecanoic acid	PFUnA	2058-94-8	— ^c	—	8.6	— ^c	—	2.8	0.9	TBD	TBD	TBD
Perfluorododecanoic acid	PFDoA	307-55-1	— ^c	—	85	— ^c	—	14	4	TBD	TBD	TBD
Perfluorotridecanoic acid	PFTrDA	72629-94-8	—	—	85	—	—	14	4	TBD	TBD	TBD
Perfluorotetradecanoic acid	PFTeDA	376-06-7	— ^c	—	850	— ^c	—	139	42	TBD	TBD	TBD
Perfluorobutanesulfonic acid	PFBS	375-73-5	1900	817	10	1900	EPA RSL	2.9	0.9	TBD	TBD	TBD
Perfluoropentanesulfonic acid	PFPeS	2706-91-4	—	—	110	—	—	—	—	TBD	TBD	TBD
Perfluorohexanesulfonic acid	PFHxS	355-46-4	130	2.8	25	130	EPA RSL	2.4	0.7	TBD	TBD	TBD
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	—	—	7.9	—	—	2.6	0.8	TBD	TBD	TBD
Perfluorooctanesulfonic acid	PFOS	1763-23-1	13	8.7	0.75	13	EPA RSL	0.5	0.1	TBD	TBD	TBD
Perfluorononanesulfonic acid	PFNS	68259-12-1	—	—	—	—	—	—	—	TBD	TBD	TBD
Perfluorodecanesulfonic acid	PFDS	335-77-3	—	—	25	—	—	8	3	TBD	TBD	TBD
Perfluorododecanesulfonic acid	PFDoS	79780-39-5	—	—	—	—	—	—	—	TBD	TBD	TBD
4:2 Fluorotelomer sulfonic acid	4:2 FTS	757124-72-4	—	—	—	—	—	—	—	TBD	TBD	TBD
6:2 Fluorotelomer sulfonic acid	6:2 FTS	27619-97-2	—	—	240	—	—	78	24	TBD	TBD	TBD
8:2 Fluorotelomer sulfonic acid	8:2 FTS	39108-34-4	—	—	—	—	—	—	—	TBD	TBD	TBD
N-methyl perfluorooctanesulfonamide	NMeFOSA	31506-32-8	—	—	—	—	—	—	—	TBD	TBD	TBD
N-ethyl perfluorooctanesulfonamide	NEtFOSA	4151-50-2	—	—	—	—	—	—	—	TBD	TBD	TBD
Perfluorooctanesulfonamide	PFOSA	754-91-6	—	—	150	—	—	25	8	TBD	TBD	TBD
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	2355-31-9	—	—	—	—	—	—	—	TBD	TBD	TBD
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	2991-50-6	—	—	—	—	—	—	—	TBD	TBD	TBD
N-methyl perfluorooctanesulfonamidoethanol	NMeFOSE	24448-09-7	—	—	—	—	—	—	—	TBD	TBD	TBD
N-ethyl perfluorooctanesulfonamidoethanol	NEtFOSE	1691-99-2	—	—	—	—	—	—	—	TBD	TBD	TBD

Title: Draft RI WP

Site/Project Name: PFAS Release, RHBFSF

Site Location: JBPHH Oahu HI

Revision Number: 00

Revision Date: June 2024

Matrix: Solid – Surface Soil and Swale Sediment

Analytical Group: PFAS

Analyte	Abbreviation	CAS No.	EPA RSL ^a	Eco SL	DOH EALs ^b	PSL	PSL Reference	Project LOQ Goal	Project LOD Goal	Lab-Specific Limits		
										LOQ	LOD	DL
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	23	—	0.02	23	EPA RSL	0.01	0.002	TBD	TBD	TBD
4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	—	—	190	—	—	61	19	TBD	TBD	TBD
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9CI-PF3ONS	756426-58-1	—	—	—	—	—	—	—	TBD	TBD	TBD
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11CI-PF3OUdS	763051-92-9	—	—	—	—	—	—	—	TBD	TBD	TBD
3-Perfluoropropyl propanoic acid	3:3 FTCA	356-02-5	—	—	—	—	—	—	—	TBD	TBD	TBD
2H,2H,3H,3H-Perfluorooctanoic acid	5:3 FTCA	914637-49-3	—	—	—	—	—	—	—	TBD	TBD	TBD
3-Perfluoroheptyl propanoic acid	7:3 FTCA	812-70-4	—	—	—	—	—	—	—	TBD	TBD	TBD
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7	—	—	—	—	—	—	—	TBD	TBD	TBD
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5	—	—	—	—	—	—	—	TBD	TBD	TBD
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1	—	—	—	—	—	—	—	TBD	TBD	TBD
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6	—	—	—	—	—	—	—	TBD	TBD	TBD

Note: Units are in µg/kg; PFAS will be reported in the neutral form.

— not available

µg/kg microgram per kilogram

CAS Chemical Abstracts Service

DL detection limit

EPA Environmental Protection Agency, United States

LOD limit of detection

PSL project screening level

RSL regional screening level

SL screening level

TBD to be determined

^a PSLs derived from EPA RSL for protection of groundwater using a THQ of 0.1 and a target cancer risk of 1E-06— November 2023 (DoD 2024c).

^b DOH Interim Soil and Water EALs for PFAS (Table A-1 soil action levels soil action levels [potentially affected groundwater IS a current or potential drinking water resource; surface water body IS located within 150 meters of release site]) (DOH 2024).

^c The November 2023 EPA RSL for this analyte is not yet approved for use within the DoD cleanup program.

Table 15-2: Project Screening Levels and Laboratory-Specific Limits for Subsurface Soil

Matrix: Subsurface Soil

Analytical Group: PFAS

Analyte	Abbreviation	CAS No.	EPA RSL ^a	DOH EALs ^b	PSL	PSL Reference	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits		
									LOQ	LOD	DL
Perfluorobutanoic acid	PFBA	375-22-4	7800	189	7800	EPA RSL	62	19	TBD	TBD	TBD
Perfluoropentanoic acid	PFPeA	2706-90-3	—	5.9	—	—	1.9	0.6	TBD	TBD	TBD
Perfluorohexanoic acid	PFHxA	307-24-4	3200	6.4	3200	EPA RSL	2.1	0.6	TBD	TBD	TBD
Perfluoroheptanoic acid	PFHpA	375-85-9	—	0.5	—	—	0.2	0.1	TBD	TBD	TBD
Perfluorooctanoic acid	PFOA	335-67-1	19	0.35	19	EPA RSL	0.12	0.03	TBD	TBD	TBD
Perfluorononanoic acid	PFNA	375-95-1	19	2.0	19	EPA RSL	0.7	0.2	TBD	TBD	TBD
Perfluorodecanoic acid	PFDA	335-76-2	—	0.92	—	—	0.31	0.09	TBD	TBD	TBD
Perfluoroundecanoic acid	PFUnA	2058-94-8	— ^c	8.6	— ^c	—	2.8	0.9	TBD	TBD	TBD
Perfluorododecanoic acid	PFDoA	307-55-1	— ^c	42	— ^c	—	14	4	TBD	TBD	TBD
Perfluorotridecanoic acid	PFTTrDA	72629-94-8	—	42	—	—	14	4	TBD	TBD	TBD
Perfluorotetradecanoic acid	PFTeDA	376-06-7	— ^c	421	— ^c	—	139	42	TBD	TBD	TBD
Perfluorobutanesulfonic acid	PFBS	375-73-5	1900	8.7	1900	EPA RSL	2.9	0.9	TBD	TBD	TBD
Perfluoropentanesulfonic acid	PFPeS	2706-91-4	—	—	—	—	—	—	TBD	TBD	TBD
Perfluorohexanesulfonic acid	PFHxS	355-46-4	130	7.2	130	EPA RSL	2.4	0.7	TBD	TBD	TBD
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	—	7.9	—	—	2.6	0.8	TBD	TBD	TBD
Perfluorooctanesulfonic acid	PFOS	1763-23-1	13	1.4	13	EPA RSL	0.5	0.1	TBD	TBD	TBD
Perfluorononanesulfonic acid	PFNS	68259-12-1	—	—	—	—	—	—	TBD	TBD	TBD
Perfluorodecanesulfonic acid	PFDS	335-77-3	—	25	—	—	8	3	TBD	TBD	TBD
Perfluorododecanesulfonic acid	PFDoS	79780-39-5	—	—	—	—	—	—	TBD	TBD	TBD
4:2 Fluorotelomer sulfonic acid	4:2 FTS	757124-72-4	—	—	—	—	—	—	TBD	TBD	TBD
6:2 Fluorotelomer sulfonic acid	6:2 FTS	27619-97-2	—	236	—	—	78	24	TBD	TBD	TBD
8:2 Fluorotelomer sulfonic acid	8:2 FTS	39108-34-4	—	—	—	—	—	—	TBD	TBD	TBD
N-methyl perfluorooctanesulfonamide	NMeFOSA	31506-32-8	—	—	—	—	—	—	TBD	TBD	TBD
N-ethyl perfluorooctanesulfonamide	NEtFOSA	4151-50-2	—	—	—	—	—	—	TBD	TBD	TBD
Perfluorooctanesulfonamide	PFOSA	754-91-6	—	76	—	—	25	8	TBD	TBD	TBD
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	2355-31-9	—	—	—	—	—	—	TBD	TBD	TBD
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	2991-50-6	—	—	—	—	—	—	TBD	TBD	TBD
N-methyl perfluorooctanesulfonamidoethanol	NMeFOSE	24448-09-7	—	—	—	—	—	—	TBD	TBD	TBD
N-ethyl perfluorooctanesulfonamidoethanol	NEtFOSE	1691-99-2	—	—	—	—	—	—	TBD	TBD	TBD

Title: Draft RI WP

Site/Project Name: PFAS Release, RHBFSF

Site Location: JBPHH Oahu HI

Revision Number: 00

Revision Date: June 2024

Matrix: Subsurface Soil

Analytical Group: PFAS

Analyte	Abbreviation	CAS No.	EPA RSL ^a	DOH EALs ^b	PSL	PSL Reference	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits		
									LOQ	LOD	DL
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	23	0.02	23	EPA RSL	0.01	0.002	TBD	TBD	TBD
4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	—	185	—	—	61	19	TBD	TBD	TBD
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9CI-PF3ONS	756426-58-1	—	—	—	—	—	—	TBD	TBD	TBD
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11CI-PF3OUdS	763051-92-9	—	—	—	—	—	—	TBD	TBD	TBD
3-Perfluoropropyl propanoic acid	3:3 FTCA	356-02-5	—	—	—	—	—	—	TBD	TBD	TBD
2H,2H,3H,3H-Perfluorooctanoic acid	5:3 FTCA	914637-49-3	—	—	—	—	—	—	TBD	TBD	TBD
3-Perfluoroheptyl propanoic acid	7:3 FTCA	812-70-4	—	—	—	—	—	—	TBD	TBD	TBD
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7	—	—	—	—	—	—	TBD	TBD	TBD
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5	—	—	—	—	—	—	TBD	TBD	TBD
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1	—	—	—	—	—	—	TBD	TBD	TBD
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6	—	—	—	—	—	—	TBD	TBD	TBD

Note: Units are in µg/kg; PFAS will be reported in the neutral form.

— not available

µg/kg microgram per kilogram

CAS Chemical Abstracts Service

DL detection limit

EPA Environmental Protection Agency, United States

LOD limit of detection

PSL project screening level

RSL regional screening level

SL screening level

TBD to be determined

^a PSLs derived from EPA RSLs using a THQ of 0.1 and a target cancer risk of 1E-06—November 2023 (DoD 2024c).

^b DOH Interim Soil and Water EALs for PFAS (Table A-1 soil action levels soil action levels [potentially affected groundwater IS a current or potential drinking water resource; surface water body IS located within 150 meters of release site]) (DOH 2024).

^c The November 2023 EPA RSL for this analyte is not yet approved for use within the DoD cleanup program.

Table 15-3: Project Screening Levels and Laboratory-specific Limits for Groundwater Evaluation

Matrix: Water

Analytical Group: PFAS

Analyte	Abbreviation	CAS No.	EPA RSL ^a	DOH EALs ^b	PSL	PSL Reference	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits		
									LOQ	LOD	DL
Perfluorobutanoic acid	PFBA	375-22-4	1800	14615	1800	EPA RSL	594	180	TBD	TBD	TBD
Perfluoropentanoic acid	PFPeA	2706-90-3	—	1538	—	—	508	153.8	TBD	TBD	TBD
Perfluorohexanoic acid	PFHxA	307-24-4	990	1923	990	EPA RSL	327	99	TBD	TBD	TBD
Perfluoroheptanoic acid	PFHpA	375-85-9	—	77	—	—	25	7.7	TBD	TBD	TBD
Perfluorooctanoic acid	PFOA	335-67-1	6	12	6	EPA RSL	2	0.6	TBD	TBD	TBD
Perfluorononanoic acid	PFNA	375-95-1	5.9	12	5.9	EPA RSL	2	0.59	TBD	TBD	TBD
Perfluorodecanoic acid	PFDA	335-76-2	—	8	—	—	3	0.8	TBD	TBD	TBD
Perfluoroundecanoic acid	PFUnA	2058-94-8	600 ^c	19	—	—	6	1.9	TBD	TBD	TBD
Perfluorododecanoic acid	PFDoA	307-55-1	100 ^c	26	—	—	9	2.6	TBD	TBD	TBD
Perfluorotridecanoic acid	PFTTrDA	72629-94-8	—	26	—	—	9	2.6	TBD	TBD	TBD
Perfluorotetradecanoic acid	PFTeDA	376-06-7	2000 ^c	256	—	—	84	25.6	TBD	TBD	TBD
Perfluorobutanesulfonic acid	PFBS	375-73-5	600	1695	600	EPA RSL	198	60	TBD	TBD	TBD
Perfluoropentanesulfonic acid	PFPeS	2706-91-4	—	—	—	—	—	—	TBD	TBD	TBD
Perfluorohexanesulfonic acid	PFHxS	355-46-4	39	77	39	EPA RSL	13	3.9	TBD	TBD	TBD
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	—	38	—	—	13	3.8	TBD	TBD	TBD
Perfluorooctanesulfonic acid	PFOS	1763-23-1	4	7.7	4	EPA RSL	1	0.4	TBD	TBD	TBD
Perfluorononanesulfonic acid	PFNS	68259-12-1	—	—	—	—	—	—	TBD	TBD	TBD
Perfluorodecanesulfonic acid	PFDS	335-77-3	—	38	—	—	13	3.8	TBD	TBD	TBD
Perfluorododecanesulfonic acid	PFDoS	79780-39-5	—	—	—	—	—	—	TBD	TBD	TBD
1H,1H, 2H, 2H-Perfluorohexane sulfonic acid	4:2 FTS	757124-72-4	—	—	—	—	—	—	TBD	TBD	TBD
1H,1H, 2H, 2H-Perfluorooctane sulfonic acid	6:2 FTS	27619-97-2	—	1500	—	—	495	150	TBD	TBD	TBD
1H,1H, 2H, 2H-Perfluorodecane sulfonic acid	8:2 FTS	39108-34-4	—	—	—	—	—	—	TBD	TBD	TBD
N-methyl perfluorooctanesulfonamide	NMeFOSA	31506-32-8	—	—	—	—	—	—	TBD	TBD	TBD
N-ethyl perfluorooctanesulfonamide	NEtFOSA	4151-50-2	—	—	—	—	—	—	TBD	TBD	TBD
Perfluorooctanesulfonamide	PFOSA	754-91-6	—	46	—	—	15	4.6	TBD	TBD	TBD
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	2355-31-9	—	—	—	—	—	—	TBD	TBD	TBD
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	2991-50-6	—	—	—	—	—	—	TBD	TBD	TBD
N-methyl perfluorooctanesulfonamidoethanol	NMeFOSE	24448-09-7	—	—	—	—	—	—	TBD	TBD	TBD
N-ethyl perfluorooctanesulfonamidoethanol	NEtFOSE	1691-99-2	—	—	—	—	—	—	TBD	TBD	TBD

Title: Draft RI WP

Site/Project Name: PFAS Release, RHBFSF

Site Location: JBPHH Oahu HI

Revision Number: 00

Revision Date: June 2024

Matrix: Water

Analytical Group: PFAS

Analyte	Abbreviation	CAS No.	EPA RSL ^a	DOH EALs ^b	PSL	PSL Reference	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits		
									LOQ	LOD	DL
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	1.5	12	1.5	EPA RSL	0.5	0.15	TBD	TBD	TBD
4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	—	1154	—	—	381	115	TBD	TBD	TBD
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9Cl-PF3ONS	756426-58-1	—	—	—	—	—	—	TBD	TBD	TBD
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11Cl-PF3OUdS	763051-92-9	—	—	—	—	—	—	TBD	TBD	TBD
3-Perfluoropropyl propanoic acid	3:3FTCA	356-02-5	—	—	—	—	—	—	TBD	TBD	TBD
2H,2H,3H,3H-Perfluorooctanoic acid	5:3FTCA	914637-49-3	—	—	—	—	—	—	TBD	TBD	TBD
3-Perfluoroheptyl propanoic acid	7:3FTCA	812-70-4	—	—	—	—	—	—	TBD	TBD	TBD
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7	—	—	—	—	—	—	TBD	TBD	TBD
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5	—	—	—	—	—	—	TBD	TBD	TBD
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1	—	—	—	—	—	—	TBD	TBD	TBD
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6	—	—	—	—	—	—	TBD	TBD	TBD

Note: Units are in ng/L; PFAS will be reported in the neutral form.

EPA Environmental Protection Agency, United States

PSL project screening level

RSL regional screening level

SL screening level

TBD to be determined

^a EPA RSL using a THQ of 0.1 and a target cancer risk of 1E-06 – Tap Water – November 2023 (DoD 2024c).

^b DOH Interim Soil and Water EALs for PFAS (Table A-1 soil action levels soil action levels [potentially affected groundwater IS a current or potential drinking water resource; surface water body is located within 150 meters of release site]) (DOH 2024). The state screening levels are used to generate project LOQ and LOD goals.

^c The August 2023 memorandum (DoD 2023c) accounts for the PFAS included in the May 2023 EPA RSL update.

Title: Draft RI WP

Site/Project Name: PFAS Release, RHBFSF

Site Location: JBPHH Oahu HI

Revision Number: 00

Revision Date: June 2024

Worksheet #16: Project Schedule/Timeline Table

Activities	Organization	Anticipated Date of Initiation	Anticipated Date of Completion	Deliverable	Deliverable Due Date
Prepare and submit Preliminary RI WP Worksheets 10, 11, 15, 17	AECOM	28 September 2023	24 April 2024	Draft WP	24 April 2024
Prepare RTCs	AECOM	5 May 2024	7 May 2024	N/A	N/A
Prepare Draft RI WP	AECOM	5 May 2024	19 May 2024	Draft WP	19 May 2024
Prepare RTCs	AECOM	10 June 2024	13 June 2024	N/A	N/A
Prepare Draft RI WP for Regulatory Agency	AECOM	10 June 2024	21 June 2024	Draft WP	21 June 2024
Prepare RTCs	AECOM	6 August 2024	7 August 2024	N/A	N/A
Prepare Final RI WP	AECOM	6 August 2024	30 August 2024	Final WP	30 August 2024
Vegetation Clearance	AECOM	16 September 2024	25 September 2024	N/A	N/A
Geophysical Toning	AECOM	16 September 2024	20 September 2024	N/A	N/A
Field Investigation	AECOM	21 September 2024	22 June 2025	N/A	N/A
Surveying	AECOM	23 June 2025	27 June 2025	N/A	N/A
Data Evaluation	AECOM	14 February 2025	7 November 2025	N/A	N/A
Prepare and Submit In-Progress Draft RI Report	AECOM	27 September 2025	24 January 2026	Draft RI	14 January 2026
Prepare and Submit Draft RI Report for Regulatory Agency	AECOM	26 March 2026	24 May 2026	Draft RI	24 May 2026
Prepare and Submit Draft-Final RI Report	AECOM	9 July 2026	21 September 2026	Draft-Final RI	21 September 2026
Prepare and Submit Draft-Final RI Report for Regulatory Agency	AECOM	22 October 2026	20 November 2026	Draft-Final RI	20 November 2026
Prepare and Submit Final RI Report	AECOM	5 January 2027	18 February 2027	Final RI	18 February 2027

N/A not applicable
RI remedial investigation
RTC response to comments
WP Work Plan

Worksheet #17: Sampling Design and Rationale

This section describes the sampling design and rationale for the RI at the Site located on the RHBFSF, JBPHH, Oahu, Hawaii. The specific PFAS that will be assessed in soil, swale drainage sediment (Area A), and groundwater are listed in Worksheet #15.

The principal objectives of the RI are to collect additional data to refine the current CSM, and to:

- Update the CSM.
- Characterize the nature and extent of PFAS in environmental media at the Site.
- Evaluate if exposure to residual concentrations of PFAS at the Site poses unacceptable risks to human health and/or the environment by conducting a screening ecological risk assessment and human health risk assessment.

The RI will utilize current guidance found in the *Revised Interim General Guideline for PFAS Remedial Investigations*, (DON 2023o), *PFAS 101 Regional Screening Levels Used in DoD Cleanups* (DoD 2024c), and *Navy Emerging Chemicals Workgroup Issue Paper January 2024 Interim Final: Recommended Ecological Screening Values for Per- and Polyfluoroalkyl Substances Version 4* (DON 2024b).

17.1 SAMPLING DESIGN OVERVIEW

This section describes the sampling design/sampling strategies to be implemented for the Site.

The soil and swale drainage sediment sampling strategy will use a judgmental sampling approach for further identifying potential PFAS presence shown on Figure 10 for Area A and Figure 11 for Area B. Discrete soil samples will be collected using direct push technology or hand augering with split spoons. Soil sampling locations are further described in Sections 17.2.1 through 17.2.2. The sampling approach will be used to determine PFAS concentrations in soil by collecting soil at the following sample depths from borings within Area A and Area B. Boring and sample depths are described below:

- *Surface Soil Sampling Locations:* These locations will only collect surface soil samples from 0–0.5 foot bgs.
- *Surface and Subsurface Soil Sampling Locations:* Up to five depths will be sampled from these boring locations. Surface soil samples will be collected from a depth of 0–0.5 foot bgs. Subsurface soil samples will be collected at 1-foot intervals from target depths of 2–3, 5–6, 11–12, and 17–18 feet bgs. If boring refusal is met before the target depth, then soil from the greatest depth interval attained will be collected. For example, if refusal is encountered at 8 feet bgs, then four samples will be collected at 0–0.5, 2–3, 5–6, and 7–8 feet bgs. If refusal is not encountered, then the maximum subsurface sampling depth will be 18 feet bgs. The proposed 18-foot bottom sampling depth is based on drilling refusal and/or poor sample recovery experienced in Area A at depths greater than 18 feet bgs for well RHMW17. In Area B, drilling refusal and/or poor sample recovery is anticipated to occur at depths ranging from 5 feet bgs to 26 feet bgs, based on site conditions presented in historical boring logs from RHP01, RHP02, RHP03, RHP06, and RHP08.
- *Subsurface Soil Sampling Locations Collected from Beneath Fill:* Subsurface soil samples will be collected from the former excavation areas and surge rock areas from native soils that are beneath the fill and gravel. The first planned sample depth will be the first 6 inches of soil

found immediately beneath the fill or gravel material. The next targeted sample depths will be 2–3, 5–6, 11–12, and 17–18 feet bgs. Subsurface soil samples collected at the former excavation areas will only collect native soil materials beneath the fill. For example, if fill material exists to 3 feet bgs, the first sample collected is at 3–3.5 feet, and the next sample interval is 5–6 feet bgs. If refusal is encountered before the next target depth interval, the next sample will be collected from the 1-foot interval before refusal is met. For example, if drilling refusal occurs at 5 feet bgs, soil from the 4–5-foot interval will be collected.

