Naval Facilities Engineering Systems Command Hawaii
JBPHH HI

Final

Remedial Investigation Work Plan Per- and Polyfluoroalkyl Substances Release Red Hill Bulk Fuel Storage Facility

JOINT BASE PEARL HARBOR-HICKAM OAHU HI

PEARL HARBOR FISC SITE 30

August 2026

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August 2026

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

Final
Work Plan/Sampling and Analysis Plan
August 2026

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, Contract Task Order N6274223F0178

AECOM CTO Manager:	Jeff Hart	7/9/2026 Date
AECOM QA Program Manager:	Scott Lewis	7/10/2026 Date
NAVFAC Hawaii RPM:	Niels Heidner	7/28/2026 Date

EXECUTIVE SUMMARY

This remedial investigation (RI) work plan (WP) for per- and polyfluoroalkyl substances (PFAS) documents the proposed sampling and analysis associated with known and suspected aqueous film-forming foam (AFFF) release areas located at the Red Hill Bulk Fuel Storage Facility (Facility), Joint Base Pearl Harbor-Hickam, Oahu, Hawaii (Figure 1). This WP has been prepared for the United States (U.S.) Department of the Navy (Navy) under the Comprehensive Long-Term Environmental Action, Navy VI program contract number N62742-23-D-1802, contract task order number N6274223F0178. The purpose of this RI is to evaluate the nature and extent of chemicals of potential concern (COPCs) (PFAS and comingled petroleum hydrocarbons [PHCs]) in soil and groundwater at the Facility.

SITE DESCRIPTION

The RI focuses on two PFAS source areas: Area A (Figure 2) and Area B (Figure 3). Area A comprises approximately 0.6 acres and includes Building (Bldg.) 313 and the (b) (3) entrance. Prior to the November 2022 AFFF (b) (3) release, Bldg. 313 housed the AFFF storage and pump room that previously supplied the AFFF to the Facility fire suppression system. Storage of AFFF has been discontinued and the system is no longer active. This area was also the location of a legacy AFFF storage and distribution system that served an oily waste aboveground storage tank (AST) known as the former Slop Tank (Figure 4). Area A was the location of the November 2022 AFFF (b) (3) release and emergency response cleanup actions. Area A contains 3 perched (shallow) groundwater monitoring wells and 4 basal (deep) groundwater monitoring wells. PHCs were observed as fuel product in a perched groundwater monitoring well comingled with PFAS in Area A; therefore, PHCs are included as COPCs for the RI at Area A.

Surrounding Area A is an existing network of basal groundwater monitoring wells within the Facility. These wells were installed to monitor for potential fuel releases from the Facility. For the PFAS RI, this network will be used to evaluate potential migration of PFAS from Area A in the underlying basal groundwater aquifer that is a sole source drinking water aquifer.

Area B comprises approximately 37 acres of the westernmost part of the Facility with no documented releases of PFAS. Area B is included in the RI because PFAS were detected in groundwater monitoring wells following the November 2022 AFFF (b) (3) release at Area A. As shown on Figure 3, Area B contains several current and historical features, including the following:

- (b) (3)
- The distal end of the tank farm AFFF distribution system, including the tunnel drain pipe that empties into the former AFFF retention holding AST located west of the (b) (3) portal
- The granular activated carbon groundwater treatment facility for U.S. Navy Well 2254-01 (also known as the (b) (3))
- The former Oily Waste Disposal Facility (OWDF)
- The future temporary and permanent (b) (3) water treatment plants
- Existing basal groundwater monitoring wells (including RHMW2254-01) and perched groundwater monitoring wells

Land use immediately north of Area B includes the South Halawa Industrial Park, which has housed a wide variety of commercial and light industrial activities over the decades.

PREVIOUS INVESTIGATIONS

In 2008, a 5,000-barrel "Slop Tank" and piping system that included a legacy AFFF firefighting system and 200-gallon legacy AFFF AST was removed from the current Bldg. 313 compound in Area A (Figure 4). A demolition report was provided that documented the removal and results from soil sampling for PHCs (Shaw 2009).

In November 2022, modern formulation AFFF concentrate was inadvertently released from the fire suppression system in the (b) (3) tunnel and exited the (b) (3) entrance in Area A. An emergency removal action was conducted and all heavily impacted soil was excavated and disposed of. Confirmation samples were collected from the limits of excavation and analyzed for PFAS. Results from several confirmation samples exceeded the current Department of Defense (DoD)-approved screening levels (ASD 2025) in soil. Groundwater wells near the release site were monitored periodically for 1 year and none of the results exceeded the current DoD-approved screening levels (ASD 2025). In September 2023, the Navy conducted a PFAS baseline groundwater monitoring event which included groundwater monitoring wells that extended west of the periodic sampling events associated with Area A and several off-site groundwater monitoring wells west of the Facility. PFAS were detected above current DoD-approved screening levels (ASD 2025) in basal groundwater samples from several wells located in Area B, as well as one off-site basal groundwater monitoring well (NMW32) located west of the Facility. Preliminary assessments indicate that PFAS observed in NMW32 are not from a source located at the Facility (DON 2023o).

Previous investigations in Area B included the following:

- The investigation of the former OWDF (for petroleum-related constituents), including a previous RI (DON 1996b, 2000) and removal action (DON 1996a), as well as ongoing follow-on activities. No historical documentation of AFFF use was identified during these investigations.
- The Former Holding Tank and Leach Tank and Collection, Holding, and Transfer Tank site characterizations (DON 2024f) were conducted in response to the November 2021 Jet Propellant 5 release at (b) (3). Fuel from this release entered a stormwater sump and sanitary sump and was inadvertently pumped to the Former Holding Tank and Leach Tank and Collection, Holding, and Transfer Tank areas, where it was released to the environment. PFAS was not analyzed during these site characterizations, which are ongoing under another regulatory program.
- A basewide PFAS preliminary assessment for Joint Base Pearl Harbor-Hickam was completed in 2023, which included evaluation of potential AFFF release areas at the Facility and identified the November 2022 AFFF (b) (3) release as the regulatory driver for the current RI (DON 2023l).

Preliminary investigation phases to this RI began in September 2024 with expedited activities to move the program forward based on agreements between the Navy and regulatory agencies in project scoping meetings summarized in Worksheet #9 of this document. The expedited work was completed in September 2025 and included the following:

- One perched and two basal groundwater monitoring wells were installed in Area A between November 2024 and June 2025, with associated soil sampling and analyses.
- Four groundwater sampling events were conducted between September 2024 and September 2025 from up to 43 groundwater monitoring wells located in and around Areas A and B (including the 3 wells described in the previous bullet).

On September 10 and 11, 2025, the Navy, State of Hawaii Department of Health, and U.S. Environmental Protection Agency (EPA) conducted a 2-day scoping meeting to review the expedited sampling results and agreed on the RI approach. This WP documents the agreed upon RI approach, as summarized below and detailed in the subsequent worksheets.

REMEDIAL INVESTIGATION

The field phase of the RI will be conducted to evaluate the extent of COPCs greater than project screening levels in Area A and Area B. This will include collecting sufficient soil and groundwater samples to develop statistically defensible exposure point concentrations for risk assessment. The RI will use standard composite and discrete sampling and analytical methods, with laboratory analyses conducted using EPA Method 1633 to support decision-making.

The following sampling and related activities are planned in Area A:

- Ten surface soil samples and five swale surface soil samples will be collected from low-lying areas and drainage swales within the Bldg. 313 compound to evaluate potential PFAS that may be a direct exposure risk, and the potential for migration by stormwater runoff beyond the boundaries of Area A.
- Seven soil borings will be drilled and sampled to bedrock or refusal with the soil samples analyzed for PFAS and PHCs.
- Three soil borings will be drilled in the grassy area in the western part of the Bldg. 313 compound and sampled to bedrock or refusal with the soil samples (including surface soil samples) analyzed for PFAS.
- Seven shallow borings will be drilled and sampled below clean fill in decision units previously excavated during the emergency response actions associated with the November 2022 AFFF (b) (3) release.
- Six shallow soil borings will be drilled in the southeast corner of the Bldg. 313 compound in the former location of the 200-gallon former legacy AFFF AST with surface and subsurface soil sampled for PFAS.
- A perched groundwater monitoring well will be installed if perched groundwater is encountered.
- Two groundwater monitoring events will be conducted at Area A and the surrounding groundwater monitoring well network, separated by approximately 6 months to evaluate potential seasonal variations in groundwater parameters. These events will occur after the final groundwater monitoring wells have been installed for this phase of the RI at Area A.

The following sampling and related activities are planned in Area B:

- Twenty-five soil borings will be advanced to perched groundwater or bedrock and sampled for PFAS in the vicinity of the (b) (3), former OWDF, and water treatment facilities (current and future) to investigate the nature and extent of AFFF in soil that have the potential to impact the perched groundwater systems.
- Thirteen soil borings will be advanced to perched groundwater or to bedrock or refusal and sampled for PFAS in the vicinity of the southern and northern boundaries of the Facility at Area B, including soil borings adjacent to existing basal groundwater monitoring wells that have PFAS that exceed DoD-approved screening levels (ASD 2025).

- If perched groundwater is encountered in these borings, up to 18 temporary wells will be installed, purged, and sampled for PFAS to define the nature and extent, which may be used to locate permanent perched groundwater monitoring wells, if necessary. The temporary wells will be surveyed to evaluate groundwater elevations and flow patterns.
- A basal groundwater well and perched groundwater well (if perched groundwater is encountered) will be installed east of RHP01 along (b) (3), to evaluate the extent of PFAS in the southeast portion of Area B.
- Two groundwater monitoring events will be conducted at Area B separated by approximately 6 months to evaluate potential seasonal variations in groundwater parameters including PFAS concentrations in appropriate wells. These events will occur after the final groundwater monitoring wells have been installed for this phase of the RI.
- Multilevel basal groundwater monitoring well RHMW15 will be tested to determine whether Teflon and Viton well components meet the data quality objectives for PFAS COPCs in the Area B basal groundwater investigation. If the results meet project data quality objectives, RHMW15 will be sampled in the two groundwater monitoring events described in the previous bullet.
- Two off-site basal groundwater monitoring wells will be installed north of Area B in the Halawa Industrial Park to evaluate the potential for groundwater flow and PFAS transport to or from the Facility.

The environmental samples to be used for decision-making will be analyzed for site COPCs at a laboratory accredited under the DoD Environmental Laboratory Accreditation Program using EPA Methods. The definitive data to be used for decision-making will be validated in accordance with Worksheets #34–#36 and will be used to characterize the nature and extent of COPCs in the media of concern and evaluate potential risks to human health and the environment. The preliminary conceptual site models that identify the potential receptors and exposure pathways are presented on Figure 31 to Figure 32. The results of the field sampling and baseline human health and ecological risk assessments will provide the basis for recommendations of any further assessment or evaluations in an RI report.

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ACRONYMS AND ABBREVIATIONS

%	percent
µg/kg	microgram per kilogram
µg/L	microgram per liter
AECOM	AECOM Technical Services, Inc.
AFFF	aqueous film-forming foam
ASD	Assistant Secretary of Defense
AST	aboveground storage tank
bgs	below ground surface
Bldg.	building
CAS	Chemical Abstracts Service
CCV	continuing calibration verification
CDR	Commander
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CHT	collection, holding, and transfer
COC	chain-of-custody
COPC	chemical of potential concern
CSM	conceptual site model
CTO	contract task order
DL	detection limit
DLNR	Department of Land and Natural Resources, State of Hawaii
DO	dissolved oxygen
DoD	Department of Defense
DOH	Department of Health, State of Hawaii
DQI	data quality indicator
DQO	data quality objective
DRO	diesel range organics
DU	decision unit
E&R	Environment and Remediation
EAL	environmental action level
EIS	extracted internal standard
ELAP	Environmental Laboratory Accreditation Program
EPA	Environmental Protection Agency, United States
ER	Environmental Restoration
ERA	ecological risk assessment
Eurofins	Eurofins Environment Testing
Facility	Red Hill Bulk Fuel Storage Facility
ft	foot or feet
FTS	fluorotelomer sulfonic acid
GC-FID	gas chromatography-flame ionization detector
GC-MS	gas chromatography-mass spectrometry
GRO	gasoline range organics
GW	groundwater
HEER	Hazard Evaluation and Emergency Response
HHRA	human health risk assessment

HSA	hollow-stem auger
ICAL	initial calibration
ID	identification
IDW	investigation-derived waste
JBPHH	Joint Base Pearl Harbor-Hickam
JP-5	Jet Propellant 5
LC-MS/MS	liquid chromatography tandem mass spectrometry
LCS	laboratory control sample
LNAPL	light non-aqueous phase liquid
LOD	limit of detection
LOQ	limit of quantitation
MB	method blank
MCL	maximum contaminant level
MDL	method detection limit
mg/kg	milligram per kilogram
mgd	million gallons per day
MPC	measurement performance criteria
MS	matrix spike
MSD	matrix spike duplicate
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
ND	non-detect
ng/L	nanogram per liter
no.	number
NTU	nephelometric turbidity unit
ORP	oxidation-reduction potential
OWDF	Oily Waste Disposal Facility
PA	preliminary assessment
PAH	polynuclear aromatic hydrocarbon
PARCCS	precision, accuracy, representativeness, comparability, completeness, and sensitivity
PFAS	per- and polyfluoroalkyl substances
PFBA	perfluorobutanoic acid
PFDA	perfluorodecanoic acid
PFHxA	perfluorohexanoic acid
PFHxS	perfluorohexanesulfonic acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
PHC	petroleum hydrocarbon
PID	photoionization detector
ppmv	part per million by volume
PQO	project quality objective
PSL	project screening level

PSQ	principal study question
PVC	polyvinyl chloride
Q1	Quarter 1
Q2	Quarter 2
Q3	Quarter 3
Q4	Quarter 4
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
QSM	Quality Systems Manual
RCRA	Resource Conservation and Recovery Act
(b) (3)	(b) (3)
RI	remedial investigation
RPD	relative percent difference
RPM	remedial project manager
RRO	residual range organics
RSL	regional screening level
SAP	sampling and analysis plan
SGC	silica gel cleanup
SIM	selected ion monitoring
SL	screening level
SOP	standard operating procedure
TGM	Technical Guidance Manual
THQ	target hazard quotient
TPH	total petroleum hydrocarbons
TR	target risk
U.S.	United States
VOC	volatile organic compound
WP	work plan
WTF	water treatment facility

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

Site Name/Number:	Pearl Harbor Fleet Industrial Supply Center Site 30
Operable Unit:	Joint Base Pearl Harbor-Hickam (JBPHH), Oahu, Hawaii
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* (IDQTF 2005) and the United States (U.S.) Environmental Protection Agency (EPA) *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: Naval Facilities Engineering Systems Command (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 (QA) project plans (QAPPs) are included in this document.

This document also includes the following appendixes:

- *Appendix A*: Figures
- *Appendix B*: Analytical Data Tables
- *Appendix C:* Standard Operating Procedures (on CD-ROM)
- *Appendix D:* Analytical Data Package Requirements
- *Appendix E:* Well Completion Diagrams and Monitoring Well Designs
- *Appendix F:* Multilevel Monitoring Well Supplemental Material
- *Appendix G:* Selected Figures from Final Evaluation Report (NAVFAC Atlantic 2023)
- *Appendix H:* Response to Comments

Worksheet #3: Distribution List

WP/SAP Recipient	Title	Organization	Telephone Number	Email Address
Niels Heidner	RPM	Navy	808-602-6245	niels.f.heidner.civ@us.navy.mil
Charlotte Rangel	RPM	Navy	808-603-2947	charlotte.c.rangel.civ@us.navy.mil
Jennah Oshiro	RPM	DOH	808-586-4249	jennah.oshiro@doh.hawaii.gov
Lucrina Jones	RPM	EPA Region 9	415-972-3006	jones.lucrina@epa.gov
Matt Cohen	RCRA Site Remediation Section Manager	EPA Region 9	415-972-3691	cohen.matt@epa.gov
Jeff Hart	CTO Manager	AECOM	(b) (6)	jeff.hart@aecom.com
Bianca Mintz	Deputy CTO Manager	AECOM	(b) (6)	bianca.mintz@aecom.com
Belinda Turran	Deputy CTO Manager	AECOM	(b) (6)	belinda.turran@aecom.com
Brant Landers	Project Chemist	AECOM	(b) (6)	brant.landers@aecom.com
Scott Lewis	QA Program Manager	AECOM	(b) (6)	scott.lewis@aecom.com

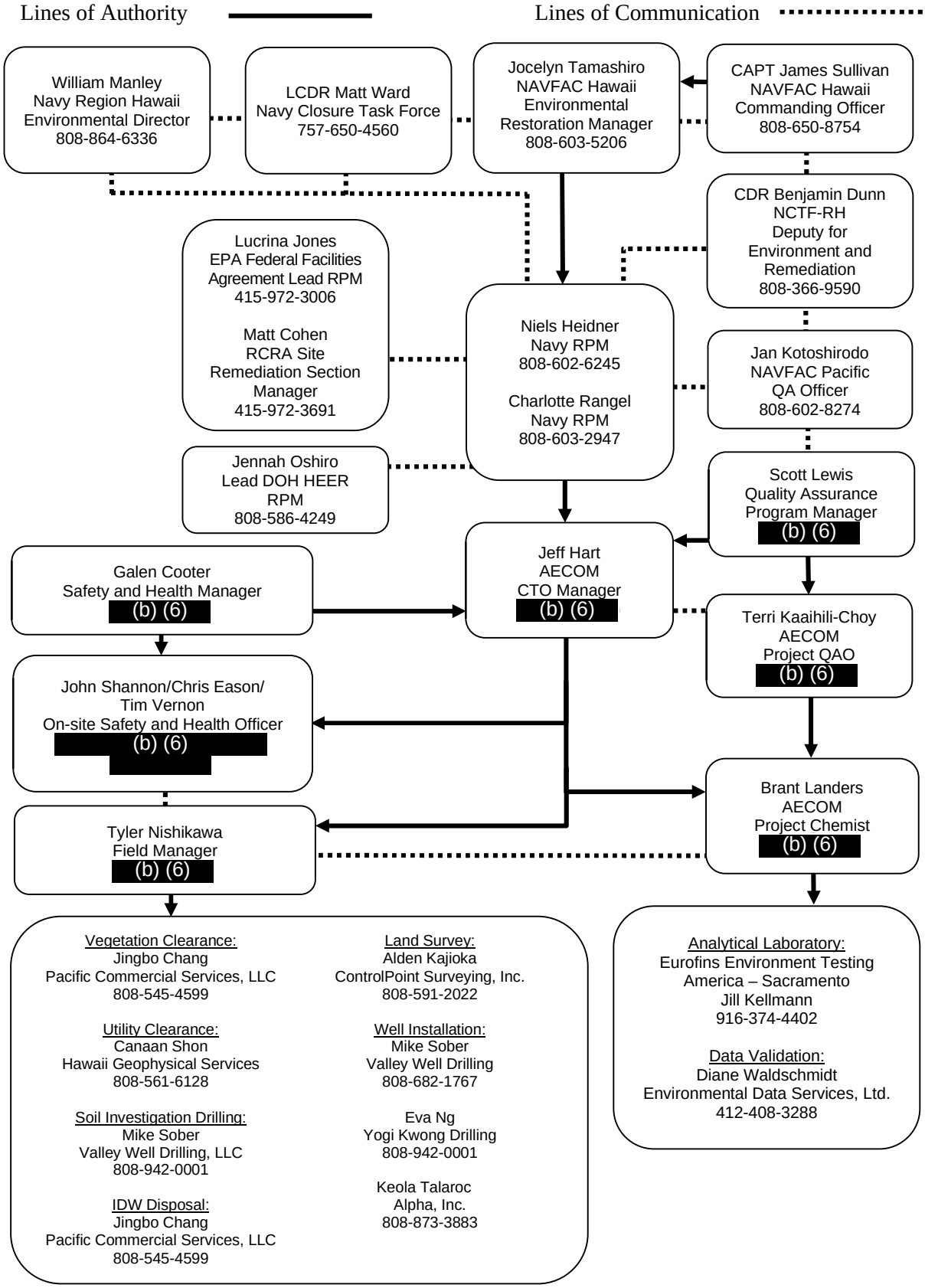
DOH Department of Health, State of Hawaii
Navy Department of the Navy, United States
RCRA Resource Conservation and Recovery Act
RPM remedial project manager

Worksheet #4: Project Personnel Sign-Off Sheet

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

Project Personnel	Organization, Title
Jeff Hart	AECOM, CTO Manager
Bianca Mintz	AECOM, Deputy Project Manager
Belinda Turran	AECOM, Deputy Project Manager
Brant Landers	AECOM, Project Chemist
Scott Lewis	AECOM, QA Program Manager
Tyler Nishikawa	AECOM, Field Manager

Worksheet #5: Project Organizational Chart



Worksheet #6: Communication Pathways

The communication pathways for the WP are shown below.

Communication Driver	Responsible Entity	Name	Telephone Number	Procedure
Regulatory Agency Interface	Navy RPM	Niels Heidner Charlotte Rangel	808-602-6245 808-603-2947	The Navy RPM will forward all project documentation. The Navy will ensure EPA Region 9 and DOH are notified of major changes. While input on corrective actions will be sought beforehand whenever practical, notification will occur within 24 hours of implementation.
Project Management	AECOM CTO Manager	Jeff Hart	(b) (6)	The AECOM CTO manager will direct and approve all AECOM communication to the Navy's RPM and provide monthly status reports to the Navy contracting officer. The AECOM CTO manager will notify the Navy RPM of field changes or modifications by close of business the following day.
QA/QC Management	AECOM QA Program Manager	Scott Lewis	(b) (6)	The AECOM QA program manager will designate responsible project quality personnel to perform specified QA and QC activities and report to project and program management. Issues, non-conformances, and corrective actions will be reported to NAVFAC Pacific QA manager within 1 day of non-conformance issuance.
Field Progress Reports	AECOM Field Manager	Tyler Nishikawa	(b) (6)	The AECOM field manager will communicate relevant field information to the AECOM CTO manager and AECOM project chemist daily during field activities, by telephone or email.
Stop Work Due to Safety Issues	All Field Staff	All Field Staff	N/A	All field staff have the authority to stop work by field subcontractors or field sampling personnel. Field work will then restart upon satisfactory implementation of appropriate corrective actions.
WP Changes Prior to Field/Laboratory work	AECOM CTO Manager	Jeff Hart	(b) (6)	Substantial changes to the planning documents will require the AECOM CTO manager to prepare amended worksheets before the activities begin.
WP Changes in the Field	AECOM Field Manager	Tyler Nishikawa	(b) (6)	The AECOM field manager will notify the CTO manager of changes to the procedures specified in the WP during field activities. The AECOM CTO manager will determine the appropriate course of action and document these changes in the RI report.
Field Corrective Actions	AECOM Field Manager	Tyler Nishikawa	(b) (6)	The AECOM field manager will have the authority to stop work and issue corrective response actions to field sampling personnel. Modes of communication will be by telephone or email within 24 hours.
Daily COC Reports and Shipping Documentation	AECOM Field QC Coordinator/SSHO	George Sauer	(b) (6)	COCs and shipping records will be submitted via fax or email to the AECOM project chemist at the end of each day that samples are collected.
Sample Receipt Variances	Laboratory Project Manager	Jill Kellmann	916-374-4402	All variances in sample receipt will be reported to the AECOM project chemist by the laboratory within 24 hours of variance. A signed copy of the COCs and a completed Sample Condition Report will be provided to the project chemist within 24 hours of sample receipt.
Reporting Laboratory Data Quality Issues	Laboratory Project Manager	Jill Kellmann	916-374-4402	QA/QC issues that potentially affect data usability will be reported by the laboratory project manager to the project chemist by email within 1 business day. If significant problems are identified from the laboratory that impacts the usability of the data, the project chemist will inform the Navy RPM within 1 day of notification.
	Navy RPM	Niels Heidner Charlotte Rangel	808-602-6245 808-603-2947	If significant problems with the laboratory are identified, the Navy RPM will inform the Navy QA manager for evaluation to determine what corrective actions will be taken with respect to the accreditation process.

Communication Driver	Responsible Entity	Name	Telephone Number	Procedure
Reporting Lab Quality Variances	Laboratory Project Manager	Jill Kellmann	916-374-4402	All laboratory QA/QC variance issues will be reported to AECOM project chemist by the laboratory within 1 day of variance. The variance(s) will be reported to the AECOM CTO manager on the same business day and to the Navy within 2 business days.
Analytical Corrective Actions	AECOM Project Chemist	Brant Landers	(b) (6)	The AECOM project chemist will immediately notify the AECOM CTO manager and the laboratory project manager by email of field or analytical procedures that were not performed in accordance with the planning documents. The AECOM project chemist will document the non-conformance, issue the corrective actions to be taken, and verify implementation of the corrective actions by the laboratory.
Reporting Data Validation Issues	Data Validation Project Manager	Diane Waldschmidt	412-408-3288	All data validation issues will be reported to the AECOM project chemist by the data validators by telephone or email. The validators will generate memos to the laboratory regarding incomplete deliverables or discrepancies. The issue(s) will also be reported to the AECOM CTO manager or the project chemist within 1 business day by telephone or email.
Data Validation Corrective Actions	AECOM Analytical and Data Validation Advisor	Terri Kaaihili-Choy	(b) (6)	The AECOM analytical and data validation advisor will have the authority to issue corrective response actions to laboratory and data validation firms. Corrective actions may be issued to the laboratory as a result of data validation results. Modes of communication will be by telephone or email within 24 hours after audit.

COC chain-of-custody
N/A not applicable
QC quality control
RI remedial investigation
SSHO site safety and health officer

Worksheet #7: Personnel Responsibilities Table

Project-specific responsibilities are provided in the following table.

Name	Title	Organizational Affiliation	Responsibilities
Niels Heidner	RPM	Navy	Coordinates with the regulatory agencies and other stakeholders. Contract technical administration and project oversight.
Charlotte Rangel	RPM	Navy	Coordinates with the regulatory agencies and other stakeholders. Contract technical administration and project oversight.
Jennah Oshiro	RPM	DOH	Provides regulatory oversight for the project.
Lucrina Jones	RPM	EPA	Provides regulatory oversight for the project.
Jan Kotoshirodo	QA Manager	NAVFAC Pacific	Provides QA surveillance during the procurement process and, following the award of the contract, monitors compliance with contract and project performance standards.
Leighton Wong	CLEAN Program Manager	AECOM	Ensures compliance with contractual and technical procedures across the program.
Scott Lewis	QA Program Manager	AECOM	Reviews all technical procedures. Oversees project QA and ensures that overall technical direction correlates with other Navy CLEAN sites.
Jeff Hart	CTO Manager	AECOM	Coordinates with the Navy and provides overall technical direction and guidance for the project. Shares responsibility with the Navy RPM for the distribution of project-related documents. Identifies project problems or non-conformance and initiates corrective action.
George Sauer	SSHO (on-site)/ Field QC Coordinator	AECOM	Implements the site-specific accident prevention plan; prepares, implements, and oversees the AHAs; and conducts daily tailgate health and safety meetings. Maintains the QA/QC field logbook, ensures the collection of QA/QC samples as proposed in the WP, and documents the collection. Provides QC review of field logbook maintained by the AECOM field manager.
Galen Cooter	CLEAN Safety and Health Manager	AECOM	Directs and oversees the accident prevention plan and procedures.
Tyler Nishikawa	Field Manager	AECOM	Plans and oversees the implementation of field sampling, monitors adherence to activity-specific SOPs, and coordinates with subcontractors in the field.
Jack Kronen	Field Geologist	AECOM	Identifies sampling locations and directly oversees utility clearing, vegetation clearing, and intrusive activities (e.g., well installations). Describes soil and records the description in sampling logs and records well construction details.
Brant Landers	Project Chemist	AECOM	Provides specific technical assistance for the project, including development of the project work and analytical plans and reporting document. Assists with analytical laboratory and data validation procurement, oversight/management, and coordination. Oversees all field sampling activities to ensure adherence to the WP. Coordinates with the analytical laboratory and data validation firms. Reviews and evaluates analytical data and summarizes data validation reports. Assists with sample collection, as needed.
Terri Choy	Analytical and Data Validation Advisor	AECOM	Assists with analytical and data validation, as well as data usability issues.
Margie Pascua	Database Manager	AECOM	Manages and maintains the project database, provides data reports on an as-needed basis.
Jill Kellmann	Laboratory Project Manager	Eurofins	Manages analytical data generation.
Ian Manis	Laboratory QA Officer	Eurofins	Performs laboratory QA oversight.

Name	Title	Organizational Affiliation	Responsibilities
Diane Waldschmidt	Data Validation Task Manager	Environmental Data Services	Manages analytical data validation produced by the laboratory.
Alden Kajioka	Land Survey Subcontractor	ControlPoint Surveying, Inc.	Conducts land survey of RI sampling locations (e.g., land coordinates) and ground surface and wellhead elevations.
Jingbo Chang	Vegetation Clearance Subcontractor	Pacific Commercial Services, LLC	Conducts vegetation clearance to the site.
Canaan Shon	Geophysical Surveyor Subcontractor	Hawaii Geophysical Services	Conducts geophysical survey for utility clearance before collecting subsurface soil samples.
Eva Ng	Soil Investigation Drilling Subcontractor	Yogi Kwong Drilling	Performs drilling activities (i.e., subsurface soil borings).
Mike Sober	Well Installation Subcontractors	Valley Well Drilling, LLC	Performs drilling operations and monitoring well installation and development.
Eva Ng		Yogi Kwong Drilling	Performs drilling operations and monitoring well installation and development.
Keola Talaroc		Alpha, Inc.	Performs drilling operations and monitoring well installation and development.
Jingbo Chang	IDW Subcontractor	Pacific Commercial Services, LLC	Manages and disposes of IDW generated on this project.

AHA activity hazard analysis
CLEAN Comprehensive Long-Term Environmental Action Navy
Eurofins Eurofins Environment Testing
IDW investigation-derived waste
SOP standard operating procedure
SSHO site safety and health officer

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 provided on demand via AECOM University. PFAS sampling SOPs are provided in Appendix C.

Worksheet #9: Project Scoping Session Participants Sheet

Project Name: PFAS Substances Release, Red Hill Bulk Fuel Storage Facility
Projected Date(s) of Sampling: September 2024
CTO Manager: Watson Tanji

Site Name: Red Hill Bulk Fuel Storage Facility
Site Location: JBPHH, Oahu, HI

Date of Session: April 12, 2024
Scoping Session Purpose: Scoping Meeting No. 1 – Discussion on the Red Hill PFAS RI.

Name	Project Role	Affiliation	Email Address
Christopher Lichens	Federal Facilities Agreement Lead RPM	EPA	lichens.christopher@epa.gov
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Project Name: PFAS Substances Release, Red Hill Bulk Fuel Storage Facility
Projected Date(s) of Sampling: September 2024
CTO Manager: Watson Tanji

Site Name: Red Hill Bulk Fuel Storage Facility
Site Location: JBPHH, Oahu, HI

Date of Session: April 12, 2024
Scoping Session Purpose: Scoping Meeting No. 1 – Discussion on the Red Hill PFAS RI.