- *Sediment Sampling Locations:* Sediment grab samples will be collected from material found in the concrete drainage swale located south and southeast of Bldg. 313. Depending on the amount of material present, up to six samples will be collected.

Primary and field duplicate samples will be collected from each site in accordance with Naval Facilities Engineering Systems Command, Pacific Environmental Restoration Program Procedure III-B, *Field QC Samples* (DON 2015). Field duplicate samples will be collected at a rate of 10 percent (a minimum of one per site) in accordance with Procedure III-B, *Field QC Samples* (DON 2015). Each field duplicate subsample will be collected vertically to the primary subsamples within the same boring.

All soil samples will be collected in accordance with Procedure I-B-1, *Soil Sampling* (DON 2015). Each soil boring will involve collecting a representative soil sample retrieved from a discrete 3- to 6-inch depth interval, within a 1-foot target interval. Each soil sample will be placed into a wide-mouth plastic (high-density polyethylene) container or equivalent in the field (Worksheet #19), sealed with Teflon-free plastic caps, and labeled (with sample number, date and time of collection, and sampling location). The sample will be placed in a cooler containing wet ice to maintain the temperature at 4 degrees Celsius \pm 2 degrees Celsius until the samples are delivered to the laboratory.

Analytical methods and respective sample volumes/masses are presented in Worksheet #19. The designated sample volumes for each analysis are designed to provide the required sample volume for each analysis and are based on method-specific requirements. The samples will be sent to and analyzed by a DoD ELAP-accredited laboratory, and the samples analysis will be performed following the baseline requirements of the *DoD Quality System Manual* (DoD and DOE 2023).

The field activities will be conducted in general accordance with the *Final Project Procedures Manual, U.S. Navy Environmental Restoration Program, NAVFAC Pacific* (DON 2015), and the project-specific accident prevention plan. Detailed description of the project tasks, procedures, and methodologies are presented in Worksheet #14.

PFAS-specific considerations for the project were developed using guidance outlined in the *Interim Per- and Polyfluoroalkyl Substances (PFAS) Site Guidance for NAVFAC Remedial Project Managers (RPMs) November 2020 Update* (DON 2020b). Worksheet #14 contains PFAS-specific sample collection requirements. Decontamination procedures, incompatible materials, and prevention of cross-contamination will be discussed in detail in Worksheet #14.

17.2 SOIL SAMPLING DESIGN AND LOCATIONS

The soil sampling approach will include soil borings with soil sampling from the surface and at multiple targeted subsurface depths, and sediment samples will be collected as grab samples (Figure 10). Discrete soil samples will be collected from several areas across Area A and judgmentally selected. Samples collected in Areas A and B are intended to characterize the nature and extent of the remaining residual presence of PFAS in the soils and sediment from the November 2022 AFFF Adit

6 release incident, and to determine if any historical releases (prior to 2022) affected soil in these areas. The areas listed in the following sections were selected for evaluation.

17.2.1 Area A

Confirmation samples collected during the removal action were collected, per lead regulatory agency (DOH) requirements, as multi-increment samples. Subsurface soils will be resampled using the sampling approach proposed in this WP. The usability of both the discrete and multi-increment data sets will be reviewed and discussed in the RI report. Additionally, the subsurface soils near the underground AFFF pipeline will be investigated further. In general, soil boring soil samples will target surface soil, collected at 0–0.5 foot bgs, and discrete 3- to 6-inch interval subsurface soil samples are planned to be collected from within the 1-foot target depth intervals (2–3, 5–6, 11–12, and 17–18 feet bgs). In locations where sampling is conducted beneath clean fill, sample intervals above the fill will not be collected. If refusal is encountered during the direct push sampling for subsurface soil, the boring location will be moved less than 2 feet within the area cleared for utilities then the samples will be attempted again; if the direct push rig is unable to advance, then the interval nearest refusal will be collected.

17.2.1.1 SUBSURFACE SOIL SAMPLING AT APRON AREA OUTSIDE ADIT 6

Three subsurface samples will be collected from the apron area outside the Adit 6 entrance (Formerly DU 3). Soil will be collected from the 0- to 0.5-foot soil interval found immediately beneath the clean fill material. Additional subsurface samples may be collected from the 1-foot target intervals described above. At this location, clean fill is assumed to extend to 2 feet bgs.

17.2.1.2 SUBSURFACE SOIL SAMPLING AT CORNER APRON

Three subsurface samples will be collected from the corner apron (Formerly DU 2) and the area where the concrete-lined storm water culvert was in place (Formerly DU 1). Discrete subsurface soil samples will be collected from the 0- to 0.5-foot interval beneath the clean fill. Discrete 3- to 6-inch interval subsurface soil samples are planned to be collected from within the 1-foot target depth intervals, before drilling refusal is encountered at these areas (Formerly DUs 1 and 2). At this location, clean fill is assumed to extend to 2 feet bgs.

Two subsurface soil samples will be collected from the area situated in-between the road (Formerly DU 5) between the storm culvert inlet (Formerly DU 1) and culvert outlet area (Formerly DU 4). Subsurface soil samples will be collected from the 0- to 0.5-foot interval beneath the clean fill. Discrete subsequent subsurface sampling at 3- to 6-inch intervals within the targeted 1-foot soil intervals is planned for the target depth intervals of 2–3, 5–6, 11–12, and 17–18 feet bgs.

17.2.1.3 SUBSURFACE SOIL SAMPLING AT AREA IN BETWEEN ROAD, BETWEEN STORM CULVERT INLET, CULVERT OUTLET AREA

If refusal is encountered during the direct push sampling for subsurface soil, then the samples will be attempted again; if the direct push rig is unable to advance, then the interval nearest refusal will be collected. If there is not a sampleable subsurface interval, then the sampling location will be abandoned and reattempted nearby. At this location, clean fill is assumed to extend to 2 feet bgs.

17.2.1.4 SURFACE AND SUBSURFACE SOIL SAMPLING AT FORMER BOX CULVERT DRAINAGE AREA

Samples collected in this area will be used to further assess the nature and extent of residual concentrations of PFAS that may have previously been released to the surface pavement or soils near Adit 6 and mobilized in surface water runoff. These samples will be used to evaluate if PFAS releases

have affected this outfall area. Seven locations will be drilled and sampled near the stormwater headwall/outfall (Formerly DU 4). At these boring locations, surface samples will be collected at 0–0.5 foot bgs, and discrete 3- to 6-inch interval subsurface soil samples are planned to be collected from within the 1-foot target depth intervals (2–3, 5–6, 11–12, and 17–18 feet bgs). Based on previous drilling in this area, refusal is anticipated to occur at a depth of 10 feet bgs; therefore, it is estimated that a 9–10 foot bgs sample interval will be the deepest interval collected from this area.

17.2.1.5 SURFACE AND SUBSURFACE SOIL SAMPLING AT THE DOWN-SLOPING AREAS NORTH OF ADIT 6

Samples collected in this area are intended to evaluate if any releases from the former AFFF AST have affected site soils. Seven borings will be drilled near the location of the former AFFF AST. Five borings will be placed around the concrete pad that held the AST. Two borings will be located down-slope and downgradient of the former AST. A surface soil sample (0–0.5 foot bgs) and discrete 3- to 6-inch subsurface soil samples are planned from within the 1-foot target depth intervals of 2–3, 5–6, 11–12, and 17–18 feet bgs. However, the anticipated depth to refusal is estimated to be 5 feet bgs in this area.

17.2.1.6 SUBSURFACE SOIL SAMPLING AT THE SURGE ROCK DRAINAGE AREA

Six boring locations are proposed to be drilled near the swale outflow in this area of Area A. These samples will be used to evaluate if stormwater runoff from the drainage swale has mobilized residual PFAS and impacted soils in this area. It is anticipated that subsurface soil samples will be collected from the 0- to 0.5-foot soil interval directly beneath the surge rock/gravel. At this location, clean fill is assumed to extend to 2 feet bgs. If refusal is not met during subsurface sampling, discrete 3- to 6-inch soil samples will be collected from within the 1-foot soil target depth intervals of 2–3, 5–6, 11–12, and 17–18 feet bgs. The anticipated depth for refusal during drilling in this area is approximately 5 feet bgs.

17.2.1.7 SURFACE AND SUBSURFACE SOIL SAMPLING AT BLDG. 313 PUMP HOUSE, PIPING AREA, AND FORMER SLOP TANK

Twelve borings are proposed to be positioned around and outside of the concrete footprint of Bldg. 313. Samples from these borings are intended to evaluate if Bldg. 313 or former slop tank activities have potentially impacted site soils from releases of AFFF. A surface soil sample (0–0.5 foot bgs) or shallow soil sample will be collected beneath the asphalt from the upper 0.5 foot of native soil, and discrete 3- to 6-inch subsurface soil samples will be collected from within the target 1-foot intervals from the target depths of 2–3, 5–6, 11–12, and 17–18 feet bgs. If refusal is encountered during subsurface soil sampling, then the 1-foot soil interval before refusal will be collected as the last subsurface soil sample interval.

17.2.1.8 SURFACE AND SUBSURFACE SOIL SAMPLING AT SLOPED AREA BETWEEN ROAD AND BLDG. 313

Two boring for subsurface soil sampling are also proposed from the sloped area situated between the road and Bldg. 313. This is the area where underground piping for AFFF from the fire suppression system ran and was being excavated, and a new pipeline was in progress of being installed during the site reconnaissance visit. Subsurface samples will be collected from the 0.5-foot interval beneath the existing fill material. Discrete 3- to 6-inch subsurface soil sampling within 1-foot depth intervals is planned for the target intervals of 2–3, 5–6, 11–12, and 17–18 feet bgs. If refusal is encountered during subsurface soil sampling, then the 1-foot soil interval before refusal will be collected as the last subsurface soil sample interval.

17.2.1.9 *SEDIMENT AND SURFACE SOIL SAMPLING AT THE LOWER DRAINAGE SWALE*

Up to three sediment grab samples will be collected from the lower drainage swale. In addition, three surface soil samples (0–0.5 foot bgs) will also be collected near the edge of the drainage swale. These samples will be used to evaluate sediments in the runoff from the drainage swale and surface soil from Bldg. 313 and surrounding upslope areas for residual concentrations of PFAS.

17.2.1.10 *SEDIMENT AND SURFACE SOIL SAMPLING AT THE DOWNSLOPE OF ROAD*

Up to two sediment grab samples will be collected from the unpaved area downslope of the road, southwest of Bldg. 313. Additionally, up to two surface soil samples (0–0.5 foot bgs) will be collected from this area. Sampling at the base of the slope will further evaluate potential for PFAS presence resulting from stormwater runoff from uphill areas, and across the road.

17.2.2 **Area B**

17.2.2.1 *SURFACE AND SUBSURFACE SOIL SAMPLING IN AREAS BETWEEN AND AROUND WELLS RHP06 AND RHP08*

Four borings are proposed for the Area B locations between and around existing monitoring wells RHP06 and RHP08. Surface and subsurface samples will be taken from this area to evaluate potential sources of PFOS exceedances in groundwater. Surface soil samples will be collected at a depth of 0–0.5 foot bgs. Discrete 3- to 6-inch subsurface soil samples will be collected from within 1-foot intervals from the target depths of 2–3, 5–6, 11–12, and 17–18 feet bgs. For soil samples taken near pre-existing monitoring wells, based on boring logs, bedrock is expected to be encountered at 16 feet bgs at RHP06. If refusal is encountered during subsurface soil sampling, then the 1-foot soil interval before refusal will be collected as the last subsurface soil sample intervals.

17.2.2.2 *SURFACE AND SUBSURFACE SOIL SAMPLING IN BETWEEN WELLS RHP01, RHP02, AND RHP03*

Six borings are proposed for the Area B locations between and around existing monitoring wells RHP01, RHP02, and RHP03. Surface and subsurface samples will be taken from this area to determine potential sources of PFOS exceedances in groundwater. Surface soil samples will be collected at a depth of 0–0.5 foot bgs. Discrete 3- to 6-inch subsurface soil samples will be collected from within 1-foot intervals from the target depths of 2–3, 5–6, 11–12, and 17–18 feet bgs. For soil samples taken near pre-existing monitoring wells, based on boring logs, bedrock is expected to be encountered at the following depths: 8 feet bgs at RHP01, 5 feet bgs at RHP02, and 5 feet bgs at RHP03. If refusal is encountered during subsurface soil sampling, then the 1-foot soil interval before refusal will be collected as the last subsurface soil sample intervals.

17.2.2.3 *SURFACE AND SUBSURFACE SOIL SAMPLING AT THE WESTERNMOST EXTENT OF THE RHBFSF*

Three borings are proposed at the westernmost extent of the RHBFSF in the OWDF. Surface and subsurface samples will be taken from this area to delineate the PFOS detections observed from wells located within Area B. Surface soil samples will be collected at a depth of 0–0.5 foot bgs. Discrete 3- to 6-inch subsurface soil samples will be collected from within 1-foot intervals from the target depths of 2–3, 5–6, 11–12, and 17–18 feet bgs. For soil samples taken near pre-existing monitoring wells, based on boring logs, bedrock is expected to be encountered at the following depths: 20 to 25 feet bgs at OWDFMW03A and OWDFMW03B and approximately 39 feet bgs at OWDFMW08A and OWDFMW08B. If refusal is encountered during subsurface soil sampling, then the 1-foot soil interval before refusal will be collected as the last subsurface soil sample intervals.

17.3 GROUNDWATER MONITORING WELL INSTALLATION

Five basal groundwater monitoring wells are proposed for installation: two in Area A and three in Area B. The approximate location of these monitoring wells is shown on Figure 11. If elevated heads that indicate perched aquifers are encountered while drilling, then a shallower monitoring well will be set in the perched zone and the basal groundwater monitoring well will be restarted and installed nearby, resulting in a monitoring well cluster for that location. Soil samples will be collected during drilling of all the proposed monitoring wells. Discrete representative soil samples will be collected at 3 to 6-inch intervals from within at 1-foot intervals from the target depths of 2–3, 5–6, 11–12, and 17–18 feet bgs, if soil is encountered.

17.3.1 Area A Groundwater Monitoring Well Installation

The purpose of the two new Area A monitoring wells is to evaluate the local groundwater gradient and PFAS concentrations in groundwater within Area A. The proposed well locations were selected to complement the locations of existing basal monitoring wells RHMW06 and RHMW17, to get a better understanding of local groundwater gradients at Area A, and to identify PFAS concentrations in groundwater. Specifically, proposed monitoring well #1 will be placed closed to the approximate location of a Former AFFF 200-gallon tank. (b) (3) (A)

the proposed location is topographically downgradient of the Former AFFF 200-gallon AST, in an area where perched water is likely to have intercepted any potential release from the AST and, if present, can be sampled by an associated perched water well.

17.3.2 Area B Groundwater Monitoring Well Installation

The three additional basal groundwater monitoring wells in Area B are intended to delineate PFOS in groundwater to the east of PFOS exceedances detected during the non-routine sampling event. It is currently unknown if the exceedances in groundwater within Area B resulted from the November 2022 AFFF Adit 6 release, a historical AFFF release, or another PFAS source. The three proposed locations are to the east of the existing plume delineation well RHP01 along Icarus Way and between proposed monitoring wells RHP08B, RHP08C, and existing multilevel well RHMW15. The proposed monitoring wells RHP08B and RHP08C are not expected to yield a representative groundwater sample for PFAS because they are proposed to be constructed with submerged screens. Multi-level monitoring well RHMW15 cannot be utilized for PFAS sampling because it utilizes sampling equipment or materials that potentially contain PFAS. The installation and development of these additional monitoring wells in Area B will aid in evaluating the extent of PFOS in groundwater across Area B.

17.4 GROUNDWATER SAMPLING DESIGN AND LOCATIONS

Once installation and development efforts are complete at the newly installed wells, two rounds of groundwater sampling will be conducted at all existing and newly installed wells within Area A and Area B, and at the westernmost extent of the RHBFSF with the sampling events being conducted to evaluate maximum seasonal variations of the rainy and dry seasons.

Two existing wells, RHMW06 and RHMW17, will be sampled within Area A. Well RHMW06 is located west of the known release area, and well RHMW17 is located northeast of Bldg. 313. Three groundwater-bearing zones will be sampled from well RHMW17: two perched zones in wells RHMW17S and RHMW17D (if sufficient water volume is found during the field investigation) and the basal groundwater zone. Basal groundwater samples will also be collected from the two proposed monitoring wells #1 and #2 (Figure 11) as well as the potential perched monitoring wells in Area A, if encountered. Groundwater sampling will be conducted at these wells once installation and development efforts are completed. The data will be used to evaluate if the November 2022 AFFF Adit 6 release or any prior historical releases have affected groundwater at Area A.

The non-routine wells located within the RHBFSF at Area B with PFOS detections above the EPA residential tap water RSL of 4 ng/L will also be sampled during this investigation (wells RHP01, RHP02, and RHP07). Additional monitoring wells located to the west (wells RHP03, RHP06, RHP08, OWDFMW03A, OWDFMW03B, OWDFMW08A, and OWDFMW08B) will also be sampled to evaluate the extent of potential PFOS presence. Well RHMW2254-01 at the RHS Pump House, will be sampled. These wells are located approximately 0.5 mile west of Area A. Basal groundwater samples will also be collected from the three Area B proposed monitoring wells #3, #4 and #5 (Figure 11) to delineate the extent of potential PFOS presence in the eastern portion of Area B. Samples of perched groundwater will be collected from OWDFMW03B and OWDFMW08B. If encountered, samples of perched groundwater will also be collected from the perched monitoring well in the well cluster. Groundwater sampling will be conducted at these wells once installation and development efforts are completed. The data will also be used to assess whether PFAS presence at Area B are related to the November 2022 AFFF Adit 6 release, historical releases prior to 2022, or other PFAS sources. The weekly and monthly groundwater PFAS monitoring data previously collected as a part of the emergency response groundwater monitoring program will also be considered and evaluated in the RI report.

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

Sampling Location/ID Number	Number of Sampling Locations	Matrix	Depth (ft bgs)	Analytical Group	Number of Primary Samples	Number of Field Duplicate Samples	Sampling SOP Reference
Area A							
Apron Area Outside Adit 6	3	Subsurface Soil ^b	2-2.5	PFAS	2	—	Procedure I-B-1, <i>Soil Sampling</i> (DON 2015)
			5-6		9	2	
			11-12				
			17-18				
Corner Apron	3	Subsurface Soil ^b	2-2.5	PFAS	2	—	
			5-6		9	2	
			11-12				
			17-18				
Area in between Road, Between Storm Culvert Inlet, Culvert Outlet Area	2	Subsurface Soil ^b	2-2.5	PFAS	2	—	
			5-6		6	1	
			11-12				
			17-18				
(Former Box Culvert Drainage Area)	7	Surface Soil	0-0.5	PFAS	7	—	
		Subsurface Soil	2-3		21	2	
			5-6				
			9-10				
Down-Sloping Areas North of Adit 6	2	Surface Soil	0-0.5	PFAS	2	1	
		Subsurface Soil	2-3		4	1	
			4-5				
Surge Rock Drainage Area	6	Subsurface Soil ^b	2-2.5	PFAS	2	1	
			4-5		6	2	
This Bldg. 313, Piping Area and Former Slop Tank	12	Surface Soil	0-0.5	PFAS	12	1	
		Subsurface Soil	2-3		48	4	
			5-6				
			11-12				
			17-18				
Sloped Area between Road and Bldg. 313	2	Surface Soil	0-0.5	PFAS	2	1	
		Subsurface Soil	2-3		8	1	
			5-6				
			11-12				
			17-18				

Title: Draft RI WP

Site/Project Name: PFAS Release, RHBFSF

Site Location: JBPHH Oahu HI

Revision Number: 00

Revision Date: June 2024

Sampling Location/ID Number	Number of Sampling Locations	Matrix	Depth (ft bgs)	Analytical Group	Number of Primary Samples	Number of Field Duplicate Samples	Sampling SOP Reference
Lower Drainage Swale	3	Surface Soil	0-0.5	PFAS	3	—	Procedure I-B-1, <i>Soil Sampling</i> (DON 2015)
	3	Sediment	0-0.5		3	1	
Downslope of Road	1	Surface Soil	0-0.5	PFAS	1	N/A	
	1	Sediment	0-0.5		1	N/A	
RHMW06, RHMW17, RHMW17D, and RHMW17S	2	Basal Groundwater	N/A	PFAS	2	N/A	Procedure I-C-3, <i>Monitoring Well Sampling</i> (DON 2015)
	2	Basal Groundwater ^c	N/A	PFAS	2	N/A	
Area A Proposed Monitoring Well Clusters 01 to Well 02 (Perched and Basal Aquifers)	2	Perched Groundwater ^{c,d}	N/A	PFAS	2	1	
	2	Basal Groundwater ^c	N/A	PFAS	2	1	
Area A Field QC Samples							
Area A Field QC Samples	Number of Sampling Locations	Matrix	Depth (ft bgs)	Analytical Group	Field Blank	Equipment Rinsate	Sampling SOP Reference
Field QC Samples Collected during Surface Soil and Sediment Sampling	N/A	Field QC	N/A	PFAS	1	1	Procedure III-B, Field QC Samples (Water, Soil) (DON 2015)
Field QC Samples Collected during Subsurface Soil Sampling					1	7	
Field QC Samples Collected during Groundwater Sampling					1	1	Procedure I-C-3, <i>Monitoring Well Sampling</i> (DON 2015)
Area B							
Between and around RHP06 and RHP08	4	Surface Soil	0-0.5	PFAS	4	—	Procedure I-B-1, <i>Soil Sampling</i> (DON 2015)
		Subsurface Soil	2-3		16	2	
			5-6				
			11-12				
			15-16				
Between RHP03, RHP02 and RHP01	6	Surface Soil	0-0.5	PFAS	6	—	
		Subsurface Soil	2-3		18	3	
			5-6				
			7-8				
Westernmost Extent of RHBFSF	3	Surface Soil	0-0.5	PFAS	3	—	Procedure I-B-1, <i>Soil Sampling</i> (DON 2015)
		Subsurface Soil	2-3		12		
			5-6				
			11-12				
			17-18				
RHP01 to RHP03, RHP06 to RHP08, and RHMW2254-01	7	Basal Groundwater ^c	N/A	PFAS	7	N/A	

Title: Draft RI WP

Site/Project Name: PFAS Release, RHBFSF

Site Location: JBPHH Oahu HI

Revision Number: 00

Revision Date: June 2024

Sampling Location/ID Number	Number of Sampling Locations	Matrix	Depth (ft bgs)	Analytical Group	Number of Primary Samples	Number of Field Duplicate Samples	Sampling SOP Reference
Area B Proposed Monitoring Well Clusters 01 to Well 03 (Perched and Basal Aquifers)	3	Basal Groundwater ^c	N/A	PFAS	3	1	Procedure I-C-3, <i>Monitoring Well Sampling</i> (DON 2015)
	3	Perched Groundwater ^{c,d}	N/A	PFAS	3	1	
Westernmost Extent of RHBFSF (Perched and Basal Aquifers)	2	Basal Groundwater ^c	N/A	PFAS	2	1	
	2	Perched Groundwater ^{c,d}	N/A	PFAS	2	1	
Area B Field QC Samples							
Field QC Samples Collected during Surface Soil Sampling	1	Field QC	—	PFAS	1	1	Procedure III-B, <i>Field QC Samples (Water, Soil)</i> (DON 2015)
Field QC Samples Collected during Subsurface Soil Sampling	1	Field QC	—	PFAS	1	3	
Field QC Samples Collected during Groundwater Sampling	1	Field QC	—	PFAS	1	1	Procedure I-C-3, <i>Monitoring Well Sampling</i> (DON 2015)

ft foot or feet

ID identification

N/A not applicable

SOP standard operating procedure

^a SOP or worksheet that describes the sample collection procedures.

^b Depth of non-native fill material is uncertain, therefore, subsurface soil samples collected beginning with the first 0-to-6-inch interval of native material immediately beneath fill material, and then, as written, from within each following 1-ft interval.