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Jeff Johnson	CLEAN Technical Director	AECOM	jeff.johnson@aecom.com

CDR	Commander
CLEAN	Comprehensive Long-Term Environmental Action Navy
E&R	Environment and Remediation
HEER	Hazard Evaluation and Emergency Response
NCTF-RH	Navy Closure Task Force-Red Hill
no.	number
SHWB	Solid and Hazardous Waste Branch
UST	underground storage tank

Comments/Decisions: Presentation of the U.S. Department of the Navy's (Navy) 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 remedial investigation (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 per- and polyfluoroalkyl substances (PFAS) toxicity values established by EPA and the State of Hawaii Department of Health (DOH). These toxicity values are consistent with the current Department of Defense (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.

Date of Session: July 3, 7, 13, 2024
Scoping Session Purpose: Discussion on adding expedited quarterly groundwater monitoring to the Red Hill PFAS RI.

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Jeff Hart	CTO Manager	AECOM	jeff.hart@aecom.com

LCDR Lieutenant Commander
UST underground storage tank

Comments/Decisions:

Three scoping meeting sessions were conducted via teleconference to collaboratively determine the scope for a short-term groundwater monitoring program to evaluate seasonal variability of PFAS compounds in groundwater monitoring wells in the Red Hill Bulk Fuel Storage Facility (Facility) study area.

The regulatory agencies identified 66 wells to be considered for this groundwater monitoring program, including wells that have not been constructed and wells located outside of the Facility boundary, and indicated that sampling should be conducted every 3 months (quarterly) by EPA Method 1633 for 40 PFAS, with sampling to be expedited.

The Navy indicated that the current agreement should be limited to 1 year of quarterly groundwater sampling, with groundwater samples to be analyzed by EPA Method 1633, and limited to wells that are currently constructed and within the Facility boundary; and with expedited sampling to begin in September 2024 if the regulatory agencies provide provisional agreement to the portion of the WP that addressed these activities.

Final Decision:

The Navy will submit a revised draft WP to include 1 year of quarterly groundwater sampling with expedited sampling to begin in September 2024. The groundwater samples are to be analyzed by EPA Method 1633, limited to 30 wells that are currently constructed (and 1 well that is currently being drilled), and within the Facility boundary. The regulatory agencies intend to provide provisional agreement to the portion of the WP that addressed these activities.

Additional scoping meetings are tentatively scheduled to begin on August 14, 2024, to address potential comments on the draft WP that was submitted for regulatory review on June 18, 2024.

Date of Session: August 14 and 27, 2024
Scoping Session Purpose: Scoping Meetings No. 2 and No. 3 – Discussion on regulatory comments on the Draft RI WP and conditional approval for expedited field work.

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Date of Session: August 14 and 27, 2024
Scoping Session Purpose: Scoping Meetings No. 2 and No. 3 – Discussion on regulatory comments on the Draft RI WP and conditional approval for expedited field work.

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Comments/Decisions:

Two scoping meeting sessions were conducted via teleconference to collaboratively discuss comments provided by the EPA and DOH on the draft RI WP. The Navy's approach to obtain conditional approval of expedited field work was also discussed.

Final Decision:

It was agreed that OWDFMW01, OWDFMW04A, and OWDFMW05A will be sampled for the quarterly groundwater sampling. In addition, OWDFMW02A will be sampled for one round. RHP08C will not be sampled. The proposed locations for the expedited installation of cluster wells within Area A were agreed upon.

The Navy will submit a revised draft WP to include 1 year of quarterly groundwater sampling with expedited sampling to begin in September 2024. The groundwater samples are to be analyzed by EPA Method 1633, limited to 34 wells that are currently constructed, and within the Facility boundary. The regulatory agencies will provide conditional approval for the portion of the WP that addressed these activities.

Date of Session: January 22, 2025
Scoping Session Purpose: Scoping Meeting No. 4 – Provide updates on drilling in Area A and present the results of the Quarter 1 groundwater sampling event.

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Comments/Decisions:

An update on the progress of drilling new monitoring wells PFMW02 and PFMW01 was provided. The results of the Quarter 1 (Q1) groundwater sampling event were presented. The perched water below (b) (3), which is fed by the cooling water line from the pumps, was discussed.

Final Decision:

It was agreed that eight additional former Oily Waste Disposal Facility (OWDF) wells would be added to the quarterly groundwater sampling program. The Navy will provide cross sections showing perched water zones with the former OWDF and (b) (3) area. Soil sampling locations and remaining cluster well locations will be determined at the next scoping meeting.

Date of Session: September 10 and 11, 2025
Scoping Session Purpose: Scoping Meeting No. 5 – Provide an overview of the updates to the RI WP and achieve consensus on sampling and analytical strategies.

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Comments/Decisions:

The Navy presented an in-depth conceptual site model (CSM) for Area A and Area B, and the results and observations from the expedited activities (i.e., quarterly groundwater sampling, drilling, and well installation), and the attendees discussed the recommended RI activities and overall sampling plan.

Final Decision:

A summary of the general agreements and actions items is provided below.

- General
  - At the time of the scoping meeting, DoD policy requires use of EPA Method 1633 for the collection for definitive PFAS data (ASD 2024). DoD instruction further requires that definitive data supporting the Environmental Restoration (ER) Program be generated by DoD Environmental Laboratory Accreditation Program (ELAP)–accredited laboratories (DoD 2025b). Accordingly, total oxidizable precursor assay and total organic fluorine analyses do not meet the project data quality objectives (DQOs) and will not be used for collection of definitive data.
  - DoD guidance does not recommend analysis of PFAS in soil using multi-increment sampling techniques for CERCLA risk assessment (ASD 2024; DoD 2025c). To compromise, if a potential PFAS source area is identified in soil using the proposed high-resolution site characterization techniques, the Navy will consider conducting high-resolution site characterization soil sampling in a high density of borings in the potential source area based on the results of the sampling proposed in the WP. The DOH agreed to this approach.
  - After the well installation is complete at both Area A and Area B, all wells (i.e., newly installed wells and wells previously sampled during the expedited quarterly sampling) will be sampled for two rounds (wet and dry seasons). The Navy will provide graphics to view PFAS results and evaluate seasonal variability in the WP.
  - Sample location identifiers will be revised to make them more readily distinguishable.
  - The Navy will provide updated figures presenting proposed sampling locations to EPA and DOH.
  - The Navy will evaluate how to present the DOH PFAS environmental action levels (EALs) in the main body of the RI WP (not in an appendix) and RI report, for reference purposes only.
  - EPA stated that the Navy’s proposed sampling plan addressed their requests in their August 26, 2025, letter (EPA 2025b).

- Area A
  - The depth of the proposed deep PFAS and petroleum soil borings PTPFSSB02, PTPFSSB04, and PTPFSSB05 will be increased to 50 feet below ground surface (bgs) or refusal in bedrock, to target the interval with petroleum impacts in well PFMW01B. If groundwater is encountered, a grab sample will be collected. Note: All sample identifiers have been revised.
  - Two shallow PFAS soil boring locations will be added along the northwestern fence line of the area (PTPFSSB06 and PTPFSSB07). Note: All sample identifiers have been revised.
  - For the CSMs, the Navy will consider adding the slop tank discharge to the ecological CSM and adding a release of petroleum as a contributing source. For the Area A human health risk assessment (HHRA) CSM, the Navy will consider adding a direct discharge to Halawa Stream.
- Area B
  - South Halawa Stream will be evaluated as a potentially complete exposure pathway in the HHRA.
  - Proposed soil and perched groundwater grab sample location PFSBSB20 will be moved southwest of OWDFMW05B (now PFSBSB23). Note: All sample identifiers have been revised.
  - An additional soil boring and perched groundwater grab sample location will be added southwest of the (b) (3) sump (PFSBSB06). Note: All sample identifiers have been revised.

Follow on Discussion: February 11, 2026
Purpose: The Navy and EPA held a coordination call to discuss the proposed sampling design for Area B.

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Comments/Decisions: A summary of the discussion and agreements are provided below:

- *Area B:* The Navy and EPA agreed to add three temporary wells (two where borings were already planned, and one in a new soil boring location) to support soil and perched groundwater characterization.
  - Install temporary wells at two of the previously proposed soil borings (RHB-BS-S15 and RHB-BS-S17) along the northern facility boundary at Area B to evaluate perched groundwater conditions north of OWDFMW03B and OWDFMW05B.
  - Add one new soil boring and temporary monitoring well for the collection of soil samples and a groundwater grab sample approximately 100 feet southwest of OWDFMW05B in the proposed location of the future permanent water treatment facility (WTF) area to further characterize soil and perched groundwater in this area.

Worksheet #10: Conceptual Site Model

10.1 OVERVIEW

This WP details the proposed sampling and analysis program to investigate releases of PFAS-containing materials at Area A and Area B, along with comingled petroleum hydrocarbons (PHCs) at Area A at the Facility (Figure 1).

The objectives of the RI are as follows:

- Characterize the nature and extent of PFAS and comingled PHCs in soil and groundwater outside and adjacent to Red Hill (b) (3) and Building (Bldg.) 313 within "Area A," and basal groundwater in groundwater monitoring wells surrounding Area A.
- Characterize the nature and extent of PFAS, including potential source area(s) of PFAS in soil and groundwater in Area B, located in the southwest portion of the Facility (Figure 3).
- Develop a hydrogeologic and contaminant CSM for the perched groundwater in the vicinity of the former OWDF facility and in the vicinity of Adit 3.
- Evaluate PFAS in basal groundwater outside the Facility, directly north of the Facility border, to understand groundwater flow and PFAS transport in this medium.
- Evaluate risks to human health and the environment associated with potential exposure to PFAS and comingled PHCs in the study as defined above.

The data collection proposed in this WP will evaluate site conditions and determine whether any further action is necessary to address potential PFAS and comingled PHC sources at the Facility within the Area A boundary ("Area A") and potential PFAS sources at Area B Boundary ("Area B"). From this point forward, the term chemicals of potential concern (COPCs) will be used to refer to PFAS and PHCs in Area A and PFAS in Area B, respectively.

This worksheet presents the preliminary CSMs for Area A and Area B. Results of the RI field activities will be used to refine and update the CSM and conduct the risk assessment.

10.2 SITE DESCRIPTION, HISTORY, AND ENVIRONMENTAL SETTING

10.2.1 Site Description and History

The Facility 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 Facility is owned by the Defense Logistics Agency and formerly operated by Naval Supply Systems Command Fleet Logistics Center Pearl Harbor. This investigation focuses on two areas of known or suspected aqueous film-forming foam (AFFF) releases, which includes areas adjacent to Red Hill (b) (3) and near Bldg. 313, as well as near the (b) (3), the former OWDF, western portion of the Facility, and the Facility boundaries, designated as Area A and Area B. If other potential sources of PFAS are identified, the investigation may be expanded in subsequent phases of the RI.

10.2.1.1 RED HILL BULK FUEL STORAGE FACILITY

The Facility includes (b) (3) storage tanks constructed beneath a minimum of 100 feet of volcanic rock (Figure 1) in an underground tank farm. To help support the construction of the Facility, several facilities (plumbers' shop, switch room, metal foundry, septic tank, and crusher pit) were established and operated from 1940 to 1943. These facilities operated prior to the widespread commercial use of PFAS-containing products, which started in the 1950s. The first

documented presence of PFAS-containing material at the Facility is associated with the former 200-gallon AFFF aboveground storage tank (AST) fire suppression system for the former Slop Tank area in Area A. The former Slop Tank was installed in July 1962, was used until 1968, and was removed in 2008 (Section 10.2.1.2). A modern AFFF fire suppression system was constructed at the Facility between 2015 and 2018 and was in operation until 2024 (Section 10.2.1.2).

The Facility was evaluated for potential PFAS sources as part of the preliminary assessment (PA) for PFAS at National Priority List Sites (DON 2023l), and no potential sources of PFAS other than the November 2022 AFFF (b) (3) release (discussed below) were identified (Section 10.2.8.2).

10.2.1.2 AREA A

This section describes the relevant historical and current features in and around Area A.

(b) (3), Former Slop Tank, and Original Fire Suppression System

The locations of the historical site features in the following discussion and supporting infrastructure are shown on Figure 2. The slop tank was built in the early 1960s on a flattened lot, excavated below and north of (b) (3) and (b) (3), south of South Halawa Stream. The former Slop Tank was fed by a former 8-inch-diameter oily waste line from (b) (3) (HAER 2015). In the mid to late 1960s, various fluids were piped to the former Slop Tank, including aviation gasoline, Jet Propellant 5 (JP-5), and oily waste (see Section 10.2.8.1 for additional details). The water from the tank was 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 off-site disposal (Earl and Wright 1962). In July of 1962, a fire suppression system was constructed for the former Slop Tank area, which included a former 200-gallon AFFF AST, located above and south of the former Slop Tank, near the edge of (b) (3). A 1.5-inch AFFF line extended from the former AFFF AST to the exterior of the slop tank for fire suppression. There was no documentation of AFFF entering the slop tank area during its time in use. The former AFFF AST and associated piping were completely removed by March 2009. No documentation has been identified describing the AFFF formulation that was contained in the former Slop Tank AFFF fire suppression system, nor any maintenance records, including frequency of AFFF change-outs. Immediately north of the former AFFF AST and the lower slop tank area is a sloped vegetated area where stormwater runoff from the former AFFF tank area likely flowed, which could be a secondary source of PFAS if potential AFFF releases occurred in this area.

In 2008, the former Slop Tank and former AFFF AST were demolished, associated piping was cut and plugged, adjacent slop pump was removed, and berms that formed a containment basin around the former Slop Tank were leveled. All drainage, cleaning, and removal of pipeline occurred over secondary containment. The pipe was cleaned via a high-pressure (4,000 pounds per square inch) jet cleaning system. Pipe-cleaning rinse water was recovered and stored in drums. Tank-cleaning activities were not conducted prior to demolishing the slop tank because air monitoring samples and inspection found that the tank was clean with no residual odor and a 0 percent lower explosive limit atmosphere (Shaw 2009).

Red Hill Fire Suppression System Located at Building 313 and (b) (3)

An 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 2022c). The AFFF system was designed to provide fire protection for the Tank Farm Lower Access Tunnel of the Facility. Following the permanent defueling of the Facility tanks and pipelines in March 2024, the Navy removed the AFFF system from service.

Appendix G (NAVFAC Atlantic 2023) consists of two figures, including Current Setup, Pearl Harbor - Red Hill Collection Tanks; and Current Setup, Pearl Harbor – Building Red Hill Overview, which provide the general layout of the Facility's former AFFF fire suppression system installed between 2015 and 2018. This fire suppression system involved the construction of Bldg. 313 in the location of the former Slop Tank, which housed an AST for storing AFFF concentrate, along with the pumps and controllers for AFFF dispersal within the current Area A (Figure 4). 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 Red Hill ridge south of Area A. 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 suppression pumps, serving both the five lower tunnel AFFF zone mixing and release stations and the wet-pipe sprinkler system for the upper tunnel of the underground tank farm.

The conveyance piping for the AFFF concentrate primarily ran underground from Bldg. 313 to (b) (3), comprising 4-inch-diameter stainless steel carrier pipes surrounded by polyvinyl chloride (PVC) secondary containment pipes designed to capture potential AFFF concentrate leakage from the piping. The location of the underground piping is shown on Figure 2.

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 10.5.1).

The concentrate pipe system was identified for repair prior to the November 2022 AFFF (b) (3) release and is discussed in further detail throughout Section 10.2.1.2. The fire suppression system was modified but replacement was not completed prior to the release.

Within the tunnels, a containment system was used to capture the AFFF effluent after a fire suppression event. The containment system was designed to collect any dispersed firefighting agent, fuel, and water in retention sumps in the Red Hill tunnels. The contents of these sumps would then be transferred by a pump to a fire suppression system retention line and deposited in an AST formerly located outside (b) (3). Following the permanent defueling of the Facility tanks and pipelines in March 2024, the Navy removed the containment system from service.

Current Area A Features

Current features of Area A are depicted on Figure 2 and include the upper apron area at the entrance to (b) (3) where the November 2022 AFFF (b) (3) release occurred, and the lower area which contains Bldg. 313. Between the two areas is the paved road, (b) (3), and a vegetated slope. There are also vegetated areas within and north of Area A. Area A has access roads leading to (b) (3), to the Bldg. 313 lower paved lot, and to basal groundwater monitoring well RHMW17. Basal groundwater monitoring wells RHMW06 (installed in 2014) and RHMW17 (installed in 2022) are also located within Area A. Perched monitoring wells/piezometers (RHMW17D and RHMW17S, both installed in 2022) are also located within Area A. Two new basal monitoring wells (PFMW01A and PFMW02A) and a new perched groundwater monitoring well (PFMW01B) were installed in 2025. The three perched monitoring wells are not screened in a laterally contiguous perched unit but are likely in separate

perched groundwater lenses that are not hydraulically connected to each other. This will be described in greater detail in Section 10.2.6.1.

Additional current Area A site features include the following:

- *Excavation Areas/Former Decision Units (DUs):* The front apron area outside of (b) (3) is the area where AFFF concentrate was released in 2022. Geotextile fabric and plastic sheet were laid at the limit of the excavated area at the entrance of (b) (3). Excavated areas were backfilled with clean fill consisting of soil or gravel and covered with asphalt. 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. 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 Facility fence line. Stormwater runoff could have drained to this area if prior PFAS releases occurred outside (b) (3).
- *Sloped Areas North of* (b) (3)*:* As shown on Figure 2, this area lays between (b) (3) and the former Slop Tank/Bldg. 313 Pump House. The former 200-gallon AFFF tank was located at the upper southeast end of the sloped area and piping from both legacy and recent AFFF systems extended through the vegetated slope. Stormwater runoff from the former AFFF AST area would likely flow to this area. Potential surface and subsurface releases from the former AFFF AST and former AFFF pipeline may have occurred. The unpaved area at the base of the vegetated slope immediately south of Bldg. 313 can receive stormwater runoff and erosion from uphill areas, as well as runoff from paved areas around Bldg. 313. This unpaved low-lying area could potentially have accumulated PFAS in soil.
- *Surge Rock/Drainage Area:* PFAS-affected surface materials uphill may be carried by stormwater runoff to the lower drainage swale near Area A's northern boundary. The surge rock area was installed as a temporary access road for Red Hill monitoring wells (RHMWs). No surface soil is present in this area.
- *Bldg. 313:* Bldg. 313 is a former AFFF pump house that contains the main fire suppression pumps and controllers (for water) and a separate room for the AFFF concentrate tank, AFFF pumps, and controllers. It also contained the repaired AFFF concentrate pipeline which runs from Bldg. 313 to (b) (3). Prior to the construction of Bldg. 313, a former slop tank and containment basin constructed in the early 1960s were located within the footprint of Bldg. 313. No release of AFFF is known to have occurred at Bldg. 313.
- *Lower Drainage Swale:* Stormwater runoff drains into this concrete drainage swale located in the lower lot south and southeast of Bldg. 313. Swale surface soil in the drainage could potentially contain PFAS from surface erosion and stormwater runoff. Swale surface soils were observed in this area during a recent site visit (Section 10.3).

Groundwater Monitoring Well Network Near Area A

During scoping meeting discussions, the Navy and regulatory agencies agreed that selected groundwater monitoring wells located around Area A would be included in four expedited groundwater monitoring events that were conducted between September 2024 and September 2025.

During the expedited groundwater sampling events, 12 basal wells and 2 perched wells were included to evaluate potential migration from the known Area A source in groundwater. The area covered by this well network extends from RHM[redacted] in the northeast to RHM[redacted] in the southwest and includes groundwater monitoring wells located within the Facility's Tank Farm Lower Access Tunnel (RHM[redacted], RHM[redacted], RHM[redacted], and RHM[redacted]).

10.2.1.3 AREA B

Area B is approximately 37 acres of land, portions of which are developed and portions of which are vegetated by shrub brush and low trees. Area B slopes steeply through the eastern portion of the study area but includes about 10 acres of shallower sloping land at its northwest extent. [redacted] runs along the northern perimeter from the [redacted], then cuts through the southwest and runs along the southern perimeter to its eastern extent. The concrete-lined South Halawa Stream borders the northern portion of Area B. The southeastern portion of Area B is bordered by military housing, an elementary school, and the Facility boundary, and the southwestern portion is bordered by the H201 freeway (Figure 1). Current site features for Area B are shown on Figure 3.

Former OWDF

Area B includes the former OWDF, which consisted of two different reclamation and disposal pits and basins and associated infrastructure that operated between 1943 and 1986. Both pits were in the same location and functioned similarly: oily wastewater generated from periodic cleaning of the Facility 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 transportation 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). After a two-phase RI and removal action, a containment cap and liner were constructed at the location of the former pits (Figure 3). There is no documentation of AFFF use at the former OWDF.

Existing Monitoring Wells

Existing monitoring wells in Area B include OWDF wells, delineation (RHP) wells, and RHMWs.

The OWDF wells include both basal and perched aquifer wells installed as part of the OWDF investigations. The eight basal wells are labeled OWDFMW01 (installed in the late 1990s) and OWDFMW02A through OWDFMW08A (installed in 2021). These wells are all screened below the basal potentiometric surface in confined conditions. Eight perched aquifer wells were installed in 2021: OWDFMW02B through OWDFMW08B, plus OWDFMW07C, which was the only location where perched water was encountered above the basal aquifer and below the upper perched zones. Wells OWDFMW03B, OWDFMW05B, OWDFMW06B, and OWDFMW07B are screened in a contiguous perched unit along the western end of the former OWDF. Well OWDFMW08B is screened in a perched unit that extends under [redacted], just east of the former OWDF. The lithology of this area is described in more detail in Section 10.2.5.2.

The RHP wells were installed as part of the response to the November 2021 JP-5 release at [redacted]. Eleven 2-inch diameter groundwater monitoring wells were installed around the [redacted] water development to evaluate whether light non-aqueous phase liquid (LNAPL) or dissolved JP-5 constituents were migrating away from the release area. LNAPL was not observed in the borings nor was detected in these wells. RHP01, RHP02, RHP03, RHP04, RHP05, RHP06, RHP07, and RHP08 are unconfined basal groundwater monitoring wells screened within the basal water table. RHP07 is in the lower access tunnel southeast of the JP-5 release area and is also screened across the unconfined

basal water table. RHP04B and RHP04C are collocated with RHP04A but were installed with screens substantially submerged beneath the basal groundwater table to identify any deeper PHC migration pathways, and to evaluate flow conditions and other aquifer parameters. RHP08B and RHP08C are also collocated and have submerged screens below the unconfined basal water table.

(b) (3) Water Development Tunnel

Area B contains the (b) (3) Pump House, which formerly provided potable water to the JBPHH Water Distribution System. The (b) (3) horizontal water development tunnel is (b) (3) . (b) (3) (Fourteenth Naval District 1942). Initially, the excavated basalt transmitted relatively little water as the tunnel was being excavated from west to east. The easternmost 200 feet of clinker yielded most of the water in the water development tunnel (Stearns 1943). In addition to water coming in from the east, deeper water is likely drawn up (b) (3) , causing upwelling of deeper water.

10.2.2 Surrounding Area and Land Use

The overall Facility 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; and on the south and southeast by residential neighborhoods and Moanalua Valley, respectively.

Access to Area A and Area B is (b) (3) .

(b) (3)

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 the average air temperatures on Oahu are 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 msl near the ridge line of the Koolau Range, is

139 and 137 inches, respectively (i.e., about 0.4 inches per day) (USGS 2017a, 2017b). 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 33.9 inches (i.e., about 0.1 inches per day) (USGS 2017c, 2017d).

10.2.4 Topography and Surface Water and Stormwater Drainage Patterns

10.2.4.1 General Area Topography and Surface Water and Stormwater 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 northwestern and southern 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 ground surface elevation of the Red Hill ridge line tank farm area is approximately 420–560 feet msl. The ridge's northwest and southeast flanks drop steeply to South Halawa Valley, where the Site is located, and to Moanalua Valley, where valley floor elevations in the tank farm area range from approximately 180–250 feet msl and 100–160 feet msl, respectively. North Halawa Valley lies north of South Halawa Valley with a low intervalley ridge between them, which is the site of Halawa Quarry.

At the Red Hill Facility, stormwater runoff predominantly occurs along major roads, specifically down (b) (3), moving down the ridge from east to west. Runoff also occurs along the main Red Hill ridge line and down the side slopes of the ridge (roughly to the north and south). South Halawa Stream is located north of the ridge and is channelized with concrete from east of RHMW11, west to the confluence of North Halawa and South Halawa Streams, near the H3/H-201 Interchange west of the Facility. Farther east, past RHMW11, South Halawa Stream is not channelized. The topography for the Facility is shown on Figure 5.

10.2.4.2 Area A Topography and Surface Water and Stormwater Drainage Patterns

Area A is situated on sloping terrain at approximately 240–360 feet above msl and east of the channelized portion of South Halawa Stream. Area A is located on the north-facing slope of the southern wall of South Halawa Valley. (b) (3) is located at the tunnel entrance, across the street from Bldg. 313, east of (b) (3). 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.

In Area A, major stormwater runoff captured from Red Hill ridge to (b) (3) is diverted by the drainage ditch that extends along the southern edge of (b) (3) in the vicinity of Area A. Once captured by the drainage ditch, stormwater runoff is diverted along (b) (3) from east to west, and from the northern portion of Area A toward South Halawa Stream via swales and a concrete drainage channel along the eastern perimeter of the Bldg. 313 compound. Minor drainage may occur over Area A, but this is mostly limited by the relatively flat topography of Area A and its small area.

10.2.4.3 AREA B TOPOGRAPHY AND SURFACE WATER AND STORMWATER DRAINAGE PATTERNS

Area B is located southwest of Area A, mostly within the Facility property boundary, and sits between 85 and 300 feet msl. 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 slopes steeply through the eastern portion of the study area but includes about 10 acres of shallower sloping land at its northwest extent. Area B land that is not currently covered by scrub brush and low trees, includes the former OWDF, where the (b) (3) currently operates, (b) (3) (b) (3), and the South Halawa Stream.

In Area B, stormwater runoff from the valley walls between the southern ridge and (b) (3) located closer to South Halawa Stream, is diverted by the stormwater drainage ditch that extends along the southern edge of (b) (3). Stormwater in the drainage ditch flows from east to west to the (b) (3) entrance road, where it is diverted into the channelized portion of South Halawa Stream. Runoff from (b) (3) merges with South Halawa Stream, north of the Facility boundary, west of the Halawa Industrial Park and at the eastern end of the animal quarantine station. In the eastern portion of Area B, minor runoff occurs from up the ridge and down toward (b) (3) along topographic low points. In the western portion of Area B, minor runoff occurs downslope toward South Halawa Stream.

10.2.5 Geology and Soils

Soils in the vicinity of the Facility 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 bgs. Along the slopes, the basaltic bedrock is covered with 0–30 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.

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 aa lava of the Tertiary Koolau basalt (Izuka 1992). Aa flows typically consist of a relatively low-permeability central core, bounded by spiny, fragmented margins called “clinker.” Spaces in the clinker margin of the aa flows allow efficient lateral transmission of basal groundwater while the massive basalt cores tend to 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 aa 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 Facility’s 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.

10.2.5.1 AREA A

There are four basal monitoring wells installed in Area A, which provide detailed lithologic information about Area A through the total depth of each well. The wells extend approximately 20 feet below msl. The basal aquifer in this area is unconfined. As observed on the cross section (Figure 6), the area is composed of a relatively shallow alluvium layer overlying highly heterogeneous basalt. The depth to alluvium generally increases toward the north, closer to South Halawa Valley, as observed at PFMW02A compared to the other monitoring wells such as PFMW01A and RHMW06.

10.2.5.2 AREA B

Detailed lithologic logging was conducted during monitoring well installation at the former OWDF in 2021 as part of the ongoing OWDF site assessment. Area B is underlain by a highly heterogeneous system of interbedded stratigraphic layers (Figure 7a, Figure 7b, Figure 7c). In the (b) (3) area and at the former OWDF, low-permeability materials include aquitards that support multiple perched groundwater units well above a confining unit. Both the confining unit and perched groundwater zone pinch out up-ridge toward the east of Area B. The confining unit is present at all basal monitoring well locations within the former OWDF, generally increasing in thickness in the downslope direction (toward the west), with the extent of the confining unit ranging from 23 to 121 feet (Figure 7a, Figure 7b, Figure 7c). Confining conditions are not present in the southeastern portions of Area B, in areas under the Red Hill ridge, or near the (b) (3).

10.2.6 Groundwater Hydrogeology

Generally, groundwater in Hawaii exists in two principal aquifer types: basal and caprock. Caprock groundwater has not been identified at the Facility. A third type, perched groundwater, also occurs in limited formations throughout the region, including at both Area A and Area B. 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., very stiff clays, lithified fine tuff, or clay-infilled or weathered basalts). 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 encountered at both Area A and Area B. A hydrograph of a perched water well (PFMW01B) at the Facility is shown on Figure 8.

Elevated Heads: Elevated head conditions were observed during the drilling of monitoring well RHMW11 as continuous saturation within the confining unit (weathered basalt) (perched conditions not observed) (DON 2018). Similar but distinguishable conditions were observed during the drilling and installation of monitoring wells RHMW12A, RHMW14, and test-boring RHTB01 on the South Halawa Valley floor, and at RHMW16.

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.

Unconfined Groundwater: Unconfined groundwater is observed higher up on the ridge, not in the valleys. In unconfined aquifers, water only partially fills the aquifer and the saturated portion rises to what is known as the "water table." Unconfined groundwater monitoring wells at the Site typically extend 20 feet below the water table and about 10 feet into the unsaturated section.

Confined Groundwater: Confined groundwater is encountered, specifically in South Halawa Valley and in paleo-valleys at the Site. In a confined aquifer, water fills the entire aquifer and is overlain by a less permeable unit known as a "confining unit" or "confining bed." Confined groundwater is held under pressure in a well, advances through the confined unit, and rises above the height of the aquifer to an elevation known as the "potentiometric surface." Confined groundwater wells have fully saturated screens positioned below the confining unit, extending generally 20 feet into the aquifer.

Confining Unit: As described above, confined groundwater is overlain by a less permeable unit that inhibits downward flow and is known as a "confining unit" or "confining bed." At the former OWDF, and in Area B, the confining unit encountered is massive aa.

Basal groundwater elevations in the southern Oahu region range from 0 feet 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 et al. 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. At Red Hill, the basal groundwater horizontal gradients are extremely flat and groundwater flow direction is influenced by a high degree of anisotropy (resulting from the heterogeneity of the basalt) and by pumping at the [redacted].