^c Number of groundwater samples proposed for a single sampling event. Two rounds of groundwater sampling will be conducted.

^d Perched aquifer may not be encountered during drilling and well installation, and/or perched groundwater well may be dry during the sample event.

Worksheet #19: Field Sampling Requirements Table

Matrix	Analytical Group	Preparation Reference/Method SOP Analytical Reference/Method SOP	Containers	Sample Mass/Volume	Preservation Requirement	Maximum Holding Time (preparation/analysis)
Soil and Sediment ^a	PFAS	Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids, and Tissue by LC-MS/MS Analysis Method: PFAS by EPA Method 1633 Analysis SOP: TBD	4 oz HDPE jar with non-Teflon (PTFE) lined lid	4 oz	Sample stored at 0- 6°C Extracts of solid samples at < 6°C	90 days to extraction ^c 90 days extraction to analysis ^c
Groundwater and Surface Water ^b	PFAS	Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids, and Tissue by LC-MS/MS Analysis Method: PFAS by EPA Method 1633 Analysis SOP: TBD	2 × 500 mL + 1 × 125 mL HDPE bottle with non-Teflon (PTFE) lined lid	2 × 500 mL + 1 × 125 mL	Sample stored at < 6°C Extracts of water samples at < 6°C	28 days to extraction ^{c,d} 90 days extraction to analysis ^c

EPA Environmental Protection Agency, United States

g gram

HDPE high-density polyethylene

LC-MS/MS liquid chromatography tandem mass spectrometry

mL milliliter

MS matrix spike

oz ounce

PFAS per- and polyfluoroalkyl substances

PTFE polytetrafluoroethylene

SOP standard operating procedure

TBD to be determined; analytical laboratory references will be included in a later iteration of workplan.

^a Sample results will be reported on a dry weight basis. Solid samples (soils, sediments, and biosolids that contain more than 50 mg total suspended solids).

^b Liquid samples (waters, sludges, and similar materials containing less than 50 mg total suspended solids per sample).

^c Refer to EPA Method 1633 for hold time caveats.

^d Aqueous samples (including leachates) should be analyzed as soon as possible; however, samples may be held in the laboratory for up to 28 days from collection when stored at or below 6°C and protected from the light. When stored at or below -20°C and protected from the light, aqueous samples may be held for up to 90 days. Refer to EPA Method 1633 caveats.

Title: Draft RI WP

Site/Project Name: PFAS Release, RHBFSF

Site Location: JBPHH Oahu HI

Revision Number: 00

Revision Date: June 2024

Worksheet #20: Field Quality Control Sample Summary Table

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates	No. of Field Blanks	No. of Equipment Blanks
Area A					
Surface Soil	PFAS	27	4	1	1
Sediment		4	1	0	0
Subsurface Soil		119	15	1	7
Groundwater ^a		8	1	1	1
Area B					
Surface Soil	PFAS	13	2	1	1
Subsurface Soil		46	6	1	3
Groundwater ^a		17	2	1	1

no. number

PFAS per- and polyfluoroalkyl substances

^a Number of groundwater samples proposed for a single sampling event. Two rounds of groundwater sampling will be conducted. Perched aquifer may not be encountered during drilling and well installation, and/or perched groundwater wells maybe be dry during the sample event.

Worksheet #21: Project Sampling SOP References Table

Reference Number	Title, Revision Date and/or Number ^a	Originating Organization of Sampling SOP	Equipment Type	Comments
N/A	Revised Interim General Guidance for Per- and Polyfluoroalkyl Substances (PFAS) Remedial Investigations November 2023 (DON 2023o)	NAVFAC	N/A	N/A.
N/A	Michigan Department of Environmental Quality General PFAS Sampling Guidance(MDEQ 2018)	MDEQ	PFAS-free sampling equipment and general guidance	Avoid specific items (e.g., Teflon) and best practices listed in Worksheet #14 to prevent introducing contamination with samples.
N/A	Sampling Guidance, Soil, Water, and Sediment Sampling for PFAS Analysis (AECOM 2018).	AECOM	PFAS-free sampling equipment and general guidance	Avoid specific items (e.g., Teflon) and best practices listed in Worksheet #14 to prevent introducing contamination with samples.
N/A	PFAS Environmental Sampling Guidance (ESG) (DOE 2023)	DOE	PFAS-free sampling equipment and general guidance	Avoid specific items (e.g., Teflon) and best practices listed in Worksheet #14 to prevent introducing contamination with samples.
I-A-5	Utility Clearance (DON 2015).	NAVFAC Pacific	Metal detector/magnetometer; ground penetrating radar	Review available site records, as-built plans, and dig permit; utility locator service should use appropriate sensing equipment to locate utilities that might not have appeared on the as-built plans.
I-A-6	IDW Management (DON 2015).	NAVFAC Pacific	N/A	N/A.
I-A-8	Sample Naming (DON 2015).	NAVFAC Pacific	N/A	N/A.
I-B-1	Soil Sampling (DON 2015).	NAVFAC Pacific	Stainless steel or disposable plastic trowel for surface soil samples	Avoid specific items (e.g., Teflon) listed in Worksheet #14 to prevent introducing contamination with samples.
I-C-1	Monitoring Well Installation and Abandonment (DON 2015).	NAVFAC Pacific	N/A	N/A.
I-C-2	Monitoring Well Development (DON 2015).	NAVFAC Pacific	N/A	Avoid specific items (e.g., Teflon) listed in Worksheet #14 to prevent introducing contamination with samples.
I-C-3	Monitoring Well Sampling (DON 2015).	NAVFAC Pacific	Bladder pump or bailers	Avoid specific items (e.g., Teflon) listed in Worksheet #14 to prevent introducing contamination with samples.
I-E	Soil and Rock Classification (DON 2015).	NAVFAC Pacific	N/A	N/A.
I-F	Equipment Decontamination (DON 2015).	NAVFAC Pacific	N/A	N/A.
I-I	Land Surveying (DON 2015).	NAVFAC Pacific	Theodolite/global positioning system receiver	Use WGS84, Zone 55N. Horizontal accuracy should be ± 0.1 foot; vertical accuracy for ground surface elevations shall be ± 0.1 foot; monitoring wellheads shall be ± 0.01 foot.
III-A	Laboratory QC Samples (Water, Soil) (DON 2015).	NAVFAC Pacific	N/A	N/A.
III-B	Field QC Samples (Water, Soil) (DON 2015).	NAVFAC Pacific	N/A	N/A.
III-D	Logbooks (DON 2015).	NAVFAC Pacific	N/A	N/A.

Title: Draft RI WP

Site/Project Name: PFAS Release, RHBFSF

Site Location: JBPHH Oahu HI

Revision Number: 00

Revision Date: June 2024

Reference Number	Title, Revision Date and/or Number ^a	Originating Organization of Sampling SOP	Equipment Type	Comments
N/A	Revised Interim General Guidance for Per- and Polyfluoroalkyl Substances (PFAS) Remedial Investigations November 2023 (DON 2023o)	NAVFAC	N/A	N/A.
III-E	Record Keeping, Sample Labeling, and Chain of Custody (DON 2015).	NAVFAC Pacific	N/A	Avoid specific items (e.g., Teflon) listed in Worksheet #14 to prevent introducing contamination with samples.
III-F	Sample Handling, Storage and Shipping (DON 2015).	NAVFAC Pacific	N/A	Avoid specific items (e.g., Teflon) listed in Worksheet #14 to prevent introducing contamination with samples.

DOH Department of Health, State of Hawaii

IDW investigation-derived waste

N/A not applicable

NAVFAC Naval Facilities Engineering Systems Command

QC quality control

SOP standard operating procedure

^a Applicable procedures from the Project Procedures Manual (DON 2015)

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.
Horiba Water Quality Parameter Probe ^b	Calibrate with calibration solutions (pH buffers and conductivity and turbidity solutions).	Decontaminate after every use. Keep batteries charged.	Calibrate with calibration solutions.	Visually inspect probes for wear or damage. Run a calibration.	Daily	Stable readings achieved (three or more successive readings within 10% of each other)	If readings do not stabilize, do not use device.	Field Manager	Procedure I-C-3: Monitoring Well Sampling (DON 2015) and manufacturer's specifications for all inspection, testing, maintenance, and calibrations.
Water Level Meter	N/A.	Decontaminate after every use. Test batteries before each use.	Battery/audio tone LED light test button.	Visually inspect meter for wear or damage.	Daily	Pass battery self-test and inspection	Replace meter.	Field Manager	Procedure I-C-3: Monitoring Well Sampling (DON 2015) and manufacturer's specifications for all inspection, testing, maintenance.
Battery-operated electronic balance	Initial calibration and every 10 samples, calibration verification with 100 gram weight.	According to the manufacturer's recommendations.	Accuracy and precision per manufacturer's specifications.	Visually inspect balance for wear or damage before calibration.	Daily	≤2 grams	Recalibrate balance.	Field Manager	Manufacturer's specifications for all inspection, testing, maintenance, and calibrations.
Bladder or submersible pumps	N/A	Decontaminate pumps between wells and dispose of tubing.	Determine if pumps are working correctly. Adjust flow rate (purge rate) to yield 100–300 mL/minute. Operate at low flow for several minutes.	Visually inspect for damage.	Daily	Pump is not creating significant draw-down (i.e., ≤0.2 feet)	Reduce pumping rate and continue to monitor draw-down with water level meter until acceptance criterion is met.	Field Manager	Procedure I-C-3: Monitoring Well Sampling (DON 2015) and manufacturer's specifications for all inspection, testing, maintenance, and calibrations.

Title: Draft RI WP

Site/Project Name: PFAS Release, RHBFSF

Site Location: JBPHH Oahu HI

Revision Number: 00

Revision Date: June 2024

Field Equipment	Calibration Activity	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference ^a
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 or 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.

% percent

ADCP Acoustic Doppler Current Profiler

dB decibel

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).

^b Used for monitoring temperature, pH, specific conductivity, turbidity, and dissolved oxygen.

Title: Draft RI WP

Site/Project Name: PFAS Release, RHBFSF

Site Location: JBPHH Oahu HI

Revision Number: 00

Revision Date: June 2024

Worksheet #23: Analytical SOP References Table

[Laboratory Name and Address - TBD]

[Point of Contact Name - TBD]

[Point of Contact Phone Number - TBD]

Lab SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Variance to QSM (Yes/No)	Modified for Project Work? (Yes/No)
Preparation and Analytical Methods – Analytical Laboratory TBD						
TBD	EPA Method 1633, Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS, 01/2024	Definitive	PFAS (Soil, sediment, and water)	Preparation of Extracts	No	No
TBD	EPA Method 1633, Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS, 01/2024	Definitive	PFAS (Soil, sediment, and water)	LC-MS/MS	No	No

Note: The laboratory SOPs listed in Worksheet #23 are the most current revisions at the time of publication of this Work Plan. The project team will review the laboratory SOPs immediately prior to sample submittal to ensure that the laboratory performs analysis using SOPs that are DoD ELAP-accredited (DoD and DOE 2023).

DoD Department of Defense

ELAP Environmental Laboratory Accreditation Program

QSM Quality Systems Manual

Worksheet #24: Analytical Instrument Calibration Table

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference ^a
LC-MS/MS EPA Method 1633	Ion Transitions (Parent-> Product)	Every field sample, standard, blank, and QC sample.	The requirements of EPA Method 1633 must be met. Per method requirements: If a qualitative or quantitative standard containing an isomeric mixture (branched and linear isomers) of an analyte is commercially available for an analyte, the quantification ion used must be the quantification ion identified in Table 10 of EPA Method 1633 unless interferences render the product ion unusable as the quantification ion. DoD Specific Requirement: In cases where interferences render the product ion unusable, the client must grant permission before using the alternative product ion and the deviation and reason for the deviation must be documented in the case narrative.	N/A.	Lab Manager/Analyst	TBD
	Mass Calibration	At instrument setup; at least annually or as specified by the manufacturer, whichever is more frequent; after major maintenance; and when needed based on EPA Method 1633 requirements or QC results, before analysis. Mass calibration shall be performed using the calibration compounds and procedures prescribed by the manufacturer.	As recommended or required by the instrument manufacturer and EPA Method 1633 requirements.	Correct the problem, then repeat mass calibration.	Lab Manager/Analyst or certified instrument technician	TBD
	Mass Accuracy Verification	The mass calibration must be verified after each subsequent mass calibration.	The laboratory must follow the instructions for their instrument software to confirm the mass calibration, mass resolution, and peak relative response. If the manufacturer's instructions include options for evaluation of mass resolution, the tightest resolution requirements (typically called unit resolution) must be met.	Correct the problem, then repeat verification.	Lab Manager/Analyst or certified instrument technician	TBD

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference ^a
LC-MS/MS EPA Method 1633 (cont'd)	Ion Abundance Ratio	Each analyte report as detected in field or QC samples.	For concentration reported at or above the LOQ, the IAR must fall within +/-50% of the IAR observed in the mid-point initial calibration standard. If sample concentration reported is below the LOQ, the IAR must fall within +/-50% of the IAR observed in either the mid-point initial calibration standard or the initial CCV. The total response of all isomers in the quantitative standard must be used to define the IAR. In samples, the total response must include only branched isomer peaks that have been identified in either the quantitative or qualitative standard. If qualitative or quantitative standards are not commercially available for purchase, only the linear isomer can be identified and quantitated in samples.	If acceptance criteria are not met, reanalyze a fresh aliquot of extract. If reanalysis passes, report reanalysis. If reanalysis confirms the original result and all sample preparation avenues have been exhausted, report the original result and "I" qualify the result. Document the exceedance in the case narrative.	Lab Manager/Analyst	TBD
	Retention Time	Every field sample, standard, blank, and QC sample for each analyte, EIS, and NIS.	On days an ICAL is performed, retention times shall be set using the midpoint standard of the ICAL. On days an ICAL is not performed, the retention times are set using either the midpoint of the ICAL or the initial CCV of the day.	N/A.	Lab Manager/Analyst	TBD
	Retention Time Window (EIS RRT)	Each analyte that has a labeled EIS analog.	The retention time window used must be of sufficient width to detect earlier-eluting branched isomers. The retention time of each analyte, EIS, and NIS must be within +/- 0.4 minutes of the ICAL or CCV used to establish the RT windows. For all target analytes with exact corresponding isotopically labeled analogs, target analytes must elute within +/- 0.1 minutes of the associated EIS compound.	Correct the problem and reanalyze the samples.	Lab Manager/Analyst	TBD
	ISC	At the beginning of each analytical sequence, prior to sample analysis.	Analyte-spiked concentrations (nominal concentrations) must be at LOQ. The signal-to-noise ratio of the ISC standard (Section 7.3.4) must be greater than or equal to 3:1 for the quantitation and confirmation ions that exist and must meet the IAR requirements. If the analyte has no confirmation ions, then a 10:1 signal to noise ratio is required. The measured concentration of each target analyte in the ISC must fall within $\pm 30\%$ of its nominal concentration.	Correct the problem, rerun Instrument Sensitivity Check. If the problem persists, repeat ICAL. No samples shall be analyzed until acceptance criteria for ISC has been met. Flagging is not appropriate.	Lab Manager/Analyst or certified instrument technician	TBD
	ICAL for all analytes	At instrument setup and when needed based on EPA Method 1633 requirements of QC results, before sample analysis.	Initial calibration is performed using a series of at least six solutions, with at least five of the six calibration standards being within the quantitation range, and with the lowest standard at or below the LOQ. (If a second-order calibration model is used, then one additional concentration is required, with at least six of the seven calibration standards within the quantitation range.)	Correct the problem, then repeat ICAL. Samples should not be run without a valid calibration in accordance with EPA Method 1633 requirements.	Lab Manager/Analyst or certified instrument technician	TBD

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference ^a
LC-MS/MS EPA Method 1633 (cont'd)	ICAL with a minimum of 6 points	After continuing calibration fails.	At least five of the six calibration standards being used should be within the quantification range, and the lowest standard at or below the LOQ. If a second-order calibration model is used, then one additional concentration is required, with at least six of the seven calibration standards within the quantitation range, and the lowest standard at or below the LOQ. Signal-to-noise ratio must be $\geq 3:1$ for the quantitation ions and the confirmation ions or $\geq 10:1$ if the analyte only has a quantitation ion. One of the following two approaches must be used to evaluate the linearity of the instrument calibration: Option 1: The relative standard deviation (RSD) of the RR or RF values for each target analyte and isotopically labeled compound must be $\leq 20\%$. Option 2: The relative standard error (RSE) for each target analyte and EIS compound must be $\leq 20\%$.	Flagging is not appropriate. Perform instrument maintenance and recalibrate.	Lab Manager/Analyst or certified instrument technician	TBD
	Calibration Verification (CV or CCV)	After a passing ISC, at the beginning of each analytical sequence, after every 10 field samples, and at the end of the analytical sequence.	Analysis of mid-level calibration solution. The CV is a mid-level calibration standard. The target analyte concentration must be within $\pm 30\%$ of their true value. If the analyte failed high and was not detected in the bracketed samples, reanalysis is not needed.	Analyze a fresh aliquot of the CV standard. If the CCV passes, reanalyze the sample extracts bracketed by the CCV with exceedances and report the data. If either fails or if immediate reanalysis of CCV in duplicate cannot be performed all samples since acceptable CCV must be reanalyzed.	Lab Manager/Analyst	TBD
	Instrument Blanks	At the beginning of the analytical sequence and immediately following the highest standard analyzed in the calibration, daily prior to analyzing standards after each CCV, and immediately following samples with PFAS concentration exceeding the quantification range.	In addition to the requirements of EPA Method 1633, the following must be met: The instrument blank must not contain any target analyte that would yield a response equivalent to the mass of the analyte that would be present in a whole-volume sample at or above the analyte's DL.	If acceptance criteria are not met, analyze one or more additional instrument blanks until the response of the analyte is no longer detectable, or perform additional troubleshooting steps to identify and minimize other potential sources of PFAS contamination.	Lab Manager/Analyst	TBD
	Qualitative Identification Standards	Analyzed daily prior to sample analysis.	In instances when a quantitative isomeric mixture is not commercially available, if a qualitative isomeric mixture standard is commercially available, it must be used to determine the retention times of the branched isomers of that analyte.	N/A.	Lab Manager/Analyst	TBD

Title: Draft RI WP

Site/Project Name: PFAS Release, RHBFSF

Site Location: JBPHH Oahu HI

Revision Number: 00

Revision Date: June 2024

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference ^a
LC-MS/MS EPA Method 1633 (cont'd)	Bile Salt Interference Check	After initial calibration and during each analytical sequence, regardless of the sample matrix to be analyzed.	The retention time of the bile salts must fall outside of the retention time window for any of the linear or branched PFOS isomers. If the mobile phase used is not acetonitrile, TCDCA and TUDCA must be evaluated in the same manner as TDCA.	No samples shall be analyzed until acceptance criteria for the bile salt standard(s) has been met. The chromatographic conditions must be adjusted to meet the requirement and the initial calibration must be repeated before any field samples are analyzed.	Analyst/Supervisor	TBD

%RSD	relative standard deviation
CCV	continuing calibration verification
CV	calibration verification
DL	detection limit
EIS	extracted internal standards
ICAL	initial calibration
ICC	initial calibration check
ICV	initial calibration verification
ISC	instrument sensitivity check
LOQ	limit of quantitation
NEtFOSA	N-ethyl perfluorooctanesulfonamide
NetFOSE	N-methyl perfluorooctanesulfonamidoacetic acid
NMeFOSA	N-methyl perfluorooctanesulfonamide
NMeFOSE	N-methyl perfluorooctanesulfonamidoethanol
PFOS	perfluorooctane sulfonic
PFOSA	perfluorooctane sulfonic acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
QC	quality control
RF	response factor
RRT	relative retention time
TCDCA	taurochenodeoxycholic acid
TDCA	taurodeoxycholic acid
TUDCA	tauroursodeoxycholic acid

^a The analytical SOP References table is listed in Worksheet #23. Calibration procedures and analysis must be consistent with the DoD QSM laboratory's current accreditation and Table B-24 in QSM 6.0 (DoD and DOE 2023).

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
LC-MS/MS	Backflush of column, injection port and pre-columns; cleaning of ion spray cone; adjustment of collision energies and others as needed.	Sensitivity check	Check pressure, gas supply, needle, and mobile phase filters daily. Ion source, injector liner, column, column flow. Monitor instrument performance via tuning, calibrations, and blanks.	Prior to initial calibration and/or as necessary	Initial calibration or calibration verification passes method specifications	Perform additional maintenance prior to instrument calibration or calibration verification.	Analyst or certified instrument technician	TBD
	Clean curtain and orifice front plate.	Maintain sensitivity	Visually inspect and clean.	Weekly	CCV/ICV pass criteria	Refer to the manufacturer's operating manual.	Analyst or certified instrument technician	TBD
	Clean rear orifice plate, QJet, Ion Guide, Q0 and IQ1 lenses.	Maintain sensitivity	Clean.	As needed	CCV/ICV pass criteria	Refer to the manufacturer's operating manual.	Analyst or certified instrument technician	TBD
	Roughing pump oil.	Maintenance check	Fill.	As needed	Maintain vacuum	Refer to the manufacturer's operating manual.	Analyst or certified instrument technician	TBD
	Manual tune if not within in criteria. Perform the following as needed: replace column, clean source, clean injection port/liner, clean spray chamber.	Sensitivity check	Check pressure, gas supply, needle, and mobile phase filters daily. Ion source, injector liner, column, column flow. Monitor instrument performance via tuning, calibrations, and blanks.	Prior to initial calibration and/or as necessary	CCV pass criteria	Recalibrate.	Analyst or certified instrument technician	TBD
	Locate and replace any pinched or damaged lines. Check the junction between the pump head and the pump casting for evidence of liquid leaks. Normal friction and wear may gradually result in small liquid leaks around the piston seal. If leaks occur, replace the piston seals.	Pressure check	Instrument performance and sensitivity.	Prior to initial calibration and/or as necessary	CCV pass criteria	Recalibrate.	Analyst or certified instrument technician	TBD

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference ^a
LC-MS-MS (cont'd)	Replace analytical columns as needed.	Sensitivity check	Instrument performance and sensitivity. Review peak shapes, RTs, and peak separation on ICAL, ICC, and CCV samples.	As needed	CCV pass method criteria	Recalibrate.	Analyst or certified instrument technician	TBD
	Preventative maintenance.	N/A	Poor instrument performance; method QC checks are not within acceptable criteria.	Every 6 months of when instrument performance deteriorates	ICAL within acceptable method criteria and EIS recover within method criteria	Service provider performs preventative maintenance and mass calibration. Run tune check. Reanalyze samples with new ICAL, ICC, ISC, and instrument blank.	Analyst or certified instrument technician	TBD

CCV continuing calibration verification

ICC initial calibration check

ICV initial calibration verification

ISC instrument sensitivity check

RT retention time

^a Specify the appropriate reference letter or number from the analytical SOP References table updated in future draft workplan (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 laboratory
Sample Custody and Storage	Sample custodian/Designated analytical laboratory
Sample Preparation	Laboratory analyst/Designated analytical laboratory
Sample Determinative Analysis	Laboratory analyst/Designated analytical laboratory
Sample Archiving	
Field Sample Storage	90 days from sample receipt
Sample Extract/Digestate Storage	90 days from extraction/digestion
Biological Sample Storage	Not applicable or per project scope
Sample Disposal	
Personnel/Organization	Sample custodian/Designated analytical laboratory
Number of Days from Analysis	90 days
AECOM no. QC	AECOM Technical Services, Inc. number quality control

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

27.1 COC SAMPLE IDENTIFICATION NUMBER

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

FXzzz

Where:

F	=	Designating the sampling team's home office (e.g., Honolulu office)
X	=	Designating CTO ____ (This designator is assigned for each CTO)
zzz	=	Chronological number, starting with 001

Quality control (QC) samples will be included in the chronological sequence.