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 2017). 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 Facility 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 Facility 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 Facility is also categorized by the EPA as 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 municipal drinking water supply well is located in the Facility ([redacted]) (Figure 3). 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 that skims the water table and from which water is pumped.

[redacted] *Flow Optimization Study:* Between April 7 and June 20, 2022, the [redacted] Flow Optimization Study was conducted to optimize the groundwater capture zone around [redacted] created by pumping at [redacted], while minimizing the withdrawal of groundwater from the sole source aquifer (DON 2023m). During the study period, transducers were used to record continuous groundwater levels, at 10-minute intervals, throughout the Red Hill monitoring well network and some off-site wells while different pumping scenarios were implemented at [redacted] Figure 9). Due to the flat gradients observed in basal groundwater near the Facility, the Flow Optimization Study contoured drawdown instead of water levels (Figure 10), using GroundWater Desktop "KT3D_H2O" Version 4.0 logarithmic drift model to account for pumping (SSPA 2023).

10.2.6.1 AREA A

Perched Water: Perched water was not encountered at all locations during drilling at Area A and exhibited different properties in the areas in which it was encountered. Perched water was encountered in wells RHMW17 and PFMW01B, but not in PFMW02A:

- *RHMW17:* Monitoring wells RHMW17S and RHMW17D are screened at different depths in the annular space of basal monitoring well RHMW17, which is in the northeastern portion of Area A. RHMW17S is screened in a perched water lens observed between 42 to 52 feet bgs (200 to 210 feet msl). RHMW17D is screened in a perched water lens between 167 and 172 feet bgs (80 to 85 feet msl). Both of these two distinct perched zones are well above the underlying basal aquifer. Soil samples collected above each perched zone was impacted by JP-5 petroleum constituents, but LNAPL has not been detected in either perched zone.
- *PFMW01B:* Monitoring well PFMW01B is located approximately 100 feet southwest of RHMW17 and was installed with a screened depth of 35 and 65 feet bgs (184 to 214 feet msl). During drilling, perched water was observed seeping from a fractured portion of the PFMW01B borehole annulus between 30 and 35 feet bgs, and, over a period of approximately 1 week, groundwater accumulated at a static level between 52 and 54 feet bgs, indicating extremely slow recharge at this location. Petroleum LNAPL has been observed in PFMW01B up to 0.65 feet thick on top of the water table.
- *PFMW02B:* Located approximately 135 feet northwest of PFMW01B, no perched water was encountered at this location.

In summary, perched water was encountered at certain locations, at significantly different depths, with different apparent conditions and recharge rates (Figure 6). It is therefore not known how extensive or contiguous any of the perched water in Area A is.

Basal Aquifer: As shown on Figure 6, the basal aquifer near Area A is unconfined. Groundwater gradients are relatively flat (Figure 9), with groundwater elevations typically between 17 and 19 feet msl. Both the groundwater gradients and groundwater elevations are influenced by pumping conditions of the [redacted]. Figure 10 shows drawdown contours at the Facility during the [redacted] Flow Optimization

Study when (b) (3) was pumping at its current average rate of (b) (3) million gallons per day (mgd), prior to the installation of wells PFMW01A and PFMW02A. A maximum of 0.4 feet of drawdown for the entire Facility occurs around the (b) (3) water development tunnel, with decreasing amounts of drawdown radiating outward from (b) (3). Specifically, Area A experiences approximately 0.1 feet of drawdown in the basal aquifer when (b) (3) is pumping at (b) (3) mgd compared to when (b) (3) is not pumping. The basal wells in Area A at the time of the study (RHM(b) (3) and RHM(b) (3)) responded consistently and rapidly to (b) (3) pumping.

10.2.6.2 AREA B

From August 2022 to August 2023, a synoptic water level study was performed in Area B as part of the former OWDF investigation, using transducers installed in 8 perched groundwater wells, in 18 basal groundwater monitoring wells, and in the (b) (3). The basal groundwater monitoring wells incorporated in the study included confined OWDF wells and unconfined RHP wells and RHMWs, as shown on Figure 3. The former OWDF water level study monitored various (b) (3) pumping rates, with water levels recorded at 10-minute intervals. Results from this study provide insight into the behavior and nature of the perched units and basal aquifer at Area B.

Perched Water: At least two distinct perched groundwater units that behave differently are present in Area B (Figure 7a, Figure 7b, Figure 7c):

- Downslope perched groundwater monitoring wells OWDFMW03B, OWDFMW05B, OWDFMW06B, and OWDFMW07B respond similarly to hydraulic stresses, recover well from purging, and appear to be in the same perched groundwater unit. By contrast, as discussed in the next two bullets, the other three perched groundwater monitoring wells respond differently to stresses and do not appear to be in reciprocal hydraulic communication with each other or with the downslope wells.
- Perched groundwater around OWDFMW08B and the (b) (3) sump is approximately 15 feet higher than the downslope area. The groundwater in OWDFMW08B is at a similar elevation as (slightly higher than) the water located beneath the (b) (3) tunnel, which is artificially supplied by the pump coolant water and simultaneously artificially drained by the (b) (3) sump.
- Perched groundwater monitoring wells OWDFMW02B and OWDFMW04B are often nearly dry, without enough water to sample, and do not recover from purging even when left overnight, suggesting that they may accumulate infiltrating water over time but might not be located within any substantial perched units. When present, perched groundwater near the most upslope OWDFMW04B well is approximately 30 feet higher than OWDFMW08B and approximately 45 feet higher than the downslope perched unit.

The four downslope perched water wells and OWDFMW08B consistently have enough water to sample and were selectively sampled during expedited groundwater monitoring events.

As expected, perched groundwater monitoring wells do not respond to pumping at (b) (3). Water may flow from the upslope (b) (3) perched groundwater unit to the downslope perched groundwater unit at the former OWDF, though conditions between upslope and downslope perched units are a data gap to be evaluated during the current RI. Hydrographs show that perched groundwater does respond to precipitation. Water level equipotential lines for both the downslope and upslope perched groundwater units from a wet or rainy period are shown on Figure 11 and for a dry period on Figure 12. As described above, upslope perched wells OWDFMW02B and OWDFMW04B do not consistently have measurable water, are likely not located within continuous perched zones that extend to other wells

and are therefore not included in this analysis. For the downslope perched groundwater wells, groundwater levels increase during wet periods, rising approximately 5 feet. Gradients remain in the southwesterly direction. In both wet and dry periods, the downslope perched groundwater elevations range from 12 to 20 feet below the upslope OWDFMW08B well, such that easterly flow cannot occur. In the upslope perched unit near (b) (3), water levels do not appreciably change between the wet and dry periods. Water at OWDFMW08B generally flows toward (b) (3).

Basal Aquifer: Confined and unconfined basal groundwater monitoring wells in Area B respond strongly and rapidly as a unit in response to (b) (3) pumping (Figure 9). Basal aquifer water levels are drawn toward (b) (3) when pumping, as shown in the flow optimization study (Figure 10) (DON 2023m). Water levels within the former OWDF drawdown are approximately 0.1 to 0.2 feet when (b) (3) is pumping at (b) (3) mgd. Drawdown occurs throughout Area B, ranging from approximately 0.2 feet of drawdown below the former OWDF to 0.4 feet around (b) (3), when (b) (3) is constantly pumping at (b) (3) mgd. The confined basal groundwater conditions below the former OWDF area inhibit downward flow, but the basal aquifer is unconfined in upslope regions near (b) (3).

10.2.7 Vegetation and Wildlife

The Facility 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 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 Results and Removal Actions

10.2.8.1 Demolition of Jet Propellant 5 Slop Tank at (b) (3) (2008)

Soil samples were not analyzed for PFAS (Shaw 2009) after the removal of the former 5,000-barrel Slop Tank in 2008. Additional details are available in Section 10.2.1.

10.2.8.2 Preliminary Assessment Potential Per- and Polyfluoroalkyl Substances National Priorities List Sites

A basewide PA was conducted to identify and evaluate sites potentially impacted by PFAS releases at JBPHH. The PA identified potential historical sites where compounds containing PFAS may have been used or released (DON 2022a). Within the Facility boundary, only Bldg. 313 near (b) (3) was identified as warranting further evaluation, based on the November 2022 AFFF (b) (3) release. The PA described the emergency response actions implemented immediately following the release, and recommended this RI be conducted.

10.2.8.3 AFFF RELEASE AND RESPONSE ACTIONS AT (b) (3) (NOVEMBER 2022)

On November 29, 2022, approximately 1,100 gallons of AFFF concentrate (AFFF 3%-C6 solution) were released from the fire suppression system at the entrance of (b) (3) within the Facility (DoD 2023d; EPA Region 9 2023). More details including the immediate release response are described in Section 10.2.1.2.

Confirmation Sampling: Prior to backfilling the excavation areas, confirmation sampling was conducted at the excavation boundaries in accordance with the SAP reviewed by the EPA and approved by DOH (DON 2022b). Between December 2 and 15, 2022, multi-increment soil samples were collected from excavation areas outside of (b) (3) and analyzed for PFAS using draft EPA Method 1633 and for 2-(2-butoxyethoxy)ethanol using EPA Method 8015. The former DUs used for the confirmation sampling program and detected PFAS results are presented on Figure 13. Further discussion of the sampling and analysis conducted is presented in Section 10.2.8.4.

Confirmation sample results were initially compared against applicable EPA (May 2022) residential regional screening levels (RSLs) (target hazard quotient [THQ] = 0.1 and target risk [TR] of 1E-06) and DOH interim PFAS soil EALs (EPA 2022; DOH 2021b). At the time of evaluation, none of the detected PFAS exceeded their respective EPA residential soil RSLs. Several PFAS, including 6:2 fluorotelomer sulfonic acid (FTS), perfluoroheptanoic acid, perfluorohexanoic acid (PFHxA), and perfluorooctanoic acid (PFOA), were found in soil confirmation samples above their respective DOH EALs. A re-evaluation of confirmation sample results against current screening levels is discussed in Section 10.2.8.4.

Several PFAS detected in confirmation samples, including 6:2 FTS, do not have DoD-approved screening levels (ASD 2025). Among these, 6:2 FTS had the highest concentration in the soil samples collected from the release area. The maximum concentration of 6:2 FTS detected in confirmation soil samples was 150 micrograms per kilogram (µg/kg), collected from the soil area situated between the road, storm culvert, and apron (Formerly DU 2) (Section 10.5.2.1).

10.2.8.4 SAMPLING AND ANALYSIS AT (b) (3)

Multi-media 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,* (b) (3), *Joint Base Pearl Harbor-Hickam, Hawaii* (DON 2022b). The analyzed media included investigation-derived waste (IDW) (soil excavated at the spill location), site soil remaining 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. 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

Confirmation soil samples collected using multi-increment sampling techniques were collected in December 2022 from former DUs 1, 2, 3, 4A, 4B, 5, 6, and 7. The results detected 26 of the 40 PFAS reported (DON 2023d); maximum detected results of the confirmation samples are presented in

Appendix B. Six of these compounds were detected at concentrations exceeding DOH EALs, while no results exceeded EPA RSLs (2022) at the time of evaluation (DON 2023d). Additionally, synthetic precipitation leaching procedure was performed on confirmation soil samples and the leachate was analyzed for PFAS; these synthetic precipitation leaching procedure results are summarized in the January 2023 AFFF groundwater investigation and monitoring monthly report (DON 2023e).

Appendix B presents the same data screening against current screening levels identified in Assistant Secretary of Defense (ASD) Memorandum, *Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program*, the November 2024 residential soil EPA RSLs (THQ = 0.1 and TR 1E-06) are provided for reference (DoD 2024c; EPA 2024d). Soil results for PFOA, perfluorooctanesulfonic acid (PFOS), and perfluorodecanoic acid (PFDA) from the confirmation samples exceed current screening levels in all DUs (DoD 2024c; EPA 2024d), as shown on Figure 13. 6:2 FTS was the PFAS detected in soil with the greatest concentration at 150 µg/kg and does not have a currently approved screening level.

Analyses of 2-(2-butoxyethoxy)ethanol, a solvent component of the AFFF concentrate released in 2022, was detected in 2 of the 12 samples analyzed (including sample replicates); no results exceed the currently available screening criteria (EPA RSL for residential soil [THQ of 0.1 and TR of 1E-06]) (EPA 2024c).

November 2022 Release Response 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 2 piezometers (RHMW17D and RHMW17S). Samples were analyzed for PFAS using then-draft EPA Method 1633 (DON 2023j). A total of 421 groundwater samples were 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 were detected in groundwater samples. Weekly samples were collected from December 2022 to June 2023. This changed to monthly collection after June 2023 to December 2023.

Of the analytes tested, only PFDA exceeded the DoD-approved screening levels identified in the 2025 ASD Memorandum (ASD 2025). PFOS and PFOA detections were greater than the November 2024 EPA tap water RSLs THQ of 0.1 and TR of 1E-06, but not greater than the maximum contaminant levels (MCLs) identified in the 2025 ASD Memorandum (ASD 2025; EPA 2024d). A summary of the maximum detected groundwater concentration for the target PFAS for samples collected through the December 2023 monitoring is presented in Appendix B, Table B-2.

September 2023 PFAS Baseline Groundwater Sampling Event

Baseline groundwater samples were collected from 21 wells not included in the periodic monitoring events, located near and around the Facility in September 2023. Samples were analyzed for PFAS using draft EPA Method 1633 (DON 2023o). The wells sampled are shown on Figure 14.

Ten out of 40 PFAS were detected above the analytical limit of quantitation (LOQ) in the samples collected. Analytical results from 5 wells (RHP01, RHP02, RHP03, RHP07, and NMW32) showed concentrations of PFOS above the DOH EAL and tap water EPA RSL (THQ of 0.1 and TR of 1E-06) during the initial evaluation done in 2023 (DON 2023o). PFOS concentrations ranged from 9.0 nanograms per liter (ng/L) to 16.0 ng/L.

Table B-3 presents a summary of the maximum detected groundwater concentrations of target PFAS from the September 2023 baseline sampling event, compared to current screening levels established in the ASD Memorandum (ASD 2025). PFOS exceeded current screening levels (4 ng/L) in 6 wells

sampled: RHP01, RHP02, RHP03, RHP06, RHP07, and NMW32. PFOA results from the 2023 baseline groundwater sampling exceeded current screening levels (4 ng/L) in 2 wells: RHP02 and NMW32. PFOS exceedances in baseline wells (RHP01, RHP02, RHP03, RHP06, and RHP07) are unlikely related to the November 2022 AFFF (b) (3) release due to the presence of branched PFAS isomers and absence of 6:2 FTS detections. The preliminary evaluation suggests that the PFAS in these wells likely originate from a different source.

10.2.8.5 Collection, Holding, and Transfer Tank

The Collection, Holding, and Transfer (CHT) Tank is an approximately (b) (3) (b) (3) located outside (b) (3) (Figure 3). The purpose of the CHT Tank is to receive sanitary waste from a sanitary septic tank inside (b) (3) and store the sanitary waste until it is transported off-site. However, petroleum was inadvertently pumped into the CHT Tank during the November 2021 JP-5 release at (b) (3). The CHT Tank then overflowed during rain events in December 2021 and January 2022, and fluid was released to the surrounding area, which may have included some remnant JP-5 product and petroleum-impacted stormwater.

The Navy submitted a site characterization WP addendum under separate cover to EPA and DOH in March 2024 (DON 2024e) to assess the nature and lateral extent of PHCs in near-surface soil around the CHT Tank under different regulatory framework.

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 (b) (3) approximately 250 feet northwest of the CHT Tank (Figure 3). 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 (b) (3) tunnel. During the November 2021 JP-5 release, the (b) (3) sump became filled with JP-5, activating the pump that transferred JP-5 into the Former Holding Tank and Leach Tank system.

Phase 1 petroleum site investigation field work was conducted from January 11 to 13, 2022, which 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 March 9 to 17, 2022, a Phase 2 investigation was conducted using a hollow-stem auger (HSA) drilling rig to install 8 additional borings and 3 temporary wells into the shallow perched water aquifer. The results of these investigations indicated that total petroleum hydrocarbons (TPH) and related chemical constituents were observed in soil and perched groundwater above DOH EALs (DON 2022d, 2023n).

The Navy followed up with two removal actions:

- Between May 13 and May 25, 2022, the Navy excavated and removed the Holding Tank, Leach Tank, adjacent piping, and petroleum-impacted soil.
- Between August 29 and October 3, 2022, the Navy excavated and disposed of approximately an additional 1,300 cubic yards of petroleum-impacted soil to a maximum depth of approximately 30 feet bgs.

The Navy has proposed conducting an environmental hazard evaluation and preparing an environmental hazard management plan to manage COPCs that may remain safely in place. The Former Holding Tank and Leach Tank release response action remains ongoing.

10.3 SITE RECONNAISSANCE

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

- Document current site conditions (surface cover, building and 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 and safety concerns, overhead, and subsurface utilities).

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

- Area A is partially developed with paved roads, an entrance to (b) (3), Bldg. 313, and pavement footprints similar to previous footprints dating back to at least the year 2000. Bldg. 313 was constructed in 2015 over the former Slop Tank footprint. (b) (3) 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 (b) (3) at the top of the sloped embankment to Bldg. 313.
- The terrain gradually slopes downward to the north and west and gradually steepens to the west.
- The asphalt pavement over excavated areas is visibly newer than surrounding paved areas. These include areas outside of (b) (3), along the former drainage swale following the road, and pavement crossing the road where the Former Box Culvert Drainage Area was located.
- (b) (3) (A) 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. Swale surface soil accumulation was observed in the drainage swale.
- Surge rock gravel at the end of the drainage swale was observed. The surge rock provides a drivable surface connecting Bldg. 313 to RHMW17 and drainage for the swale during storm events.
- Two nearby monitoring wells (RHMW06 and RHMW17) 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) (b) (3) (A)
- The northern portion of Area A has a perimeter fence around most of it. The areas outside of the fence line are densely vegetated with grass and trees; vegetation clearance will be needed prior to the fieldwork in some areas.

- The AFFF pipeline section was in the process of being replaced/repaired in case the use of the AFFF fire suppression system was mandated by regulators during defueling activities. The defueling fire suppression plan proposes the 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 RESULTS OF THE EXPEDITED GROUNDWATER SAMPLING

Following collaborative scoping meetings with the Navy and regulatory agencies, four expedited groundwater monitoring events for PFAS were conducted at the Facility between September 2024 and September 2025. Each event included the collection and analysis of groundwater samples from up to 44 groundwater wells located within the Facility boundary.

The groundwater monitoring events were conducted on a quarterly basis from September to December 2024, January to April 2025, April to July 2025, and July to September 2025, and analyzed for various PFAS by EPA Method 1633. Monitoring wells were purged and sampled in accordance with the draft final RI WP and the Navy's ER Program Project Procedures Manual Procedures I-C-1, *Monitoring Well Installation and Abandonment*, and I-C-2, *Monitoring Well Development*. Groundwater was collected using low-flow sampling techniques in accordance with the WP and Procedure I-C-3, *Monitoring Well Sampling* (DON 2015, 2024a).

The purpose of the expedited groundwater monitoring program was to evaluate the stability and seasonal variation of the PFAS concentrations in groundwater first detected during the 2023 baseline sampling events (DON 2023e, 2023d, 2023h, 2023a, 2023i) and to refine the CSM.

10.4.1 Well Locations Sampled

The wells sampled during the four expedited groundwater monitoring events are listed in Table 10-1.

Table 10-1: Wells Sampled During Four Quarters of Expedited Groundwater Monitoring

	Well IDs			
Sample Type	Quarter 1 (Q1)	Quarter 2 (Q2)	Quarter 3 (Q3)	Quarter 4 (Q4)
Perched Wells	OWDFMW02B, OWDFMW03B, OWDFMW04B, OWDFMW08B, RHMW17D, RHMW17S	Q1 wells plus OWDFMW05B [a], OWDFMW06B [a], OWDFMW07B [a], OWDFMW07C [a]	Q3 wells plus PFMW01B [a]	Same as Q3 wells
Basal Wells Screened Across the Water Table	RHMW2254-01, RHMW01R, RHMW02, RHMW03, RHMW04, RHMW05, RHMW06, RHMW07 [b], RHMW08, RHMW17, RHMW18, RHMW20, RHMW21, RHP01, RHP02, RHP03, RHP04A, RHP05, RHP06, RHP07, RHP08	Same as Q1 wells	Same as Q1 wells	Q1 wells plus PFMW01A [a], PFMW02A [a]

Sample Type	Well IDs			
	Quarter 1 (Q1)	Quarter 2 (Q2)	Quarter 3 (Q3)	Quarter 4 (Q4)
Basal Wells Screened beneath Confining Units	RHP04B, RHP08B, OWDFMW01, OWDFMW02A, OWDFMW03A, OWDFMW04A, OWDFMW05A, OWDFMW08A	Q1 wells plus OWDFMW06A [a], OWDFMW07A [a]	Same as Q2 wells	Same as Q2 wells
Basal Wells Screened at Deeper Depths	RHP04C	Same as Q1 wells	Same as Q1 wells	Same as Q1 wells

ID identification
[a] Indicates this is the first sampling event for the well during the expedited groundwater sampling.
[b] RHMW07 is an elevated head well.

10.4.2 Laboratory Analyses

Groundwater samples collected during the expedited groundwater monitoring events were analyzed for up to 50 specific PFAS, based on the project laboratory's current DoD ELAP accreditation for EPA Method 1633 (Appendix B, Table B-5 through Table B-7). Groundwater samples collected during the Q1 and Quarter 2 (Q2) were analyzed for 40 PFAS following EPA Method 1633 as listed in Worksheet #15 of the draft RI WP (DON 2024a). Four additional PFAS (perfluoropropanoic acid [PFPrA], perfluorohexadecanoic acid, perfluorooctadecanoic acid, and bis(trifluoromethylsulfonyl)amine) were added and retained for analysis in the Quarter 3 (Q3) monitoring event, and six additional PFAS (1H,1H,2H,2H-perfluorododecane sulfonic acid, perfluorobutane sulfonamide, perfluorohexane sulfonamide, 2H-perfluoro-2-octenoic acid, 2H-perfluoro-2-decenoic acid, and perfluoro[4-ethylcyclohexane]sulfonic acid) were added for analysis in the Quarter 4 (Q4) monitoring event. Details regarding the addition of 10 PFAS in Q3 and Q4 are included in Section 10.4.3.

10.4.3 Expedited Groundwater Monitoring Analytical Results

The analytical results of the expedited groundwater monitoring event are presented in Appendix B, Table B-4 through Table B-7 and summarized below.

10.4.3.1 AREA A

Perched Groundwater Wells

Perched groundwater monitoring wells in or near Area A are screened in different, discontinuous perched water units. Although there were some detections of PFAS in the Area A wells, there were no exceedances of current DoD-approved screening levels (ASD 2025) in perched or basal wells within Area A in any quarter, with the exception of PFMW01B. PFMW01B was sampled only during Q3 and Q4, and four PFAS exceeded the screening levels in each sampling event. Analytical results for perched wells in Area A are presented in Appendix B, Table B-4 and shown on Figure 15, Figure 16, Figure 17, and Figure 18.

Basal Groundwater Wells

Samples from many basal aquifer groundwater monitoring wells located in Area A and the surrounding groundwater monitoring well network had detectable PFAS; however, no PFAS were detected above the DoD-approved screening levels (ASD 2025) in these wells during these events. Detected concentrations were relatively stable throughout the sampling events, and no seasonal trends were observed (Figure 19, Figure 20, Figure 21, and Figure 22).

The Q4 sample from newly installed basal groundwater well PFMW01A had higher concentrations of PFOS, PFOA, and 6:2 FTS than the three adjacent groundwater monitoring wells (RHMW17, PFMW02A, and RHMW06) but still did not exceed DoD-approved screening levels.

10.4.3.2 AREA B

Perched Groundwater Wells

Area B has multiple different perched units. One contiguous perched unit is located toward the western end of Area B and is monitored by wells OWDFMW03B, OWDFMW05B, OWDFMW06B, and OWDFMW07B. Located at an approximately 15-foot higher elevation, a second perched unit encompasses monitoring well OWDFMW08B and a portion of [redacted]. The perched unit near [redacted] is not directly influenced by the lower-lying perched unit at the western end of the former OWDF. Two additional perched groundwater monitoring wells (OWDFMW02B and OWDFMW04B) are located at higher elevations south/southwest of [redacted]. These two wells accumulate some water over time but rarely have sufficient water to sample and do not appear to be in hydraulic communication with the two perched units.

Analytical results for all perched groundwater monitoring wells that were part of the expedited sampling events in Area B are presented in Appendix B, Table B-6. Results for all PFAS were similar across all four quarters and no seasonal trends were observed.

PFOS: All sampled perched groundwater monitoring wells in Area B exceeded the PFOS DoD-approved screening level (4 ng/L) (ASD 2025) in all four monitoring events. PFOS is not defined below the current DoD-approved screening levels (ASD 2025) within perched Area B wells ([redacted]).

PFOA: All sampled perched groundwater monitoring wells screened within the perched unit in Area B exceeded the PFOA DoD-approved screening level (4 ng/L) in all four monitoring events; however, PFOA concentrations measured in intermediate perched well OWDFMW07C did not exceed the DoD-approved screening levels (ASD 2025) in any event (Q2, Q3, and Q4) ([redacted]). PFOA is not defined below the project screening level (PSL) within perched Area B wells ([redacted]).

Perfluorobutanoic Acid (PFBA), PFHxA, Perfluorohexanesulfonic Acid (PFHxS): PFBA, PFHxA, and PFHxS were detected in every perched well in Area B during all four monitoring events ([redacted]). All perched groundwater monitoring wells in Area B exceeded the DoD-approved screening level (ASD 2025) for PFHxS (10 ng/L) in at least two quarters during the expedited groundwater monitoring events. PFBA, PFHxA, perfluorononanoic acid (PFNA), and PFHxS are not defined below the current DoD-approved screening levels (ASD 2025) within perched Area B wells.

Basal Groundwater Wells

Analytical results for basal groundwater monitoring wells in Area B are presented in Appendix B, Table B-7. Results for all PFAS were similar in each of the four expedited groundwater monitoring events and no seasonal trends were observed.

The concentration of PFDA exceeded the current DoD-approved screening levels (0.52 ng/L) (ASD 2025) for well RHP01 in Q3 in a single sample. All other exceedances in Area B basal wells are discussed below.

PFOS: All PFOS exceedances in the basal groundwater monitoring wells were in unconfined wells screened at the basal groundwater table, east of the former OWDF except for OWDFMW05A ([redacted] (b) (3)). RHP01 to RHP03, RHP05 to RHP07, and OWDFMW04A had PFOS exceedances of the DoD-approved screening level (4 ng/L) (ASD 2025) in each quarterly sampling event.

The concentration of PFOS in the duplicate sample for OWDFMW05A, which is confined, was detected at DoD-approved screening level (4 ng/L) (ASD 2025) for Q3 (3.8 and 4 ng/L) and Q4 (4 and 4.1 ng/L). PFOS did not exceed the PSL in the Q1 or Q2 samples. PFOS is defined in the basal aquifer below the PSL to the west of Area B by OWDFMW03A, OWDFMW06A, and OWDFMW07A; however, it is not fully defined below the PSL to the south of OWDFMW05A where detected concentrations are reported at the DoD-approved screening levels (ASD 2025). PFOS in the basal aquifer is also not fully defined to the east, nor to the north along the Facility boundary toward the Halawa Industrial Park ([redacted] (b) (3)). Concentrations increase to the east and northeast.

PFOA: Similar to PFOS, PFOA exceeded the DoD-approved screening level of 4 ng/L (ASD 2025) in Area B basal groundwater monitoring wells screened at the water table east of the former OWDF (RHP01 to RHP03, RHP05 to RHP07, and OWDFMW04A) ([redacted] (b) (3)). PFOA is defined in the basal aquifer below the PSL to the west and south of Area B; however, it is not fully defined to the east, nor to the north along the Facility boundary toward the Halawa Industrial Park (Figure 17). Concentrations increase in the basal groundwater to the east and northeast.

PFBA, PFHxA, PFHxS: PFBA, PFHxA, and PFHxS detections did not exceed DoD-approved screening levels (ASD 2025) in the Area B basal groundwater monitoring wells during expedited monitoring.

10.5 PRELIMINARY EXPOSURE ASSESSMENT

The CSMs for Area A and Area B summarize the known information and existing conditions at the Site; integrate known, suspected, and potential sources of PFAS COPCs; identify migration mechanisms and potential receptors; and evaluate how and where potential receptors may be exposed to PFAS COPCs. The preliminary CSMs were developed using historical information, the current environmental setting (Section 10.2), and previous investigations (Section 10.2.8). A visual representation of the Area A CSM is presented on Figure 27, and preliminary CSM exposure diagrams for Area A are presented on Figure 28 and Figure 29. A visual representation of the Area B CSM is presented on Figure 30, and preliminary CSM exposure diagrams for Area B are presented on Figure 31 and Figure 32.

10.5.1 PFAS Release Mechanisms

The potential release mechanisms for most PFAS at the Site are associated with AFFF, which include incidental leaks, accidental spills, and releases that may have occurred during equipment maintenance and testing, and training. A significant AFFF spill occurred on November 29, 2022, at Area A, 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 modern formulation AFFF liquid concentrate, which occurred at the [redacted] (b) (3) tunnel at the Facility as described in Section 10.2.8.

There is no known source for PFAS at Area B, nor are there any known releases of AFFF. However, several PFAS were consistently detected above the DoD-approved screening levels (ASD 2025) during expedited groundwater monitoring events between September 2024 and September 2025. (Section 10.4). Perched groundwater from groundwater monitoring wells at Area B that exceed DoD-approved screening levels (ASD 2025) are local to the Facility; however, the source of the PFOS and PFOA in basal groundwater wells is currently unknown.

10.5.2 Fate and Transport Considerations

10.5.2.1 General Properties of Aqueous Film-Forming Foam and Per- and Polyfluoroalkyl Substances

PFAS are a large, complex class of synthetic organic compounds with unique chemical properties (ITRC 2018). 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. They became commercially available beginning in the 1950s. PFAS 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.

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., $–[CF_2]_6CF_3$ or $–[CH_2]_2[CF_2]_7CF_3$) and the head is a functional group at the end of the fluorocarbon chain (e.g., carboxylate [$–COO^–$], sulfonate [$–SO_3^–$], N-alkyl sulfonamides [$–SO_2NR_2$], or alcohol [–OH]). In simplified terms, the tail and head impart the important 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 were recognized as an emerging concern in the early 2000s primarily with the detection of PFOA and PFOS in the blood of the general human population, and nationwide PFAS detections in public water supply systems, raising concerns about potential risks to human health and the environment (ITRC 2020). In April 2024, EPA designated PFOA and PFOS, including their salts and structural isomers, as CERCLA hazardous substances. The rationale for the designation is based on evidence indicating that PFOA and PFOS released into the environment may present risks to public health or the environment (40 Code of Federal Regulations Part 302).

Many PFAS are resistant to degradation, especially at the terminal end when only fluorine-carbon bonds remain. Once in the environment, these terminal product PFAS are persistent and can travel great distances in air as aerosols or absorbed to particulate matter and can dissolve in surface water, including stormwater runoff, and groundwater. During transport in water, the partitioning rates of PFAS to soils will depend on environmental conditions (ITRC 2018). 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.

10.5.2.2 Site-Specific PFAS Fate and Transport Considerations

This WP focuses on those PFAS covered by EPA Method 1633 and approved by DoD for quantitative analyses. The potential release mechanisms for most PFAS at the Site are associated with AFFF. 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.

The fate and transport of PFAS in soil and groundwater—including chemical partitioning to and from soil, soil vapor, and porewater—are complicated by the complex and variable character of PFAS chemicals, the variability of the geologic stratigraphy, and groundwater conditions at the Facility. The generic PSLs do not account for the complex hydrogeology in the vadose zone between ground surface (where PFAS have the potential to be released) and the underlying basal aquifer. At both Area A and Area B, the vadose zone above the basal aquifer is heterogeneous, with thicknesses ranging from 100 to

300 feet. The heterogeneous lithologies create confined basal aquifer conditions in some locations and unconfined basal aquifer conditions in other locations. Perched water conditions and elevated heads, as described above, have been observed in portions of the vadose zone. Site-specific hydrogeologic conditions include semipermeable to impermeable perched units, weathered bedrock (saprolite), massive competent bedrock, and fractured bedrock. Additionally, the highest levels of PFOS were measured in perched groundwater associated with comingled LNAPL at PFMW01B (located at the southwest corner of the current Bldg. 313 and former Slop Tank compound), which complicates PFAS fate and transport in the vadose zone, as comingled petroleum can alter PFAS mobility and precursor degradation rates.

10.5.3 Site-Specific Exposure Pathways

The exposure pathway evaluation identified potentially complete current and future exposure pathways for human and ecological receptors at the Site. The preliminary CSM 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 become available. A summary of the current CSMs and a description of site exposure pathways by human and ecological receptors are presented on Figure 28 and Figure 29 for Area A, and on Figure 31 and Figure 32 for Area B and are briefly discussed below. Pictorial CSMs are presented on Figure 27 and Figure 30 for Area A and Area B, respectively.

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

Currently and in the foreseeable future, there is no anticipated residential use on the Site. However, hypothetical residential receptors are considered to provide conservative potential risk estimates. Though the Site is located on a military installation, portions of the Site could potentially be accessed by trespassers hunting for pigs. In addition, the boundary of Area B intercepts the adjacent military housing. Any other visitors to the Site are assumed to have similar activities as occupational workers (no ground-intrusive work) or construction workers (could include ground-intrusive work). On-site occupational workers are people who work at the Site and larger Facility. They are anticipated to spend their workday within the Site and surrounding grounds outside the tunnels. Construction workers also work at the Facility and are assumed to work in excavations as part of construction, maintenance activities, or in utility trenches. These work activities would expose construction workers to chemicals associated with subsurface soils up to 10 feet in depth. As there is no current on-site construction (no soil disturbance) at Area A, the current pathway is considered incomplete. Since construction activities may potentially take place in the future, future exposure is considered potentially complete if construction activities take place. Those currently working in support of the activities within the tunnel are considered occupational workers due to the lack of soil disturbance.

In Area B, current exposure to the construction worker is potentially complete based on the current construction work that is underway for the WTF. Soil excavated from that location is part of this RI. The analysis required for disposal showed that PFAS concentrations were above EPA RSLs. The sampling was performed using DOH multi-increment sampling protocol. The sampling proposed along the perimeter of this location will be used to quantitively assess the potential current risk to construction workers as the multi-increment sampling for off-site disposal cannot be used in a quantitative risk assessment.

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 the Facility and the Site is a drinking water source. Since the November 2021 fuel release, the Navy's (b) (3) has been offline. The groundwater beneath the Facility is not currently serving as a drinking water source but may be used by hypothetical future residents and future occupational workers and could become a drinking water source if well (b) (9) comes back online. Off-site residents who may use the (b) (3) water supply as their water source in the future could be exposed to chemicals in the groundwater via direct ingestion and dermal contact. Also, future occupational workers, and visitors who use tap water at the Facility could potentially be exposed to chemicals via ingestion; however, there are currently no tap water faucets for general use at the Facility and this pathway is considered potentially complete but limited compared to other pathways. Perched groundwater is not a current or potential drinking water source and is considered too deep (approximately 30 feet bgs) and exposure to the basal aquifer which is greater than 100 feet bgs for potential exposures to construction workers during normal excavation work activities; therefore, pathways of exposure to perched groundwater are incomplete. Migration of potentially lower-quality perched groundwater to the basal drinking water aquifer is possible. The potential for the perched groundwater to discharge to South Halawa Stream (off-site to the north) is currently not well understood and will not be evaluated in this WP. A preliminary exposure pathway evaluation, identifying human receptors and potential PFAS exposure pathways for the Site, is presented on Figure 28 for Area A and Figure 30 for Area B.

Various ecological receptors, including soil invertebrates, terrestrial plants, and herbivorous/omnivorous birds and mammals were considered, as shown on Figure 29 for Area A and Figure 32 for Area B. Invertebrates and terrestrial plants can be exposed to affected surface soil 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 potentially complete but limited compared to other pathways. However, there is potential for mammals to be exposed to impacted media in vegetated areas of 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.

South Halawa Stream (off-site to the north) near Area A is not channelized, and the potential exists for stormwater runoff from Area A during storm events to flow toward the stream due to the local topography. The current proposed sampling includes surface soils that will be used to assess the potential for PFAS-impacted soils to be transported off the Site toward South Halawa Stream during storm events. If PFAS are found in Site surface soils, then an evaluation will be made to determine if off-site sampling in South Halawa Stream is necessary. In addition, it has been suggested by the regulators that the former Slop Tank in Area A may have discharged directly into South Halawa Stream (off-site to the north). The preliminary risk evaluation concluded that there were no complete exposure pathways for ecological receptors, and no sensitive species were noted in the immediate vicinity of the Facility. Because the basal aquifer is 80 feet beneath the Site and is not known to contribute to surface water or other potential ecological exposure points, the transport pathway via basal groundwater is considered incomplete for ecological receptors.

South Halawa Stream is channelized from east of RHM(b) (9) to the confluence of North Halawa and South Halawa Streams, near the H3/H-201 Interchange and is not channelized north of RHM(b) (9). West of Area B, South Halawa Stream is concrete-lined, channelized, and does not support sensitive

habitat. The concrete-lined segment runs along the remaining northwestern perimeter of the Facility. Since the stream is concrete-lined and impaired for the support of aquatic life, it is not considered a potential ecological exposure point (DON 2005). The preliminary risk evaluation concluded that there were no complete exposure pathways for ecological receptors and no sensitive species were noted in the immediate vicinity of the Facility (DON 2007). In addition, EPA's Watershed Assessment, Tracking & Environmental Results System indicates that the South Halawa Stream is completely impaired to support aquatic life. Elements considered to be impaired include nutrients, pathogens, turbidity, and exotic species. Potential sources are identified as urban runoff/storm sewers, other urban runoff, and other natural sources (DON 2005).

10.6 ENVIRONMENTAL MEDIA

Environmental media to be referenced throughout the WP for future sampling are defined below:

- *Surface Soil:* Surface soil samples will be collected from ground surface to 0.5 feet bgs and will be used to characterize both direct and indirect exposure pathways as well as potential impact to subsurface soil, perched groundwater, and basal groundwater. Swale surface soil samples will also be collected from the material found in drainage swales, and locations of sampling will be chosen based on thickness of soil accumulation, and other factors. Swale surface soil will be used to characterize both direct and indirect exposure pathways as well as potential runoff to Halawa Stream.
- *Subsurface Soil:* Subsurface soil samples will generally be collected from intervals below 0.5 feet bgs and will be used to characterize both direct and indirect exposure pathways as well as potential impact to perched and basal groundwater.
- *Perched Groundwater:* Perched groundwater samples will be collected from groundwater monitoring wells that are screened within a perched zone, above the basal aquifer. Perched groundwater samples will be used to characterize both direct and indirect exposure pathways as well as potential impact to basal groundwater and to Halawa Stream (off-site).
- *Basal Groundwater:* Basal groundwater samples will be collected from groundwater monitoring wells that are screened within the basal aquifer. Basal groundwater samples will be used to characterize both direct and indirect exposure pathways.

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), NAVFAC, Pacific ER Program Procedure I-A-1, *Development of Data Quality Objectives* (DON 2015), and the CSM presented in Worksheet #10. The DQOs are presented below.

11.1 STEP 1 – STATE THE PROBLEM

Documented uses of AFFF at the Facility are detailed in Section 10.2.1.2.

11.1.1 Step 1 – State the Problem, Area A

On November 29, 2022, an AFFF distribution system valve failed in the (b) (3) tunnel resulting in a release of approximately 1,100 gallons of modern AFFF concentrate to the tunnel floor. Liquids from the release flowed north, out the (b) (3) portal, and emergency response cleanup actions occurred as described in Section 10.2.8.3. Cleanup activity included excavation and disposal of observable PFAS-impacted soil; confirmation sampling in excavation limits using multi-increment sampling techniques; and multiple groundwater sampling events from previously installed groundwater monitoring wells. "Area A" is identified on Figure 2, and includes land known or expected to have been directly impacted by the November 2022 AFFF (b) (3) release, as well as the current fenced compound that contains Bldg. 313.

From October 2024 through July 2025, the Navy, in collaboration with the EPA and DOH, conducted expedited soil and groundwater sampling for PFAS and PHCs associated with the installation of three groundwater monitoring wells at Area A. Petroleum product identified as JP-5 by laboratory analyses was observed at the valley fill/bedrock interface during drilling, and fuel product was observed as LNAPL during groundwater sampling at the perched water monitoring well, PFMW01B.

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

11.1.2 Step 1 – State the Problem, Area B

In September 2023, the Navy conducted a PFAS baseline groundwater monitoring event to evaluate PFAS concentrations in 21 basal groundwater monitoring wells, not specifically in the vicinity of Area A (Figure 14). These wells extended to the western portion of the Facility and included 3 off-site wells. Analytical results from 6 wells (RHP01, RHP02, RHP03, RHP06, RHP07, and NMW32) showed PFOS and PFOA concentrations exceeding DoD-approved screening levels (DON 2023o; ASD 2025).

In response, the Navy conducted four expedited quarterly groundwater monitoring events between September 2024 and September 2025, which included both perched and basal groundwater monitoring wells in the western part of the Facility associated with Area B. PFAS were detected exceeding DoD-approved screening levels (ASD 2025) in perched and basal groundwater monitoring wells.

The data currently available are insufficient to adequately determine the nature and extent of PFAS at Area B. 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 Area B.

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. For this project, the principal study questions (PSQs) are defined for Area A and Area B in the following subsections.

11.2.1 Step 2 – Identify Study Goals

The project investigation goals are to evaluate COPCs (PFAS and PHCs in Area A and PFAS in Area B) in the media of concern (surface soil, subsurface soil, perched groundwater, and basal groundwater) to less than PSLs, then to conduct human health and ecological risk assessments (ERAs) to determine the risk to human health and the environment. The PSQs to achieve these study goals are provided below.

- *PSQ #1:* Do COPCs detected in the media of concern exceed PSLs?
- *PSQ #2:* Are COPCs in each media of concern defined to less than PSLs?
- *PSQ #3:* Do COPCs in each media of concern pose unacceptable risk to human health or the environment?
- *PSQ #4:* Do COPCs in basal groundwater at Area B originate from a source within the Facility?

PSQs will be reviewed and may be updated if warranted during RI data collection and analyses.

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 Area A and Area B are insufficient to evaluate the full nature and extent of COPCs associated with historical activities and releases at the Facility and to determine the risk to human health and the environment. Therefore, additional information is required to evaluate the nature and extent of COPCs, determine the risk presented by site media potentially affected by prior AFFF releases, and determine if further evaluation is warranted. This WP identifies the environmental media (surface soil, subsurface soil, perched groundwater, and basal groundwater as described in Section 10.6) that will be sampled for laboratory analysis of COPCs at Area A and Area B. Primary decision inputs will include the following:

- Validated analytical results from expedited soil and groundwater sampling events collected at the Facility between September 2024 and September 2025 for COPCs.
- Additional validated analytical results of COPCs from soil and groundwater samples identified in the following sections of this WP.
- Results from DoD-approved methods to evaluate migration from soil in the vadose zone to underlying groundwater that is a drinking water resource.
- DoD-approved risk-based toxicity parameters associated with COPCs at the time of the HHRA and ERA.
- 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 the refinement of the CSM and aid in evaluating the nature and extent of PFAS at the Facility.

- COPCs analytical results collected from response and compliance activities.
- Results from DoD-approved methods to assess the potential for COPCs to migrate from soil and perched water measured in the valley fill sediments to the underlying basal groundwater that is a drinking water resource.
- Receptors, exposure assumptions, and results of HHRAs and ERAs.

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.

11.4.1 Step 4 – Define the Spatial Boundaries of the Study Area A

In Area A, the horizontal site boundaries consist of an approximate rectangular area of about 0.6 acres 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 (b) (3) 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. The Area A horizontal RI boundaries are shown on Figure 1. A detailed discussion of Area A is provided in Section 10.2.1.

In addition to the limited horizontal extent defined by Area A, the basal groundwater surrounding Area A is part of the project study area which has been characterized by groundwater samples collected from 15 groundwater monitoring wells that extend over approximately 54 acres of the basal aquifer underlying the eastern portion of the Facility. These 15 wells were sampled for PFAS during all four quarters of the expedited groundwater sampling events that occurred between September 2024 and September 2025 and are proposed to be sampled as part of the activities proposed in this WP.

11.4.2 Step 4 – Define the Spatial Boundaries of the Study Area B

The Area B spatial boundaries consist of an area of approximately 37 acres bordered by Moanalua Freeway in the southwest; military housing to the southeast; and South Halawa Stream along the northern perimeter from the Main Security Gate in the east to Moanalua Freeway in the west. The Area B spatial boundaries are shown on Figure 1. A detailed discussion of Area B is provided in Section 10.2.1.

The study area also extends off the Facility boundary to include southern portions of the Halawa Industrial Park located adjacent to the Facility along the northern boundary.

Following a thorough evaluation of the data collected during the activities proposed in this work, 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 impacted media of concern.

11.4.3 Step 4 – Define the Temporal Boundaries of the Study

The temporal boundary for this investigation is limited to the period necessary to complete the RI field activities and data evaluation including drilling, sampling, and conducting two groundwater monitoring events.

11.4.4 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 analytical approach includes the requirements to assess environmental media for COPCs. The decision statements are provided in Table 11-1 based on the PSQs presented in Section 11.2.

Table 11-1: Decision Statements

Project Study Question	Relevant Data Inputs	Alternative Actions
PSQ #1: Do COPCs detected in the media of concern exceed PSLs?	• Validated laboratory results for COPCs • Most current ASD guidance for COPC screening criteria for human health • Most current ASD guidance for COPC screening criteria for ecological receptors	*Alternative 1:* No. Recommend NFA for COPCs in media of concern. *Alternative 2:* Yes. Proceed to PSQ #2.
PSQ #2: Are COPCs in each media of concern defined to less than PSLs?	• Validated laboratory results for COPCs • Most current ASD guidance for COPC screening criteria for human health • Most current ASD guidance for COPC screening criteria for ecological receptors	*Alternative 1:* No. Evaluate the need for additional sampling and analysis for COPCs. *Alternative 2:* Yes. Proceed to following PSQ.
PSQ #3: Do COPCs in each media of concern pose unacceptable risks to human health or the environment?	• COPC fate and transport guidance • Most current ASD guidance for risk assessment for COPCs • Most current EPA guidance for risk assessment for COPCs	*Alternative 1:* Yes. Evaluate remedial alternatives. *Alternative 2:* No. Consider NFA for COPCs in media of concern.
PSQ #4: Do COPCs in basal groundwater at Area B originate from a source within the Facility?	• Validated laboratory results • Field observations and impacted groundwater levels for flow modeling • COPC fate and transport guidance	*Alternative 1:* Yes. Evaluate remedial alternatives. *Alternative 2:* No. Consider NFA for the basal groundwater in Area B.

NFA no further action

11.5 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.

11.5.1 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 represent the chemical characteristics of the Site.

11.5.2 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 a systematic planning process to approach site investigations, including defining project objectives, developing a CSM, and preparing a detailed SAP in accordance with the *Project Procedures Manual, U.S. Navy Environmental Restoration Program, NAVFAC Pacific* (DON 2015).
- 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 2020) and those outlined in the *Bottle Selection and Other Sampling Considerations When Sampling for Per- and Poly-Fluoroalkyl Substances (PFAS)* (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 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–#36.
- Incorporate statistical analyses and evaluation of trends to support PFAS source designation and refine the CSM.
- Applicable DOH *Technical Guidance Manual* (TGM) (DOH 2025b) methodologies will be used during the RI activities:
  - Development of a CSM to summarize known site conditions; identify and screen for potential environmental hazards; and identify potential ecological and human receptors and chemical transport mechanisms (TGM Section 4, Appendix B).
  - Screening for volatile organic compounds (VOCs) using a photoionization detector (PID) for worker safety and to identify potential volatile chemicals in soil and groundwater (TGM Section 8.4.5).
  - Installation, development, purging, and low-flow sampling of groundwater monitoring wells (TGM Section 6.6.1).
  - Handling and analysis of samples, including appropriate sample containers, sample preservation and holding time, sample chain-of-custody (COC), sample packing and shipping, and use of approved analytical methods (TGM Section 11).

11.5.3 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 (SOPs) 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 (RPDs).

Potential decision errors associated with the laboratory 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 QA/quality control (QC) 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* (QSM) (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 RPDs between field duplicates, laboratory duplicate samples, and the results of spikes and blanks.

11.6 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 COPC 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.

A statistically defensible 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. The proposed sampling locations 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 locations for the monitoring wells that will evaluate the nature and extent of COPCs, define site characteristics, and refine the CSM during the RI.

Worksheet #12 specifies the measurement performance criteria (MPC) for soil and groundwater sample analytical data, and Worksheet #15 specifies the specific COPCs and corresponding screening levels for evaluating the analytical data. A summary of project tasks is included in Worksheet #14. Samples will be collected in accordance with the SOPs (DON 2015) identified 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.

Worksheet #12: Field Quality Control Samples

Measurement Performance Criteria Table – Field QC Samples

QC Sample	Analytical Group [a]	Frequency [b]	DQI	MPC
Field duplicate	All	10% of primary samples collected per matrix per analytical method	Precision	RPD ≤50% water [c] RPD ≤100% soil (judgmental) [c]
Field blank	All	Once per source of decontamination water per sampling event	Adequacy of the decontamination water quality	≤1/2 of LOQ or ≤1/10th of SL [d]
Equipment rinsate	All	5% of primary samples collected per matrix per analytical method	Adequacy of the decontamination process	≤1/2 of LOQ or ≤1/10th of SL [d]
Trip blank	VOCs, GRO (soil, water)	One per cooler for selected coolers with VOCs from Area A only	VOC cross-contamination during sample transport	≤1/2 of LOQ

% percent
DQI data quality indicator
GRO gasoline range organics
SL screening level
[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 II, *Data Validation Procedures* (DON 2015). For analytes measured above the LOQ, the MPC is described in the table. Results below the LOQ or non-detected are estimates, and RPD exceedances at these levels do not significantly impact data quality. For field duplicates above the LOQ, if RPDs exceed 50% or 100% (water and soil, respectively), no qualification is necessary, but RPDs and absolute differences should be noted in the data validation summary. Discussions of RPDs exceeding the MPC will be included in the data usability assessment as described in Worksheet #37. Assessment of field duplicate precision will be evaluated in the context of detected concentrations, reporting limits, and SLs.
[d] Data Validation Guidelines Module 6: Data Validation Procedure for PFAS 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. *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.	Historic American Engineering Record	Historical data and photographs will be used to provide site history and information about potential unknown PFAS releases.	All data are qualitative.
	DON. 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.	NAVFAC Pacific	Information about the installation of the AFFF system in the lower tunnel of the Facility will be used. Data include the construction of the AFFF conveyance system, including Bldg. 313, the type of AFFF concentrate used, and how the system works.	All data are qualitative; do not imply or discuss any AFFF release.
	Shaw Environmental, Inc. 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, Texas: 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 (b) (3). Soil samples were not analyzed for PFAS.	Samples not analyzed for PFAS.
Release Report	DON. 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 JBPHH. May 5, 2023.	NAVFAC Pacific	Report providing information on the November 2022 AFFF (b) (3) release. Provides information regarding the extent of the release and areas affected.	All data are qualitative.
	U.S. EPA, Region 9. 2023. *Aqueous Film-Forming Foam Investigation Report Red Hill Bulk Fuel Storage Facility.* Honolulu, HI: EPA Region 9. August.	U.S. EPA	Report providing information on the November 2022 AFFF (b) (3) release. Provides information regarding the extent of the release and areas affected.	Information is limited to activities and results from the November 2022 AFFF (b) (3) release.
	DOH, HEER Office. 2022. *Release Notification: Navy Red Hill Aqueous Film-Forming Foam (AFFF) Release.* Case No.: 20221129-1438.	DOH, HEER Office	Report provides background information on areas affected by the November 2022 AFFF (b) (3) release. Highlights efforts taken to inhibit the migration of AFFF.	Only provides qualitative data.
	Commander Navy Region Hawaii. 2022. *Red Hill Bulk Fuel Storage Facility,* (b) (3) *AFFF Release Report. November.*	Commander Navy Region Hawaii	Report provides information on the response actions taken after the November 2022 AFFF (b) (3) release.	Information is limited to activities and results from the November 2022 AFFF (b) (3) release.
SAP	Department of the Navy. 2022. *PFAS-Specific Sampling and Analysis Plan, Red Hill Bulk Fuel Storage Facility,* (b) (3)*, Joint Base Pearl Harbor-Hickam, Hawaii.* Revision 1. Prepared for: Red Hill OIC. December 7. JBPHH HI: Naval Facilities Engineering Systems Command Pacific. December.	NAVFAC Pacific	Data will be used to provide residual 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. *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.	NAVFAC Pacific	Data will be used to provide information regarding PFAS levels in media underneath the excavated areas as well as the nearby groundwater.	Sampling limited to near Bldg. 313.

Secondary Data	Data Source	Data Generator	How Data Will Be Used	Limitations on Data Use
Monthly Groundwater Monitoring Report	Department of Navy. 2023. *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.	NAVFAC Pacific	Data will be used to provide quantitative measure of PFAS in groundwater on a weekly basis from December 2022 to June 2023. This changed to monthly collection after June 2023 to December 2023.	Limited to PFAS in groundwater at certain wells.
	Department of Navy. 2023. *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.* Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. March 7.			
	Department of Navy. 2023. *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.* Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. April 7.	NAVFAC Pacific	Data will be used to provide quantitative measure of PFAS in groundwater on a weekly basis from December 2022 to June 2023. This changed to monthly collection after June 2023 to December 2023.	Limited to PFAS in groundwater at certain wells.
	Department of Navy. 2023. *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.* Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. May 7.			
	Department of Navy. 2023. *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.* Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. June 7.			
	Department of Navy. 2023. *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.* Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. July 7.		Data will be used to support information input of PFAS concentrations in groundwater on a monthly basis (July 2023 to December 2023). Identified PFAS to focus on for further investigation.	Limited to the groundwater wells sampled.
	Department of Navy. 2023. *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.* Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. August 7.			

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. *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.* Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. September 7.	NAVFAC Pacific	Data will be used to support information input of PFAS concentrations in groundwater on a monthly basis (July 2023 to December 2023). Identified PFAS to focus on for further investigation.	Limited to the groundwater wells sampled.
	Department of Navy. 2023. *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.* Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. October 6.			
	Department of Navy. 2023. *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.* Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. November 7.			
	Department of the Navy. 2023. *Aqueous Film-Forming Foam Soil and Groundwater Investigation and Monitoring Monthly Report November 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. December 7.			
	Department of the Navy. 2024. *Aqueous Film-Forming Foam Soil and Groundwater Investigation and Monitoring Monthly Report December 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. January 5.			
Non-routine Groundwater Sampling and Analysis	Department of Navy. 2023. *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.* Prepared by AECOM Technical Services, Inc. JBPHH HI: Naval Facilities Engineering Systems Command, Pacific. November 27.	NAVFAC Pacific	Data will be used to provide additional baseline information for PFAS and PFOS presence in groundwater from both routine and non-routine groundwater wells (September 2023).	Limited to the groundwater wells sampled.
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 JBPHH. May 5, 2023.	DoD	Findings from this investigation provide information inputs to the decision of modifying the AFFF system. Provides background information for the 2022 release.	Information is limited to activities and results from the November 2022 AFFF (b) (3) release.

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 answer the PSQs for the RI:

- Drilling for soil sampling
- Groundwater grab sampling from temporary monitoring wells
- Additional monitoring well installation for groundwater sampling
- Groundwater sampling from permanent monitoring wells
- Groundwater gauging
- Surface soil 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 C).

14.1 Pre-Work Meeting

Before mobilization, AECOM personnel will meet or coordinate with the Navy to address the following issues:

- Planned field activities
- Site-specific safety issues
- Schedule of field operations
- Deconfliction with other ongoing closure work
- Logistics including area access
- IDW management

14.2 Site Surveys and Preparation

Field team personnel will identify and locate soil sampling locations and groundwater monitoring well locations at the Site. Each area for intrusive work (soil boring and monitoring 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 remedial project manager.

Prior to ground disturbance, available utility drawings will be reviewed, and utility clearance surveys will be performed by a qualified subcontractor to locate subsurface utilities in 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 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 create an open space sufficient for sample collection or drilling activities.

To avoid and minimize potential impacts to sensitive species potentially within the project area, the following measures will be implemented:

- Any trees or woody vegetation 15 feet in height or taller will not be trimmed or cleared during the Hawaiian hoary bat (*Lasiurus cinereus semotus*) pupping season, which occurs from June 1 through September 15 (DON 2024b).
- Outdoor lighting, if used for the project, will comply with the Dark Skies Instruction to minimize potential impacts to potential Hawaiian seabirds traversing the site (DHS and USCG 2020).

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 substantive requirements of National Pollutant Discharge Elimination System and will include implementation of site-specific best management practices to control surface run-on and stormwater runoff. Noise and dust monitoring will be implemented at all proposed drilling 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 petroleum impacts (sheen, olfactory, PID). If no evidence of petroleum impact is found, the water can be discharged to the ground surface. If evidence of petroleum impact 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 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 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 HOLLOW-STEM AUGER 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.

Composite subsurface soil samples are to be collected at the Site via a HSA rig due to the known presence of weathered boulders (direct-push technology has previously failed to reach the required depth in these areas). The boreholes will be advanced with minimum 3.25-inch inside diameter HSAs to allow soil sampling and installation of temporary wells, if perched water is encountered. At a minimum, soil sampling will be conducted using a 2-inch inner diameter by 18-inch-long split-spoon sampler that will be driven continuously, in advance of the HSA for soil sample collection and logging. If perched groundwater is encountered, the borehole will be advanced to approximately 7 feet below the capillary fringe (where soil saturation is first identified). It is anticipated that perched water may be confined in some or all of the boring locations, and groundwater may rise above the original saturated soil interface, however, the screened area of the temporary wells should be located with at least 5 feet of screen below the original saturated interface, so drilling should continue to 7 feet below where water is first encountered.

If bedrock is encountered (refusal twice after relocating within the cleared area), the last soil sample will be collected from the deepest soil encountered before bedrock. Surface and subsurface soil sample 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 the previous excavation areas, samples of the native soil will be collected from beneath the existing fill. Continuously lithologic logging, in accordance with Procedure I-E, *Soil and Rock Classification* (DON 2015), will be conducted from split-spoons at 2.5 feet intervals during HSA drilling.

14.4.1 Borehole Abandonment

Boreholes will be properly abandoned if drilling refusal occurs prior to reaching the target depth for sampling and/or monitoring well construction. Abandonment will be performed in accordance with NAVFAC Pacific ER Program Procedure I-C-1, *Monitoring Well Installation and Abandonment* (DON 2015), and will involve sealing the borehole with cement-bentonite grout as described in Section 14.4.1.1. The grout will be emplaced with a tremie pipe in one operation from the bottom of the boring to within a minimum of 2 feet of the ground surface. Additional grout may need to be placed if significant settlement occurs. Bentonite pellets may be used in intervals below the water level.

14.4.1.1 GROUT

Grout used for annular seals, filling core holes, or borehole abandonment will be in accordance with Procedure I-C-1, *Monitoring Well Installation and Abandonment* (DON 2015) and in accordance with Section 2.6e of the Hawaii Well Construction and Pump Installation Standards (DLNR 2004). Specifically, one of the three mixes below will be followed:

- *Sand-cement slurry:* Sand-cement for grouting shall be mixed at a ratio of not more than one part sand to one part Portland Type I cement, by weight, and not more than 6 gallons of potable water per sack of cement.
- *Neat cement grout:* Neat cement for grouting shall be mixed at a ratio of one 94-pound sack of Portland Type I cement to not more than 6 gallons of potable water.
- *Cement-bentonite grout:* The amount of uncoated bentonite added shall not exceed 8 percent bentonite per dry weight of cement (7.5 pounds of bentonite per 94-pound sack of Portland Type I cement). Water is added at the rate of 6 gallons per 94-pound sack of cement, plus up to an additional 0.75 gallon of water for each percent of bentonite.

14.5 PETROLEUM IMPACT SCENARIOS, NOTIFICATIONS, AND RESPONSE ACTIONS

To address the potential for encountering petroleum impacts during the drilling of basal or perched groundwater monitoring wells, four scenarios have been identified and notifications and response actions have been developed. The four potential scenarios are:

- *Scenario 1:* No petroleum impact is observed and PID readings are less than 10 parts per million by volume (ppmv).
- *Scenario 2:* No petroleum impact is observed and PID readings are greater than 10 ppmv but less than 50 ppmv.
- *Scenario 3:* Moderate levels of petroleum impact are observed and PID readings are greater than 10 ppmv but less than 50 ppmv.
- *Scenario 4:* Petroleum impact is observed and PID readings exceed 50 ppmv.

Note that PID readings can be collected from borehole headspace, rock cores, or drill cuttings, as appropriate in any particular location. Details regarding notification requirements and response actions for each scenario are summarized in the following.

14.5.1 Scenario 1: No Petroleum Impacts 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.
- Any perched water will be cased off with conductor casing.

14.5.2 Scenario 2: No Petroleum Impacts 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.
- Any perched water will be cased off with conductor casing.