27.2 DESCRIPTIVE IDENTIFICATION NUMBER

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

RHAA-bbcc-dee-Dff.f

Where:

AA	=	Red Hill Site area or monitoring well number included in the PFAS RI (Table 27-1)
bb	=	Sample type and matrix (Table 27-2)
cc	=	Location number (e.g., borehole 01, 02, 03)
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 for soil samples or date for water samples
ff.f	=	Depth of sample in feet bgs (measured to the tenth of a foot). For water sample, field blanks, trip blanks, and equipment blanks, the depth field will contain the date of collection as: MMDDYY

For example, the sample number RHSA-SS01-S01-D0.05 would indicate that the sample is the first sample collected from Area A of Red Hill PFAS Investigation, at boring location numbered RHSA01, at 0.5 foot bgs. The duplicate sample would be designated as RHSA-SS01-D01-D0.5. The first subsurface soil sample from this location would be denoted by RHSA-BS01-D01-D3.0. Similarly, groundwater sample number will be RHWB01B-GW01B-S01-DMMDYY. This sample will represent a primary groundwater sample collected from proposed perched aquifer well RHWB01B on the date MMDDYY. These characters will establish a unique descriptive identifier that will be used during data evaluation.

Table 27-1: Area Identifiers

Identifier	Site Area
Area A	
RHSA	Soil Locations of Area A of Red Hill PFAS Investigation (Near Adit 6 and Bldg. 313)
RHDA	Sediment Location of Area A of Red Hill PFAS Investigation (Near Adit 6 and Bldg. 313)
RHMW06	Samples collected from existing well RHMW06
RHMW17	Samples collected from existing well RHMW17
RHMW17D	Samples collected from existing well RHMW17D
RHMW17S	Samples collected from RHMW17S
PFMW01A	Area A samples collected from proposed groundwater monitoring location RHWA01 (Basal and Boring)
PFMW01B	Area A samples collected from proposed groundwater monitoring location RHWA01 (Perched)
PFMW02A	Area A samples collected from proposed groundwater monitoring location RHWA01 (Basal and Boring)
PFMW02B	Area A samples collected from proposed groundwater monitoring location RHWA01 (Perched)
Area B	
RHSB	Soil Locations of Area B of Red Hill PFAS Investigation (Near and in between RHP wells and within OWDF)
RHP01	Samples collected from existing well RHP01
RHP02	Samples collected from existing well RHP02
RHP03	Samples collected from existing well RHP03
RHP06	Samples collected from existing well RHP06
RHP07	Samples collected from existing well RHP07
RHP08	Samples collected from existing well RHP08
PFMW03A	Area B samples collected from proposed groundwater monitoring location RHWB01 (Basal and Boring)
PFMW03B	Area B samples collected from proposed groundwater monitoring location RHWB01B (Perched)
PFMW04A	Area B samples collected from proposed groundwater monitoring location RHWB02 (Basal and Boring)
PFMW04B	Area B samples collected from proposed groundwater monitoring location RHWA02B (Perched)
PFMW05A	Area B samples collected from proposed groundwater monitoring location RHWB03 (Basal and Boring)
PFMW05B	Area B samples collected from proposed groundwater monitoring location RHWB03B (Perched)
OWDFMW03A	Samples collected from existing well OWDFMW03A (Basal)
OWDFMW03B	Samples collected from existing well OWDFMW03B (Perched)
OWDFMW08A	Samples collected from existing well OWDFMW08A (Basal)
OWDFMW08B	Samples collected from existing well OWDFMW08B (Perched)

Table 27-2: Sample Type and Matrix Identifiers

Identifier	Sample Type	Matrix
SS	Surface soil	Soil
SD	Sediment	Swale Sediment
BS	Subsurface soil	Soil
GW	Groundwater	Water
WQ	Water Blanks	Water
WW	Water Waste IDW	Water
WS	Soil Waste IDW	Soil

Table 27-3: Field QC Sample Type Identifiers

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

27.3 HANDLING, SHIPPING, AND CUSTODY

All samples collected for analysis will be recorded in the field logbook in accordance with Procedure III-D, *Logbooks* (DON 2015). All samples will be labeled and recorded on COC forms in accordance with Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody 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 Section 5.8, “Handling Samples and Test Items” of the *Department of Defense (DoD) and Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories*, Version 5.4 (DoD and DOE 2021).

Worksheet #28: Laboratory QC Samples Table

Matrix All matrices
Analytical Group PFAS
Analytical Method/SOP Reference Analytical Method: EPA Method 1633
Preparation Method: EPA Method 1633
Laboratory SOPs: TBD
Analytical Organization TBD

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
EIS	Every field sample, standard, blank, and QC sample.	Field and QC samples EIS compound recoveries must be within the acceptance limit specified for the matrix of the sample provided by the method (Tables 5, 6, 7, and 8). In addition to the requirements of EPA Method 1633, the following must be met for analytes not included in EPA 1633: 1) QC samples and field samples must recover within in-house limits. Preliminary in-house acceptance criteria of 20%–150% must be used until in-house limits are generated in accordance with Sections 9.4 of EPA Method 1633. 2) The lower limit of inhouse acceptance criteria cannot be < 20%. 3) Must meet laboratory-derived limits.	1) If the recovery of any EIS in a sample is outside of the acceptance limits in Tables 6 or 8, then a diluted sample extract must be analyzed, or a smaller sample mass/volume must be extracted (Section 15.3.1). If EIS recoveries still fall outside of the acceptance range, the client must be contacted for additional measures to be taken. 2) Document and discuss the failure in the case narrative. 3) Apply qualifier to the affected analyte results of all samples associated with the failures.	Analyst, Lab QA Officer	Accuracy	For analytes in EPA Method 1633 analyte list, meet EPA Method 1633 acceptance criteria. For analytes not included in EPA Method 1633 analyte list, meet laboratory-derived limits.
Non-Extracted Internal Standard Compounds	Every field sample, standard, blank, and QC sample.	The NIS areas in the field samples and QC samples must be within 50% to 200% of the mean area of the corresponding NIS in the most recent initial calibration.	1) Repeat the analysis using a fresh aliquot of the extract. If failure does not confirm, report the second analysis. If the failure confirms, examine the project-specific requirements. Contact the client as to additional measures to be taken. 2) If peak areas are unacceptable, analyze a second aliquot. If second analysis meets criteria, report it. Insufficient volume—qualify and document. 3) Examine the project specific requirements. Contact the client as to additional measures to be taken. 4) Document and discuss the failure in the case narrative. 5) Apply a flag to the result associated with the failure.	Analyst, Lab QA Officer	Accuracy	Meet EPA Method 1633 limits.

Matrix All matrices
Analytical Group PFAS
Analytical Method/SOP Reference Analytical Method: EPA Method 1633
Preparation Method: EPA Method 1633
Laboratory SOPs: TBD
Analytical Organization TBD

QC Sample	Frequency & Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	Measurement Performance Criteria
Method Blank	One per preparatory batch of no more than 20 samples.	In addition to the method requirements, the following must be met: No analytes detected > 1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is greater.	1) Correct problem. If required, re-extract and reanalyze method blank and all samples processed with the contaminated blank. 2) With project-specific approval, samples may be re-extracted and analyzed outside of hold times, as necessary for corrective action associated with QC failure. If continued retesting results in repeated blank contamination, the laboratory must document and report the failures. 3) Examine the project-specific requirements. Contact the client for additional measures that need to be taken. 4) If reanalysis cannot be performed, data must be qualified and explained in the Case Narrative. 5) Apply Blank flag to all results for the specific analyte(s) in all samples in the associated preparatory batch.	Analyst/Supervisor	Accuracy Contamination bias	No analytes detected > 1/2 LOQ or > 1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is greater.
LCS and LLLCS	One LCS and LLLCS per preparatory batch of no more than 20 samples. Shall contain all EIS, NIS, and all analytes to be reported.	The LCS must be a mid-level spiked QC sample and the LLLCS must be a QC sample spiked at two times the LOQ. The recoveries of analytes included in EPA Method 1633 analyte list must meet the acceptance criteria stated in the EPA Method 1633 (Tables 5, 6, 7, and 8). The recoveries of analytes not included in EPA Method 1633 analyte list must meet in-house limits. Preliminary in-house acceptance criteria of 40%–150% must be used until in-house limits are generated per EPA Method 1633. The lower limit of in-house acceptance criteria cannot be <40%.	In addition to the method requirements the following must be met: 1) Investigate and eliminate the source of poor recovery before proceeding with further analysis. 2) Correct the problem, then re-extract and reanalyze the LCS and all the samples in the associated preparatory batch for failed analytes, if sufficient sample material is available. 3) Samples may be re-extracted and analyzed outside of holding times as necessary for corrective action. 4) If reanalysis cannot be performed, data must be qualified and explained in the case narrative. 5) Apply a flag to specific analyte(s) in all samples in the associated preparatory batch.	Analyst/Supervisor	Accuracy Bias	For analytes included in EPA Method 1633 analyte list, meet EPA Method 1633 limits. For analytes not included in EPA Method 1633 analyte list, meet laboratory derived limits.

DQI data quality indicator
LCS laboratory control sample
LLLCS low-level laboratory control sample
LLOPR low-level ongoing precision and recovery
MD matrix duplicate
NIS non-extracted internal standards
OPR ongoing precision and recovery
QA quality assurance
RPD relative percent difference

Worksheet #29: Project Documents and Records Table

Document ^a	Storage/Archive Location
Sample Collection Documents and Records	Storage:
Field logbook (and sampling notes)	AECOM Technical Services, Inc.
Field sample forms (e.g., boring logs, sample log sheets, drilling logs)	1001 Bishop Street Suite 1600
Chain of custody records	Honolulu, HI 96813
Air Bills	Phone: 808-523-8874
Photographs	Once NIRIS uploads are complete, a hard copy of pertinent documents shall be shipped to:
Field task modification forms	Iron Mountain
Field sampling SOPs	2456 Lugonia Ave
Laboratory documents and records	Redlands, CA 92374
Sample collection logs	Phone: 800-899-4766
Health and safety sign in sheets	
Accident Prevention Plan acknowledgement	
Surveyed locations	
Communication logs	
Documentation of deviation from methods	
Excavation permits	
Explosive safety submission determination request	
Corrective action forms/documentation of the audits	
Documentation of internal QA review	
Identification of QC samples	
Meteorological data from field	
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	

Document ^a	Storage/Archive Location
Instrument calibration reports	Storage: AECOM Technical Services, Inc. 1001 Bishop Street Suite 1600 Honolulu, HI 96813 Phone: 808-523-8874
Laboratory sample identification numbers	
Reporting forms, completed with actual results	
Signatures for laboratory sign-off (e.g., laboratory QA manager)	
Standards traceability records	
Project Data Assessment Records	Once NIRIS uploads are complete, a hard copy of pertinent documents shall be shipped to: Iron Mountain 2456 Lugonia Ave Redlands, CA 92374 Phone: 800-899-4766
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
NIRIS	Naval Installation Restoration Information Solution
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	Sampling Locations	Analytical Group	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)
Area A						
Surface Soil	RHSA01 to RHSA35	PFAS	EPA Method 1633 – Lab SOP TBD	21 days	TBD	TBD
Sediment	RHDA01 to RHDA04					
Subsurface Soil	RHSA01 to RHSA35					
Groundwater	RHMW17, RHMW17D, RHMW17S, RHWA01, RHWA01B, RHWA02, RHWA02B					
Field QC	N/A					
Area B						
Surface Soil	RHSB01 to RHSB13	PFAS	EPA Method 1633 – Lab SOP TBD	21 days	TBD	TBD
Subsurface Soil	RHSB01 to RHSB13					
Groundwater	RHP01, RHP02, RHP03, RHP06, RHP07, RHP08, RHWB01, RHWB01B, RHWB02, RHWB02B, RHWB03, RHWB03B, OWDFMW03A, OWDFMW03B, OWDFMW08A, OWDFMW08B					
Field QC	N/A					

^a Laboratory meets accreditation requirements to support project needs.

All samples will be sent to a DoD ELAP-accredited laboratory: TBD.

Data packages will be due 21 days after samples are received at the laboratory. 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: (Appendix D)

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

Title: Draft RI WP

Site/Project Name: PFAS Release, RHBFSF

Site Location: JBPHH Oahu HI

Revision Number: 00

Revision Date: June 2024

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	TBD/AECOM	Third-Party Data Validator/Project Chemist	Laboratory Project Manager	Laboratory Project Manager	Third-Party Data Validator/Project Chemist

AECOM AECOM Technical Services, Inc.

COC chain of custody

CTO contract task order

QC quality control

SDG sample delivery group

TBD to be determined

Title: Draft RI WP

Site/Project Name: PFAS Release, RHBFSF

Site Location: JBPHH Oahu HI

Revision Number: 00

Revision Date: June 2024

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.

Title: Draft RI WP

Site/Project Name: PFAS Release, RHBFSF

Site Location: JBPHH Oahu HI

Revision Number: 00

Revision Date: June 2024

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	30 days after laboratory revised deliverable is received	Data Validator, TBD	CTO Manager (AECOM) and RPM (Navy)
Third-Party DQAR	Once, after all data are generated	30 days after final revised laboratory deliverable is received	Data Validator, TBD	CTO Manager (AECOM) and RPM (Navy)
Field Audit Report	Once, during the initial three weeks of the field work	5 days after field audit is completed	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

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 (TBD, AECOM)	Step I	Internal
Field procedures	Determine whether field procedures are performed in accordance with this WP/SAP and prescribed procedures.	QA Program Manager (Scott Lewis, AECOM)	Step I	Internal
Field logbook and notes	Review the field logbook and any field notes on a weekly basis and place them in the project file. Copies of the field logbook and field notes will be provided to the CTO manager and included in the Field Audit Report.	Field Manager (TBD, AECOM)	Step I	Internal
Instrument calibration sheets	Determine whether instrument mass calibrations were performed in accordance with manufacturer's requirements and in accordance with WP/SAP requirements. Determine whether instrument initial calibrations were performed in accordance with WP/SAP requirements.	Project Chemist (TBD, AECOM) & Data Validator (TBD, TBD)	Step I	Internal & External
COC forms	Review completed COC 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 (TBD, 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 (TBD, LAB)	Step I	External
Analytes	Determine whether all analytes specified in Worksheet #15 were analyzed and reported on by the laboratory.	Project Chemist (TBD, AECOM)	Step IIa	Internal
COC and field QC logbook	Examine data traceability from sample collection to project data generation.	Project Chemist (TBD, 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 MPC and completeness. In accordance with the procedures stated in DoD DVG Module 6, 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 (TBD, TBD) & Project Chemist (TBD, AECOM)	Steps IIa & IIb	Internal & External
DoD Validation Guidelines	<i>Department of Defense General Data Validation Guidelines</i> (DoD 2019b).	Data Validator (TBD, TBD)	Step IIa	External
PFAS	<i>DoD Data Validation Guidelines Module 6: Data Validation Procedure for Per and Polyfluoroalkyl Substances Analysis</i> by QSM Table B-24 (DoD 2022), according to current version of DoD QSM Table B-24 (DoD and DOE 2023).	Data Validator (TBD, TBD)	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 (TBD, AECOM) & Field Manager (TBD, AECOM)	Step IIb	Internal
Field QC samples	Establish that the number of QC samples specified in Worksheet #20 were collected and analyzed.	Project Chemist (TBD, AECOM)	Step IIb	Internal

Title: Draft RI WP

Site/Project Name: PFAS Release, RHBFSF

Site Location: JBPHH Oahu HI

Revision Number: 00

Revision Date: June 2024

Data Review Input	Description	Responsible for Verification (name, organization)	Step I/IIa/IIb ^a	Internal/External
Project quantitation limits and data qualifiers	Establish that sample results met the project quantitation limits and qualify the data in accordance with Department of Defense General Data Validation Guidelines (DoD 2019b).	Data Validator (TBD, TBD) & Project Chemist (TBD, 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 (TBD, TBD)	Step IIa	External

% percent

AECOM AECOM Technical Services, Inc.

COC chain of custody

CTO contract task order

ELAP Environmental Laboratory Accreditation Program

MPC measurement performance criteria

QA quality assurance

SAP Sampling and Analysis Plan

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 MPC in the WP/SAP. See Table 11, page 118, UFP-QAPP manual, V.1 (DoD 2005).

Worksheet #37: Usability Assessment

A systematic data quality assessment 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 remedial investigation (RI). The evaluation will consider any deviations from proposed field activities or sampling and handling procedures. The analytical results of the water, soil, and sediment sampling will be compared to the project quality objectives presented in Worksheets #12 and #28 to determine whether the measurement performance criteria (MPC) 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, completeness, and sensitivity (PARCCS) 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 RI 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.

37.1 FIELD ACTIVITY AND DATA VERIFICATION SUMMARY

The AECOM Technical Services, Inc. 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. 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 an on-site data review against the Work Plan/Sampling and Analysis Plan requirements for completeness and accuracy per Worksheet #22 (standard operating procedure requirements for calibration, maintenance, and testing). In addition, the review process will verify that standard operating procedures for field sampling and analysis were followed.

The chain-of-custody 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.

37.2 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 be validated by a Stage 4 Validation (Electronic and Manual, following *DoD Data Validation Guidelines Module 6; Data Validation Procedure for Per- and Polyfluoroalkyl Substances Analysis by QSM Table B-24* (DoD 2022)). 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 Data Validation Guidelines Module 6; Data Validation Procedure for Per- and Polyfluoroalkyl Substances Analysis by QSM Table B-24* (DoD 2022)).

The analytical data will be evaluated for quality assurance and QC based on the *DoD Data Validation Guidelines Module 6; Data Validation Procedure for Per- and Polyfluoroalkyl Substances Analysis*

by QSM Table B-24 (DoD 2022), the Department of Defense (DoD) and Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories (DoD and DOE 2023).

The RI will use the *DoD Data Validation Guidelines Module 6: Data Validation Procedure for Per and Polyfluoroalkyl Substances Analysis* by QSM Table B-24 to evaluate and qualify data (DoD 2019a; 2022).

Sample data that do not meet the *DoD Validation Guidance Procedures* (DoD 2019a) and the *QSM* (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 2019a). The project requires reporting non-detects as U-qualified at the limit of detection and requires reporting detects between the detection limit and limit of quantitation with a J qualification (Table 37-2).

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.
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 the published method and project QC 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

Table 37-2: Reporting Requirements

Reporting Requirements	Non-detects or results Below (<) DL	Results Below (<) LOD	Results Below (<) LOQ
DoD QSM reporting	LOD value U	Reported Result J	Reported Result J
DL	detection limit		
LOD	limit of detection		

Once the data are reviewed and qualified according to the *DoD Validation Guidance Procedure Modules* (DoD 2019a) and the *QSM* (DoD and DOE 2023), a data quality assessment process will summarize the quality assurance/QC evaluation of the data according to the PARCCS 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 PARCCS 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)

Figure 1
Vicinity Map
Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substance
Release at Red Hill Bulk Fuel Storage Facility
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

\\10.115.65.93\docs\isolated\N6274223\F0178_60716457\HNL11900_CAD_GIS\920_929_GIS_Graphics\920_GIS\02_Maps\07_Redacted_WP\Fig 2 - Former Site Layout and Features.mxd 6/20/2024

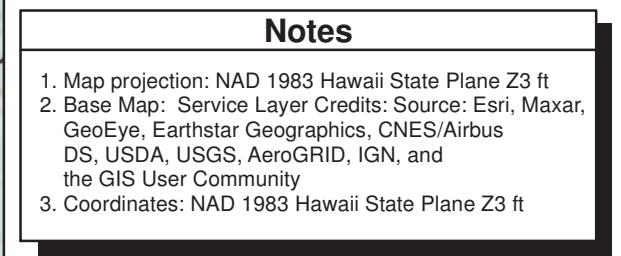
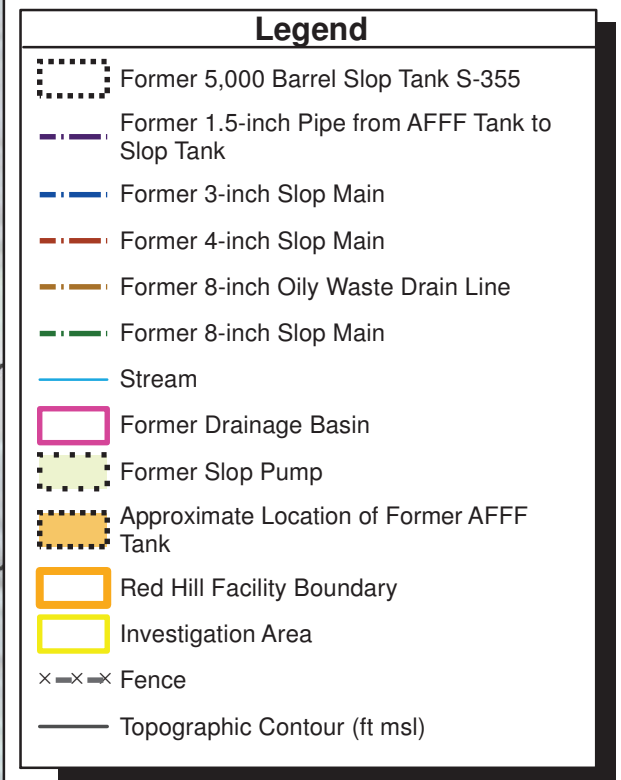
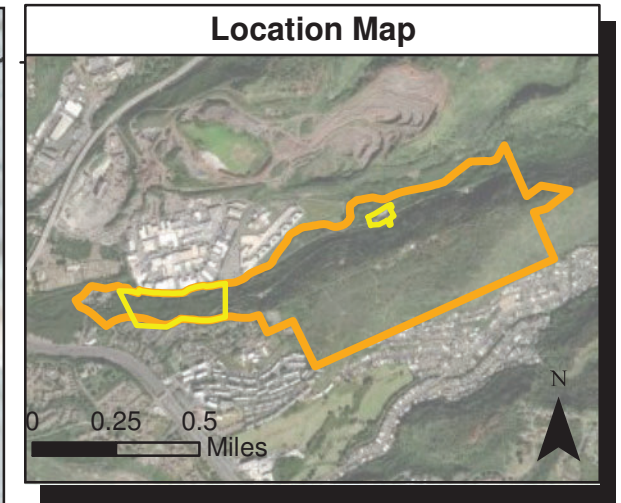
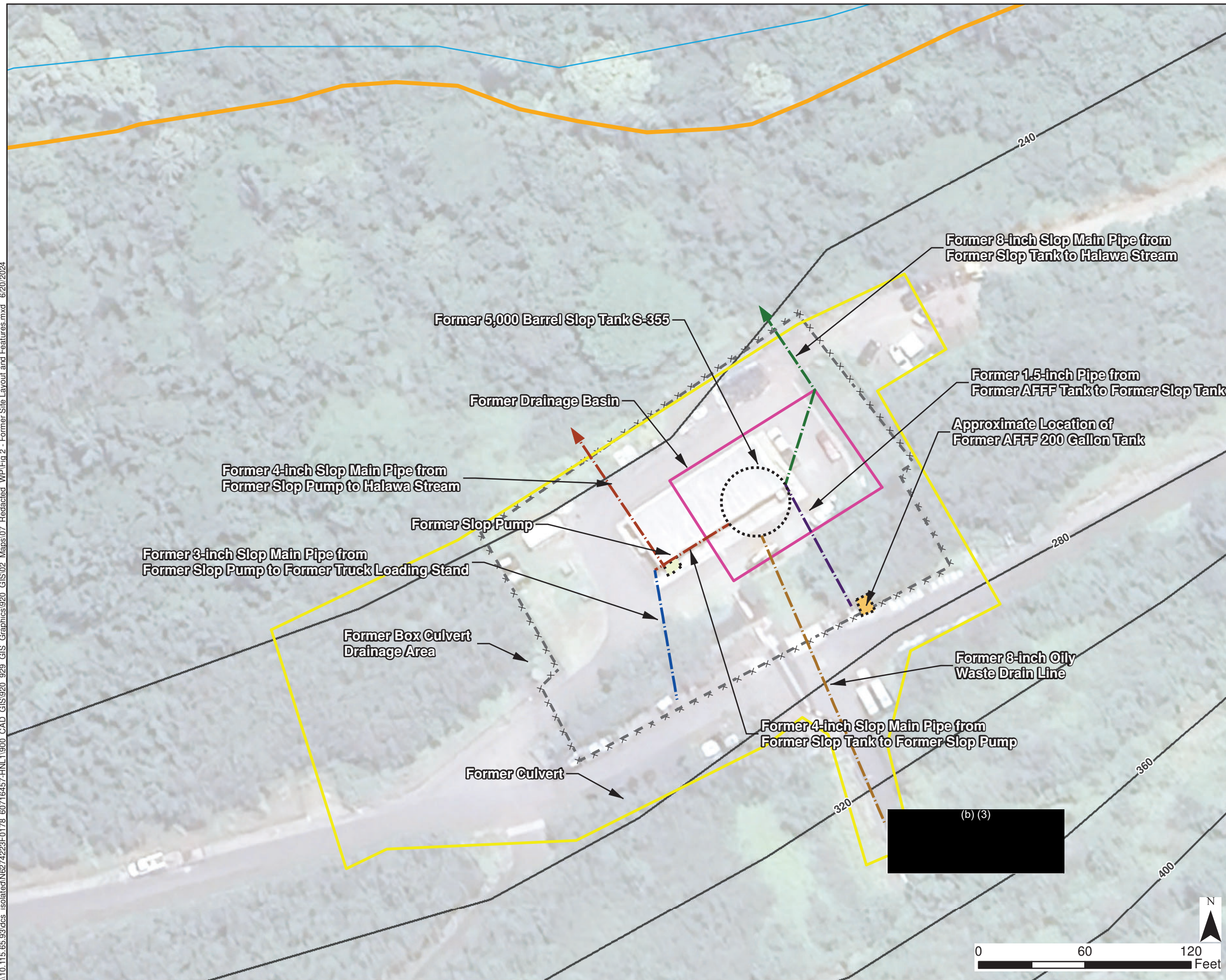


Figure 2
Area A Former Site Layout and Features
Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substance
Release at Red Hill Bulk Fuel Storage Facility
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

(b) (3)

Figure 3
Current Site Layout and Features
Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substance
Release at Red Hill Bulk Fuel Storage Facility
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

\\10.115.65.93\docs_isolated\N6274223F0178_60716457-HNL11900_CAD_GIS\920_929_GIS_Graphics\920_GIS\02_Maps\07_Redacted_WP\Fig 4 - Previous Confirmation Sample Locations_rev.mxd 6/20/2024

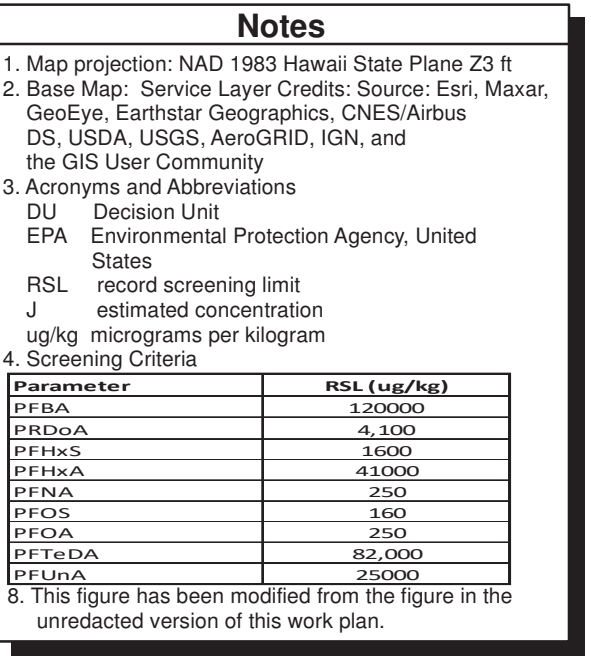
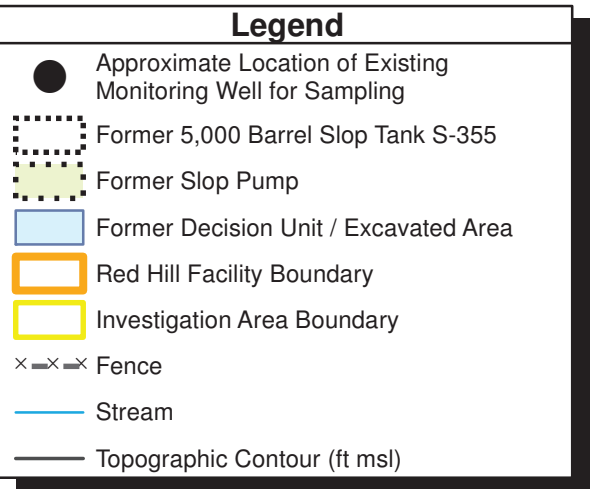
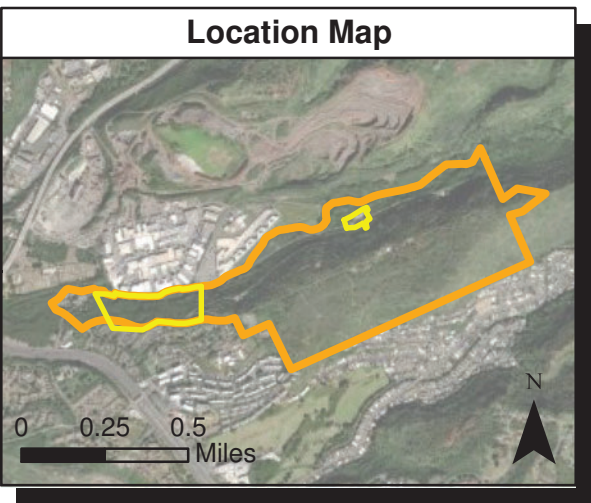
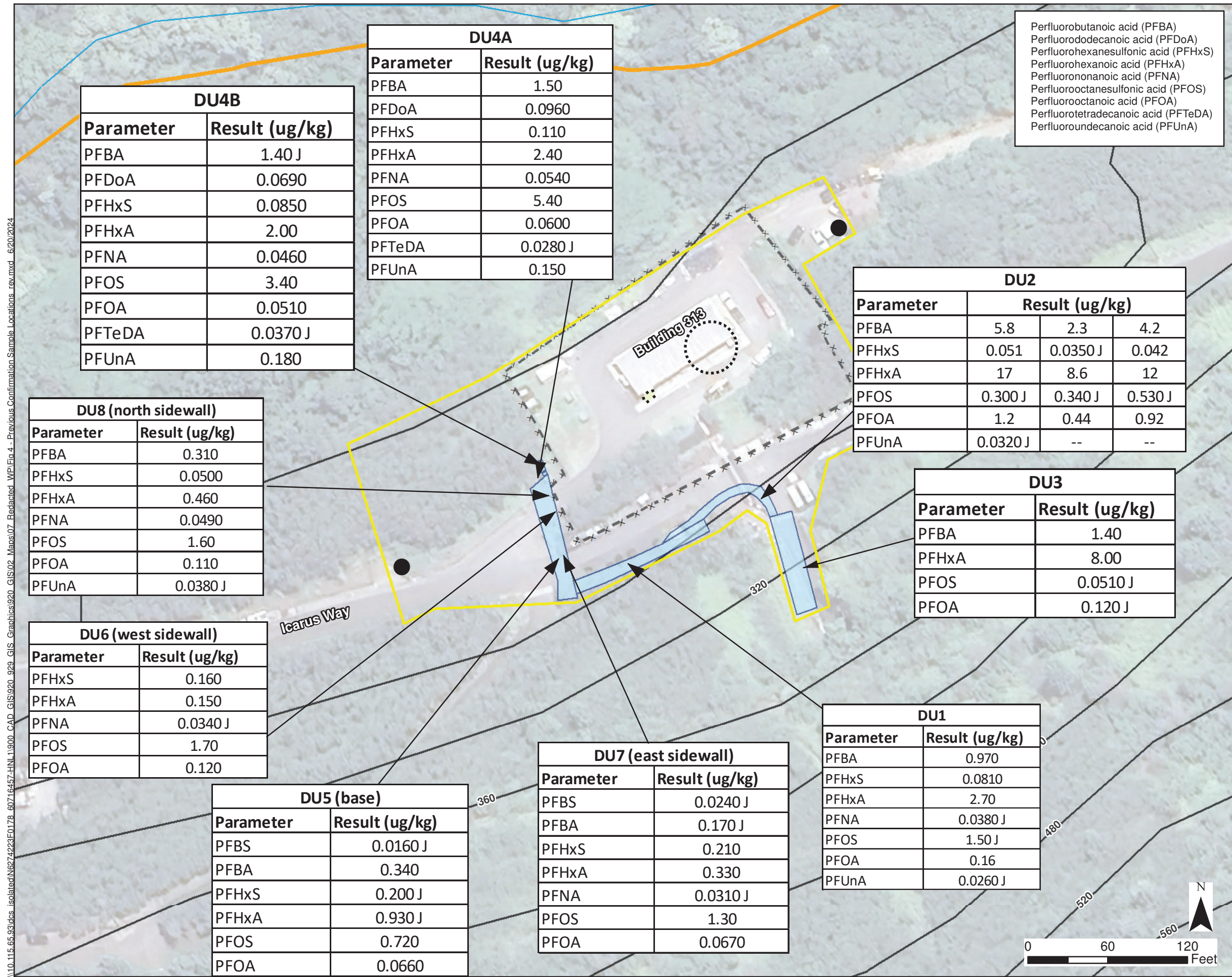


Figure 4
Area A Previous Confirmation Sample / Former Decision Unit Soil Results
Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substance
Release at Red Hill Bulk Fuel Storage Facility
Red Hill Bulk Fuel Storage Facility
JBPBH, O'ahu, Hawai'i

(b) (3)

Figure 5
Baseline Groundwater Sampling
Detected PFAS
Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substance
Release at Red Hill Bulk Fuel Storage Facility
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

(b) (3)

Figure 6
Pictorial Conceptual Site Model - Area A
Remedial Investigation Work Plan
Per-and Polyfluoroalkyl Substances Release
at Red Hill Bulk Fuel Storage Facility
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

(b) (3)

Figure 7
Pictorial Conceptual Site Model - Area B
Remedial Investigation Work Plan
Per-and Polyfluoroalkyl Substances Release
at Red Hill Bulk Fuel Storage Facility
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

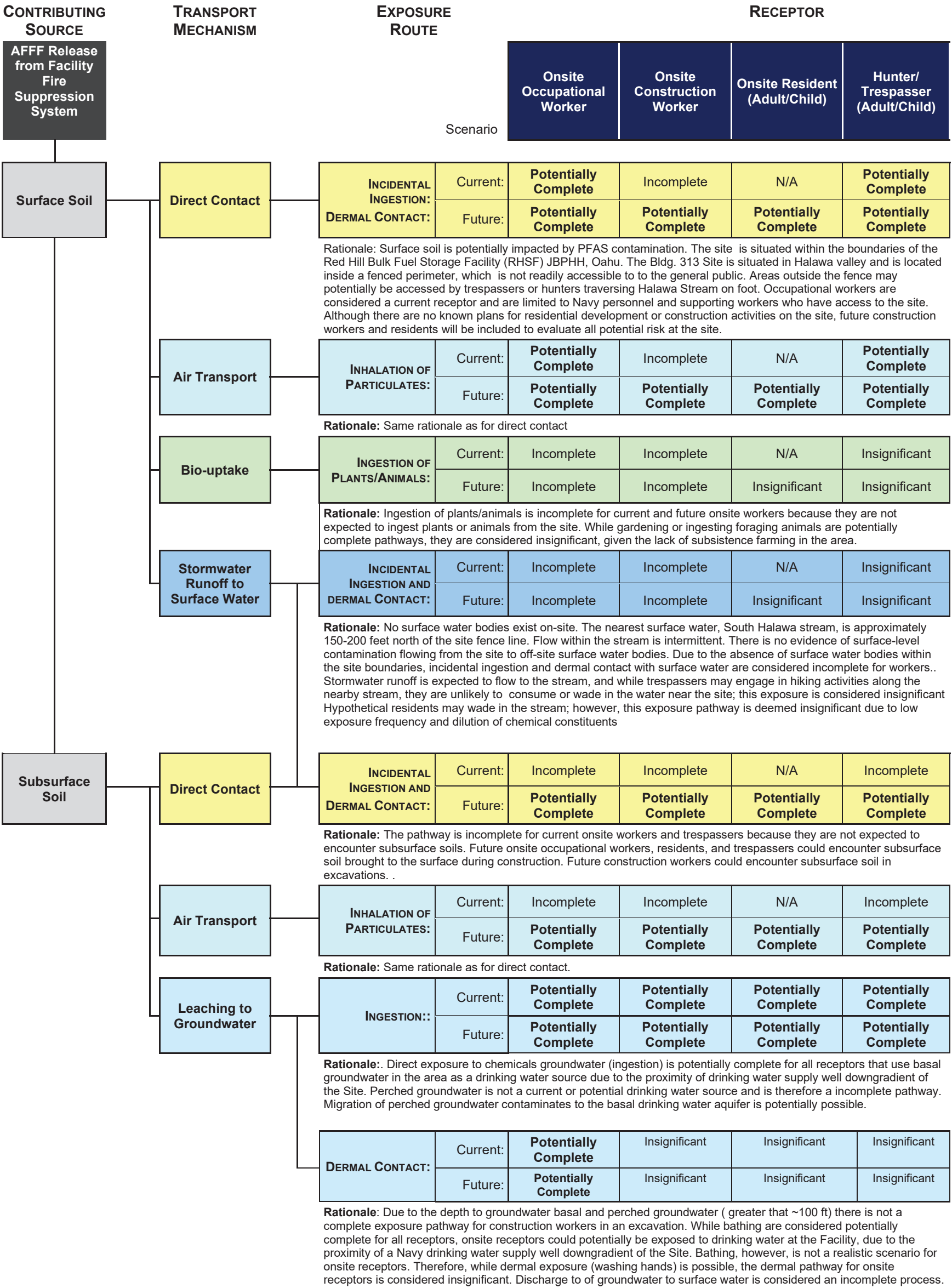
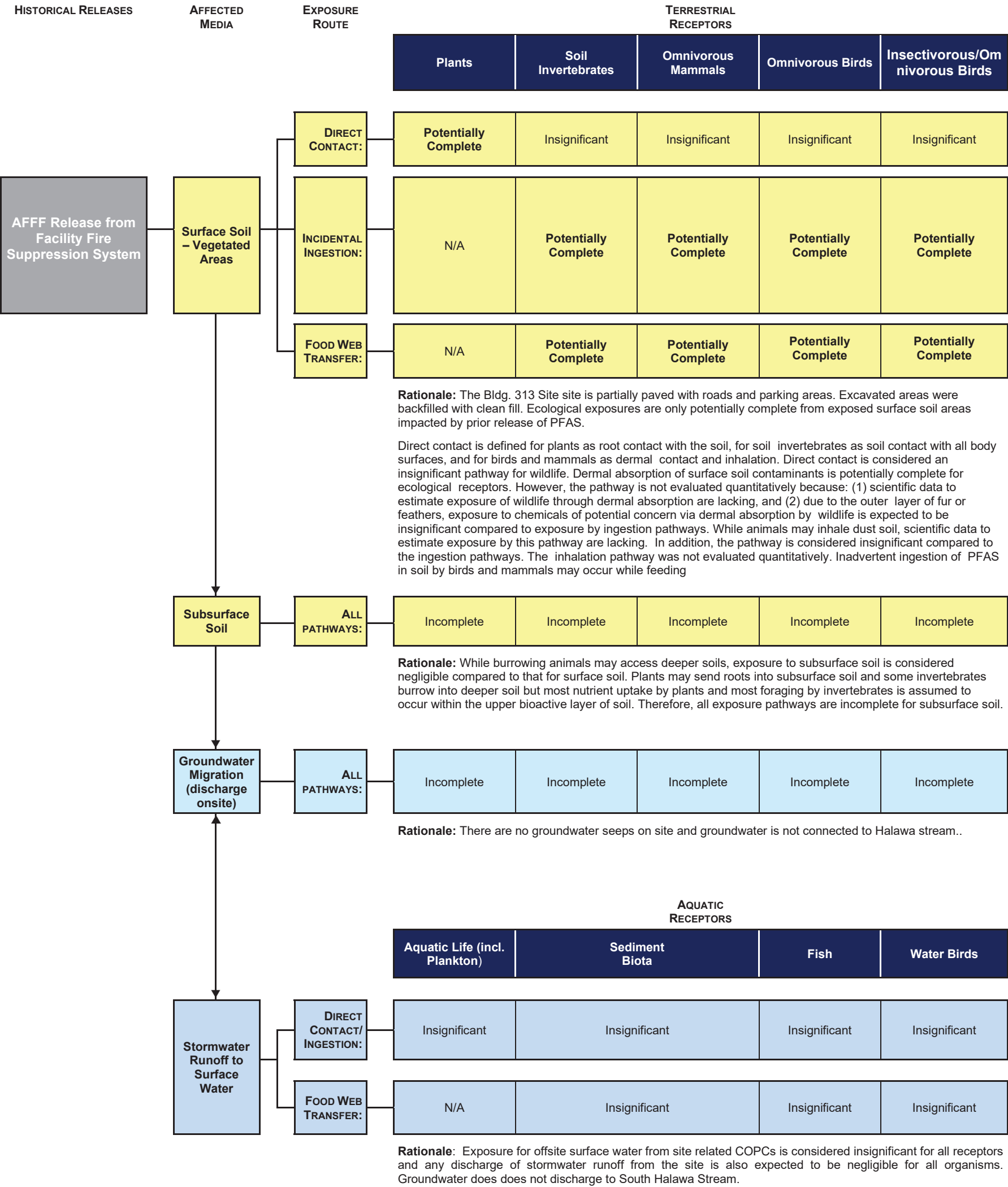


Figure 8
Human Health Exposure Pathway Evaluation
Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
at Red Hill Bulk Fuel Storage Facility
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i



N/A
COPC

Not applicable: Exposure route does not exist, or is not normally evaluated as such in ecological risk assessment.
chemical of potential concern

Figure 9
Ecological Conceptual Site Model/Exposure Pathway Evaluation
In-Progress Draft
Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
at Red Hill Bulk Fuel Storage Facility
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

\\10.115.65.93\dcs_isolated\N6274223\F0178_60716457-HNL\1900_CAD_GIS\920_929_GIS_Graphics\920_GIS\02_Maps\07_Redacted_WP\Fig 10 - Area A Proposed Sampling Locations.mxd 6/20/2024