14.5.3 Scenario 3: Moderate Levels of Petroleum Impacts Observed, PID Reading Between 10 ppmv and 50 ppmv

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

- The Navy will notify the regulatory agencies via email within 24 hours after contamination is encountered.
- Soil or groundwater sampling for PFAS 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 present the opportunity for misuse, if publicly reported, or generate responses on non-validated results.
- Conductor casing will be used to isolate contaminated soil and any perched water.
- Drilling efforts will continue.

14.5.4 Scenario 4: Petroleum Impacts Observed, PID Reading Greater than 50 ppmv

Petroleum impacts are observed (e.g., strong olfactory or visual oily staining, or observation of sheen or mobile fuel product) and PID readings are greater than 50 ppmv. In this scenario:

- Drilling will be discontinued, boreholes will be stabilized, and the Navy Contracting Officer's Representative will be immediately contacted.
- Upon discovery of oily staining or observation of sheen or 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. In addition, the closure site assessment investigation team will be notified to determine the appropriate course of action regarding sampling for PHCs.

- Soil and groundwater sampling for PFAS 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 present the opportunity for misuse, if publicly reported, or generate responses on non-validated results.
- 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.

14.6 TEMPORARY GROUNDWATER WELL DRILLING, INSTALLATION AND ABANDONMENT PROCEDURES

Temporary wells will be installed to collect groundwater grab samples from select soil borings in Area A and in Area B.

14.6.1 Temporary Well Drilling and Installation

Borings that will be completed as temporary wells will be drilled using minimum 3.25-inch inside diameter HSAs and will be advanced to a minimum of 7 feet below the first observation of perched groundwater. Perched groundwater has been observed between 35 and 45 feet below ground in confined conditions in the former OWDF area and will likely rise several feet above the initial observation of saturation as the boring progresses. It is important that the bottom of the temporary well screen is placed at least 5 feet below the initial observation of water; therefore, the depth of the first observation of water and the total depth of the borehole should be noted on the boring log prior to well construction and all well material should be located prior to beginning installation. At a minimum, well construction material shall include:

- Two 5-foot lengths of threaded 1.5-inch diameter schedule 40 PVC well screen with pre-packed filter pack
- One threaded 1.5-inch diameter schedule 40 PVC well endcap
- Three to four 10-foot lengths of threaded 1.5-inch diameter schedule 40 PVC well casing
- One threaded hanging cap with eyebolt

Steps to construct the well:

1. Collect a static water level, check for floating product and the total depth of the borehole, with a decontaminated oil-water interface probe.
2. Construct the 10-foot screen and endcap and connect one length of well casing and hanging cap with eyebolt with sufficient rope to ensure well casing and screen can be recovered from the borehole.
3. Install the casing in the inner annulus of the auger, until screen endcap sits at the total depth of the borehole and hanging cap is within 1 foot of ground surface. Leave cap on well casing.
4. Remove the auger from the borehole with drill rig.
5. Cover open borehole with opening for well casing.
6. Remove rig from the drill site.

The temporary well screen will consist of 1.5-inch diameter schedule 40 PVC with pre-packed filter pack consisting in two 5-foot sections and will include a bottom cap for a total of 10-foot screen for each temporary well. Temporary well casing will consist of compatible 1.5-inch diameter schedule 40 PVC in 10-foot lengths.

A temporary benchmark monument will be installed adjacent to each temporary well at ground surface and will be used as the reference point for measuring the depth to groundwater at each well. These points will be surveyed after completion of the groundwater sampling event to determine absolute groundwater elevations at each temporary well.

14.6.2 Temporary Well Development Purging, Sampling, and Abandonment

After a temporary well is installed, sampling will occur once development is complete depending on conditions encountered in the field. Because these temporary wells will only be used to determine an initial presence of contaminants (if any) and assess the extent of perched groundwater, well development or sampling can occur immediately after installation following guidelines listed in DOH Section 6.6.8.3 (DOH 2021a) and in accordance with Procedure I-C-2, *Monitoring Well Development* Figure 35. However, as conditions allow, temporary well development will utilize a PFAS-free low-flow purge pump or PFAS-free bailer to purge until water quality parameters have stabilized per the guidelines outlined below, or three well volumes are removed.

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 (ORP) stabilizes to within ±10 millivolts.
- Dissolved oxygen (DO) concentration stabilizes to within ±0.3 milligram per liter.
- Turbidity to less than 200 nephelometric turbidity units (NTUs) or to within ±10 percent at readings higher than 200 NTUs in areas of known turbid groundwater.

Sampling will be conducted once the temporary well has recharged sufficiently, in accordance with Procedure I-C-3, *Monitoring Well Sampling* Figure 35 and the general PFAS sampling guidance, Michigan Department of Environmental Quality *General PFAS Sampling Guidance* Figure 39.

Once the groundwater sample has been collected, well screen and casing will be removed from each borehole and disposed of as construction debris. The borehole will then be filled from total depth to ground surface in accordance with Section 14.4.1.

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.

One perched monitoring well is proposed for installation in Area A if perched water is encountered while advancing soil boring RHA-BS-S14. One perched well and one basal well are proposed for installation in Area B if perched water is encountered during drilling of the basal well. Two off-site basal wells are proposed for installation north of the Facility near Area B.

Basalt bedrock is anticipated to be encountered at shallow depths within Area A and Area B. At each basal groundwater monitoring well location, both a pilot borehole (for detailed lithologic logging) and a rotary drilled borehole (for monitoring well installation) will be advanced.

Procedures for monitoring well drilling and installation are described below in the following 10 steps:

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. Surface completion
9. Well development
10. Initial groundwater sampling
11. Borehole, corehole, and well abandonment

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

14.6.3 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 HSA, bucket-auger, or air-rotary drilling or coring methods until competent bedrock is encountered. Soil will be collected at specific intervals using split-spoon samplers (if using HSA method) or directly from drill cuttings (if using bucket-auger or air-rotary methods). Logged soil cuttings will be screened for 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 Section 14.6.8 if perched water is observed or to maintain the integrity of the borehole at the surface if unconsolidated material is encountered.

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 soon as practicable.

14.6.4 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.

14.6.5 True Vertical Depth 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.

14.6.6 Evaluation of Groundwater Conditions

14.6.6.1 Unconfined Conditions

After drilling to a depth of approximately 7 feet below 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 14.6.9.

14.6.6.2 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 gallons per minute after the borehole is cleared with air, bailing, or other acceptable methods. Water level recovery data will be evaluated further to recommend an appropriately 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.

14.6.6.3 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 petroleum impact. Groundwater in the borehole will be cleared, and water level observations will be conducted at the start and end of each day. 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 from the borehole. 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 14.6.4). Procedures for evaluating the headspace tests and required actions and notifications are described in Section 14.5.

If there is no evidence of petroleum impact 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 14.514.5. More information on the identification of perched aquifers, well construction, and logging can be found in *Monitoring Well Installation Work Plan, Red Hill Bulk Fuel Storage Facility* (DON 2024c).

14.6.7 Drilling for Lithologic 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 an HSA rig. 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 International 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., aa clinker flow-top breccias [clinker sub-types], inflated pahoehoe lobes, massive aa dense core interiors) will be included in the rock core logs.

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 Company 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 petroleum impact during pilot borehole drilling is described in Section 14.6.6.3. 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 14.6.4). 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 State of Hawaii Department of Land and Natural Resources (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.

14.6.8 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 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 petroleum-impacted soil or the presence of perched groundwater (as described in Section 14.5) 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 perched groundwater. Alternatively, the well borehole may be abandoned in accordance with DLNR standards (2004) and redrilled 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 perched groundwater encountered above 30 feet msl.
- Should extend through any observed petroleum-impacted vadose zone 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. Conductor annular space will be grouted by either cement-bentonite grout or neat cement grout by pumping through a steel tremie pipe placed on the outside of the conductor casing. The base of the conductor casing will be grouted in place with a 3- to 5-feet-thick cement-bentonite grout plug, then the grout plug will be left undisturbed for a minimum of 24 hours for curing before emplacing grout above the plug to the surface with a steel tremie pipe. Placing the grout in the annular space may be done in stages or lifts with time allowed for the grout to set to prevent distortion or collapse of the casing by heat and/or pressure. Following the grouting procedure, the grout will be left undisturbed for a minimum of 24 hours for curing.

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.

14.6.8.1 Procedure for Installing Temporary Conductor Casing in Alluvial Valley Fill

Should the conditions meeting Scenario 4: Petroleum Impacts Observed, PID Reading Greater than 50 ppmv be encountered, the requirements as described in Section 14.5.4 will be followed. After completion of the referenced requirements, should the completion of the well with conductor casing be determined to be necessary, the installation of a temporary casing will be completed as follows. Resume coring while recording PID detects along the core until readings are below 10 ppmv, or until the base of the core is reached. PID detections above 10 ppmv exceed Scenario 2 and, therefore, require temporary casing to continue. Once PID detections are below 10 ppmv or the base of the core is reached, the HQ core pipe will be removed from the core hole, and the core hole will be over-drilled with a PQ casing-advance system to depth. The bit will be removed, and the PQ casing will be lifted to up to 10 feet above the total depth of the hole. Uncoated bentonite pellets will be placed through the drill water in the interval created, up to 10 feet above the total depth of the hole to fill the borehole and will be allowed to hydrate. Once the pellets are hydrated, the PQ over-drill casing will be advanced to the total depth of the core (or depth of the core, if PID readings are below 10 ppmv and coring will continue) into the hydrated bentonite to press bentonite gel into the annulus between the core hole wall and the casing. The bentonite slurry will then be left to cure for at least 12 hours.

Once the bentonite slurry has cured, HQ lithologic coring will resume and continue contact with the volcanic bedrock and/or perching interval following petroleum impact scenarios as described in Section 14.5 based on PID readings. The seal will be verified with PID readings, LNAPL measurements, and borehole video if necessary. If the seal fails, conductor casing will be advanced to the total depth of the core hole and the special case method will be followed as described below. Once the core hole has been completed, the hole will be abandoned prior to installing the groundwater monitoring well. The perched water interval will be filled with sand and the remaining core hole will

be filled with grout in accordance with DLNR standards (2004). The PQ casing will be removed as grout is installed to ensure petroleum impacts will not migrate downhole.

In some cases, a different method for installing the bentonite gel seal to the casing annulus will be used. The bentonite gel will be mixed and circulated down the inside of the PQ core pipe and up through the annulus to the surface, then left to thicken for at least 12 hours prior to HQ coring. After curing, the cured bentonite will be removed from inside the PQ casing while the HQ casing is advanced to the bottom of the core hole. HQ lithologic coring will then continue following petroleum impact scenarios as described in Section 14.5 based on PID detections. Once the core hole has been completed, the hole will be abandoned prior to installing the groundwater monitoring well. The perched water interval will be filled with sand, and the remaining core hole will be filled with grout in accordance with DLNR standards (2004). The PQ casing will be removed as grout is installed to ensure petroleum impacts will not migrate downhole.

14.6.9 Well Design and Completion

14.6.9.1 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. Temporary wells will be similar to the permanent wells, without the permanent conductor casing and will be installed with pre-pack screens.

14.6.9.2 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 impact 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 the 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 10-foot-thick seal of uncoated PFAS-free bentonite pellets will be emplaced via tremie pipe and allowed to hydrate. If the top of sand is above water level, a 10-foot-thick seal of bentonite granules or chips will be emplaced via tremie pipe in two lifts and allowed to hydrate with PFAS-free water after each foot of bentonite pellets (non-polymer coated) has been placed.
- *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.

14.6.9.3 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 sack 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.

14.6.10 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 E.

14.6.10.1 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.

14.6.10.2 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 inches 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.

14.6.11 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 a minimum of 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 NTUs (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 DO, 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. Groundwater sampling will occur no sooner than 14 days after well development is completed.

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.

At Area A, it is anticipated that soil borings will be limited to a maximum of about 18 feet bgs at most locations due to the presence of large, unweathered boulders observed during expedited drilling for well installation between September 2024 and June 2025. At Area B, previous drilling has indicated that continuous sampling can be implemented using HSA methods to depths as great as 45 feet bgs. In all cases, HSA drilling and sampling will continue until the augers can no longer be advanced, or if

perched groundwater is encountered, to approximately 7 feet below the first encountered saturated soil.

Soil samples will be continuously sampled and composited over selected depth intervals up to 30 feet bgs, targeting fine-grained materials (e.g., slits and clays) where PFAS are most likely to adsorb. At each soil boring location, a maximum of six soil samples (one surface soil and five subsurface soil) are proposed be collected for laboratory analysis of PFAS and at select Area A location to include PHCs:

- *Interval 1:* One discrete analytical soil sample will be collected at ground surface (0.0–0.5 feet bgs interval) in areas not covered with asphalt or other manmade material.
- *Interval 2:* One composite analytical subsurface soil sample will be collected from the 0.5–2 feet bgs interval. If the soil boring location is covered with manmade material, the top of the composite interval will correspond to the bottom of the manmade material.
- *Interval 3:* One composite analytical subsurface soil sample will be collected from the 2–10 feet bgs interval.
- *Interval 4:* One composite analytical soil sample will be collected from the 10–20 feet bgs interval (anticipated up to ~18 feet bgs for shallow boring locations in Area A and locations near the RHP wells in Area B).
- *Interval 5 (if sufficient depth is achieved):* One composite analytical soil sample will be collected from the 20–30 feet bgs interval.
- *Interval 6:* A 1-foot composite analytical soil sample interval will be collected at the bottom of the boring or within the capillary fringe if perched groundwater is encountered.

Analytical soil samples will be collected from the entire depth interval sampled. However, if refusal is encountered during drilling, prior to the anticipated total depth, the deepest interval collected from the borehole will be the 1-foot target depth interval before refusal. The target composite sample interval immediately above will extend from the target start depth to 1 foot above the total depth.

More information on the soil sampling design is provided in Worksheet #17.

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 C). Soil sampling will be conducted using stainless steel or non-PFAS-containing disposable hand trowels/scoops to acquire a grab sample of surface soil and subsurface soil from the target depth intervals. Select locations at Area A will also be sampled for petroleum.

14.7.1.1 Soil Sampling, Compositing, and Sample Handling

For grab samples collected from the surface soil 0-0.5 feet, soil from the entire 6-inch interval will be collected and submitted to the lab for analysis. For grab samples collected from the subsurface soil collected at the total depth of the boring, soil from the entire 1-foot interval will be collected and submitted to the lab for analysis.

Composited subsurface soil samples will be prepared in the field by collecting fine-grained soil (e.g., clays, silts, and fine sands) from each designated sample intervals greater than 1-foot, with fines collected from across the full interval to the extent practicable. If refusal is encountered before the target interval depth is reached, the composite will be prepared from the start of the interval to the total

depth achieved. Coarse material (e.g., gravel, cobbles, and rock fragments) will be excluded, except where fine-grained soil is adhered to the coarse material and can be reasonably retained. The collected material will be combined in a dedicated and disposable single use mixing container (e.g., 5-gallon bucket equipped with a disposable high-density polyethylene liner) for homogenization. Each composited interval of soil will then be thoroughly mixed using a dedicated and disposable PFAS-free tool until visually uniform. Adequate mixing will be achieved by stirring the material in a circular motion and periodically turning the material over.

Following mixing, using plastic disposable sample scoops, the mixed material will be transferred into the sample containers. Sampling should ensure each scoop of material is of the same size and is collected in a consistent manner. Field duplicates and primary samples will be collected after material from a specific interval is sieved and homogenized to target fine soils most likely to be bound to PFAS. The homogenized soil composite will be split into primary and duplicate sample containers, which will be analyzed independently at the laboratory. Where samples require analysis of other COPCs, PFAS sample containers will be filled first, followed by the diesel range organics (DRO)/residual range organics (RRO) and polynuclear aromatic hydrocarbon (PAH) sample containers. If limited soil material is available, all recovered fine-grained soil from the interval may be collected and submitted for analysis in the appropriate sample jar(s), based on the recovery.

Composite samples for VOCs and gasoline range organics (GRO) will consist of a 5-point composite, prepared by collecting five 5-gram plugs evenly spaced across the sample interval. The plugs will be placed directly into a 4-ounce glass soil jar preserved with 25 mL of methanol. VOC and GRO samples plugs will be collected before soil is placed into the mixing container for compositing to avoid potential volatilization loss.

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 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 Swale Surface Soil Sampling

Swale surface soil grab samples will be collected from the material found in drainage swales in Area A. Sampling locations will be chosen based on thickness of soil accumulation. Swale surface soil sampling will be conducted in accordance with Procedure I-B-1, *Soil Sampling* (DON 2015) and the general PFAS sampling guidance, Michigan Department of Environmental Quality *General PFAS Sampling Guidance* (MDEQ 2018b). Swale surface soil sampling will be conducted using stainless steel or non-PFAS-containing disposable hand trowels/scoops to acquire a grab sample of soil.

14.7.3 Groundwater Sampling

Two rounds of groundwater sampling (wet and dry seasons) are planned for after all proposed monitoring wells are installed. Monitoring wells sampled during the expedited sampling event will also be sampled as part of these rounds.

Sampling will be conducted in accordance with Procedure I-C-3, *Monitoring Well Sampling* (DON 2015) and the general PFAS sampling guidance, Michigan Department of Environmental Quality *General PFAS Sampling Guidance* (MDEQ 2018a).

Preferably, permanent wells will be sampled using a sampling pump (PFAS-free design) and low-flow, minimal-drawdown (micro-purge) sampling techniques. 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.
- ORP stabilizes to within ±10 millivolts.
- DO concentration stabilizes to within ±0.3 milligram per liter.
- 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 containers using the submersible bladder pump at low-flow rates of less than 0.3 liters 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.

14.7.4 Groundwater Gauging

Prior to each groundwater sampling event, all wells will be gauged with an oil-water interface probe. Perched wells in the same units will be gauged as close as possible to each other, temporally to form a synoptic snapshot. In addition, many of the temporary wells, from which groundwater grab samples are being collected, will also be gauged and compared to a nearby surveyed benchmark to help refine some of the groundwater water flow directions in existing perched water bodies at Area B.

14.7.5 Field Quality Control Sampling

Field QC samples will be collected to evaluate field variability and sampling error in accordance with Procedure III-B, *Field QC Samples* (DON 2015). Refer to Worksheets #12 and #20 for a summary of the field QC samples that will be collected on this project. Field QC samples include field duplicates, equipment rinsates, field blanks, and trip blanks. These samples will be analyzed for the same COPCs as the primary samples; trip blanks are only applicable for volatile COPCs. The required QC samples are summarized in Worksheet #20.

The laboratory will follow the analytical procedures outlined in the SOPs listed in Worksheet #23. Laboratory QC samples are presented in Worksheet #28.

14.7.6 Multilevel Groundwater Sampling and Equipment Blank Evaluation

Prior to initiating the equipment blank sampling, the project team will evaluate multilevel sampling equipment for available replacement parts that have materials considered acceptable for PFAS sampling. This will be done in coordination with other Red Hill sampling programs that utilize the same wells and equipment, to identify any conflicts or limitations in converting the sampling equipment to PFAS-free components. All feasible replacements will be installed prior to conducting the equipment blank evaluation.

Triplicate equipment blanks will be collected using the multilevel sampling equipment under field-representative conditions by filling and flushing samples though the sampling string and collecting equipment rinsate.

In addition to equipment blanks, field blanks will be collected to assess potential impacts introduced during sample handling, transport, and exposure to the field environment. Field blanks will be prepared using PFAS-free water and exposed to the same conditions as equipment blank samples.

Field QC samples for groundwater including field blanks and equipment rinsate and duplicate samples will be collected according to the procedures described in Procedure III-B, *Field QC Samples (Water, Soil)* (DON 2015) and those procedures outlined in Section 14.8.

The decision to use or not use multilevel wells for PFAS sampling will be based on a qualitative and quantitative assessment of the equipment blank results in relation to site data. The sampling equipment is considered acceptable if all PFAS in equipment blanks are non-detect (ND) as U-qualified at or below the limit of detection (LOD), or if detected PFAS are below half the LOQ or less than 1/10th the PSL; PFAS with very low screening levels will be evaluated in the context of the site and project goals.

Equipment will be recommended unsuitable for PFAS sampling if PFAS are detected consistently above the LOQ in any equipment blank. Detected concentrations that are equal to or greater than 1/10th of the PSL will be evaluated in the context of the site and project goals. The evaluation should ensure that any PFAS potentially leaching from sampling equipment are not used to represent site data, particularly in low concentration scenarios.

If the multilevel monitoring well equipment associated with RHMW15 is determined to be suitable for sampling, then the sampling zone straddling the water table will be used to collect basal groundwater from this location. Groundwater sampling from multilevel wells will be performed in accordance with fluid sampling procedures in Appendix E.

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:

1. Disassemble non-disposable equipment, if possible.
2. Wash with a non-phosphate detergent (Alconox, Liquinox, or other non-PFAS-containing suitable detergent), potable water solution, and a PFAS-free plastic brush.
3. Rinse in a bath with potable water.
4. Spray with laboratory-grade isopropyl alcohol.

5. Triple rinse in a bath with deionized or distilled water, provided and certified PFAS-free by the laboratory.
6. Spray with deionized or distilled water, provided and certified PFAS-free by the laboratory.

If non-disposable equipment is used (e.g., drilling equipment used in more than one sampling location), equipment rinsate blank and field blank samples will be collected with a frequency as described in Procedure III-B, *Field QC Samples* (DON 2015). Equipment rinsate and field blank sample results will be used to evaluate the effectiveness of the decontamination process and determine whether cross-contamination may have occurred during sample collection.

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 U.S. Samples will be documented on COC forms in accordance with Procedure III-F, *Sample Handing, 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 well development water from groundwater sampling activities and 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 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 personal protective equipment and sampling equipment that is not impacted will be collected in plastic trash bags and disposed of as municipal solid waste off-site. Any visibly impacted 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 the Facility 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. In April 2023, EPA designated PFOA and PFOS as CERCLA hazardous substances (40 Code of Federal Regulations Part 302). The disposal options for IDW will be in accordance with the ASD Memorandum *Guidance on Destruction or Disposal of Materials Containing Per- and Polyfluoroalkyl Substances in the United States* (DoD 2023c) and the EPA's *Interim Guidance on the Destruction and Disposal of Perfluoroalkyl and Polyfluoroalkyl Substances and Materials Containing Perfluoroalkyl and Polyfluoroalkyl Substances—Version 2* (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 a review of Resource Conservation and Recovery Act and Toxic Substances Control Act regulations, and discussions with facilities authorized to receive CERCLA waste.

14.12 DATA EVALUATION (TIER 1)

PFAS analytical results will be screened against PSLs based on the ASD Memorandum, *Investigating Per- and Polyfluoroalkyl Substances within the DoD Cleanup Program* (ASD 2025), which references EPA residential soil and tap water RSLs (2024c) using a THQ of 0.1 and TR of 1E-06. If the EPA RSL is less than the pooled method detection limit (MDL) of EPA Method 1663 (EPA 2024c), the

project is using the MCL, if available, as the screening level for groundwater (EPA 2025a); otherwise, the pooled MDL is applied (EPA 2024b). Ecological screening levels will be incorporated for surface soil screening (DON 2024d; Grippo et al. 2024). Selection of PFAS PSL is further described in Worksheet #15, Section 15.1.

Table 14-1 identifies the State of Hawaii PFAS EALs for soil and groundwater. Only DoD-approved screening values are incorporated as PSLs as described in Worksheet #15. DOH EALs are provided as references and will not be used in determining the PSLs. PFAS results will be compared to PSLs for decision-making purposes. During evaluation, all current DoD-approved screening values will be applied in the screening process, in accordance with DoD policy (ASD 2025), which states that PSLs will be determined using the most appropriate values supported by current science at the time of evaluation.

Other soil and groundwater COPCs (VOC, PAHs, TPH as GRO, DRO, and RRO) will be evaluated against PSLs based on the more conservative value of the DOH Tier 1 EALs and EPA RSLs as described in Worksheet #15, Section 15.2. COPC exceedances of the PSLs in soil or groundwater will trigger further evaluation as described in Worksheet #11.

Table 14-1: DOH PFAS EALs for Soil and Groundwater

Chemical Parameter	Abbreviation	CAS No.	DOH Soil EAL [a] (µg/kg)	DOH Groundwater EAL [a] (ng/L)
Perfluoropropanoic acid	PFPrA	422-64-0	1.3	1299
Perfluorobutanoic acid	PFBA	375-22-4	221	14,615
Perfluorobutanesulfonic acid	PFBS	375-73-5	163	2,000
Perfluorodecanoic acid	PFDA	335-76-2	0.51	7.69
Perfluoroheptanoic acid	PFHpA	375-85-9	26.7	76.9
Perfluorohexanoic acid	PFHxA	307-24-4	342	1,923
Perfluorohexanesulfonic acid	PFHxS	335-46-4	3.80	10.0
Perfluorononanoic acid	PFNA	375-95-1	4.68	10.0
Perfluorooctanoic acid	PFOA	335-67-1	1.10	4.0
Perfluorooctanesulfonic acid	PFOS	1763-23-1	0.236	4.0
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	0.676	10.0
Trifluoroacetic acid	TFA	76-05-1	992	46,753
Perfluoropentanoic acid	PFPeA	2706-90-3	24.4	1,538
Perfluoroundecanoic acid	PFUnA	2058-94-8	63.2	19.2
Perfluorododecanoic acid	PFDoA	307-55-1	84.7	25.8
Perfluorotridecanoic acid	PFTrDA	72629-94-8	84.7	25.8
Perfluorotetradecanoic acid	PFTetDA	376-06-7	847	258
Perfluoropentanesulfonic acid	PFPeS	2706-91-4	101	581
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	7.85	38.5
Perfluorodecanesulfonic acid	PFDS	335-77-3	126	38.5
1H,1H, 2H, 2H-Perfluorooctanesulfonic acid	6:2 FTS	27619-97-2	236	1,500
Perfluorooctanesulfonamide	PFOSA	754-91-6	5.06	46.2
4,8-Dioxa-3H-perfluorononanonic acid	ADONA	919005-14-4	185	1,154

Chemical Parameter	Abbreviation	CAS No.	DOH Soil EAL [a] (µg/kg)	DOH Groundwater EAL [a] (ng/L)
6:2 Fluorotelomer alcohol	6:2 FTOH	647-42-7	2,623	5,000
8:2 Fluorotelomer alcohol	8:2 FTOH	678-39-7	1,573	4,231
6:2 Fluorotelomer thioether amido sulfonate	6:2 FTTAoS	88992-47-6	6,321	1,923

— analyte does not have an established screening value
CAS Chemical Abstracts Service
[a] DOH EALs are based on the 2024 (Revised January 2026) for PFAS where groundwater is a potential source of drinking water and a surface water body is located within 150 meters of the Site (DOH 2026). DOH EALs will not be used in determining the PSLs; PFAS results will be compared to only DoD-approved screening levels for decision-making purposes.

14.13 DATA

Data generated during this investigation will include the following:

- Laboratory analytical results for PFAS in soil and groundwater. Select sample locations will also have analytical results for VOCs, GRO, DRO, RRO, and PAHs. The selected laboratory is currently DoD ELAP–accredited for all preparation and analytical methods associated with the 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 Color Company 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, which will include groundwater quality parameters data (temperature, pH, conductivity, turbidity, ORP, and DO) and static water level.

The selected laboratory will maintain current DoD ELAP accreditation 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 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. Global Positioning System 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 QA plan. Reported data will be provided as electronic data deliverables. The laboratory deliverables will be consistent with Section 4.2 of the DoD *General Data Validation Guidelines* (DoD 2019a).

Analytical data will be submitted by the laboratory to the data validation firm. 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.

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 QSM (DoD and DOE 2023).

14.13.1.3 Data Management

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

SOPs and the PFAS sampling guidance in Appendix C 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 laboratory QC requirements in the DoD QSM will also be followed by the DoD ELAP–accredited laboratory (DoD and DOE 2023).

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 and Worksheets #31 through #33). The 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. The laboratory deliverables will be consistent with Module 2 of the DoD QSM (DoD and DOE 2023) and the DoD *General Data Validation Guidelines* (DoD 2019a).

Analytical data will be submitted by the laboratory to the data validation firm. 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 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

A third-party data validation firm will validate all analytical laboratory data results. 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 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 Modules 1,4 and 6* (DoD 2020a, 2021, 2022). Data received from the validation firm will be uploaded into the Environmental Quality Information System (environmental data management software).

The project chemist will review the analytical data before they are validated to address time-critical issues such as re-extraction, matrix interference, and holding times. The findings of the validation will be submitted 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

15.1 PFAS Reference Limits and Evaluation Tables

This worksheet presents a detailed list of the PFAS PSLs for surface soil, subsurface soil, and groundwater. The collected samples will be sent to and analyzed by a DoD ELAP–accredited laboratory. The sample analysis will be done following the baseline requirements of the *Department of Defense (DoD) Quality System Manual (QSM)* (DoD and DOE 2023), in accordance with the ASD Memorandum, *Establishing a Consistent Methodology for the Analysis of Per- and Polyfluoroalkyl Substances in Matrices Other than Drinking Water* (ASD 2024) and *DoD Environmental Data Quality Workgroup Memorandum, EPA Method 1633 Clarification Update, February 29, 2024* (DoD 2024a). The project is using a laboratory accredited to EPA Method 1633 by the DoD ELAP for 44 PFAS analyzed in each matrix. An explanation of the PSLs chosen and the analyte lists are presented below.

DoD-approved soil and groundwater PFAS screening levels are identified in the ASD Memorandum, *Investigating Per- and Polyfluoroalkyl Substances within the DoD Cleanup Program* (ASD 2025) and subsequent online updates (ASD 2025). Additionally, surface soil screening levels were developed using relevant ecological screening values (DON 2024d; Grippo et al. 2024). Soil and groundwater PSLs for PFAS are identified as follows:

- EPA residential soil and tap water RSLs, respectively (EPA 2024c). The selected RSLs are derived using a THQ of 0.1 and a target cancer risk of 1E-06 (EPA 2024c).
- Navy Emerging Chemicals Workgroup Issue Paper recommended ecological screening values and Derivation of PFAS Ecological Screening Values (DON 2024d; Grippo et al. 2024).

Based on limitations of the analytical instrumentation, the standard method reporting limits may exceed the screening criteria for some PFAS. In such cases, when PFAS has an EPA RSL below the pooled MDL identified in EPA Method 1633, the project will use the MCL, if established, as the screening level for groundwater (EPA 2025a). Where there is no established MCL, the project will use the pooled MDL identified in EPA Method 1633 as the screening level for soil and groundwater (ASD 2025; EPA 2024b). In cases where the EPA RSL is greater than the MCL or an identified ecological screening value, the lower value is applied as the PSL.

The November 2024 RSL update contained four additional PFAS (perfluoroundecanoic acid, perfluorododecanoic acid, perfluorotetradecanoic acid, and perfluorooctadecanoic acid) that are not yet approved for use in the DoD Cleanup Program, but are included as target analytes in EPA Method 1633 (ASD 2025; EPA 2024d). The RSLs are listed in the tables below to generate LOD goals for these PFAS but are not currently used as PSLs. EPA Method 1633 also includes PFAS without currently available screening levels. These will be reported, and sensitivity of detection limit (DL) and LOQ for these analytes will be compared to estimates listed in the test method.