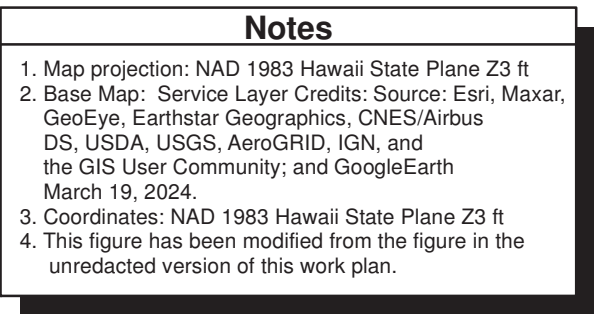
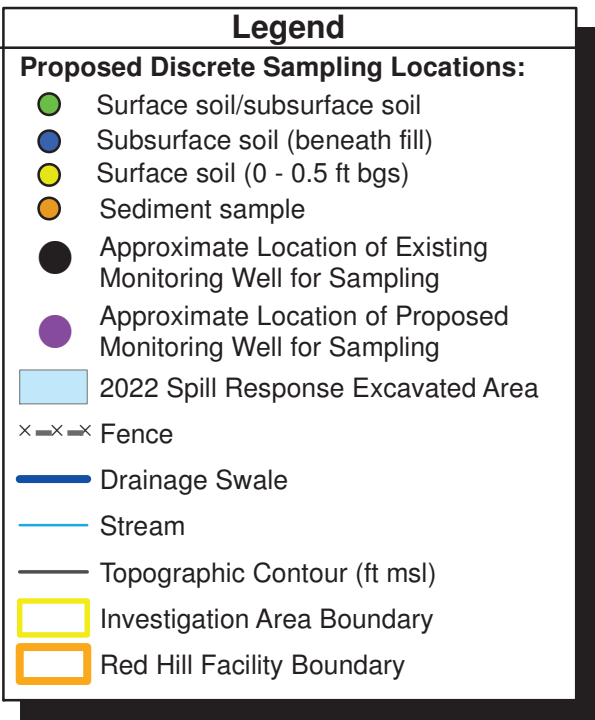
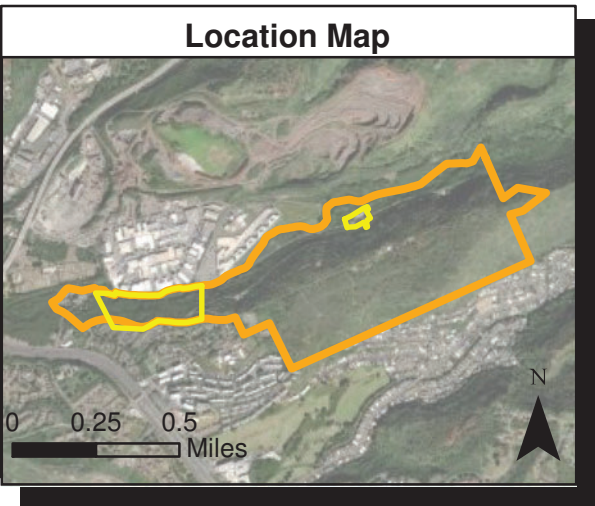
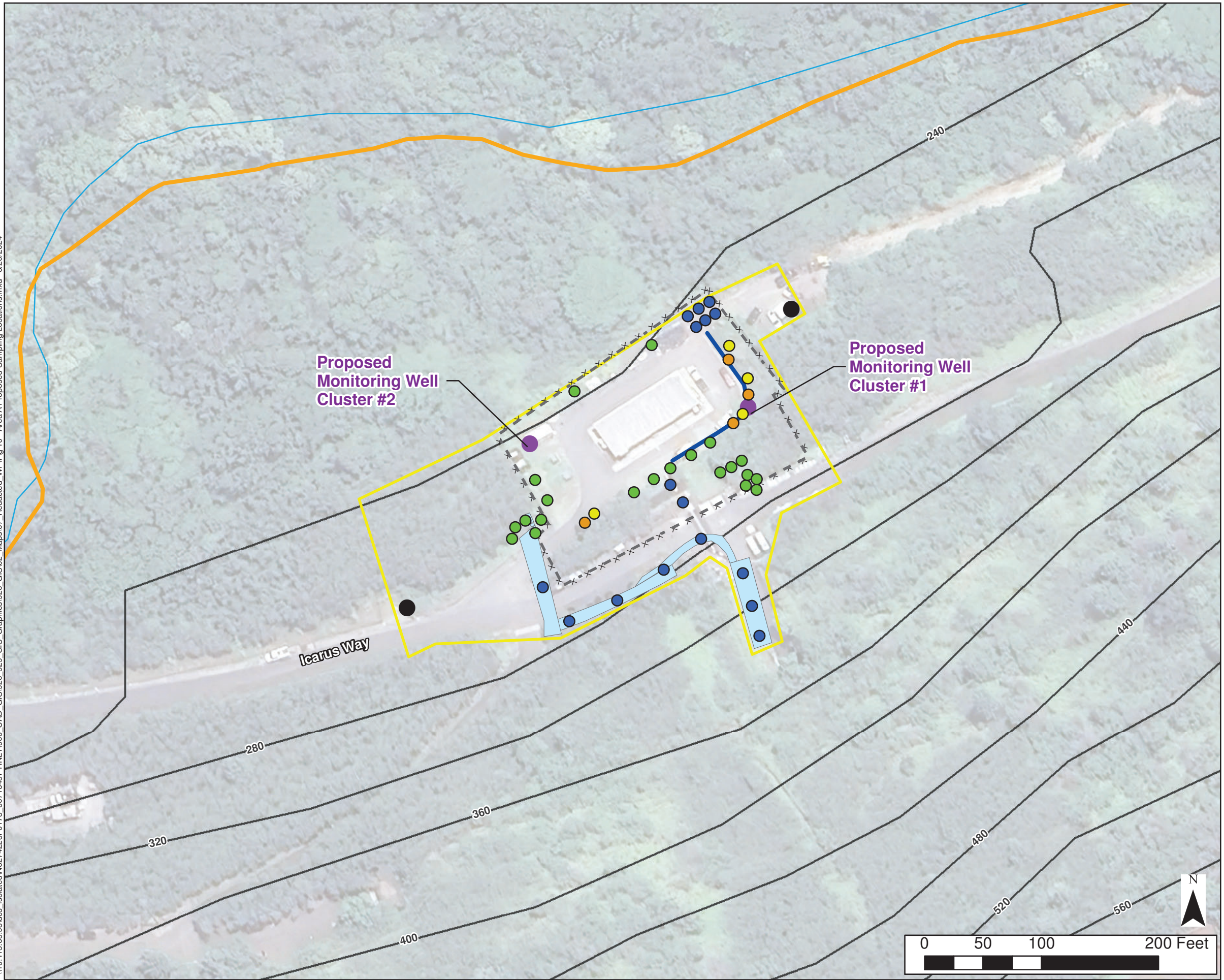
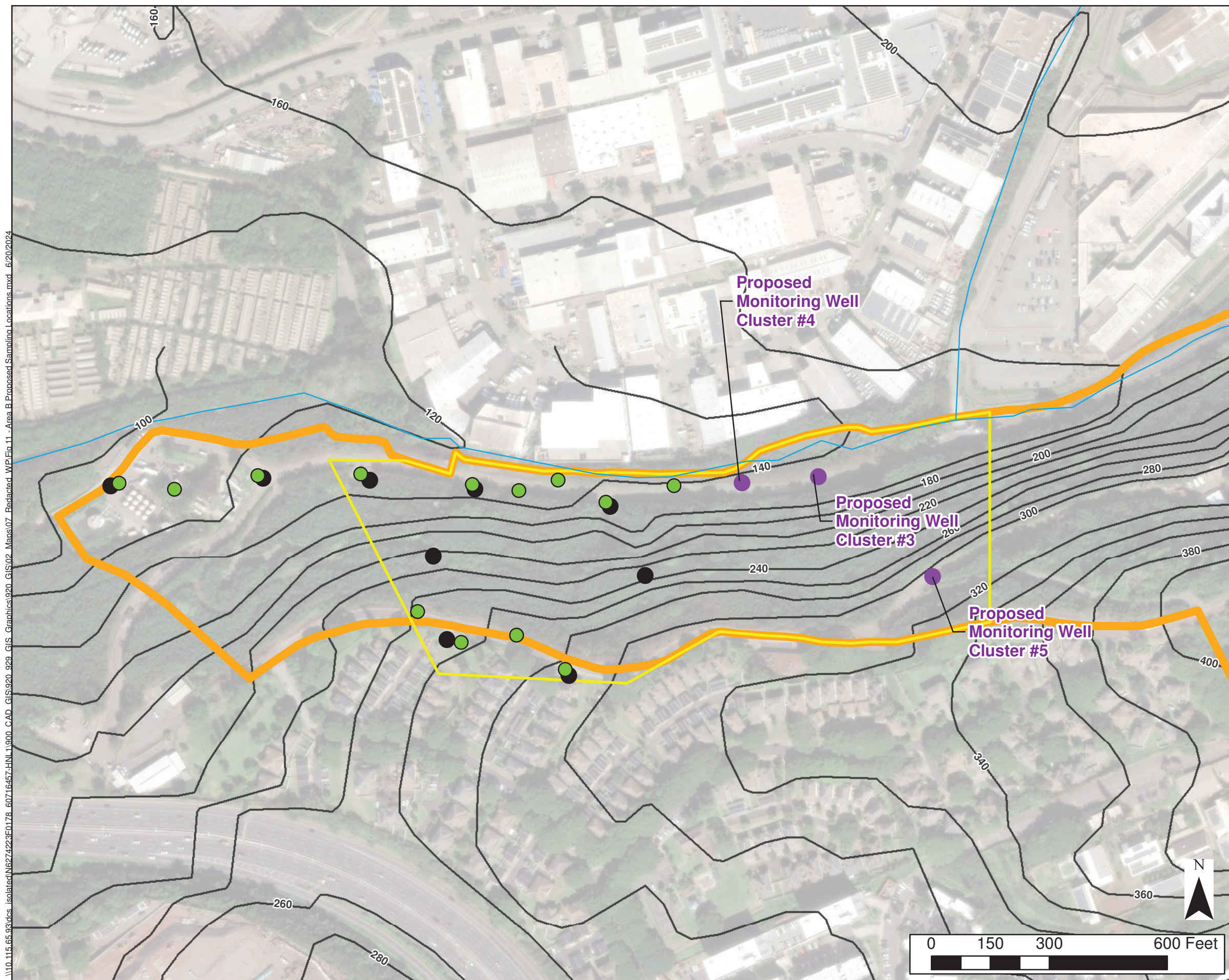
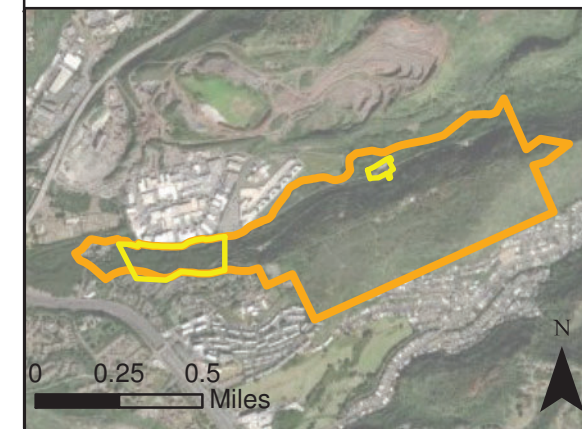


Figure 10
Proposed Sampling Locations - Area A
Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substance
Release at Red Hill Bulk Fuel Storage Facility
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

\\10.115.65.93\dcms_isolated\N6274223\F0178_60716457-HNL\1900_CAD_GIS\920_929_GIS\920_929_Graphics\920_GIS\02_Maps\07_Redacted_WP\Fig.11 - Area B Proposed Sampling Locations.mxd 6/20/2024



Location Map



Legend

- Soil Sample Locations
- Approximate Location of Proposed Monitoring Well for Sampling
- Approximate Location of Proposed Basal Monitoring Well and Perched Monitoring Well Cluster
- Stream
- Topographic Contour (ft msl)
- Red Hill Shaft Pump House
- Investigation Area Boundary
- Red Hill Facility Boundary

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; and GoogleEarth March 19, 2024.
- Coordinates: NAD 1983 Hawaii State Plane Z3 ft
- This figure has been modified from the figure in the unredacted version of this work plan.

Figure 11
Proposed Soil Sampling Locations - Area B
Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substance
Release at Red Hill Bulk Fuel Storage Facility
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

Appendix B:
Standard Operating Procedures
(on CD-ROM at end of document)

I. Field Procedures

Procedure I-A Planning

Procedure I-A-6 Investigation-Derived Waste Management

Procedure I-A-8 Sample Naming

Procedure I-B Sampling

Procedure I-B-1 Soil Sampling

Procedure I-B-2 Geophysical Testing

Procedure I-C Well Construction and Well Development

Procedure I-C-3 Monitoring Well Sampling

Procedure I-F Equipment Decontamination

Procedure I-H Direct-Push Sampling Techniques

Procedure I-I Land Surveying

II. 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

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 (40 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 D), 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 <i>drum</i> 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)	
<input type="checkbox"/> Soil	_____
<input type="checkbox"/> Water	_____
<input type="checkbox"/> Solid Waste	_____
<input type="checkbox"/> Other	_____
PROJECT TYPE	
<input type="checkbox"/> RI	<input type="checkbox"/> RFI
<input type="checkbox"/> UST	<input type="checkbox"/> 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.

[illegible]

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									
LITHOLOGY	DEPTH (FEET)	DESCRIPTION	USCS SYMBOL	Est. % of			COMMENTS		
				G	S	F			
							Description taken _____ feet		
							from _____ end of trench.		

Figure I-B-1-2: Field Log of Trench/Pit

[illegible]

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 3.4 of 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 ($^{\circ}\text{C}$) 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 $4 \pm 2^{\circ}\text{C}$. Preliminary data (Soroni et al. 2001) demonstrate an effective 2-day (48-hour) holding time at $4 \pm 2^{\circ}\text{C}$ 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 $<-7^{\circ}\text{C}$ (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 $4 \pm 2^{\circ}\text{C}$ 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 $4 \pm 2^{\circ}\text{C}$ 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 $4 \pm 2^{\circ}\text{C}$ 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 effects 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 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 <input type="checkbox"/>		HIGH TIDE:		CURRENT TIDE:				
		Falling <input type="checkbox"/>		LOW 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: </td										
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.

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 discrete 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 (\pm) 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 (\pm) 0.1 feet. Benchmark elevation accuracy and elevation of other permanent features, including monitoring wellheads, shall be (\pm) 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 (\pm) 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 (\pm) 0.1 feet. Benchmark elevation accuracy and elevation of other permanent features, including monitoring wellheads, shall be (\pm) 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 (\pm) 3 to 5 meters is required, a licensed surveyor will be required. When a level of precision of (\pm) 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 (\pm) 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.

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 TRIPPLICATES)

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/swerffr/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

Type of Sample	Minimum QC Sample Frequency	
	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/swerffr/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 _____			Sample Disposal Shipment Comments:						
Bill To: Company: Address:			# of containers:						
TAT:			Preservatives:						
Sample ID (EPA ID)			Matrix/QC						
Sample ID (Inventory Use Only)			Field Duplicate (MS/MSD)						
Date Collected			Other (drum, sludge, etc.)						
Time Collected			Water						
Lab ID			TPH 8015B						
Sample ID (EPA ID)			CLP VOCs						
Date Collected			CLP SVOCs						
Time Collected			CLP Pesticides						
Lab ID			CLP Metals						
Sample ID (EPA ID)			EPA 8080 (PCBs only)						
Date Collected			EPA 8240						
Time Collected			EPA 8270						
Lab ID			Total Lead by EPA 6010						
Sample ID (EPA ID)			Extra Volume						
Date Collected			MS/MSD						
Time Collected			HOLD						
Lab ID			Total # of Containers						
Sample ID (EPA ID)			TOTALS:						
Date Collected			For Lab Use						
Time Collected			Lab No.:						
Lab ID			Dear COC match samples: Y or N Broken bottles: 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 ID (EPA ID)			Date						
Date Collected			Time						
Time Collected			Date						
Lab ID			Time						
Sample ID (EPA ID)			Date						
Date Collected			Time						
Time Collected			Date						
Lab ID			Time						
Sample ID (EPA ID)			Date						
Date Collected			Time						
Time Collected			Date						
Lab ID			Time						
Sample ID (EPA ID)			Date						
Date Collected			Time						
Time Collected			Date						
Lab ID			Time						
Sample ID (EPA ID)			Date						
Date Collected			Time						
Time Collected			Date						
Lab ID			Time						
Sample ID (EPA ID)			Date						
Date Collected			Time						
Time Collected			Date						
Lab ID			Time						
Sample ID (EPA ID)			Date						
Date Collected			Time						
Time Collected			Date						
Lab ID			Time						
Sample ID (EPA ID)			Date						
Date Collected			Time						
Time Collected			Date						
Lab ID			Time						
Sample ID (EPA ID)			Date						
Date Collected			Time						
Time Collected			Date						
Lab ID			Time						
Sample ID (EPA ID)			Date						
Date Collected			Time						
Time Collected			Date						
Lab ID			Time						
Sample ID (EPA ID)			Date						
Date Collected			Time						
Time Collected			Date						
Lab ID			Time						
Sample ID (EPA ID)			Date						
Date Collected			Time						
Time Collected									

Generic Chain-of-Custody/Analytical Request Form

Attachment III-E-3
Sample Completed Chain-of-Custody

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:		Samples Affected (List by Accession AND Sample No.)
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)		
<input type="checkbox"/>	Calibration Corr. Coefficient <0.995	<input type="checkbox"/>	Repeat calibration	
<input type="checkbox"/>	%RSD>20%	<input type="checkbox"/>	Made new standards	
<input type="checkbox"/>	Blank >MDL	<input type="checkbox"/>	Reran analysis	
<input type="checkbox"/>	Does not meet criteria:	<input type="checkbox"/>	Sample(s) redigested and rerun	
<input type="checkbox"/>	Spike	<input type="checkbox"/>	Sample(s) reextracted and rerun	
<input type="checkbox"/>	Duplicate	<input type="checkbox"/>	Recalculated	
<input type="checkbox"/>	LCS	<input type="checkbox"/>	Cleaned system	
<input type="checkbox"/>	Calibration Verification	<input type="checkbox"/>	Ran standard additions	
<input type="checkbox"/>	Standard Additions	<input type="checkbox"/>	Notified	
<input type="checkbox"/>	MS/MSD	<input type="checkbox"/>	Other (please explain)	
<input type="checkbox"/>	BS/BSD	<input type="checkbox"/>		
<input type="checkbox"/>	Surrogate Recovery	<input type="checkbox"/>		
<input type="checkbox"/>	Calculations Error	<input type="checkbox"/>		

<input type="checkbox"/>	Holding Times Missed	
<input type="checkbox"/>	Other (Please explain	Comments:

3. Results of Corrective Action	
<input type="checkbox"/>	Return to Control (indicated with)
<input type="checkbox"/>	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 (HNO₃), sulfuric acid (H₂SO₄), 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, HNO₃, H₂SO₄, 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 does 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

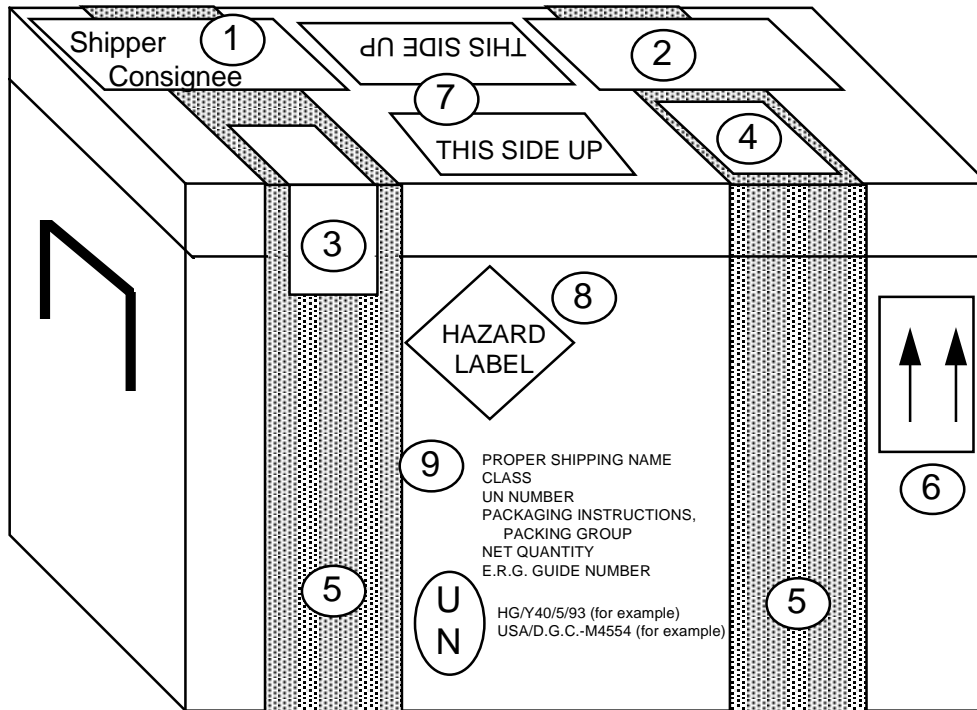
Attachment III-F-6: Commercial Invoice – Soil

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 | 6 DIRECTION ARROWS STICKER - TWO REQUIRED |
| 2 USDA PERMIT (Letter to Laboratory from USDA) | 7 THIS SIDE UP STICKERS |
| 3 CUSTODY SEAL | 8 HAZARD LABEL |
| 4 USDA 2" X 2" SOIL IMPORT PERMIT | 9 HAZARDOUS MATERIAL INFORMATION |
| 5 WATERPROOF STRAPPING TAPE | 10 PACKAGE SPECIFICATIONS |

Attachment III-F-2
Packing Groups

PACKING GROUP OF THE SUBSTANCE	PACKING GROUP I		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
	0	0	0	0	0	0	0

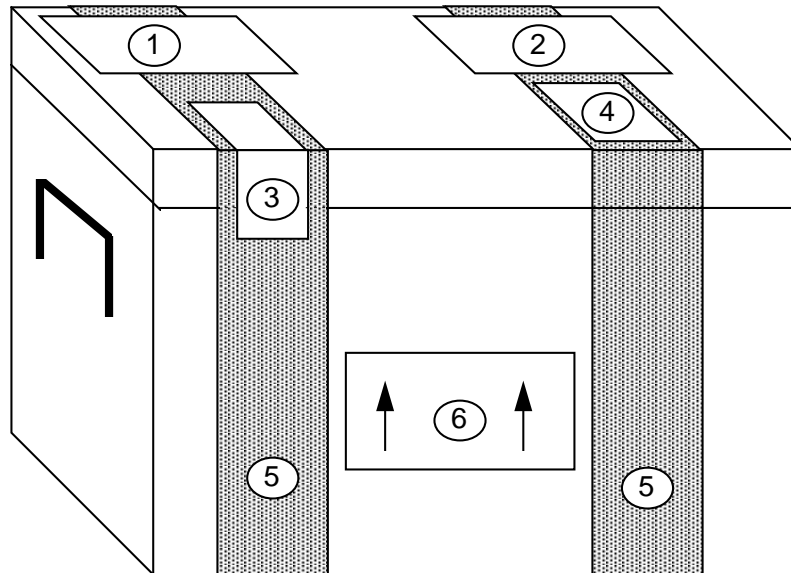
and the applicable UN Numbers are:

Attachment III-F-4
SW-846 Preservative Exception

<u>Measurement</u>	<u>Vol. Req.</u> <u>(mL)</u>	<u>Container</u> ²	<u>Preservative</u> ^{3,4}	<u>Holding Time</u> ⁵
MBAS	250	P,G	Cool, 4°C	48 Hours
NTA	50	P,G	Cool, 4°C	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 4°C 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 (HNO₃) in water solutions at concentrations of 0.15% by weight or less (pH about 1.62 or greater); Sulfuric acid (H₂SO₄) 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				IMPORTER - IF OTHER THAN CONSIGNEE				
COUNTRY OF ORIGIN OF GOODS Guam, USA								
COUNTRY OF ULTIMATE DESTINATION USA								
INTERNATIONAL AIR WAYBILL NO.				<div style="border: 1px solid black; width: 200px; height: 40px; margin: 0 auto;"></div> <p>(NOTE: All shipments must be accompanied by a Federal Express International Air Waybill)</p>				
MARKS/NOS	NO. OF PKGS	TYPE OF PACKAGING	FULL DESCRIPTION OF GOODS	QT Y	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
<div style="border: 1px solid black; padding: 5px;">Check one <input type="checkbox"/> F.O.B. <input type="checkbox"/> C&F <input type="checkbox"/> C.I.F.</div>								

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)

Joe Smith, Ogden

Joe Smith

1/1/94

Name/Title

Signature

Date

Attachment III-F-7
Commercial Invoice – Water

DATE 1/1/94		OF EXPORTATION		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 <Lab Name> <Lab Address>				
COUNTRY Guam, USA		OF EXPORT		IMPORTER - IF OTHER THAN CONSIGNEE				
COUNTRY Guam, USA		OF ORIGIN OF GOODS						
COUNTRY USA		OF ULTIMATE DESTINATION						
INTERNATIONAL AIR WAYBILL NO.				<div style="border: 1px solid black; width: 200px; height: 40px; margin: 0 auto;"></div> (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	QT Y	UNIT OF MEASURE	WEIGHT	UNIT VALUE	TOTAL VALUE
	3	coolers	Water samples for lab analysis only				\$1.00	\$3.00
		TOTAL NO. OF PKGS.				TOTAL WEIGHT		TOTAL INVOICE VALUE
		3						\$3.00
<div style="text-align: right;">Check one <input type="checkbox"/> F.O.B. <input type="checkbox"/> C&F <input type="checkbox"/> C.I.F.</div>								

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)

Joe Smith, Ogden

Joe Smith

1/1/94

Name/Title

Signature

Date

**Attachment III-F-8
Soil Import Permit**



UNITED STATES
DEPARTMENT OF
AGRICULTURE

Animal and Plant
Health Inspection
Service

Plant Protection and
Quarantine

Soil Permit

Permit
Number: S-52299

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

Approving Official *Deborah M. Knott*
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

<p>U.S. DEPARTMENT OF AGRICULTURE</p> <p>ANIMAL AND PLANT HEALTH INSPECTION SERVICE</p> <p>PLANT PROTECTION AND QUARANTINE</p> <p>HYATTSVILLE, MARYLAND 20782</p> <p>SOIL SAMPLES</p> <p>RESTRICTED ENTRY</p> <hr/> <p>The material contained in this package is imported under authority of the Federal Plant Pest Act of May 23, 1957.</p> <hr/> <p>For release without treatment if addressee is currently listed as approved by Plant Protection and Quarantine.</p> <hr/> <p>PPQ FORM 550 <i>Edition of 12/77 may be used</i></p> <p>(JAN 83)</p>
--

Soil Samples Restricted Entry Label

<p>SOIL ENCLOSED</p> <p>Origin of Soil _____</p>
--

Soil Origin Label

Appendix C:
Accident Prevention Plan

(provided under separate cover)

Appendix D: Analytical Data Package Requirements

LC-MS/MS “Full” Deliverables

Item #	Deliverable
1	Chain of Custody
2	Sample results with analysis and extraction/preparation dates
3	Analyte Identification (correct CAS number, two ion transitions documentation, S/N ratios, ion transition ratios [both transitions])
4	Summary of MS/MSD/Duplicate recoveries and control limits (listing or link with associated samples -when requested)
5	Summary of LCS/LCSD recoveries and control limits (listing or link with associated samples)
6	Method blanks (listing or link with associated samples)
7	Summary of instrument blanks - metals only (listing or link with associated samples)
8	Summary of surrogate recoveries
9	Summary of initial calibration data (RRF and %RSD, or r if applicable)
10	Summary of continuing calibration (%D and RRF)
11	Summary of internal standards (area response and retention time)
12	Summary of instrument tuning (listing or link with associated samples, must show 12 hour clock)
13	Injection logs
14	Extraction/preparation logs
15	Case narrative to discuss anomalies
16	Raw data associated with the summary forms listed above
17	Raw data for item #2 which includes chromatograms, log books, quantitation reports, and spectra

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

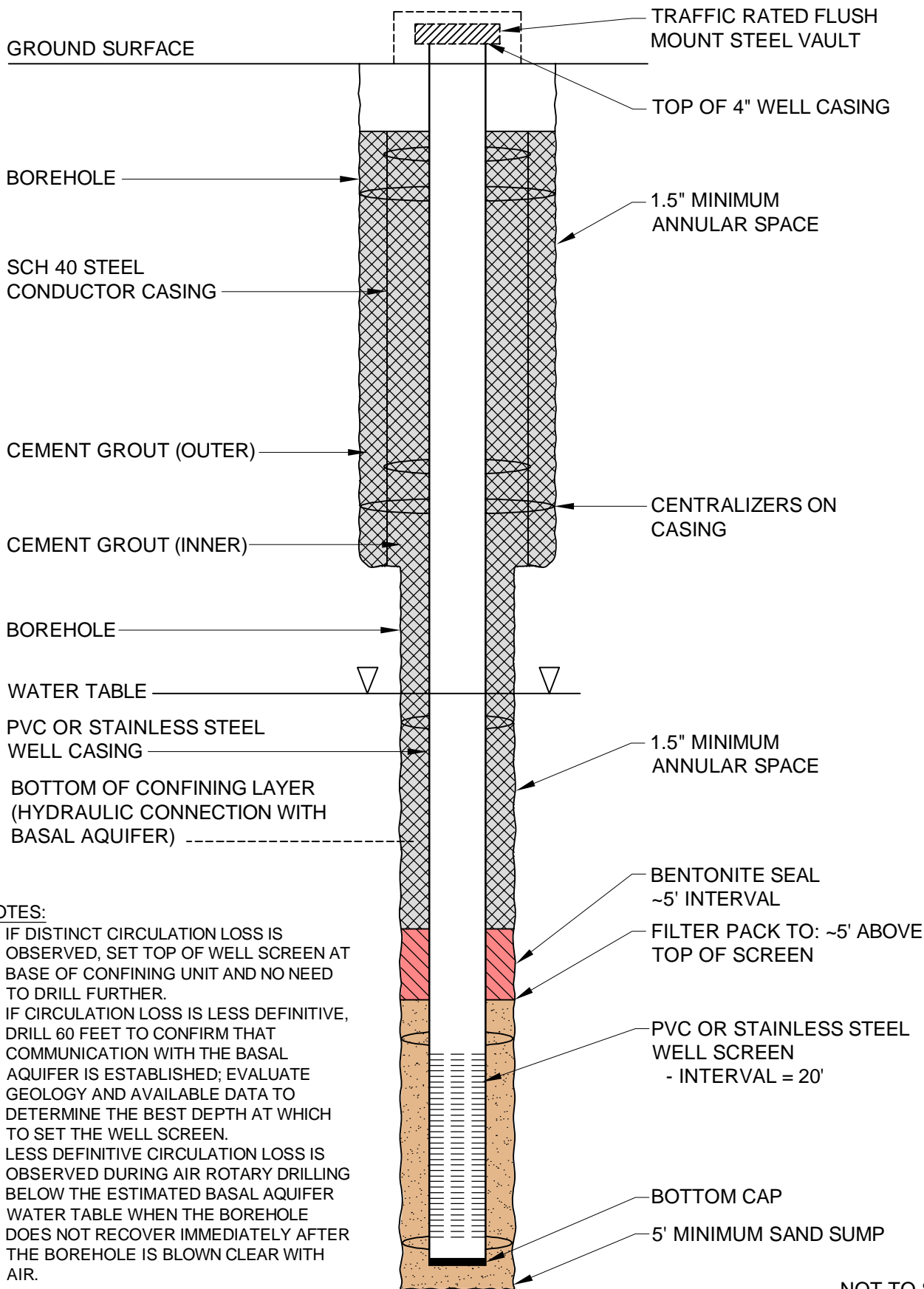
Miscellaneous Analysis Deliverables

Item #	Deliverable
1	Chain of Custody
2	Sample results with analysis and extraction/preparation dates
3	Summary of duplicate recoveries and control limits (listing or link with associated samples)
4	Method blanks (listing or link with associated samples)
5	Extraction/preparation logs
6	Case narrative to discuss anomalies
7	Raw data associated with the summary forms listed above
8	Raw data for item #2 which includes log books

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

Appendix E:
Well Completion Diagrams and Monitoring Well Designs

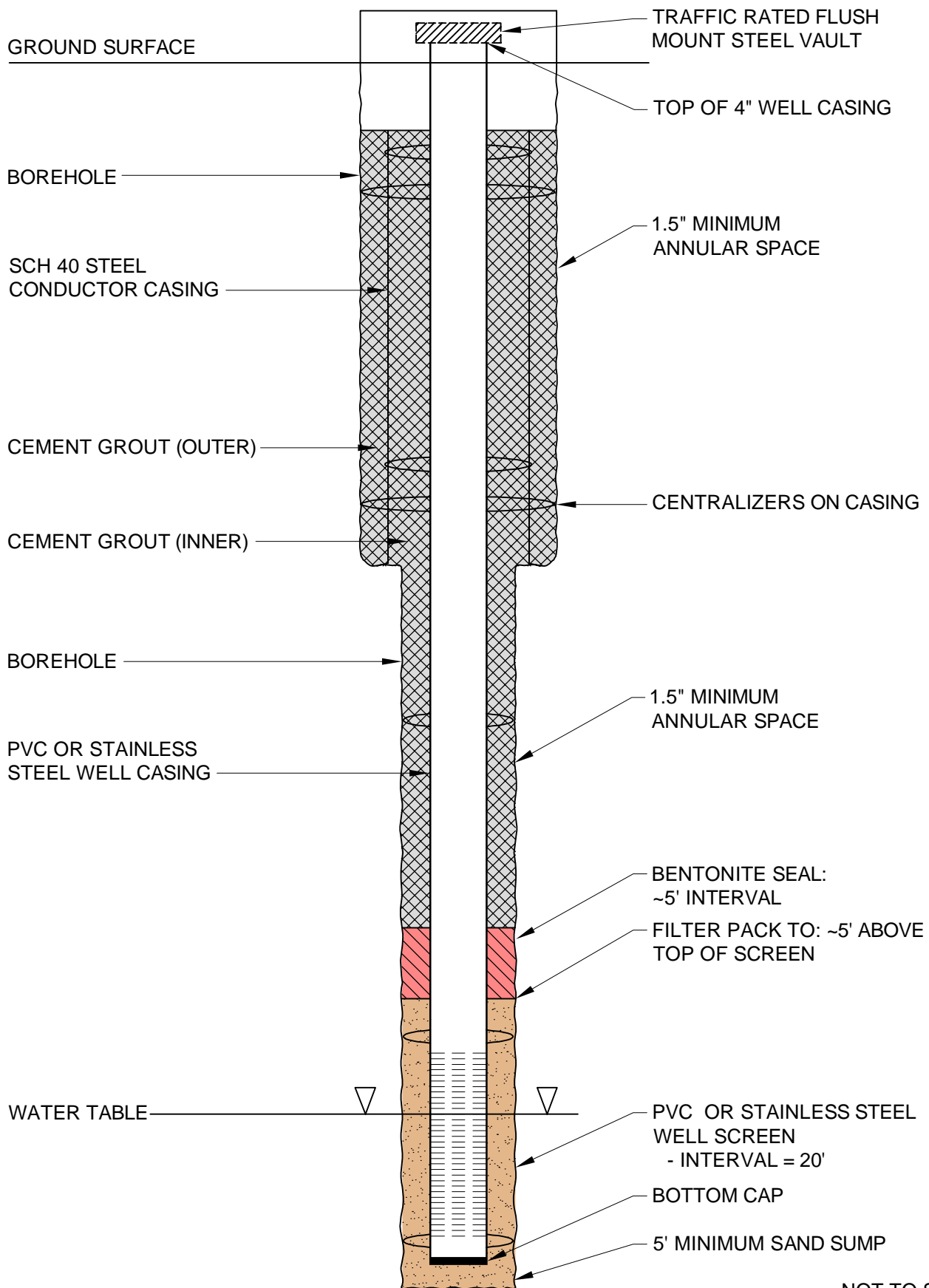
\\vescomat.com\UCS_Hedrick\CLEAN\CM\N827422\3707B_40718457-HILL\1\POD_CAD_GIS\10_0_CAD_20-SHEETS\Cross Section\CrossSec_TrimM_ConfinedCond_Cr_20240505.dwg 05/05/24 4:07 PM Namod



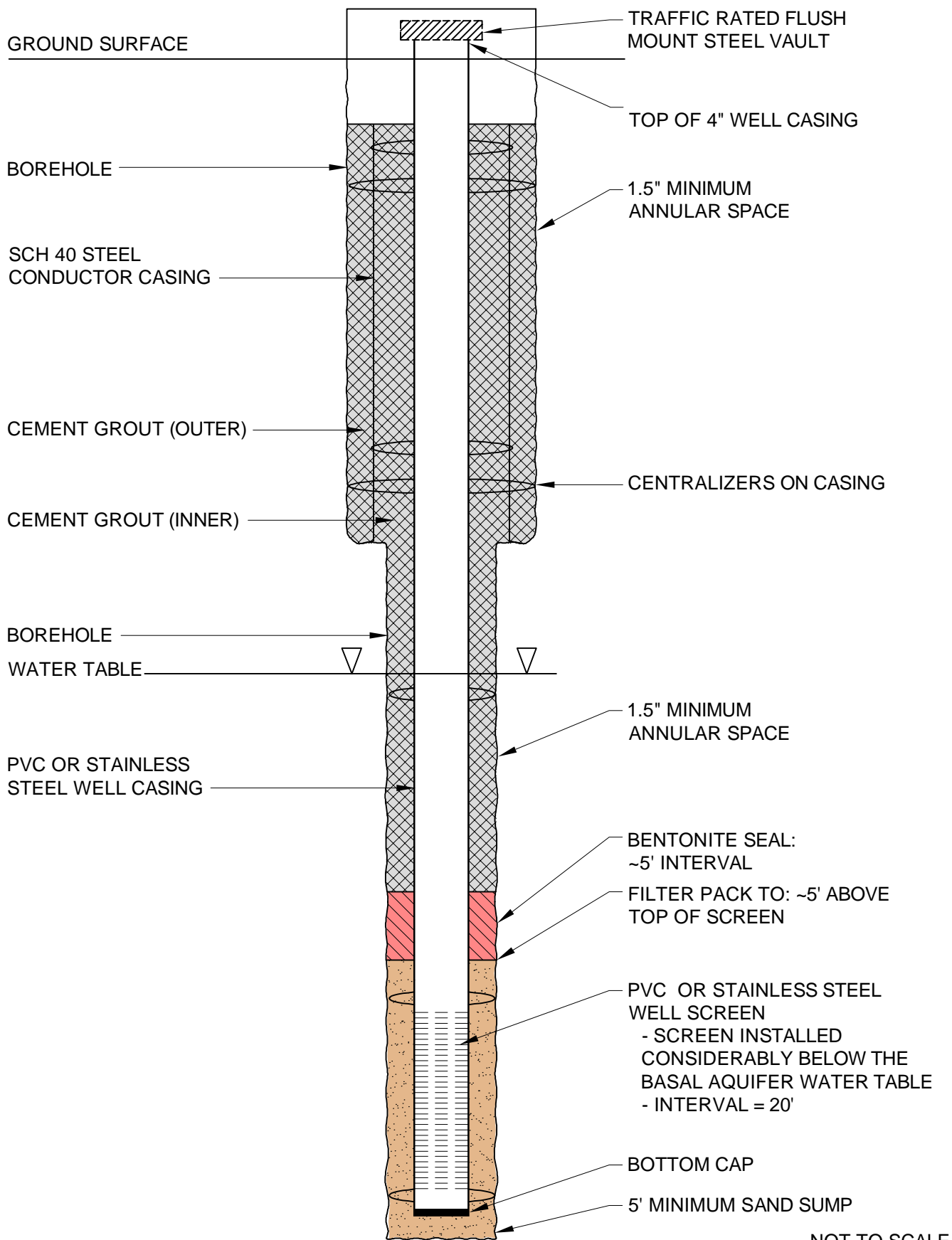
NOTES:

1. IF DISTINCT CIRCULATION LOSS IS OBSERVED, SET TOP OF WELL SCREEN AT BASE OF CONFINING UNIT AND NO NEED TO DRILL FURTHER.
2. IF CIRCULATION LOSS IS LESS DEFINITIVE, DRILL 60 FEET TO CONFIRM THAT COMMUNICATION WITH THE BASAL AQUIFER IS ESTABLISHED; EVALUATE GEOLOGY AND AVAILABLE DATA TO DETERMINE THE BEST DEPTH AT WHICH TO SET THE WELL SCREEN.
3. LESS DEFINITIVE CIRCULATION LOSS IS OBSERVED DURING AIR ROTARY DRILLING BELOW THE ESTIMATED BASAL AQUIFER WATER TABLE WHEN THE BOREHOLE DOES NOT RECOVER IMMEDIATELY AFTER THE BOREHOLE IS BLOWN CLEAR WITH AIR.

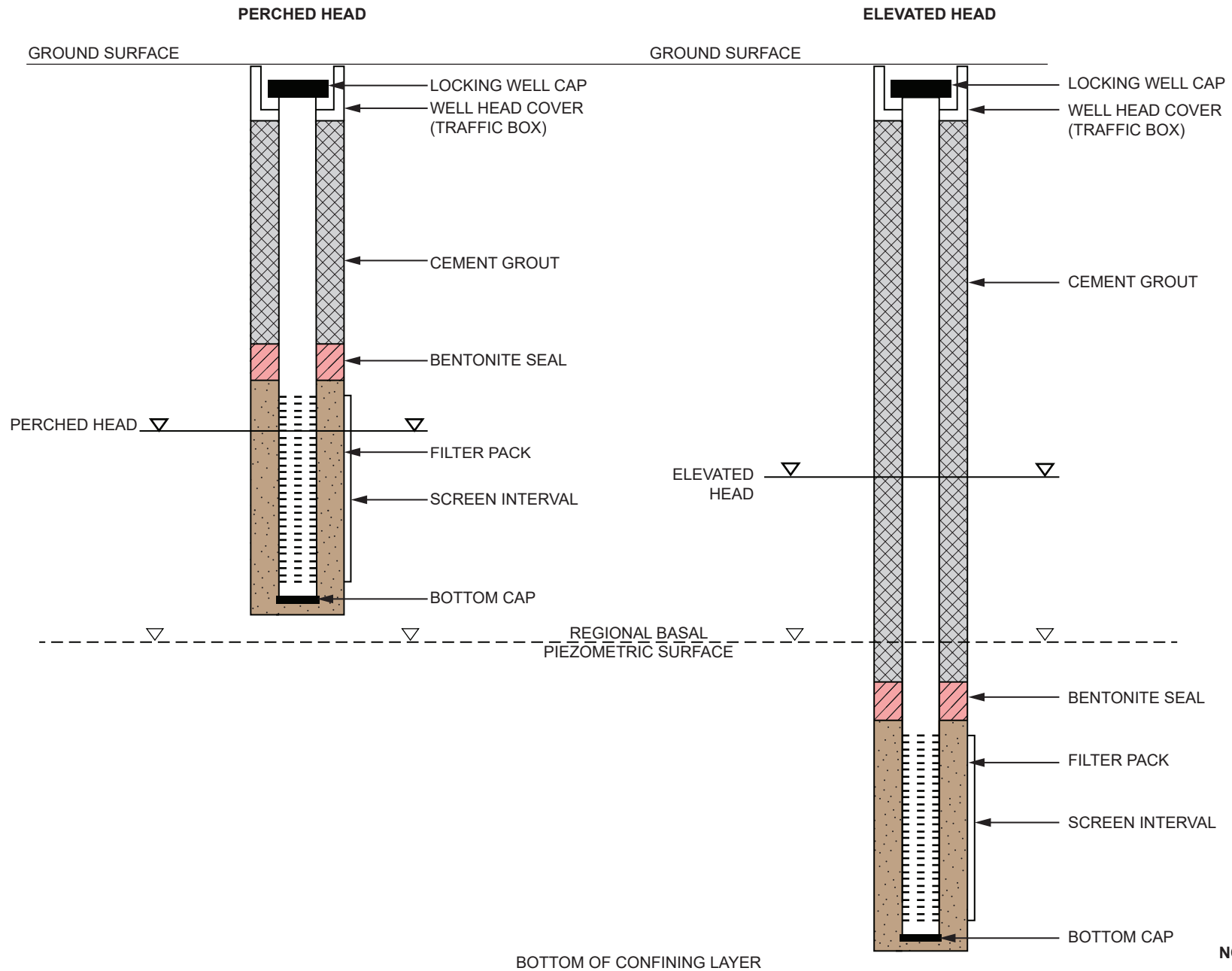
Typical Well Construction Diagram for Monitoring Well (Confined Conditions)
Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substance Release at Red Hill Bulk Fuel Storage Facility
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i



Typical Well Construction Diagram for Monitoring Well (Unconfined Conditions)
Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substance Release at Red Hill Bulk Fuel Storage Facility
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i



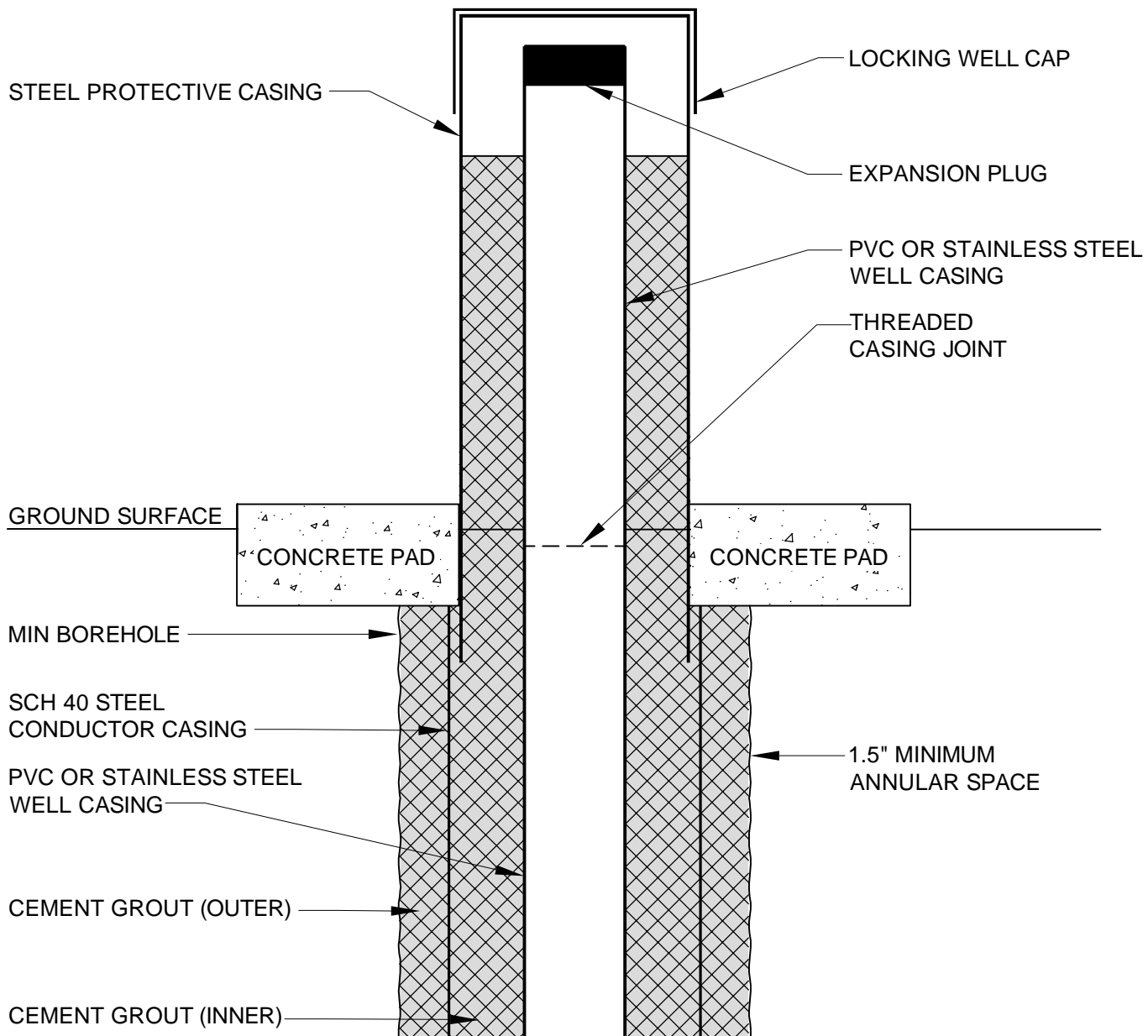
Typical Well Construction Diagram for Monitoring Well (Unconfined Conditions - Deep Well)
Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substance Release at Red Hill Bulk Fuel Storage Facility
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i



Typical Well Construction Diagram for Perched and Elevated Head Aquifers
Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substance Release at Red Hill Bulk Fuel Storage Facility
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

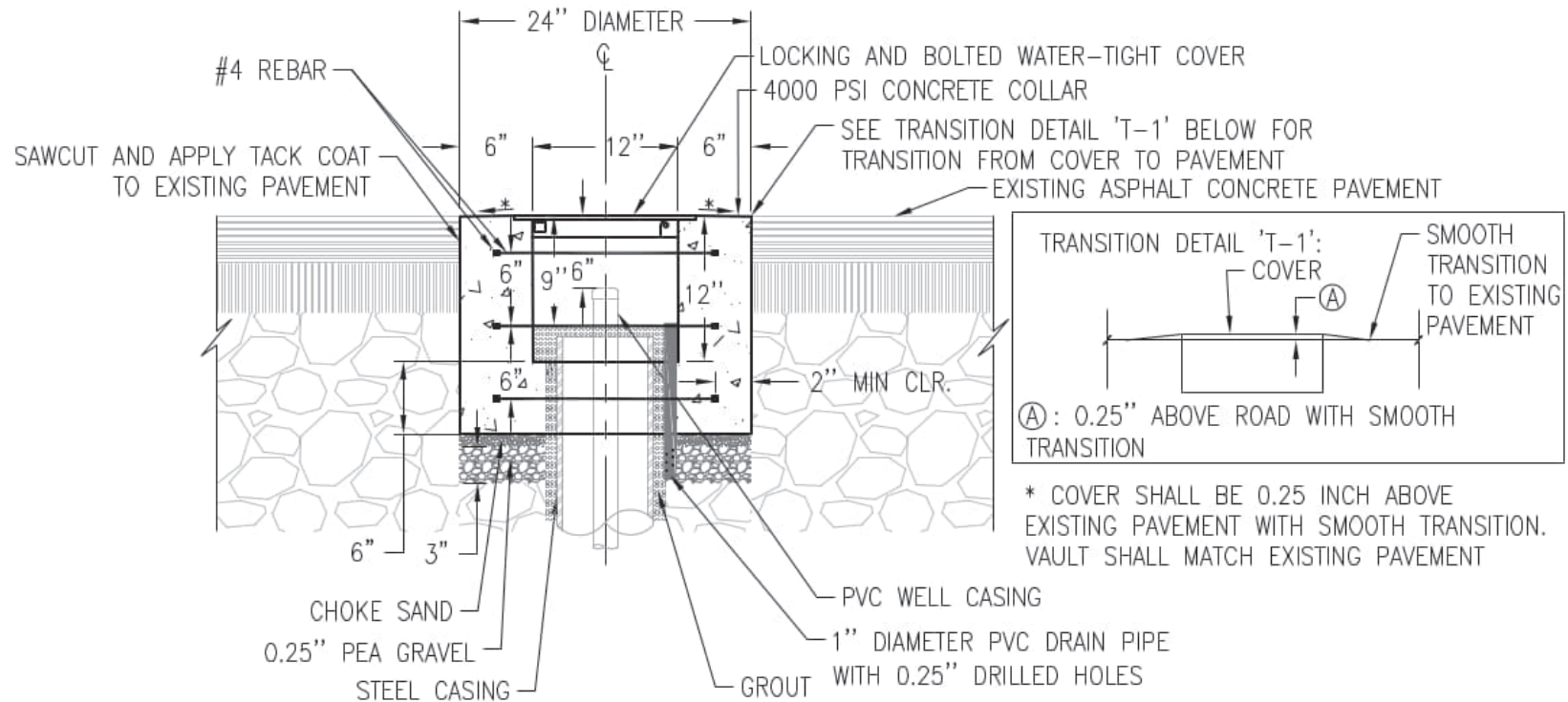
Appendix F: Surface Completion

\\nascomad.com\PCS_Installed\CLEAN\CM\627422320178_60716457-HILL\900_CAD_GIS\VPID_CAD\20-SHEETS\Cross Section\MonumentStyle WellSurfComp_Cr_20240505.dwg 05/05/24 6:38 PM Namrod