The usability of ND data of analytes with laboratory reporting limits above the EPA RSLs 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 quantitatively evaluated, and the 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 with DoD policy and in accordance with the ASD Memorandum, *Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program* (ASD 2025), as updated at the time of reporting. The risk assessment will adhere to the established CERCLA risk assessment process, using the most current and DoD-approved toxicity and screening values at the time of evaluation. The evaluation of state PFAS screening levels are to be considered during the feasibility study phase, consistent with CERCLA.

The PFAS PSLs and reporting limits for the primary laboratory (Eurofins Environment Testing [Eurofins] Sacramento) are provided in Section 15.1.1. Section 15.1.2 lists the PFAS PSLs and reporting limits for the secondary backup laboratory (Eurofins Denver). If the primary lab experiences significant delays due to instrumentation issues, capacity constraints, or other disruptions, the backup lab will be utilized to analyze samples to maintain the project schedule.

Section 15.2 presents the analytical lists for the additional Area A PHC COPCs.

15.1.1 Primary PFAS Laboratory

Matrix: Surface Soil

Analytical Group: PFAS

Analyte	Abbreviation	CAS No.	EPA RSL [a]	ASD Memorandum [a]	ECO SL [b]	PSL [c]	PSL Reference	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits		
										LOQ	LOD	DL
Perfluoropropanoic acid	PFPrA	422-64-0	3,900	3,900	—	3,900	EPA RSL	1,287	390	1	0.5	0.25
Perfluorobutanoic acid	PFBA	375-22-4	7,800	7,800	2,980	2,980	ECO SL	983	298	0.4	0.2	0.1
Perfluoropentanoic acid	PFPeA	2706-90-3	—	—	—	—	—	—	—	0.2	0.1	0.05
Perfluorohexanoic acid	PFHxA	307-24-4	3,200	3,200	6,200	3,200	EPA RSL	1,056	320	0.2	0.1	0.05
Perfluoroheptanoic acid	PFHpA	375-85-9	—	—	1000	1,000	ECO SL	330	100	0.2	0.1	0.05
Perfluorooctanoic acid	PFOA	335-67-1	0.019	0.070	3840	0.07	Pooled MDL	0.02	0.007	0.2	0.1	0.062
Perfluorononanoic acid	PFNA	375-95-1	19	19	24.2	19	EPA RSL	6	1.9	0.2	0.1	0.05
Perfluorodecanoic acid	PFDA	335-76-2	0.013	0.06	67.7	0.06	Pooled MDL	0.02	0.006	0.2	0.1	0.05
Perfluoroundecanoic acid	PFUnA	2058-94-8	1,900 [d]	—	—	—	—	—	—	0.2	0.1	0.05
Perfluorododecanoic acid	PFDoA	307-55-1	320 [d]	—	—	—	—	—	—	0.2	0.1	0.05
Perfluorotridecanoic acid	PFTrDA	72629-94-8	—	—	—	—	—	—	—	0.2	0.1	0.05
Perfluorotetradecanoic acid	PFTeDA	376-06-7	6,300 [d]	—	—	—	—	—	—	0.2	0.1	0.058
Perfluorohexadecanoic acid	PFHxDA	67905-19-5	—	—	—	—	—	—	—	0.2	0.1	0.05
Perfluorooctadecanoic acid	PFODA	16517-11-6	250,000 [d]	—	—	—	—	—	—	0.2	0.1	0.05
Perfluorobutanesulfonic acid	PFBS	375-73-5	1,900	1,900	817	817	ECO SL	270	81.7	0.2	0.1	0.05
Perfluoropentanesulfonic acid	PFPeS	2706-91-4	—	—	—	—	—	—	—	0.2	0.1	0.05
Perfluorohexanesulfonic acid	PFHxS	355-46-4	130	130	145	130	EPA RSL	43	13	0.2	0.1	0.05
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	—	—	—	—	—	—	—	0.2	0.1	0.05
Perfluorooctanesulfonic acid	PFOS	1763-23-1	0.63	0.63	4	0.63	EPA RSL	0.2	0.06	0.2	0.1	0.05
Perfluorononanesulfonic acid	PFNS	68259-12-1	—	—	—	—	—	—	—	0.2	0.1	0.05
Perfluorodecanesulfonic acid	PFDS	335-77-3	—	—	—	—	—	—	—	0.2	0.1	0.05
Perfluorododecanesulfonic acid	PFDoS	79780-39-5	—	—	—	—	—	—	—	0.2	0.1	0.05
1H,1H, 2H, 2H-Perfluorohexane sulfonic acid	4:2 FTS	757124-72-4	—	—	—	—	—	—	—	0.4	0.2	0.1
1H,1H, 2H, 2H-Perfluorooctane sulfonic acid	6:2 FTS	27619-97-2	—	—	—	—	—	—	—	0.4	0.2	0.1
1H,1H, 2H, 2H-Perfluorodecane sulfonic acid	8:2 FTS	39108-34-4	—	—	—	—	—	—	—	0.4	0.2	0.1
N-methyl perfluorooctanesulfonamide	NMeFOSA	31506-32-8	—	—	—	—	—	—	—	0.2	0.1	0.05
N-ethyl perfluorooctanesulfonamide	NEtFOSA	4151-50-2	—	—	—	—	—	—	—	0.2	0.1	0.05
Perfluorooctanesulfonamide	PFOSA	754-91-6	—	—	—	—	—	—	—	0.2	0.1	0.063
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	2355-31-9	—	—	—	—	—	—	—	0.2	0.1	0.05

Matrix: Surface Soil

Analytical Group: PFAS

Analyte	Abbreviation	CAS No.	EPA RSL [a]	ASD Memorandum [a]	ECO SL [b]	PSL [c]	PSL Reference	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits		
										LOQ	LOD	DL
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	2991-50-6	—	—	—	—	—	—	—	0.2	0.1	0.05
N-methyl perfluorooctanesulfonamidoethanol	NMeFOSE	24448-09-7	—	—	—	—	—	—	—	1	0.5	0.25
N-ethyl perfluorooctanesulfonamidoethanol	NEtFOSE	1691-99-2	—	—	—	—	—	—	—	1	0.5	0.25
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	23	23	—	23	EPA RSL	7.6	2.3	0.2	0.1	0.05
4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	—	—	—	—	—	—	—	0.2	0.1	0.05
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9Cl-PF3ONS	756426-58-1	—	—	—	—	—	—	—	0.2	0.1	0.05
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11Cl-PF3OUdS	763051-92-9	—	—	—	—	—	—	—	0.2	0.1	0.075
3-Perfluoropropyl propanoic acid	3:3FTCA	356-02-5	—	—	—	—	—	—	—	0.4	0.2	0.1
2H,2H,3H,3H-Perfluorooctanoic acid	5:3FTCA	914637-49-3	—	—	—	—	—	—	—	1	0.5	0.25
3-Perfluoroheptyl propanoic acid	7:3FTCA	812-70-4	—	—	—	—	—	—	—	1	0.5	0.25
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7	—	—	—	—	—	—	—	0.2	0.1	0.05
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5	—	—	—	—	—	—	—	0.2	0.1	0.05
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1	—	—	—	—	—	—	—	0.2	0.1	0.05
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6	—	—	—	—	—	—	—	0.2	0.1	0.062
bis(trifluoromethylsulfonyl)amine	TFSI	82113-65-3	2,300	2,300	—	2,300	EPA RSL	759	230	0.2	0.1	0.063

Note: Units are in µg/kg. PFAS will be reported in the neutral form.
— not available
ECO ecological
[a] EPA Residential Soil RSL using a THQ of 0.1 and a target cancer risk of 1E-06 – November 2024 (EPA 2024d; ASD 2025).
[b] Navy Emerging Chemicals Workgroup Issue Paper recommended ecological screening values and Derivation of PFAS Ecological Screening Values (DON 2024d; Grippo et al. 2024).
[c] The November 2024 EPA RSLs for certain analytes are below the method's pooled MDL; therefore, the method's pooled MDL is used as the screening value to establish consistent and measurable values (ASD 2025; EPA 2024d).
[d] The November 2024 EPA RSL for this analyte is not yet approved for use within the DoD Cleanup Program.

Matrix: Subsurface Soil

Analytical Group: PFAS

Analyte	Abbreviation	CAS No.	EPA RSL [a]	ASD Memorandum [a]	PSL [b]	PSL Reference	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits		
									LOQ	LOD	DL
Perfluoropropanoic acid	PFPrA	422-64-0	3,900	3,900	3,900	EPA RSL	1,287	390	1	0.5	0.25
Perfluorobutanoic acid	PFBA	375-22-4	7,800	7,800	7,800	EPA RSL	2,574	780	0.4	0.2	0.1
Perfluoropentanoic acid	PFPeA	2706-90-3	—	—	—	—	—	—	0.2	0.1	0.05
Perfluorohexanoic acid	PFHxA	307-24-4	3,200	3,200	3,200	EPA RSL	1,056	320	0.2	0.1	0.05
Perfluoroheptanoic acid	PFHpA	375-85-9	—	—	—	—	—	—	0.2	0.1	0.05
Perfluorooctanoic acid	PFOA	335-67-1	0.019	0.07	0.07	Pooled MDL	0.02	0.007	0.2	0.1	0.062
Perfluorononanoic acid	PFNA	375-95-1	19	19	19	EPA RSL	6	1.9	0.2	0.1	0.05
Perfluorodecanoic acid	PFDA	335-76-2	0.013	0.06	0.06	Pooled MDL	0.02	0.006	0.2	0.1	0.05
Perfluoroundecanoic acid	PFUnA	2058-94-8	1,900 [c]	—	—	—	—	—	0.2	0.1	0.05
Perfluorododecanoic acid	PFDoA	307-55-1	320 [c]	—	—	—	—	—	0.2	0.1	0.05
Perfluorotridecanoic acid	PFTrDA	72629-94-8	—	—	—	—	—	—	0.2	0.1	0.05
Perfluorotetradecanoic acid	PFTeDA	376-06-7	6,300 [c]	—	—	—	—	—	0.2	0.1	0.058
Perfluorohexadecanoic acid	PFHxDA	67905-19-5	—	—	—	—	—	—	0.2	0.1	0.05
Perfluorooctadecanoic acid	PFODA	16517-11-6	250,000 [c]	—	—	—	—	—	0.2	0.1	0.05
Perfluorobutanesulfonic acid	PFBS	375-73-5	1,900	1,900	1,900	EPA RSL	627	190	0.2	0.1	0.05
Perfluoropentanesulfonic acid	PFPeS	2706-91-4	—	—	—	—	—	—	0.2	0.1	0.05
Perfluorohexanesulfonic acid	PFHxS	355-46-4	130	130	130	EPA RSL	43	13	0.2	0.1	0.05
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	—	—	—	—	—	—	0.2	0.1	0.05
Perfluorooctanesulfonic acid	PFOS	1763-23-1	0.63	0.63	0.63	EPA RSL	0.2	0.06	0.2	0.1	0.05
Perfluorononanesulfonic acid	PFNS	68259-12-1	—	—	—	—	—	—	0.2	0.1	0.05
Perfluorodecanesulfonic acid	PFDS	335-77-3	—	—	—	—	—	—	0.2	0.1	0.05
Perfluorododecanesulfonic acid	PFDoS	79780-39-5	—	—	—	—	—	—	0.2	0.1	0.05
1H,1H, 2H, 2H-Perfluorohexane sulfonic acid	4:2 FTS	757124-72-4	—	—	—	—	—	—	0.4	0.2	0.1
1H,1H, 2H, 2H-Perfluorooctane sulfonic acid	6:2 FTS	27619-97-2	—	—	—	—	—	—	0.4	0.2	0.1
1H,1H, 2H, 2H-Perfluorodecane sulfonic acid	8:2 FTS	39108-34-4	—	—	—	—	—	—	0.4	0.2	0.1
N-methyl perfluorooctanesulfonamide	NMeFOSA	31506-32-8	—	—	—	—	—	—	0.2	0.1	0.05
N-ethyl perfluorooctanesulfonamide	NEtFOSA	4151-50-2	—	—	—	—	—	—	0.2	0.1	0.05
Perfluorooctanesulfonamide	PFOSA	754-91-6	—	—	—	—	—	—	0.2	0.1	0.063
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	2355-31-9	—	—	—	—	—	—	0.2	0.1	0.05
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	2991-50-6	—	—	—	—	—	—	0.2	0.1	0.05

Matrix: Subsurface Soil

Analytical Group: PFAS

Analyte	Abbreviation	CAS No.	EPA RSL [a]	ASD Memorandum [a]	PSL [b]	PSL Reference	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits		
									LOQ	LOD	DL
N-methyl perfluorooctanesulfonamidoethanol	NMeFOSE	24448-09-7	—	—	—	—	—	—	1	0.5	0.25
N-ethyl perfluorooctanesulfonamidoethanol	NEtFOSE	1691-99-2	—	—	—	—	—	—	1	0.5	0.25
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	23	23	23	EPA RSL	7.6	2.3	0.2	0.1	0.05
4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	—	—	—	—	—	—	0.2	0.1	0.05
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9Cl-PF3ONS	756426-58-1	—	—	—	—	—	—	0.2	0.1	0.05
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11Cl-PF3OUdS	763051-92-9	—	—	—	—	—	—	0.2	0.1	0.075
3-Perfluoropropyl propanoic acid	3:3FTCA	356-02-5	—	—	—	—	—	—	0.4	0.2	0.1
2H,2H,3H,3H-Perfluorooctanoic acid	5:3FTCA	914637-49-3	—	—	—	—	—	—	1	0.5	0.25
3-Perfluoroheptyl propanoic acid	7:3FTCA	812-70-4	—	—	—	—	—	—	1	0.5	0.25
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7	—	—	—	—	—	—	0.2	0.1	0.05
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5	—	—	—	—	—	—	0.2	0.1	0.05
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1	—	—	—	—	—	—	0.2	0.1	0.05
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6	—	—	—	—	—	—	0.2	0.1	0.062
bis(trifluoromethylsulfonyl)amine	TFSI	82113-65-3	2,300	2,300	2,300	EPA RSL	759	230	0.2	0.1	0.063

Note: Units are in µg/kg. PFAS will be reported in the neutral form.
— not available
[a] EPA Residential Soil RSL using a THQ of 0.1 and a target cancer risk of 1E-06 – November 2024 (EPA 2024d; ASD 2025).
[b] The November 2024 EPA RSLs for certain analytes are below the EPA-approved analytical MDL; therefore, the method's pooled MDL is used as the screening value to establish consistent and measurable values (ASD 2025; EPA 2024d).
[c] The November 2024 EPA RSL for this analyte is not yet approved for use within the DoD Cleanup Program.

Matrix: Groundwater

Analytical Group: PFAS

Analyte	Abbreviation	CAS No.	EPA RSL [a]	ASD Memorandum [a]	PSL	PSL Reference	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits		
									LOQ	LOD	DL
Perfluoropropanoic acid	PFPrA	422-64-0	980	980	980	EPA RSL	323	98	10	5	2.5
Perfluorobutanoic acid	PFBA	375-22-4	1,800	1,800	1,800	EPA RSL	594	180	4	2	1
Perfluoropentanoic acid	PFPeA	2706-90-3	—	—	—	—	—	—	2	1	0.5
Perfluorohexanoic acid	PFHxA	307-24-4	990	990	990	EPA RSL	327	99	2	1	0.5
Perfluoroheptanoic acid	PFHpA	375-85-9	—	—	—	—	—	—	2	1	0.5
Perfluorooctanoic acid	PFOA	335-67-1	0.0027	4	4 [c]	MCL	1	0.4	2	1	0.5
Perfluorononanoic acid	PFNA	375-95-1	5.9	5.9	5.9	EPA RSL	2	0.59	2	1	0.5
Perfluorodecanoic acid	PFDA	335-76-2	0.004	0.52	0.52 [d]	POOL MDL	0.2	0.052	2	1	0.5
Perfluoroundecanoic acid	PFUnA	2058-94-8	600 [b]	—	—	—	—	—	2	1	0.5
Perfluorododecanoic acid	PFDoA	307-55-1	100 [b]	—	—	—	—	—	2	1	0.55
Perfluorotridecanoic acid	PFTrDA	72629-94-8	—	—	—	—	—	—	2	1	0.58
Perfluorotetradecanoic acid	PFTeDA	376-06-7	2000 [b]	—	—	—	—	—	2	1	0.81
Perfluorohexadecanoic acid	PFHxDA	67905-19-5	—	—	—	—	—	—	2	1	0.5
Perfluorooctadecanoic acid	PFODA	16517-11-6	80,000 [b]	—	—	—	—	—	2	1.4	0.9
Perfluorobutanesulfonic acid	PFBS	375-73-5	600	600	600	EPA RSL	198	60	2	1	0.5
Perfluoropentanesulfonic acid	PFPeS	2706-91-4	—	—	—	—	—	—	2	1	0.5
Perfluorohexanesulfonic acid	PFHxS	355-46-4	39	10	10 [c]	MCL	3	1	2	1	0.5
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	—	—	—	—	—	—	2	1	0.5
Perfluorooctanesulfonic acid	PFOS	1763-23-1	0.2	4	4 [c]	MCL	1	0.4	2	1	0.5
Perfluorononanesulfonic acid	PFNS	68259-12-1	—	—	—	—	—	—	2	1	0.5
Perfluorodecanesulfonic acid	PFDS	335-77-3	—	—	—	—	—	—	2	1	0.5
Perfluorododecanesulfonic acid	PFDoS	79780-39-5	—	—	—	—	—	—	2	1	0.53
1H,1H, 2H, 2H-Perfluorohexane sulfonic acid	4:2 FTS	757124-72-4	—	—	—	—	—	—	4	2	1
1H,1H, 2H, 2H-Perfluorooctane sulfonic acid	6:2 FTS	27619-97-2	—	—	—	—	—	—	4	2	1
1H,1H, 2H, 2H-Perfluorodecane sulfonic acid	8:2 FTS	39108-34-4	—	—	—	—	—	—	4	2	1
N-methyl perfluorooctanesulfonamide	NMeFOSA	31506-32-8	—	—	—	—	—	—	2	1	0.5
N-ethyl perfluorooctanesulfonamide	NEtFOSA	4151-50-2	—	—	—	—	—	—	2	1	0.5
Perfluorooctanesulfonamide	PFOSA	754-91-6	—	—	—	—	—	—	2	1	0.5
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	2355-31-9	—	—	—	—	—	—	2	1	0.5
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	2991-50-6	—	—	—	—	—	—	2	1	0.5

Matrix: Groundwater

Analytical Group: PFAS

Analyte	Abbreviation	CAS No.	EPA RSL [a]	ASD Memorandum [a]	PSL	PSL Reference	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits		
									LOQ	LOD	DL
N-methyl perfluorooctanesulfonamidoethanol	NMeFOSE	24448-09-7	—	—	—	—	—	—	10	5	2.5
N-ethyl perfluorooctanesulfonamidoethanol	NEtFOSE	1691-99-2	—	—	—	—	—	—	10	5	2.5
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	1.5	1.5	1.5	EPA RSL	0.5	0.15	1.5	0.7	0.39
4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	—	—	—	—	—	—	2	1	0.5
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9Cl-PF3ONS	756426-58-1	—	—	—	—	—	—	2	1	0.58
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11Cl-PF3OUdS	763051-92-9	—	—	—	—	—	—	2	1	0.5
3-Perfluoropropyl propanoic acid	3:3FTCA	356-02-5	—	—	—	—	—	—	4	2	1
2H,2H,3H,3H-Perfluorooctanoic acid	5:3FTCA	914637-49-3	—	—	—	—	—	—	10	5	2.5
3-Perfluoroheptyl propanoic acid	7:3FTCA	812-70-4	—	—	—	—	—	—	10	5	2.5
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7	—	—	—	—	—	—	2	1	0.5
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5	—	—	—	—	—	—	2	1	0.5
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1	—	—	—	—	—	—	2	1	0.5
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6	—	—	—	—	—	—	2	1	0.72
bis(trifluoromethylsulfonyl)amine	TFSI	82113-65-3	590	590	590	EPA RSL	195	59	2	1	0.5

Note: Units are in ng/L. PFAS will be reported in the neutral form.
[a] EPA tap water RSL using a THQ of 0.1 and a target cancer risk of 1E-06 – Tap Water – November 2024 (EPA 2024d; ASD 2025).
[b] The November 2024 EPA RSL for this analyte is not yet approved for use within the DoD Cleanup Program.
[c] The November 2024 EPA RSL for this analyte is below the method's pooled MDL; therefore, the MCL is used as the screening value. Alternatively, when the MCL is less the EPA RSL, the MCL is applied as the PSL (ASD 2025; EPA 2024d).
[d] The November 2024 EPA RSL for this analyte is below the method's pooled MDL and the analyte does not have a MCL; therefore, the method's pooled MDL is used as the screening value to establish consistent and measurable values (ASD 2025; EPA 2024d).

15.1.2 Secondary PFAS Laboratory

In the event the primary lab is experiencing delays due to instrumentation issues, capacity limitation, or other disruptions, a backup lab is identified to ensure continuity of PFAS analysis to lessen impacts to project schedule.

Matrix: Surface

Analytical Group: PFAS

Analyte	Abbreviation	CAS No.	EPA RSL [a]	ASD Memorandum [a]	ECO SL [b]	PSL [c]	PSL Reference	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits		
										LOQ	LOD	DL
Perfluoropropanoic acid	PFPrA	422-64-0	3,900	3,900	—	3,900	EPA RSL	1,287	390	2.00	1.50	0.500
Perfluorobutanoic acid	PFBA	375-22-4	7,800	7,800	2,980	2,980	ECO SL	983	298	0.400	0.200	0.100
Perfluoropentanoic acid	PFPeA	2706-90-3	—	—	—	—	—	—	—	0.200	0.100	0.0500
Perfluorohexanoic acid	PFHxA	307-24-4	3,200	3,200	6,200	3,200	EPA RSL	1,056	320	0.200	0.100	0.0500
Perfluoroheptanoic acid	PFHpA	375-85-9	—	—	1,000	1,000	ECO SL	330	100	0.200	0.100	0.0500
Perfluorooctanoic acid	PFOA	335-67-1	0.019	0.07	3840	0.07	POOL MDL	0.02	0.007	0.200	0.100	0.0500
Perfluorononanoic acid	PFNA	375-95-1	19	19	24.2	19	EPA RSL	6	1.9	0.200	0.100	0.0500
Perfluorodecanoic acid	PFDA	335-76-2	0.013	0.06	67.7	0.06	POOL MDL	0.02	0.006	0.200	0.100	0.0500
Perfluoroundecanoic acid	PFUnA	2058-94-8	1,900 [d]	—	—	—	—	—	—	0.200	0.100	0.0500
Perfluorododecanoic acid	PFDoA	307-55-1	320 [d]	—	—	—	—	—	—	0.200	0.100	0.0500
Perfluorotridecanoic acid	PFTrDA	72629-94-8	—	—	—	—	—	—	—	0.200	0.100	0.0500
Perfluorotetradecanoic acid	PFTeDA	376-06-7	6,300 [d]	—	—	—	—	—	—	0.200	0.100	0.0500
Perfluorohexadecanoic acid	PFHxDA	67905-19-5	—	—	—	—	—	—	—	0.200	0.150	0.0500
Perfluorooctadecanoic acid	PFODA	16517-11-6	250,000 [d]	—	—	—	—	—	—	0.200	0.150	0.0500
Perfluorobutanesulfonic acid	PFBS	375-73-5	1,900	1,900	817	817	ECO SL	270	81.7	0.200	0.100	0.0500
Perfluoropentanesulfonic acid	PFPeS	2706-91-4	—	—	—	—	—	—	—	0.200	0.100	0.0500
Perfluorohexanesulfonic acid	PFHxS	355-46-4	130	130	145	130	EPA RSL	43	13	0.200	0.100	0.0500
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	—	—	—	—	—	—	—	0.200	0.100	0.0500
Perfluorooctanesulfonic acid	PFOS	1763-23-1	0.63	0.63	4	0.63	EPA RSL	0.2	0.06	0.200	0.100	0.0500
Perfluorononanesulfonic acid	PFNS	68259-12-1	—	—	—	—	—	—	—	0.200	0.100	0.0500
Perfluorodecanesulfonic acid	PFDS	335-77-3	—	—	—	—	—	—	—	0.200	0.100	0.0500
Perfluorododecanesulfonic acid	PFDoS	79780-39-5	—	—	—	—	—	—	—	0.200	0.100	0.0500
1H,1H, 2H, 2H-Perfluorohexane sulfonic acid	4:2 FTS	757124-72-4	—	—	—	—	—	—	—	0.400	0.200	0.100
1H,1H, 2H, 2H-Perfluorooctane sulfonic acid	6:2 FTS	27619-97-2	—	—	—	—	—	—	—	0.400	0.200	0.100
1H,1H, 2H, 2H-Perfluorodecane sulfonic acid	8:2 FTS	39108-34-4	—	—	—	—	—	—	—	0.400	0.200	0.100
N-methyl perfluorooctanesulfonamide	NMeFOSA	31506-32-8	—	—	—	—	—	—	—	0.200	0.100	0.0500

Matrix: Surface

Analytical Group: PFAS

Analyte	Abbreviation	CAS No.	EPA RSL [a]	ASD Memorandum [a]	ECO SL [b]	PSL [c]	PSL Reference	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits		
										LOQ	LOD	DL
N-ethyl perfluorooctanesulfonamide	NEtFOSA	4151-50-2	—	—	—	—	—	—	—	0.200	0.100	0.0500
Perfluorooctanesulfonamide	PFOSA	754-91-6	—	—	—	—	—	—	—	0.200	0.100	0.0500
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	2355-31-9	—	—	—	—	—	—	—	0.200	0.100	0.0500
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	2991-50-6	—	—	—	—	—	—	—	0.200	0.100	0.0500
N-methyl perfluorooctanesulfonamidoethanol	NMeFOSE	24448-09-7	—	—	—	—	—	—	—	1.00	0.500	0.250
N-ethyl perfluorooctanesulfonamidoethanol	NEtFOSE	1691-99-2	—	—	—	—	—	—	—	1.00	0.500	0.250
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	23	23	—	23	EPA RSL	7.6	2.3	0.200	0.100	0.0500
4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	—	—	—	—	—	—	—	0.200	0.100	0.0500
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9Cl-PF3ONS	756426-58-1	—	—	—	—	—	—	—	0.200	0.100	0.0500
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11Cl-PF3OUdS	763051-92-9	—	—	—	—	—	—	—	0.200	0.100	0.0500
3-Perfluoropropyl propanoic acid	3:3FTCA	356-02-5	—	—	—	—	—	—	—	0.400	0.200	0.100
2H,2H,3H,3H-Perfluorooctanoic acid	5:3FTCA	914637-49-3	—	—	—	—	—	—	—	1.00	0.500	0.250
3-Perfluoroheptyl propanoic acid	7:3FTCA	812-70-4	—	—	—	—	—	—	—	1.00	0.500	0.250
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7	—	—	—	—	—	—	—	0.200	0.100	0.0500
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5	—	—	—	—	—	—	—	0.200	0.100	0.0500
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1	—	—	—	—	—	—	—	0.200	0.100	0.0500
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6	—	—	—	—	—	—	—	0.200	0.100	0.0500
bis(trifluoromethylsulfonyl)amine	TFSI	82113-65-3	2,300	2,300	—	2,300	EPA RSL	759	230	0.200	0.150	0.0500

Note: Units are in µg/kg. PFAS will be reported in the neutral form.
— not available
ECO ecological
[a] EPA Residential Soil RSL using a THQ of 0.1 and a target cancer risk of 1E-06 – November 2024 (EPA 2024d; ASD 2025).
[b] Navy Emerging Chemicals Workgroup Issue Paper recommended ecological screening values and Derivation of PFAS Ecological Screening Values (DON 2024d; Grippo et al. 2024).
[c] The November 2024 EPA RSLs for certain analytes are below the method's pooled MDL; therefore, the method's pooled MDL is used as the screening value to establish consistent and measurable values (ASD 2025; EPA 2024d).
[d] The November 2024 EPA RSL for this analyte is not yet approved for use within the DoD Cleanup Program.

Matrix: Subsurface Soil

Analytical Group: PFAS

Analyte	Abbreviation	CAS No.	EPA RSL [a]	ASD Memorandum [a]	PSL [b]	PSL Reference	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits		
									LOQ	LOD	DL
Perfluoropropanoic acid	PFPrA	422-64-0	3,900	3,900	3,900	EPA RSL	1287	390	2.00	1.50	0.500
Perfluorobutanoic acid	PFBA	375-22-4	7,800	7,800	7,800	EPA RSL	2574	780	0.400	0.200	0.100
Perfluoropentanoic acid	PFPeA	2706-90-3	—	—	—	—	—	—	0.200	0.100	0.0500
Perfluorohexanoic acid	PFHxA	307-24-4	3,200	3,200	3,200	EPA RSL	1056	320	0.200	0.100	0.0500
Perfluoroheptanoic acid	PFHpA	375-85-9	—	—	—	—	—	—	0.200	0.100	0.0500
Perfluorooctanoic acid	PFOA	335-67-1	0.019	0.007	0.070	POOL MDL	0.02	0.007	0.200	0.100	0.0500
Perfluorononanoic acid	PFNA	375-95-1	19	19	19	EPA RSL	6	1.9	0.200	0.100	0.0500
Perfluorodecanoic acid	PFDA	335-76-2	0.013	0.06	0.06	POOL MDL	0.02	0.006	0.200	0.100	0.0500
Perfluoroundecanoic acid	PFUnA	2058-94-8	1,900[c]	—	—	—	—	—	0.200	0.100	0.0500
Perfluorododecanoic acid	PFDoA	307-55-1	320[c]	—	—	—	—	—	0.200	0.100	0.0500
Perfluorotridecanoic acid	PFTrDA	72629-94-8	—	—	—	—	—	—	0.200	0.100	0.0500
Perfluorotetradecanoic acid	PFTeDA	376-06-7	6300[c]	—	—	—	—	—	0.200	0.100	0.0500
Perfluorohexadecanoic acid	PFHxDA	67905-19-5	—	—	—	—	—	—	0.200	0.150	0.0500
Perfluorooctadecanoic acid	PFODA	16517-11-6	250,000[c]	—	—	—	—	—	0.200	0.150	0.0500
Perfluorobutanesulfonic acid	PFBS	375-73-5	1,900	1,900	1,900	EPA RSL	627	190	0.200	0.100	0.0500
Perfluoropentanesulfonic acid	PFPeS	2706-91-4	—	—	—	—	—	—	0.200	0.100	0.0500
Perfluorohexanesulfonic acid	PFHxS	355-46-4	130	130	130	EPA RSL	43	13	0.200	0.100	0.0500
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	—	—	—	—	—	—	0.200	0.100	0.0500
Perfluorooctanesulfonic acid	PFOS	1763-23-1	0.63	0.63	0.63	EPA RSL	0.2	0.06	0.200	0.100	0.0500
Perfluorononanesulfonic acid	PFNS	68259-12-1	—	—	—	—	—	—	0.200	0.100	0.0500
Perfluorodecanesulfonic acid	PFDS	335-77-3	—	—	—	—	—	—	0.200	0.100	0.0500
Perfluorododecanesulfonic acid	PFDoS	79780-39-5	—	—	—	—	—	—	0.200	0.100	0.0500
1H,1H, 2H, 2H-Perfluorohexane sulfonic acid	4:2 FTS	757124-72-4	—	—	—	—	—	—	0.400	0.200	0.100
1H,1H, 2H, 2H-Perfluorooctane sulfonic acid	6:2 FTS	27619-97-2	—	—	—	—	—	—	0.400	0.200	0.100
1H,1H, 2H, 2H-Perfluorodecane sulfonic acid	8:2 FTS	39108-34-4	—	—	—	—	—	—	0.400	0.200	0.100
N-methyl perfluorooctanesulfonamide	NMeFOSA	31506-32-8	—	—	—	—	—	—	0.200	0.100	0.0500
N-ethyl perfluorooctanesulfonamide	NEtFOSA	4151-50-2	—	—	—	—	—	—	0.200	0.100	0.0500
Perfluorooctanesulfonamide	PFOSA	754-91-6	—	—	—	—	—	—	0.200	0.100	0.0500
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	2355-31-9	—	—	—	—	—	—	0.200	0.100	0.0500
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	2991-50-6	—	—	—	—	—	—	0.200	0.100	0.0500

Matrix: Subsurface Soil

Analytical Group: PFAS

Analyte	Abbreviation	CAS No.	EPA RSL [a]	ASD Memorandum [a]	PSL [b]	PSL Reference	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits		
									LOQ	LOD	DL
N-methyl perfluorooctanesulfonamidoethanol	NMeFOSE	24448-09-7	—	—	—	—	—	—	1.00	0.500	0.250
N-ethyl perfluorooctanesulfonamidoethanol	NEtFOSE	1691-99-2	—	—	—	—	—	—	1.00	0.500	0.250
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	23	23	23	EPA RSL	7.6	2.3	0.200	0.100	0.0500
4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	—	—	—	—	—	—	0.200	0.100	0.0500
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9Cl-PF3ONS	756426-58-1	—	—	—	—	—	—	0.200	0.100	0.0500
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11Cl-PF3OUdS	763051-92-9	—	—	—	—	—	—	0.200	0.100	0.0500
3-Perfluoropropyl propanoic acid	3:3FTCA	356-02-5	—	—	—	—	—	—	0.400	0.200	0.100
2H,2H,3H,3H-Perfluorooctanoic acid	5:3FTCA	914637-49-3	—	—	—	—	—	—	1.00	0.500	0.250
3-Perfluoroheptyl propanoic acid	7:3FTCA	812-70-4	—	—	—	—	—	—	1.00	0.500	0.250
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7	—	—	—	—	—	—	0.200	0.100	0.0500
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5	—	—	—	—	—	—	0.200	0.100	0.0500
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1	—	—	—	—	—	—	0.200	0.100	0.0500
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6	—	—	—	—	—	—	0.200	0.100	0.0500
bis(trifluoromethylsulfonyl)amine	TFSI	82113-65-3	2,300	2,300	2,300	EPA RSL	759	230	0.200	0.150	0.0500

Note: Units are in µg/kg. PFAS will be reported in the neutral form.
— not available
[a] EPA Residential Soil RSL using a THQ of 0.1 and a target cancer risk of 1E-06 – November 2024 (EPA 2024d; ASD 2025).
[b] The November 2024 EPA RSLs for certain analytes are below the EPA-approved analytical MDL; therefore, the method's pooled MDL is used as the screening value to establish consistent and measurable values (ASD 2025; EPA 2024d).
[c] The November 2024 EPA RSL for this analyte is not yet approved for use within the DoD Cleanup Program.

Matrix: Groundwater

Analytical Group: PFAS

Analyte	Abbreviation	CAS No.	EPA RSL [a]	ASD Memorandum [a]	PSL	PSL Reference	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits		
									LOQ	LOD	DL
Perfluoropropanoic acid	PFPrA	422-64-0	980	980	980	EPA RSL	323	98	35.0	25.0	10.0
Perfluorobutanoic acid	PFBA	375-22-4	1,800	1,800	1,800	EPA RSL	594	180	4.00	2.00	1.00
Perfluoropentanoic acid	PFPeA	2706-90-3	—	—	—	—	—	—	2.00	1.00	0.500
Perfluorohexanoic acid	PFHxA	307-24-4	990	990	990	EPA RSL	327	99	2.00	1.00	0.500
Perfluoroheptanoic acid	PFHpA	375-85-9	—	—	—	—	—	—	2.00	1.00	0.500
Perfluorooctanoic acid	PFOA	335-67-1	0.0027	4	4 [c]	MCL	1	0.4	2.00	1.00	0.500
Perfluorononanoic acid	PFNA	375-95-1	5.9	5.9	5.9	EPA RSL	2	0.59	2.00	1.00	0.500
Perfluorodecanoic acid	PFDA	335-76-2	0.004	0.52	0.52 [d]	POOL MDL	0.2	0.052	2.00	1.00	0.500
Perfluoroundecanoic acid	PFUnA	2058-94-8	600 [b]	—	—	—	—	—	2.00	1.00	0.500
Perfluorododecanoic acid	PFDoA	307-55-1	100 [b]	—	—	—	—	—	2.00	1.00	0.500
Perfluorotridecanoic acid	PFTrDA	72629-94-8	—	—	—	—	—	—	2.00	1.00	0.500
Perfluorotetradecanoic acid	PFTeDA	376-06-7	2,000 [b]	—	—	—	—	—	2.00	1.00	0.500
Perfluorohexadecanoic acid	PFHxDA	67905-19-5	—	—	—	—	—	—	2.00	1.00	0.500
Perfluorooctadecanoic acid	PFODA	16517-11-6	80,000 [b]	—	—	—	—	—	2.00	1.00	0.500
Perfluorobutanesulfonic acid	PFBS	375-73-5	600	600	600	EPA RSL	198	60	2.00	1.50	0.500
Perfluoropentanesulfonic acid	PFPeS	2706-91-4	—	—	—	—	—	—	2.00	1.00	0.500
Perfluorohexanesulfonic acid	PFHxS	355-46-4	39	10	10 [c]	MCL	3	1	2.00	1.00	0.500
Perfluoroheptanesulfonic acid	PFHpS	375-92-8	—	—	—	—	—	—	2.00	1.00	0.500
Perfluorooctanesulfonic acid	PFOS	1763-23-1	0.2	4	4[c]	MCL	1	0.4	2.00	1.00	0.500
Perfluorononanesulfonic acid	PFNS	68259-12-1	—	—	—	—	—	—	2.00	1.00	0.500
Perfluorodecanesulfonic acid	PFDS	335-77-3	—	—	—	—	—	—	2.00	1.00	0.500
Perfluorododecanesulfonic acid	PFDoS	79780-39-5	—	—	—	—	—	—	2.00	1.00	0.500
1H,1H, 2H, 2H-Perfluorohexane sulfonic acid	4:2 FTS	757124-72-4	—	—	—	—	—	—	4.00	2.00	1.00
1H,1H, 2H, 2H-Perfluorooctane sulfonic acid	6:2 FTS	27619-97-2	—	—	—	—	—	—	4.00	3.00	1.50
1H,1H, 2H, 2H-Perfluorodecane sulfonic acid	8:2 FTS	39108-34-4	—	—	—	—	—	—	4.00	3.00	1.50
N-methyl perfluorooctanesulfonamide	NMeFOSA	31506-32-8	—	—	—	—	—	—	2.00	1.50	0.500
N-ethyl perfluorooctanesulfonamide	NEtFOSA	4151-50-2	—	—	—	—	—	—	2.00	1.50	0.500
Perfluorooctanesulfonamide	PFOSA	754-91-6	—	—	—	—	—	—	2.00	1.00	0.500
N-methyl perfluorooctanesulfonamidoacetic acid	NMeFOSAA	2355-31-9	—	—	—	—	—	—	2.00	1.50	0.500
N-ethyl perfluorooctanesulfonamidoacetic acid	NEtFOSAA	2991-50-6	—	—	—	—	—	—	2.00	1.00	0.500

Matrix: Groundwater

Analytical Group: PFAS

Analyte	Abbreviation	CAS No.	EPA RSL [a]	ASD Memorandum [a]	PSL	PSL Reference	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits		
									LOQ	LOD	DL
N-methyl perfluorooctanesulfonamidoethanol	NMeFOSE	24448-09-7	—	—	—	—	—	—	10.0	5.00	2.50
N-ethyl perfluorooctanesulfonamidoethanol	NEtFOSE	1691-99-2	—	—	—	—	—	—	10.0	5.00	2.50
Hexafluoropropylene oxide dimer acid	HFPO-DA	13252-13-6	1.5	1.5	1.5	EPA RSL	0.5	0.15	1.50	1.00	0.500
4,8-Dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	—	—	—	—	—	—	2.00	1.00	0.500
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	9Cl-PF3ONS	756426-58-1	—	—	—	—	—	—	2.00	1.00	0.500
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	11Cl-PF3OUdS	763051-92-9	—	—	—	—	—	—	2.00	1.00	0.500
3-Perfluoropropyl propanoic acid	3:3FTCA	356-02-5	—	—	—	—	—	—	4.00	2.00	1.00
2H,2H,3H,3H-Perfluorooctanoic acid	5:3FTCA	914637-49-3	—	—	—	—	—	—	10.0	5.00	2.50
3-Perfluoroheptyl propanoic acid	7:3FTCA	812-70-4	—	—	—	—	—	—	10.0	5.00	2.50
Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7	—	—	—	—	—	—	2.00	1.00	0.500
Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5	—	—	—	—	—	—	2.00	1.00	0.500
Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1	—	—	—	—	—	—	2.00	1.00	0.500
Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6	—	—	—	—	—	—	2.00	1.00	0.500
bis(trifluoromethylsulfonyl)amine	TFSI	82113-65-3	590	590	590	EPA RSL	195	59	2.00	1.00	0.500

Note: Units are in ng/L. PFAS will be reported in the neutral form.
[a] EPA tap water RSL using a THQ of 0.1 and a target cancer risk of 1E-06 – Tap Water – November 2024 (EPA 2024d; ASD 2025).
[b] The November 2024 EPA RSL for this analyte is not yet approved for use within the DoD Cleanup Program.
[c] The November 2024 EPA RSL for this analyte is below the method's MDL; therefore, the MCL is used as the screening value. Alternatively, when the MCL is less the EPA RSL, the MCL is applied as the PSL (ASD 2025; EPA 2024d).
[d] The November 2024 EPA RSL for this analyte is below the method's pooled MDL and the analyte does not have a MCL; therefore, the method's pooled MDL is used as the screening value to establish consistent and measurable values (ASD 2025; EPA 2024d).

15.2 PETROLEUM HYDROCARBON CONSTITUENTS REFERENCE LIMITS AND EVALUATIONS TABLES

This section presents a detailed list of the soil and groundwater COPCs that will be analyzed in addition to PFAS at Area A and their corresponding PSLs for the following analyses:

- *VOCs*: EPA SW-846 Test Method 8260
- *PAHs:* EPA SW-846 Test Method 8270 Selected Ion Monitoring
- *GRO:* EPA SW-846 Test Method 8015
- *DRO and RRO:* EPA SW-846 Test Method 8015

Soil PSLs were identified as the more conservative value of the DOH Tier 1 EALs (Table A-2 soil action levels [potentially impacted groundwater is a current or potential drinking water resource; surface water body is located within 150 meters of release site]) (DOH 2024) and the EPA residential soil RSLs using a THQ of 0.1 and a target cancer risk of 1E-06 (EPA 2024d).

Groundwater PSLs were identified as the more conservative value of the DOH Tier 1 EALs (Table D-1a groundwater action levels [surface water ≤ 150 meters and potential drinking water source]) (DOH 2024) and the EPA tap water RSLs using a THQ of 0.1 and a target cancer risk of 1E-06 (EPA 2024d).

The PSLs and reporting limits for additional Area A COPCs are provided below for soil and groundwater. In addition, the following tables summarize the laboratory-specific values for the LOQ, LOD, and DL. Based on limitations of the analytical instrumentation, the standard method quantitation limit may exceed the screening criteria. In such cases, analytes not detected in samples would be treated as a ND exceedance. The usability of ND data of analytes with laboratory reporting limits above the PSLs will be evaluated in a data quality assessment report and the risk assessment uncertainty sections of the RI report.

Table 15-1: Project Screening Levels and Laboratory-Specific Limits for Soil (GRO)

Matrix: Soil

Analytical Group: GRO (EPA Method SW-846 8015)

Analyte	CAS No.	Screening Criteria		PSL	PSL Reference	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits (mg/kg)		
		EPA RSL [a] (mg/kg)	DOH EAL [b] (mg/kg)					LOQ	LOD	DL
GRO (C_6-C_{12})	-3544	—	100	100	DOH EAL	33	10	2	1.5	0.750

Note: All concentrations are in mg/kg. Reporting on a dry weight basis.
— not applicable or information not available
mg/kg milligram per kilogram
[a] EPA RSL using a THQ of 0.1 and a target cancer risk of 1E-06 – Residential Soil – November 2024 (EPA 2024c).
[b] DOH Table A-2, Soil Action Levels (potentially impacted groundwater is a current or potential drinking water resource; surface water body is located within 150 meters of release site) (DOH 2024).

Table 15-2: Project Screening Levels and Laboratory-Specific Limits for Soil (DRO/RRO)

Matrix: Soil

Analytical Group: DRO/RRO (EPA Method 8015C)

Analyte	CAS No.	Screening Criteria Reference		PSL	PSL Reference	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits (mg/kg) [c]		
		EPA RSL [a] (mg/kg)	DOH EAL [b] (mg/kg)					LOQ	LOD	DL
DRO (C_9-C_{25})	-3550	—	183	183	DOH EAL	65	22	10	8	4
RRO (C_{24}-C_{40})	-3551	—	500	500	DOH EAL	165	50	10	8	4
DRO/RRO with SGC [c]										
DRO (C_9-C_{25})	-3550	—	—	—	—	65	22	10	8	4
RRO (C_{24}-C_{40})	-3551	—	—	—	—	165	50	10	8	4

Note: All concentrations are in mg/kg. Reporting on a dry weight basis.
— not applicable or information not available
SGC silica gel cleanup
[a] EPA RSL using a THQ of 0.1 and a target cancer risk of 1E-06 – Residential Soil – November 2024 (EPA 2024c).
[b] DOH Table A-2, Soil Action Levels (potentially impacted groundwater is a current or potential drinking water resource; surface water body is located within 150 meters of release site) (DOH 2024).
[c] DRO and RRO with SGC were analyzed only in samples with detections of DRO and RRO.

Table 15-3: Project Screening Levels and Laboratory-Specific Limits for Soil (VOCs)

Matrix: Soil

Analytical Group: VOCs (EPA Method SW-846 8260)

Analyte	CAS No.	Screening Criteria Reference		PSL (mg/kg)	PSL Reference	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits (mg/kg)		
		EPA RSL [a] (mg/kg)	DOH EAL [b] (mg/kg)					LOQ	LOD	DL
Benzene	71-43-2	1.2	0.3	0.3	DOH EAL	0.09	0.03	0.25	0.2	0.05
Ethylbenzene	100-41-4	5.8	0.9	0.9	DOH EAL	0.30	0.09	0.25	0.2	0.05
m,p-Xylenes	1330-20-7	58	1.4	1.4	DOH EAL	0.46	0.14	0.25	0.2	0.05
o-Xylenes	95-47-6	58	1.4	1.4	DOH EAL	0.46	0.14	0.25	0.2	0.05
Toluene	108-88-3	490	0.78	0.78	DOH EAL	0.25	0.07	0.25	0.2	0.05
Trimethylbenzene, 1,2,4-	95-63-6	30	—	30	EPA RSL	9.9	3	0.25	0.2	0.05
Trimethylbenzene, 1,3,5-	108-67-8	27	—	27	EPA RSL	8.9	2.7	0.25	0.2	0.05
1,2-dichloroethane	107-06-2	0.46	0.023	0.023	DOH EAL	0.007	0.002	0.25	0.2	0.05
1,2-dibromoethane (ethylene dibromide)	106-93-4	0.036	0.00042	0.00042	DOH EAL	0.0001	0.00004	0.25	0.2	0.05

Note: All concentrations are in mg/kg. Reporting on a dry weight basis.
— not applicable or information not available
[a] EPA RSL using a THQ of 0.1 and a target cancer risk of 1E-06 – Residential Soil – November 2024 (EPA 2024c).
[b] DOH Table A-2, Soil Action Levels (potentially impacted groundwater is a current or potential drinking water resource; surface water body is located within 150 meters of release site) (DOH 2024).

Table 15-4: Project Screening Levels and Laboratory-Specific Limits for Soil (PAHs)

Matrix: Soil

Analytical Group: PAHs (EPA Method SW-846 8270 SIM)

Analyte	CAS No.	Screening Criteria Reference		PSL (mg/kg)	PSL Reference	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits (mg/kg)		
		EPA RSL [a] (mg/kg)	DOH EAL [b] (mg/kg)					LOQ	LOD	DL
1-Methylnaphthalene	90-12-0	0.018	0.89	0.018	EPA RSL	0.006	0.002	0.005	0.003	0.00096
2-Methylnaphthalene	91-57-6	24	1.9	1.9	DOH EAL	0.6	0.2	0.005	0.003	0.00094
Acenaphthene	83-32-9	360	120	120	DOH EAL	39	12	0.005	0.003	0.00097
Acenaphthylene	208-96-8	—	5.5	5.5	DOH EAL	1.8	0.6	0.005	0.003	0.00089
Anthracene	120-12-7	1800	4.2	4.2	DOH EAL	1.4	0.4	0.005	0.003	0.00083
Benzo(a)anthracene	56-55-3	1.1	10	1.1	EPA RSL	0.4	0.1	0.005	0.003	0.00091
Benzo(a)pyrene	50-32-8	0.11	3.6	0.11	EPA RSL	0.04	0.01	0.005	0.003	0.00093
Benzo(b)fluoranthene	205-99-2	1.1	5.8	1.1	EPA RSL	0.4	0.1	0.005	0.003	0.0011
Benzo(g,h,i)perylene	191-24-2	—	35	35	DOH EAL	12	3.5	0.005	0.003	0.0013
Benzo(k)fluoranthene	207-08-9	11	35	11	EPA RSL	3.6	1.1	0.005	0.003	0.001
Chrysene	218-01-9	110	7.3	7.3	DOH EAL	2.4	0.7	0.005	0.003	0.00085
Dibenz(a,h)anthracene	53-70-3	0.11	1.1	0.11	EPA RSL	0.04	0.01	0.005	0.003	0.00092
Fluoranthene	206-44-0	240	87	87	DOH EAL	28	8	0.005	0.003	0.0012
Fluorene	86-73-7	240	93	93	DOH EAL	31	9	0.005	0.003	0.001
Indeno(1,2,3-c,d)pyrene	193-39-5	1.1	5.7	1.1	EPA RSL	0.3	0.1	0.005	0.003	0.0009
Naphthalene	91-20-3	2	3.1	2	EPA RSL	0.6	0.2	0.005	0.003	0.00089
Phenanthrene	85-01-8	—	69	69	DOH EAL	22	7	0.005	0.003	0.0011
Pyrene	129-00-0	180	44	44	DOH EAL	14	4	0.005	0.003	0.0012

Note: All concentrations are in mg/kg. Reporting on a dry weight basis.
— not applicable or information not available
SIM selected ion monitoring
[a] EPA RSL using a THQ of 0.1 and a target cancer risk of 1E-06 – Residential Soil – November 2024 (EPA 2024c).
[b] DOH Table A-2, Soil Action Levels (potentially impacted groundwater is a current or potential drinking water resource; surface water body is located within 150 meters of release site) (DOH 2024).

Table 15-5: Project Screening Levels and Laboratory-Specific Limits for Groundwater (GRO)

Matrix: Groundwater

Analytical Group: GRO (EPA Method SW-846 8260)

Analyte	CAS No.	Screening Criteria		PSL	PSL Reference	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits (µg/L) [c]		
		EPA RSL [a] (µg/L)	DOH EAL [b,c] (µg/L)					LOQ	LOD	DL
GRO (C_6-C_{12})	-3544	—	74	74	DOH EAL	25	7	25.0	20.0	10.0

Note: All concentrations reported in µg/L.
— not available
µg/L microgram per liter
GW groundwater
[a] EPA RSL using a THQ of 0.1 and a target cancer risk of 1E-06 – Tap Water – November 2024 (EPA 2024c).
[b] DOH Table D-1a, GW Action Levels (potentially impacted groundwater is a current or potential drinking water resource; surface water body is NOT located within150 meters of release site) (DOH 2024).
[c] The summed total concentrations of GRO, DRO, and RRO in groundwater will be evaluated in accordance with the Hawaii DOH Memorandum *Comparison of HIDOH Total Petroleum Hydrocarbon (TPH) Action Levels to Data for Water Samples* (DOH 2025a).

Matrix: Groundwater

Analytical Group: DRO/RRO (EPA Method 8015C)

Analyte	CAS No.	Screening Criteria Reference		PSL	PSL Reference	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits (µg/L) [c]		
		EPA RSL [a] (µg/L)	DOH EAL [b,d] (µg/L)					LOQ	LOD	DL
DRO (C_9-C_{25})	-3550	—	91	91	DOH EAL	30	9	250	200	100
RRO (C_{24}-C_{40})	-3551	—	91	91	DOH EAL	30	9	250	200	100
DRO/RRO with SGC [c]										
DRO (C_9-C_{25})	-3550	—	—	—	—	30	9	250	200	100
RRO (C_{24}-C_{40})	-3551	—	—	—	—	30	9	250	200	100

Note: All concentrations reported in µg/L.
— not available
[a] EPA RSL using a THQ of 0.1 and a target cancer risk of 1E-06 – Tap Water – November 2024 (EPA 2024c).
[b] DOH Table D-1a, GW Action Levels (potentially impacted groundwater is a current or potential drinking water resource; surface water body is NOT located within 150 meters of release site) (DOH 2024).
[c] DRO and RRO with SGC were analyzed only in samples with detections of DRO and RRO.
[d] The summed total concentrations of GRO, DRO, and RRO in groundwater will be evaluated in accordance with the Hawaii DOH Memorandum *Comparison of HIDOH Total Petroleum Hydrocarbon (TPH) Action Levels to Data for Water Samples* (DOH 2025a).

Matrix: Groundwater

Analytical Group: VOCs (EPA Method SW-846 8260)

Analyte	CAS No.	Screening Criteria Reference		PSL (µg/L)	PSL Reference	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits (µg/L)		
		EPA RSL [a] (µg/L)	DOH EAL [b] (µg/L)					LOQ	LOD	DL
Benzene	71-43-2	0.46	5	0.46	EPA RSL	0.2	0.05	1	0.3	0.14
Ethylbenzene	100-41-4	1.5	7.3	1.5	EPA RSL	0.5	0.15	1	0.5	0.23
m,p-Xylenes [c]	1330-20-7	19	13	13	DOH EAL	4.2	1.3	2	0.3	0.15
o-Xylenes [c]	95-47-6	19	13	13	DOH EAL	4.2	1.3	1	0.3	0.15
Toluene	108-88-3	110	9.8	9.8	DOH EAL	3.2	0.9	1	0.3	0.15
Trimethylbenzene, 1,2,4-	95-63-6	5.6	—	5.6	EPA RSL	1	0.5	1	0.3	0.15
Trimethylbenzene, 1,3,5-	108-67-8	6	—	6	EPA RSL	1.9	0.6	1	0.3	0.12
1,2-dichloroethane	107-06-2	0.17	5	0.17	EPA RSL	0.06	0.02	1	0.3	0.14
1,2-dibromoethane (ethylene dibromide)	106-93-4	0.0075	0.04	0.0075	EPA RSL	0.002	0.001	1	0.5	0.2

Note: All concentrations reported in µg/L.
— not available
[a] EPA RSL using a THQ of 0.1 and a target cancer risk of 1E-06 – Tap Water – November 2024 (EPA 2024c).
[b] DOH Table D-1a, GW Action Levels (potentially impacted groundwater is a current or potential drinking water resource; surface water body is located within 150 meters of release site) (DOH 2024).
[c] References total xylene values (-m, -p, -o).

Table 15-6: Project Screening Levels and Laboratory-Specific Limits for Groundwater (PAHs)

Matrix: Groundwater

Analytical Group: PAHs (EPA Method SW-846 8270 SIM)

Analyte	CAS No.	Screening Criteria Reference		PSL (µg/L)	PSL Reference	Project LOQ Goal	Project LOD Goal	Laboratory-Specific Limits (mg/kg)		
		EPA RSL [a] (µg/L)	DOH EAL [b] (µg/L)					LOQ	LOD	DL
1-Methylnaphthalene	90-12-0	0.00063	2.1	0.00063	EPA RSL	0.0002	0.0001	0.2	0.1	0.04
2-Methylnaphthalene	91-57-6	3.6	4.7	3.6	EPA RSL	1.19	0.36	0.2	0.1	0.04
Acenaphthene	83-32-9	53	15	15	DOH EAL	4.95	1.50	0.2	0.1	0.5
Acenaphthylene	208-96-8	—	13	13	DOH EAL	4.29	1.30	0.2	0.1	0.05
Anthracene	120-12-7	180	0.02	0.02	DOH EAL	0.007	0.002	0.2	0.1	0.055
Benzo(a)anthracene	56-55-3	0.03	0.027	0.027	DOH EAL	0.009	0.003	0.2	0.1	0.04
Benzo(a)pyrene	50-32-8	0.025	0.06	0.025	EPA RSL	0.008	0.003	0.2	0.1	0.04
Benzo(b)fluoranthene	205-99-2	0.25	0.058	0.058	DOH EAL	0.02	0.01	0.2	0.1	0.05
Benzo(g,h,i)perylene	191-24-2	—	0.13	0.13	DOH EAL	0.04	0.01	0.2	0.1	0.04
Benzo(k)fluoranthene	207-08-9	2.5	0.36	0.36	DOH EAL	0.12	0.04	0.2	0.1	0.05
Chrysene	218-01-9	25	0.24	0.24	DOH EAL	0.08	0.02	0.2	0.1	0.05
Dibenz(a,h)anthracene	53-70-3	0.025	0.0048	0.0048	DOH EAL	0.0016	0.0005	0.2	0.1	0.053
Fluoranthene	206-44-0	80	0.8	0.8	DOH EAL	0.26	0.08	0.2	0.1	0.04
Fluorene	86-73-7	29	3.9	3.9	DOH EAL	1.29	0.39	0.2	0.1	0.04
Indeno(1,2,3-c,d)pyrene	193-39-5	0.25	0.018	0.018	DOH EAL	0.006	0.002	0.2	0.1	0.05
Naphthalene	91-20-3	0.12	12	0.12	EPA RSL	0.04	0.01	0.2	0.1	0.04
Phenanthrene	85-01-8	—	2.3	2.3	DOH EAL	0.76	0.23	0.2	0.1	0.04
Pyrene	129-00-0	12	4.6	4.6	DOH EAL	1.52	0.46	0.2	0.1	0.04

Note: All concentrations reported in µg/L.
— not applicable or information not available
[a] EPA RSL using a THQ of 0.1 and a target cancer risk of 1E-06 – Tap Water – November 2024 (EPA 2024c).
[b] DOH Table D-1a, GW Action Levels (potentially impacted groundwater is a current or potential drinking water resource; surface water body is located within 150 meters of release site) (DOH 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	September 28, 2023	April 24, 2024	Draft WP	April 24, 2024
Prepare Draft RI WP	AECOM	May 5, 2024	May 19, 2024	Draft WP	May 22, 2024
Prepare Draft RI WP for Regulatory Agencies	AECOM	June 1, 2024	June 21, 2024	Draft WP	June 21, 2024
Prepare Revised Draft RI WP for Regulatory Agencies	AECOM	August 7, 2024	September 5, 2024	Revised Draft WP	September 5, 2024
Prepare Revised Draft RI WP for Regulatory Agencies	AECOM	September 12, 2024	September 23, 2024	Revised Draft WP	September 23, 2024
Prepare Draft Final RI WP for Regulatory Agencies	AECOM	August 7, 2024	October 18, 2024	Draft Final WP	October 18, 2024
Conduct Scoping Meetings #1-5	Navy/Regulators	April 12, 2024	September 11, 2025	Meeting Minutes	2 weeks after each scoping meeting
Prepare Revised Draft RI WP	AECOM	September 11, 2025	November 11, 2025	Revised Draft WP	November 11, 2025
Prepare Final RI WP	AECOM	March 3, 2026	April 4, 2026	Final WP	March 27, 2026
Field Investigation	AECOM	September 21, 2024	May 8, 2027	N/A	N/A
Quarterly Groundwater Sampling, Rounds 1–4	AECOM	September 21, 2024	August 8, 2025	Data Tables	October 24, 2025
• Quarterly Groundwater Sampling, Round 1	AECOM	September 21, 2024	November 7, 2024	Data Tables	January 16, 2025
• Quarterly Groundwater Sampling, Round 2	AECOM	January 5, 2025	February 7, 2025	Data Tables	April 21, 2025
• Quarterly Groundwater Sampling, Round 3	AECOM	April 7, 2025	May 9, 2025	Data Tables	July 18, 2025
• Quarterly Groundwater Sampling, Round 4	AECOM	July 7, 2025	August 8, 2025	Data Tables	October 24, 2025
Phase 1 Area A Monitoring Well Installation (PFMW01A/B, PFMW02A)	AECOM	September 15, 2024	July 1, 2025	Sample Collection	July 31, 2025
Phase 2 Area B Soil and Groundwater Investigation	AECOM	July 27, 2026	October 30, 2026	Data Tables	November 27, 2026
Phase 2 Area A Soil and Groundwater Investigation	AECOM	September 1, 2026	December 18, 2026	Data Tables	January 15, 2027
Area B Well Installation (PFMW03A/B)	AECOM	September 1, 2026	February 12, 2026	Sample Collection	March 19, 2027
Off-site Well Installation	AECOM	February 1, 2027	May 28, 2027	Sample Collection	July 2, 2027
First Semi-Annual Groundwater Sampling Round	AECOM	June 14, 2027	July 16, 2027	Data Tables	August 20, 2027
Second Semi-Annual Groundwater Sampling Round	AECOM	January 10, 2028	February 17, 2028	Data Tables	March 17, 2028
Data Evaluation	AECOM	February 14, 2025	April 14, 2028	N/A	N/A
Risk Assessment	AECOM	February 14, 2027	May 26, 2028	N/A	N/A
Prepare and Submit In-Progress Draft RI Report	AECOM	September 27, 2027	May 26, 2028	Draft RI	June 1, 2028
Prepare and Submit Draft RI Report for Regulatory Agency	AECOM	August 1, 2028	September 29, 2028	Draft RI	September 29, 2028
Prepare and Submit Draft Final RI Report for Navy Review	AECOM	December 4, 2028	January 19, 2029	Draft Final RI	January 12, 2029
Prepare and Submit Draft Final RI Report for Regulatory Agency Review	AECOM	February 26, 2029	April 13, 2029	Draft Final RI	April 13, 2029
Prepare and Submit Final RI Report	AECOM	June 11, 2029	July 27, 2029	Final RI	July 27, 2029

N/A not applicable

Worksheet #17: Sampling Design and Rationale

This section describes the sampling design and rationale for the RI. The term COPC is used to refer to PFAS and PHCs at Area A and PFAS at Area B. For PHC COPCs, the RI will utilize current guidance from the DOH TGM (DOH 2025b). Worksheet #15 lists the COPCs and the corresponding PSLs for this project.