NOT TO SCALE

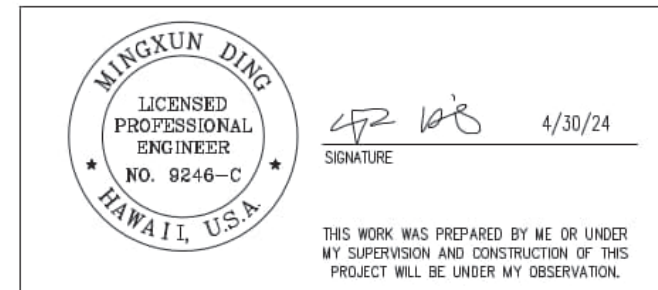
Typical Monument Style Well Surface Completion
Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substance Release at Red Hill Bulk Fuel Storage Facility
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i



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

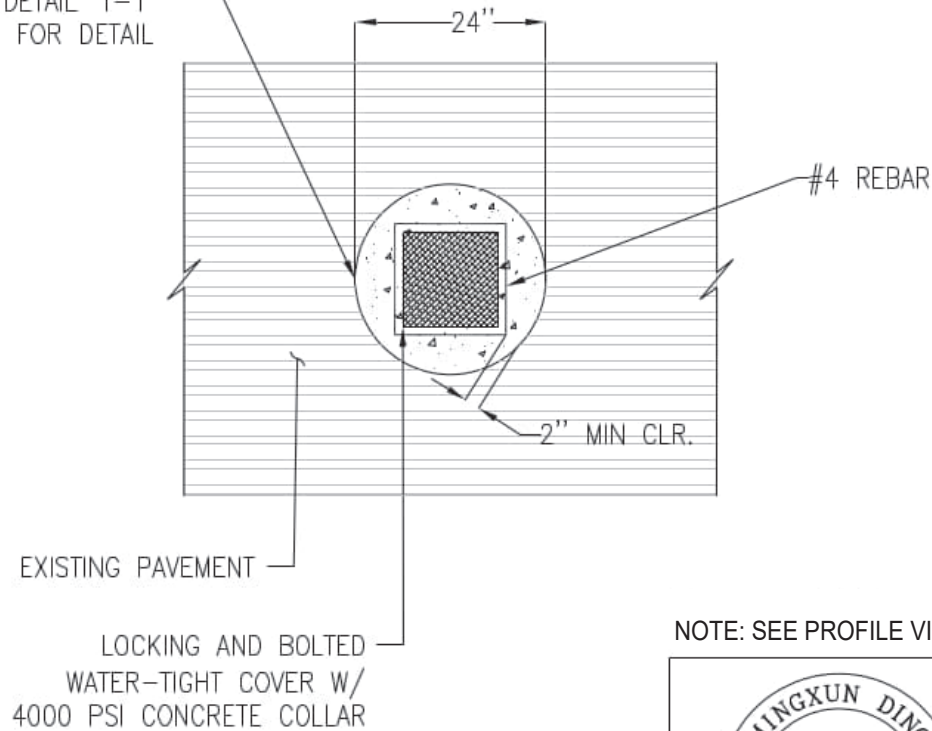
ASPHALT PATCH: USE 4" CITY MIX #4 ACP

PROFILE VIEW



Flush-Mount Vault Well Surface Completion
Remedial Investigation Work
Plan Per- and Polyfluoroalky Substance Release at Red Hill Bulk Fuel Storage Facility
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

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

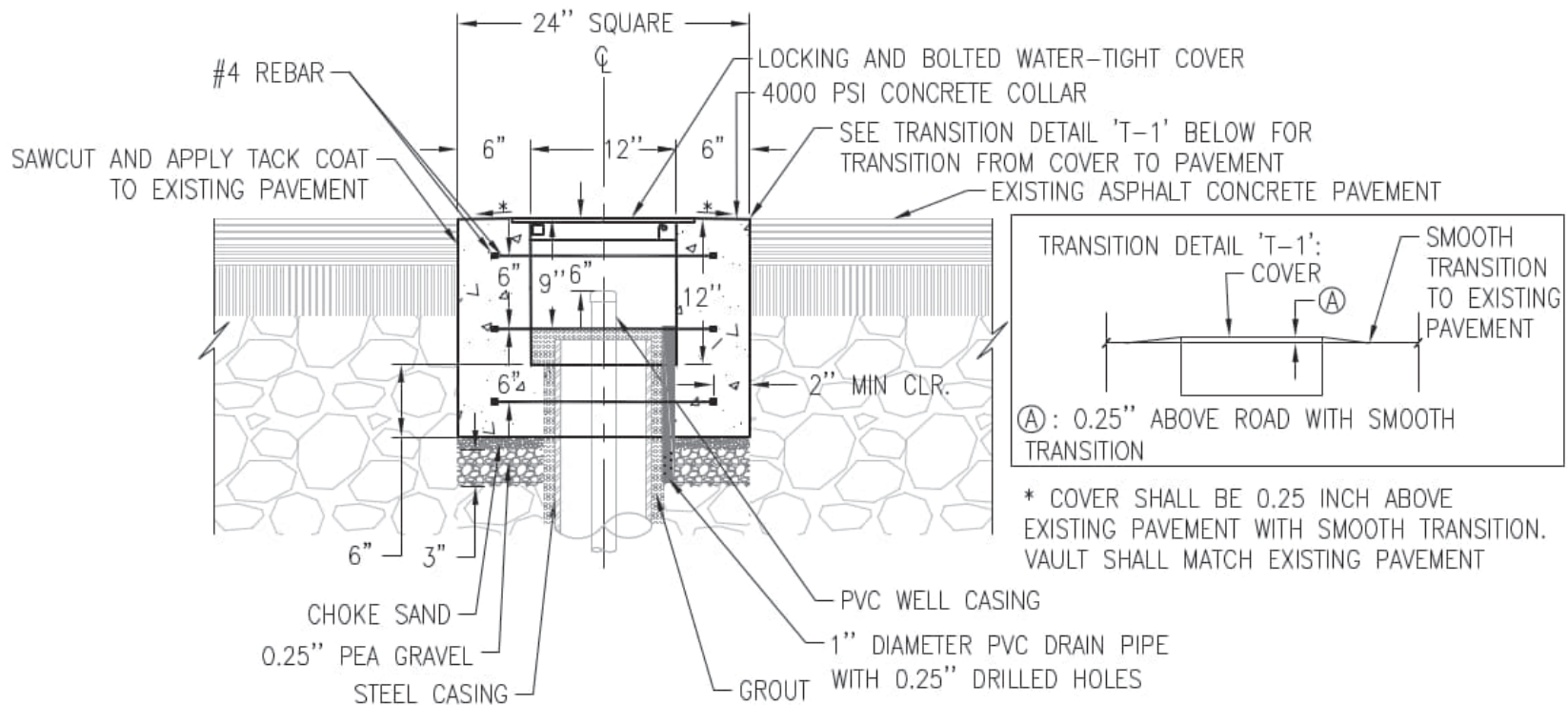


PLAN VIEW

NOTE: SEE PROFILE VIEW

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

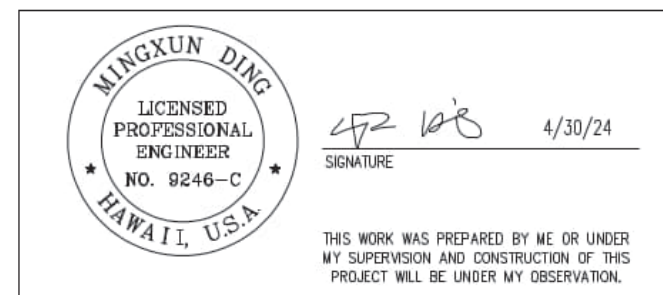
Flush-Mount Vault Well Surface Completion (cont.)
Remedial Investigation Work
Plan Per- and Polyfluoroalky Substance Release at Red Hill Bulk Fuel Storage Facility
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i



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

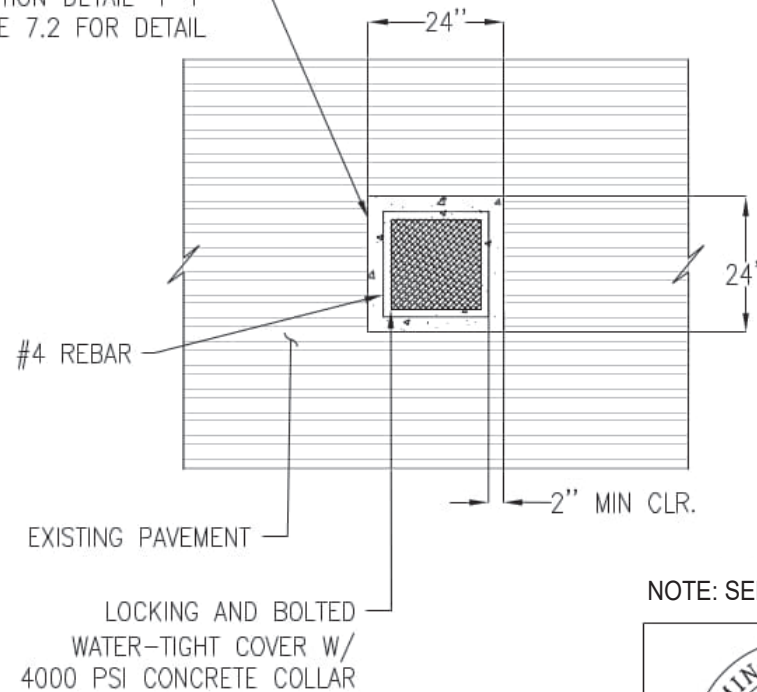
ASPHALT PATCH: USE 4" CITY MIX #4 ACP

PROFILE VIEW (SQUARE)



Flush-Mount Vault Well Surface Completion (cont.)
Remedial Investigation Work
Plan Per- and Polyfluoroalky Substance Release at Red Hill Bulk Fuel Storage Facility
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

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



NOTE: SEE PROFILE VIEW (SQUARE)

PLAN VIEW (SQUARE)

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

Flush-Mount Vault Well Surface Completion (cont.)
Remedial Investigation Work
Plan Per- and Polyfluoroalky Substance Release at Red Hill Bulk Fuel Storage Facility
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

Appendix G: References

REFERENCES

- AECOM Technical Services, Inc. (AECOM). 2018. *Per- and Polyfluoroalkyl Substances (PFAS) Sampling Guidance*. Version 2. AECOM Global PFAS Practice. June.
- ASTM International (ASTM). 2011. *Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)*. D2487-11. West Conshohocken, PA.
- . 2014. *Standard Practice for Rock Core Drilling and Sampling of Rock for Site Exploration*. D2113-14. West Conshohocken, PA.
- Department of Defense and Department of Energy, United States (DoD and DOE). 2021. *Department of Defense (DoD) and Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories*. DoD/DOE QSM Ver. 5.4. Prepared by DoD Environmental Data Quality Workgroup and DOE Consolidated Audit Program Operations Team.
- . 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.
- 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.
- . 2017. *Bottle Selection and Other Sampling Considerations When Sampling for Per- and Polyfluoroalkyl Substances (PFAS)*. Revision 1.2. Environmental Data Quality Workgroup (EDQW). July.
- . 2019a. *General Data Validation Guidelines*. Revision 1. Environmental Data Quality Workgroup. September.
- . 2019b. *General Data Validation Guidelines*. Revision 1. Environmental Data Quality Workgroup. November.
- . 2022. *Data Validation Guidelines Module 6: Data Validation Procedure for Per- and Polyfluoroalkyl Substances Analysis by QSM Table B-24*. Environmental Data Quality Workgroup. October.
- . 2023a. *Defueling Plan Supplement 2, May 15, 2023 - Red Hill Bulk Fuel Storage Facility, Oahu, Hawaii*.
- . 2023b. *Establishing a Consistent Methodology for the Analysis of Per- and Polyfluoroalkyl Substances in Matrices Other than Drinking Water*.
- . 2023c. *Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program*. Memorandum for Assistant Secretary of the Army (Installations, Energy and Environment), Assistant Secretary of the Navy (Energy, Installations and Environment), Assistant Secretary of the Air Force (Installations, Environment and Energy), Director, National Guard Bureau (Joint Staff, J3/4/7), Director, Defense Logistics Agency (Installation Management).

Washington, DC: Office of the Assistant Secretary of Defense for Energy, Installations, and Environment. August.

———. 2023d. “Joint Task Force – Red Hill Announces AFFF Investigation Findings and Publishes Video Footage.” Press Release. Headquarters, Joint Task Force-Red Hill Public Affairs Office Ford Island Conference Center Joint Base Pearl Harbor-Hickam. May 5, 2023. <chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.pacom.mil/Portals/55/JTF-RH/.PDF/AFFF%20Investigation%20Documents.pdf>.

———. 2023e. *Memorandum: Establishing a Consistent Methodology for the Analysis of Per- and Polyfluoroalkyl Substances in Media Other than Drinking Water*.

———. 2024a. *DoD Environmental Data Quality Workgroup Memorandum, EPA Method 1633 Clarification Update, February 29, 2024*. March 4.

———. 2024b. *Establishing a Consistent Methodology for the Analysis of Per- and Polyfluoroalkyl Substances in Matrices Other than Drinking Water*. Washington, DC: Assistant Secretary of Defense. May 1.

———. 2024c. “PFAS 101 Regional Screening Levels Used in DoD Cleanups.” Update to Assistant Secretary of Defense for Energy, Installations, and Environment Memorandum, “Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program,” August 24, 2023. 2024. <https://www.acq.osd.mil/eie/ee/ecc/pfas/pfas101/rsl.html>.

Department of Energy, United States (DOE). 2023. *PFAS Environmental Sampling Guidance*. August.

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*. Hazard Evaluation and Emergency Response. Revised 2017. Fall.

———. 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. *Interim Soil and Water Environmental Action Levels (EALs) for Perfluoroalkyl and Polyfluoroalkyl Substances (PFASs)*. Hazard Evaluation and Emergency Response. April 8.

———. 2023. *Interim Soil and Water Environmental Action Levels (EALs) for Perfluoroalkyl and Polyfluoroalkyl Substances (PFASs)*. Memorandum from: R. Brewer. Hazard Evaluation and Emergency Response. April 20. <https://health.hawaii.gov/heer/guidance/ehe-and-eals/#ehe6>.

———. 2024. “DOH EALs Excel Surfer (Draft Spring 2024).” <https://health.hawaii.gov/heer/files/2024/04/EAL-Surfer-HDOH-Draft-Spring-2024.xlsx>.

Department of Health, State of Hawaii, Hansen’s Disease Branch. 2022. *Release Notification: Navy Red Hill Aqueous Film Forming Foam (AFFF) Release. Case Number: 20221129-1438*. Reported On: 11/29/22 2:38 PM. Assigned SOSC: Liz Galvez. November 29.

- Department of Land and Natural Resources, State of Hawaii (DLNR). 2004. *Well Construction and Pump Installation Standards*. 2nd ed. Honolulu, HI: Commission on Water Resource Management. February.
- Department of the Navy (DON). 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.
- . 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.
- . 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.
- . 2015. *Final Project Procedures Manual, U.S. Navy Environmental Restoration Program, NAVFAC Pacific*. JBPHH HI: Naval Facilities Engineering Command, Pacific. May.
- . 2017. *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.
- . 2018. *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.
- . 2020a. *Interim Per- and Polyfluoroalkyl Substances (PFAS) Site Guidance for NAVFAC Remedial Project Managers (RPMs)/November 2020 Update*. Document 5090 Ser EV3/012. Naval Facilities Engineering Systems Command. November.
- . 2020b. *Interim Per- and Polyfluoroalkyl Substances (PFAS) Site Guidance for NAVFAC Remedial Project Managers (RPMs)/November 2020 Update*. Naval Facilities Engineering Systems Command. November.
- . 2021. *Final Site Assessment Work Plan Red Hill Oily Waste Disposal Facility Joint Base Pearl Harbor-Hickam Oahu HI*. Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Hawaii. February.

-
- . 2022a. *PFAS-Specific Sampling and Analysis Plan, Red Hill Bulk Fuel Storage Facility, Adit 6, Joint Base Pearl Harbor-Hickam, Hawaii*. Revision 1. Prepared for: Red Hill OIC. December 7. JBPHH HI: Naval Facilities Engineering Systems Command Pacific. December.
- . 2022b. *Subj: Supplement to the Command Investigation into the 6 May 2021 and 20 November 2021 Incidents at Red Hill Bulk Fuel Storage Facility*. Letter 5830 from: RADM J. P. Waters III; to: Vice Chief of Naval Operations. Encl: (1) Final Report. April 15.
- . 2022c. *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. *Aqueous Film-Forming Foam Soil and Groundwater Investigation and Monitoring Monthly Report April 2023 Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam O'ahu HI*. Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. May 7.
- . 2023b. *Aqueous Film-Forming Foam Soil and Groundwater Investigation and Monitoring Monthly Report August 2023 Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam O'ahu HI*. Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. September 7.
- . 2023c. *Aqueous Film-Forming Foam Soil and Groundwater Investigation and Monitoring Monthly Report December 2022 Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam O'ahu HI*. Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. January 7.
- . 2023d. *Aqueous Film-Forming Foam Soil and Groundwater Investigation and Monitoring Monthly Report February 2023 Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam O'ahu HI*. Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. March 7.
- . 2023e. *Aqueous Film-Forming Foam Soil and Groundwater Investigation and Monitoring Monthly Report January 2023 Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam O'ahu HI*. Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. February 7.
- . 2023f. *Aqueous Film-Forming Foam Soil and Groundwater Investigation and Monitoring Monthly Report July 2023 Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam O'ahu HI*. Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. August 7.
- . 2023g. *Aqueous Film-Forming Foam Soil and Groundwater Investigation and Monitoring Monthly Report June 2023 Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam O'ahu HI*. Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. July 7.

-
- . 2023h. *Aqueous Film-Forming Foam Soil and Groundwater Investigation and Monitoring Monthly Report March 2023 Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam O'ahu HI*. Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. April 7.
- . 2023i. *Aqueous Film-Forming Foam Soil and Groundwater Investigation and Monitoring Monthly Report May 2023 Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam O'ahu HI*. Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. June 7.
- . 2023j. *Aqueous Film-Forming Foam Soil and Groundwater Investigation and Monitoring Monthly Report October 2023 Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam O'ahu HI*. Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. November 7.
- . 2023k. *Aqueous Film-Forming Foam Soil and Groundwater Investigation and Monitoring Monthly Report September 2023 Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam O'ahu HI*. Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. October 6.
- . 2023l. *Final Technical Memorandum, Phase 2 Holding Tank and Leach Tank Characterization, November 2021 Pipeline Release, 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 Release ID No 20211120_2330. JBPHH HI: Naval Facilities Engineering Systems Command, Hawaii. July 13.
- . 2023m. *Per- and Polyfluoroalkyl Substances Delineation Non-Routine Wells Groundwater Investigation Report September 2023 Red Hill Bulk Fuel Storage Facility Joint Base Pearl Harbor-Hickam O'ahu HI*. Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. November 27.
- . 2023n. *Recommended Ecological Screening Values for Per- and Polyfluoroalkyl Substances*. Interim Final. Navy Emerging Chemicals Workgroup Issue Paper. August.
- . 2023o. *Revised Interim General Guidelines for PFAS Remedial Investigations*. NAVFAC Emerging Chemical/Contaminant Workgroup – PFAS RI Subgroup. November.
- . 2024a. *Monitoring Well Installation Work Plan, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i*. January 31.
- . 2024b. *Recommended Ecological Screening Values for Per- and Polyfluoroalkyl Substances Version 4*. Interim Final. Navy Emerging Chemicals Workgroup Issue Paper. January.
- . 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, O'ahu, Hawai'i*. 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.
- Environmental Protection Agency, United States (EPA). 1988. *Guidelines for Ground-Water Classification Under the EPA Ground-Water Protection Strategy*. EPA/440/6-86/007. PB95-169603. Washington, DC: Office of Ground-Water Protection. June.
- . 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.
- . 2022. *Regional Screening Levels for Chemical Contaminants at Superfund Sites*. EPA Office of Superfund. May.
- . 2023. *Regional Screening Levels for Chemical Contaminants at Superfund Sites*. EPA Office of Superfund. November. <https://www.epa.gov/risk/regional-screening-levels-rsls>.
- . 2024a. *Interim Guidance on the Destruction and Disposal of Perfluoroalkyl and Polyfluoroalkyl Substances and Materials Containing Perfluoroalkyl and Polyfluoroalkyl Substances — Version 2 (2024)*. Interim Guidance for Public Comment. April.
- . 2024b. *Method 1633: Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS*. EPA 821-R-24-001. Washington, DC: Office of Water (4303T), Office of Science and Technology, Engineering and Analysis Division. January.
- 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.
- Environmental Protection Agency, United States, Region 9 (EPA Region 9). 2023. *Aqueous Film Forming Foam Investigation Report Red Hill Bulk Fuel Storage Facility*. Honolulu, HI: EPA Region 9. August.
- 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.
- Interstate Technology & Regulatory Council (ITRC). 2018. “PFAS Fact Sheets.” PFAS — Per- and Polyfluoroalkyl Substances. 2018. <https://pfas-1.itrcweb.org/fact-sheets/>.
- 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.

- Lau, L. Stephen, and John F. Mink. 1995. "Groundwater Modeling in Hawaii: A Historical Perspective." In *Groundwater Models for Resources Analysis and Management*, 253–74. Boca Raton, FL: CRC Press/Lewis Publishers.
- Michigan Department of Environmental Quality (MDEQ). 2018. *General PFAS Sampling Guidance*. October.
- Mink, J. F., and L. S. Lau. 1990. *Aquifer Identification and Classification for Oahu: Groundwater Protection Strategy for Hawaii*. Technical Report No. 179. Honolulu, HI: University of Hawaii, Water Resources Research Center. November 1987; rev. February 1990.
- Munsell Color Company (Munsell). 2009. *Geological Rock-Color Chart with Genuine Munsell Color Chips. Revision of Geological Society of America (GSA) Rock-Color Chart*. Produced in cooperation with GSA. Baltimore, MD.
- Naval Energy and Environmental Support Activity (NEESA). 1983. *Initial Assessment Study of Pearl Harbor Naval Base, Oahu, Hawaii. NEESA 13-002*. Port Hueneme, CA. October.
- Nichols, W. D., P. J. Shade, and C. D. Hunt Jr. 1996. *Summary of the Oahu, Hawaii, Regional Aquifer-System Analysis*. Professional Paper 1412-A. Regional Aquifer-System Analysis—Oahu, Hawaii. U.S. Geological Survey.
- Shaw Environmental, Inc. (Shaw). 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.
- Stearns, H. T., and G. A. Macdonald. 1946. *Geology and Ground-Water Resources of the Island of Hawaii*. Bulletin 9. Prepared in cooperation with the Geological Survey. Honolulu: Hawaii (Terr.) Department of Public Lands, Division of Hydrography.
- 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.
- United States Air Force (USAF). 2007. *Final Waikakalaua Fuel Storage Annex Comprehensive Remedial Investigation Report OU-1 and OU-2 Hickam POL Facilities, Oahu, Hawaii, United States Air Force*.
- 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.
- Walker, G. P. L. 1990. "Geology and Volcanology of the Hawaiian Islands." *Pacific Science* 44 (4): 315–47.
- Wentworth, C. K. 1951. *Geology and Groundwater Resources of the Honolulu-Pearl Harbor Area, Oahu, Hawaii*. Honolulu, HI: City and County of Honolulu, Board of Water Supply.

Appendix H: Response to Comments

(provided in subsequent version)