17.1 Sampling Design Overview

This section describes the sampling design and sampling strategies to be implemented for the study areas associated with potential sources of COPCs at Area A and Area B. Surface soil, subsurface soil, groundwater, and petroleum LNAPL are media that will be analyzed for COPCs in selected locations, as described in the following sections. The results will indicate whether step-out sampling will be required.

Area A is limited in extent with known sources of PFAS and potential PFAS sources. PFAS have been detected above PSLs in subsurface soil and comingled with PHC LNAPL in a perched groundwater system extent in a single perched groundwater monitoring well. PFAS have not been detected above PSLs in four basal groundwater monitoring wells in Area A or 11 basal groundwater monitoring wells surrounding Area A.

Area B encompasses approximately 37 acres of the westernmost portion of the Facility. PFAS have been detected above PSLs and are not defined in perched groundwater monitoring wells. PFAS have been detected above PSLs and are not defined in basal groundwater monitoring wells to the north and east in the basal groundwater. No potential source has been identified at Area B. No soil samples have been analyzed for PFAS in Area B.

17.1.1 Surface and Subsurface Soil Sampling Design and Rationale

The surface and subsurface soil sampling and analysis approach at Area A and Area B will include drilling soil borings and continuously sampling soil from the surface to the total depth of the borehole for lithologic logging, and screening for volatiles. PFAS will be evaluated in each boring using vertically composited soil samples over specific intervals. PHC COPCs will be evaluated in subsurface soil at Area A, while PHCs will be evaluated at Area B under a different program.

Composited analytical soil samples will be collected and analyzed for PFAS to evaluate risk to sensitive receptors, and to develop a PFAS concentration profile with depth to assess the PFAS in soil leaching to groundwater transport pathway. Composited soil samples will consist of all the fine-grained soil (sand, silt, and clay) within a sampling interval, composited and homogenized in the field, then subsampled into sampling containers for laboratory analysis in accordance with EPA Method 1633.

A maximum of six soil samples from each boring will be analyzed for PFAS during this phase of sampling:

Surface Soil Interval 1 (0–0.5 feet bgs):

- One discrete surface soil sample will be collected from ground surface to 0.5 feet bgs at every soil boring that is not covered by asphalt or other clean fill to assess the potential for direct contact exposure by human and ecological receptors, and as a potential source for migration via surface runoff or dust transport.

Shallow Subsurface Interval 2 (0.5–2 feet bgs) and Interval 3 (2–10 feet bgs):

- Two shallow composite analytical subsurface soil samples will be collected from every soil boring to evaluate potential exposure to construction workers who may work with soil from trenches to depths of 10 feet bgs, and to refine the vertical PFAS concentrations in the shallow soil.
  - *Interval 2:* The top of the composite interval will correspond to 0.5 feet bgs or the bottom of the surface manmade fill, with the bottom of the interval at 2 feet bgs
  - *Interval 3:* 2–10 feet bgs

Deep Subsurface Interval 4 (10–20 feet bgs) and Interval 5 (20–30 feet bgs)

- Two deep composite analytical subsurface soil samples will be collected from every soil boring to develop a vertical PFAS concentration distribution profile to support evaluation of site-specific PFAS transport in the vadose zone.
  - *Interval 4:* 10–20 feet bgs
  - *Interval 5:* 20–30 feet bgs

Terminal Interval 6 (1 foot composite)

- The final deep composite analytical subsurface soil sample in each boring will be collected over a 1-foot soil interval (Interval 6)
  - If perched groundwater is encountered, a 1-foot composited analytical subsurface soil sample will be collected in the capillary fringe to assess the partitioning relationship between PFAS in saturated soil and adjacent groundwater.
  - If no groundwater is encountered, a 1-foot composited analytical subsurface soil sample will be collected at the total depth of the borehole to evaluate PFAS concentrations at or near the valley fill/bedrock interface at that location.

If drilling refusal is encountered prior to reaching the specified interval depths described above, then the corresponding composite sample will be collected from the designated interval start depth to one foot above the total depth achieved. The final soil interval collected will be from the 1-foot interval directly above total depth of the boring to further refine the PFAS vertical distribution profile.

17.2 AREA A SOIL SAMPLING DESIGN

The soil sampling approach will include drilling soil borings with soil sampling from the surface and at multiple targeted subsurface depths. Discrete and composite soil samples will be collected for analysis from soil borings judgmentally selected throughout Area A. Samples collected in Area A are intended to characterize the nature and extent of the remaining residual PFAS and comingled PHC in the soils from the November 2022 AFFF (b) (3) release incident, and to determine if any historical releases of PFAS or PHC (prior to 2022) affected soil in these areas. If perched water is encountered, soil samples at the capillary fringe will be targeted for both PFAS and PHC. If evidence of PHC is observed, including odor, elevated organic vapor readings, staining, or LNAPL, a soil sample will be targeted for both PHC and PFAS analysis. Table 17-1 provides a summary of the sample types and rationale described below.

17.2.1 PFAS Shallow Subsurface Soil Sampling

Shallow soil borings RHA-BS-S01 through RHA-BS-S06 are associated with the 200-gallon AFFF tank located along (b) (3) . RHA-BS-S01, RHA-BS-S03, and RHA-BS-S05 are topographically below the AFFF tank and are likely to detect any potential leaks. These borings are located along the northern edge of (b) (3) and downslope from the road in an area that cannot be accessed by mechanized drilling equipment. These shallow borings will be limited to a maximum of 5-8 feet bgs and will be sampled using a hand auger or similar manual digging tools.

Several shallow soil borings (RHA-BS-S07 to RHA-BS-S13) will be advanced within target DUs associated with the November 2022 AFFF (b) (3) release emergency response, where excavated, PFAS-impacted soil was removed, and the excavation was backfilled with clean material. Soil sampling in these excavations will start at the bottom of the clean fill and is intended to confirm that PFAS have been removed to current PSLs. RHA-BS-S12 is located on the other side of an open culvert that is a topographical low point at Area A, where material is likely to accumulate.

These proposed sampling locations are shown on Figure 33.

17.2.2 PFAS Surface Soil and Swale Surface Soil Sampling

A total of ten swale surface soil samples will be collected in the concrete-lined and unlined drainage swale along the southern and eastern perimeter of the Bldg. 313 paved area. Seven swale surface soil grab samples (RHA-SD-S01 through RHA-SD-S07) will be collected from the lower concrete drainage swale and three swale surface soil grab samples (RHA-SD-S08 and RHA-SD-S10) will be collected from the unpaved drainage swale located downslope of the road, southwest of Bldg. 313.

A total of ten surface soil samples will be collected from the surface soil along the southern and eastern perimeter of the Bldg. 313 paved area. These include seven surface soil samples (0 to 0.5 feet bgs) (RHA-SS-S01 through RHA-SS-S07) adjacent to the concrete drainage swale; and three surface soil samples (RHA-SS-S08 through RHA-SS-S10) adjacent to the unpaved drainage swale located downslope of the road, southwest of Bldg. 313. These samples will be used to evaluate surface soil in the runoff from the drainage swale and surface soil from Bldg. 313 and surrounding upslope areas for residual concentrations of PFAS.

These swale surface soil and surface soil sampling locations are shown on Figure 34.

17.2.3 PFAS and Petroleum Subsurface Soil Sampling

Deep soil borings, shown on Figure 35, are anticipated to be advanced to approximately 100 feet bgs, the depth where the valley fill/bedrock interface is expected, based on previous drilling in the area. Samples analyzed at the valley fill/bedrock interface are intended to assess the potential for COPCs to be transported through the valley fill and into the underlying bedrock and potentially into the underlying basal aquifer. Soil samples from the deep borings follow the strategy outlined in Section 17.1 with the target total depth of 100 feet bgs for these borings. In locations where sampling is conducted beneath fill, sampling intervals within the fill will not be collected.

If refusal is encountered above 100 feet bgs, the boring location will be moved less than 2 feet within the area cleared for utilities and the samples will be attempted again. If the boring is unable to be advanced to 18 feet bgs a second time, the interval nearest refusal will be analyzed. If evidence of PHC is observed in fine-grained soil, including PID readings above 10 ppmv, petroleum-related staining, or LNAPL, a soil sample will be targeted for both PHC and PFAS analysis.

PHC, in addition to PFAS, will be analyzed in samples at the middle and eastern end of Area A, based on the LNAPL in PFMW01B, the TPH detections in shallow soil at RHMW17, and other historical activities at Area A. Soil samples from the following borings will be analyzed for PFAS and PHC: RHA-BS-S15, RHA-BS-S16, RHA-BS-S17, and RHA-BS-S18 advanced around Bldg. 313; and RHA-BS-S14, RHA-BS-S19, and RHA-BS-S20 along the northern site boundary between Area A and South Halawa Stream. Sampling results from these borings will be evaluated along with the swale surface soil and surface soil results to determine if further sampling outside of the Area A boundary to the north and northeast is necessary. If perched water is observed in these borings, it is anticipated that at least one perched groundwater well will be installed with a location preference co-located with RHA-BS-14 at the northeast corner of the Bldg. 313 compound (Section 17.3.1).

PFAS will be analyzed in soil samples from borings RHA-BS-S21, RHA-BS-S22, and RHA-BS-S23 located in the grassy area along the western fence of the Bldg. 313 compound, to include the end of the drainage culvert that was part of the November 2022 AFFF (b) (3) release cleanup excavations (RHA-BS-S23). Unless evidence of PHC is encountered during drilling, the soil samples from these borings will not be analyzed for PHC.

If perched water is encountered while advancing soil borings in Area A, a temporary well will be installed and a groundwater grab sample will be collected. A 2-inch pre-packed screen will be installed into the borehole, the temporary well will be purged of three well volumes, and a groundwater sample will be collected. Permanent wells will not be installed. In addition, water levels will be gauged and compared to a surveyed benchmark to refine perched groundwater flow directions in Area A.

17.3 AREA A GROUNDWATER SAMPLING DESIGN

Groundwater at Area A consists of discontinuous perched zones in the valley fill alluvium which are not a drinking water source, and the underlying basal aquifer that is part of the Southern Oahu Basal Aquifer. PFAS have been detected above PSLs in a single perched groundwater monitoring well in Area A but have not exceeded PSLs in any basal groundwater monitoring wells in Area A or the surrounding groundwater monitoring well network. Table 17-1 provides a summary of the sample types and rationale described below.

17.3.1 Groundwater Monitoring Well Installation

The Navy and regulatory agencies agreed that a single perched groundwater monitoring well (PFMW04B) should be installed at RHA-BS-S14 at the northeast corner of the compound if perched groundwater is observed there. If perched groundwater is not encountered in RHA-BS-S14 but encountered in another boring at Area A, the Navy will consult with the regulatory agencies to determine if a perched groundwater monitoring well should be installed, as shown on Figure 35.

17.3.1.1 PFAS AND PETROLEUM GROUNDWATER SAMPLING

Once all new monitoring well installation and development efforts are complete, two groundwater monitoring events will occur over 6 months, targeting the wet and dry seasons. At Area A, these two seasonal groundwater monitoring events will include the 17 existing groundwater monitoring wells sampled in July and August 2025 during the expedited Q4 monitoring event and 1 new perched groundwater monitoring well. Groundwater samples collected from these wells will be analyzed for PFAS, and selected wells will be sampled for PHC, including VOCs, GRO, DRO/RRO, and PAHs. The location of Area A and surrounding groundwater monitoring wells are presented on Figure 36.

Within Area A: 4 basal groundwater monitoring wells (RHMW06, RHMW17, PFMW01A, and PFMW02A), 4 perched groundwater monitoring wells (RHMW17S, RHMW17D, PFMW01B, and the proposed new well PFMW04B), and 1 elevated head well (RHMW07), are located within the Area A boundaries. Groundwater monitoring wells in Area A will document PFAS and PHC that can be directly associated with potential sources located at Area A.

Study Area Surrounding Area A: 4 in-tunnel basal groundwater monitoring wells (RHMW01R, RHMW02, RHMW03, and RHMW21) and 4 basal groundwater monitoring wells along the northern side of the Facility (RHMW04, RHMW08, RHMW20, and RHMW18 at the southeastern boundary) will be included in the two seasonal groundwater monitoring events. PFAS results from the groundwater monitoring well network surrounding Area A will document PFAS that may be migrating away from potential sources at Area A or may indicate a different source area. Currently, no PFAS migration away from Area A or other substantial source areas are indicated from these results.

Groundwater samples collected from these wells will be analyzed for PFAS, and select wells will be sampled for PHC, including VOCs, GRO, DRO/RRO, and PAHs. The location of Area A and surrounding area groundwater monitoring wells are presented on Figure 36. All proposed Area A sampling locations, including the surrounding groundwater monitoring well network discussed throughout Sections 17.2, 17.3.1, and 17.3, are summarized on Figure 37.

Table 17-1: Area A Sample Locations and Sample Rational Summary

Sample Type	Location ID	Location Rationale/Justification
Soil Samples [a]		
Shallow Soil Boring (Max Sample Depth 30 feet bgs or Refusal)	RHA-BS-S01	Near the historical 200-gallon AFFF tank.
	RHA-BS-S02	
	RHA-BS-S03	
	RHA-BS-S04	
	RHA-BS-S05	
	RHA-BS-S06	
	RHA-BS-S07	November 2022 Removal Action.
	RHA-BS-S08	
	RHA-BS-S09	
	RHA-BS-S10	
	RHA-BS-S11	
	RHA-BS-S12	November 2022 Removal Action and culvert area.
	RHA-BS-S13	November 2022 Removal Action.
Swale Surface Soil	RHA-SD-S01 to RHA-SD-S10	Surface soil in drainage swales, and low-lying area in the southern Bldg. 313 compound.
Surface Soil	RHA-SS-S01 to RHA-SS10	Soil next to drainage swales.
Deep Soil Borings (Max Sample Depth 100 ft bgs or Refusal)	PFMW04B/ RHA-BS-S1	Soil boring selected based on LNAPL observed at PFMW01B and PFAS PSL exceedances at PFMW01B in groundwater. Investigating soil between the Area A boundary and South Halawa Stream.
	RHA-BS-S14	
	RHA-BS-S15	Soil borings selected to surround Bldg. 313 and based on LNAPL observed at PFMW01B and PFAS PSL exceedances at PFMW01B in groundwater.
	RHA-BS-S16	
	RHA-BS-S17	
	RHA-BS-S18	
	RHA-BS-S19	Investigating soil between the Area A boundary and South Halawa Stream.
	RHA-BS-S20	
	RHA-BS-S21	Soil borings selected to evaluate PFAS in the western end of Area A.
	RHA-BS-S22	
	RHA-BS-S23	

Sample Type	Location ID	Location Rationale/Justification
Groundwater Samples [b]		
Perched Groundwater Samples	PFMW04B [c]	New perched groundwater monitoring well at RHA-BS-S14.
	PFMW01B	Perched groundwater monitoring well installed in 2025 during expedited sampling. First sampled in 2025 Q3 and Q4, results exceeded PSLs.
	RHMW17S	Existing perched groundwater monitoring well.
	RHMW17D	
	RHMW07 [d]	Existing perched groundwater monitoring well (not screened in the basal aquifer).
Basal Groundwater Samples	PFMW01A	Basal monitoring wells installed in 2025 during expedited sampling. First sampled in 2025 Q4, results did not exceed PSLs.
	PFMW02A	
	RHMW06	Existing basal monitoring well in Area A.
	RHMW01R [e]	Existing in-tunnel basal monitoring well.
	RHMW17	Existing basal monitoring well in Area A.
	RHMW02 [e]	Existing in-tunnel basal monitoring well.
	RHMW03 [e]	Existing in-tunnel basal monitoring well.
	RHMW04	Existing basal monitoring well.
	RHMW05 [e]	Existing in-tunnel basal monitoring well.
	RHMW06	Existing basal monitoring well in Area A.
	RHMW08	Existing basal monitoring well. University of Hawaii's injection monitoring well for the dye tracer study.
	RHMW17	Existing basal monitoring well in Area A.
	RHMW18	Existing basal monitoring well in Area A.
	RHMW20	Existing basal monitoring well in Area A.
	RHM[redacted]	Existing in-tunnel basal monitoring well.

ft foot or feet
[a] Depth to native soil is uncertain; therefore, subsurface soil samples collected beginning with the first 0-to-6-inch interval of native material immediately beneath artificial fill material, and then, as written, from within each following 1-ft interval.
[b] Number of groundwater samples proposed for a single sampling event. Two rounds of groundwater sampling will be conducted.
[c] Perched aquifer may not be encountered during drilling and well installation, and/or perched groundwater monitoring well may be dry during the sample event.
[d] RHMW07 monitors an elevated head zone and is not screened in the basal aquifer.
[e] Sampling depth at in-tunnel wells is measured from below tunnel floor (not bgs).

17.4 AREA B SOIL AND TEMPORARY WELL SAMPLING DESIGN

The soil sampling and analysis approach at Area B is summarized in Section 17.1. Area B includes one or more continuous perched groundwater systems that will be sampled during this phase using temporary wells to define the extent of PFAS prior to the installation of permanent perched wells.

At several locations (close to OWDFMW08B, and borings west of OWDFMW05 along the western access road), results from soil and grab groundwater samples will provide information to identify the next soil boring location. Samples that are inputs to these decisions should be prioritized to allow results to be validated before decisions for step-out locations are made.

Previous perched groundwater monitoring wells installed at the former OWDF were drilled using 11.25-inch HSAs and encountered perched groundwater between 35 and 40 feet bgs, under slightly confined conditions. It is anticipated that drilling could be conducted with a 7.125-inch outside diameter HSA with a 3.75-inch inside diameter for more efficient drilling and sampling.

At selected soil boring locations in Area B, if perched water is encountered, a temporary well will be installed and a groundwater grab sample will be collected. A 2-inch pre-packed screen will be installed into the borehole, the temporary well will be purged three well volumes, and a groundwater sample will

be collected. Permanent wells will not be installed. In addition, water levels will be gauged and compared to a surveyed benchmark to refine perched groundwater flow directions around OWDFMW08B.

Area B is divided into smaller subareas with different soil sampling plans, as described below and shown on Figure 38.

17.4.1 (b) (3) Area

A series of soil borings and groundwater grab samples are planned for the upslope area around the (b) (3) sump and OWDFMW08B to refine groundwater flow direction, as well as to evaluate and identify potential sources of PFAS in soil and perched groundwater. The total depth is expected to be at or near 40 feet bgs. To estimate where the perched water extends to the west, an initial soil boring will be advanced about halfway between observed perched water at OWDFMW08B and RHP03 where no perched water was observed during drilling. As shown on Figure 39, if perched groundwater is encountered in RHB-BS-S01, RHB-BS-S02 will step out halfway to RHP03 (about 65 feet) to the east to identify where that upslope perched water-bearing zone pinches out (perched groundwater was not encountered while drilling basal well RHP03). If perched groundwater is not encountered in RHB-BS-S01, RHB-BS-S02 will step back halfway between RHB-BS-S01 and RHB-BS-S03, approximately 65 feet to the west.

17.4.2 Former OWDF, (b) (3) Portal Entrance, and (b) (3) Area

A series of soil borings, some with groundwater grab samples, and surveyed water level measurements will be drilled at the former OWDF, as shown on Figure 40. Soil at the former OWDF has not been evaluated for PFAS previously. Soil borings are located to evaluate the work areas associated with the (b) (3) portal, the current spent AFFF piping and AST, the former OWDF excavation area, the area along the Facility boundary to the northwest, and the compound (b) (3) to the west. Locations of soil borings are limited by both underground and aboveground infrastructure, including the existing National Pollutant Discharge Elimination System (b) (3) (b) (3). An optional step-out boring, RHB-BS-S40, will be installed in the low-lying area directly northwest of the CHT Tank, between the Adit 3 portal and the former OWDF removal action. RHB-BS-S27 will be installed and sampled for PFAS in soil, if PFAS is observed above the PSLs in soil or groundwater at one or both adjacent soil borings (RHB-BS-S21 and RHB-BS-S07). If groundwater is encountered at RHB-BS-S40, a temporary well will be installed and a groundwater grab sample will be collected for PFAS.

Groundwater grab samples and water level measurements will be collected at locations to further refine the perched groundwater flow direction in Area B. If soil samples along the Facility boundary to the northwest exceed the PSLs, then additional sampling may be warranted in the orange shaded area (Figure 40) between the Facility boundary and South Halawa Stream; this would be completed in a Phase 2 investigation. If a Phase 2 sampling is warranted, and those results also yield PSL exceedances in soil, a Phase 3 investigation north of South Halawa Stream (green shaded area on Figure 40) may be considered.

17.4.3 (b) (3) Area

The preliminary CSM indicates perched groundwater flows west from OWDFMW03B and OWDFMW05B, which contain the highest PFAS COPC concentrations in groundwater at Area B and are the westernmost perched groundwater monitoring wells in the current groundwater monitoring well network. In addition, PFOS has been detected in expedited groundwater monitoring samples (1.7 to 4.1 ng/L) slightly above the PSL (4.0 ng/L), in the furthest west basal groundwater well, OWDFMW05A. Finally, stormwater runoff from upgradient areas, may also flow to the northwest and into this area.

This area west of the OWDF/(b) (3) compound (b) (3) is the future location of the (b) (3) (b) (3), with initial earthmoving scheduled to occur in 2026; therefore, the timeline for characterization of this area is limited to the construction schedule and will require deconfliction to ensure both activities meet their deadlines. One objective for the soil characterization in this area is to determine if construction activities could present any risk to future works and to determine if PFAS is migrating from the former OWDF area down to this topographical low point. Another objective is to determine if PFAS COPCs detected in soil and perched groundwater in this area may be migrating to the underlying basal aquifer at concentrations that present an unacceptable risk to human health or the environment.

Currently, this western area is unevenly sloped and densely vegetated with brush and trees. Initially, borings will be advanced along an eastern access road, with the results of these samples used as inputs to support defining the nature and extent of PFAS, if necessary, in the future. At least two soil borings and associated soil and grab groundwater samples will be performed to the west of perched groundwater monitoring well OWDFMW05B to an expected total depth of 35 feet bgs or perched groundwater. Sampling results from these borings will attempt to evaluate the western extent of PFAS COPCs in the perched groundwater system and soil observed at the former OWDF/(b) (3) compound for potential direct exposure and for the potential impact to the basal aquifer.

As shown on Figure 41, soil and groundwater grab sampling for PFAS are planned for the following areas in the footprint of the proposed WTF:

- Soil boring and temporary well RHB-BS-S22 will be installed and sampled near the lower access road that extends along the northern Facility fence line, approximately 200 feet west of OWDFMW05B.
  - If PFAS concentrations in soil and perched groundwater do not exceed PSLs at RHB-BS-S22, then a step-in soil boring and temporary well RHB-BS-S24 will be installed and sampled halfway between OWDFMW05B and RHB-BS-S22 to better define perched groundwater PSL exceedances observed at OWDFMW05B.
  - If PFAS concentrations in soil and perched groundwater exceed PSLs at RHB-BS-S22, then a step-out soil boring and temporary well RHB-BS-S24 will be installed and sampled approximately 100 feet west of RHB-BS-S22 (300 feet west of OWDFMW05B) to better define perched groundwater PSL exceedances observed at RHB-BS-S22.
- Two soil borings and temporary wells (RHB-BS-S23 and RHB-BS-S25) will be installed and sampled in densely vegetated, uneven terrain south of the access road and west of the OWDF fence line to define PFAS in soil and perched groundwater here.
  - If PFAS concentrations in soil and perched groundwater exceed PSLs at RHB-BS-S23 or RHB-BS-S25, then a step-out soil boring and temporary well (RHB-BS-S26) will be installed and sampled approximately 100 feet west of RHB-BS-S23 in densely vegetated and uneven terrain to better define perched groundwater PSL exceedances observed in this area.
  - It is anticipated that an access road will be required with vegetation clearing to reach these locations with a remote access drill rig.

As described in Section 14.7.3, all soil borings where groundwater grab samples are to be collected will also be surveyed and gauged for water levels.

17.4.4 Plume Delineation Wells and the Area B Boundary Area

The plume delineation basal groundwater monitoring wells (RHP wells) were installed during the release response to the November 2021 JP-5 release at (b) (3) to evaluate any LNAPL or evidence of an expanding JP-5 plume in the basal groundwater from the release. No evidence of an expanding JP-5 plume or LNAPL has been observed in these wells; however, results from the expedited groundwater monitoring events detected PFOS and PFOA above PSLs from RHP01, RHP02, RHP03, RHP05, RHP06, and RHP07. These locations are along the northern and southern boundaries of the Facility in the vicinity of the (b) (3) and water development tunnel.

Up to 13 soil borings will be advanced near the RHP wells and along the border of the Facility (Figure 42). The anticipated total depth for these borings will vary and will be based on the depth to bedrock at the drilling location. Along the southern boundary, which is near the top of Red Hill ridge, there is expected to be a thin layer of soil, from 0 to 10 feet, and no perched water is expected to be encountered. The northern Facility boundary is closer to the bottom of the Red Hill valley and is expected to have thicker alluvium related to valley fill sediments and boulder deposits where the total depth may reach 18 feet before refusal. No perched water was observed while drilling RHP01, RHP02, and RHP03.No grab water samples are currently planned for these borings. All proposed locations are shown on Figure 42.

17.5 AREA B GROUNDWATER MONITORING WELL INSTALLATION

Figure 43 shows the additional monitoring wells proposed for installation in Area B. Basal groundwater sampling results from the expedited groundwater monitoring events showed PFOS and PFOA exceeding PSLs in RHP01, RHP02, and RHP03, along the northern boundary of the Facility. The extent of these PFAS greater than their PSLs have not been evaluated to the north (off-site) or to the east (on-site). Basal groundwater monitoring well PFMW03A is intended to evaluate PSL exceedances east of RH(b) (9) in the basal aquifer. If perched groundwater is encountered during drilling, a perched groundwater monitoring well (PFMW03B) will be installed. Off-site basal groundwater monitoring wells PFMW05A and PFMW06A are intended to evaluate the PSL exceedances to the north of the Facility boundary. Permanent perched groundwater monitoring wells will not be installed off-site; however, if perched groundwater is encountered, a grab sample will be collected using a temporary well. At both on-site and off-site locations, soil samples will be collected during monitoring well installation, with a focus on finer materials in the valley fill where PFAS tend to adsorb. To be protective of the basal aquifer, basal groundwater monitoring wells will be double cased, with an outer casing from ground surface to the valley fill/bedrock interface, and inner casing from ground surface to 27 feet above msl.

17.5.1 Area B Groundwater Sampling Design and Locations

Once all new groundwater monitoring wells are installed and developed in Area A and Area B, two rounds of groundwater sampling targeting the wet and dry seasons will be conducted at newly installed wells and existing wells previously sampled as part of the expedited sampling program. Monitoring well locations for these two seasonal groundwater monitoring events in Area B and associated off-site study area are presented on Figure 43.

In Area B, perched groundwater monitoring wells to be sampled during these two seasonal events will include wells previously sampled during the expedited program and any new perched groundwater monitoring wells installed:

- OWDFMW03B, OWDFMW05B, OWDFMW06B, OWDFMW07B, OWDFMW07C, and OWDMW08B. Wells OWDFMW02B and OWDMW04B will be sampled if sufficient volumes are available for sampling.

- As described in Section 17.4.1, if perched groundwater is encountered during drilling at basal groundwater monitoring well PFMW03A then a perched groundwater monitoring well (PFMW03B) will be installed and sampled.

In Area B and off-site areas, basal groundwater monitoring wells to be sampled during the two seasonal monitoring events will include wells previously sampled during the expedited program, and any new basal groundwater monitoring wells installed:

- RHP01, RHP02, RHP03, RHP04A, RHP04B, RHP04C, RHP05, RHP06, RHP07, RHP08, RHP08B, OWDFMW01, OWDFMW02A, OWDFMW03A, OWDFMW04A, OWDFMW05A, OWDFMW06A, OWDFMW07A, and OWDFMW08A. RHMW2254-01, the access point to the (b) (3) water development tunnel at the Pump House, will also be sampled.
- Newly installed on-site well PFMW03A will be included in the sampling event, in addition to the two newly installed off-site wells, PFMW05A and PFMW06A.

All proposed Area B sampling locations discussed throughout Sections 17.4, 17.5, and 17.5.1 are summarized on Figure 44.

17.6 MULTILEVEL WELL GROUNDWATER SAMPLING AND EQUIPMENT BLANK EVALUATION

Currently, the extent of PFAS greater than PSLs is not defined in the basal aquifer at the southeastern boundary of Area B, and multilevel basal groundwater monitoring well RHMW15 is available to sample the basal aquifer at this location. However, the four multilevel groundwater monitoring wells installed as part of the Red Hill monitoring well network (RHMW11, RHMW13, RHMW14, and RHMW15), and manufactured by Westbay Instruments, have proprietary sampling probes and tubing that incorporate Viton (fluoroelastomer/FKM) O-rings and Teflon seals, which are either inaccessible or non-replaceable. A description of the Westbay Instruments Multilevel Well sampling equipment is provided in Appendix F. Viton and Teflon contain stable formulations of PFAS (rubber or plastic) which may allow small amounts of PFAS (not including PFOS or PFOA) to migrate into surrounding liquids, and are generally not used in PFAS sampling systems (SERDP 2024).

However, Westbay Instruments conducted a study in 2019 that indicated PFAS monitoring could be conducted using their multilevel wells, if the proper testing was conducted first to quantify the nature and extent of PFAS that may leach from each site-specific system and compare these results to the DQOs of the system (Westbay 2019).

To address this concern, an equipment blank evaluation will be conducted to evaluate whether these internal components might contribute detectable levels of PFAS to groundwater samples.

The equipment blank evaluation will involve the use of laboratory-grade PFAS-free water to simulate potential groundwater samples. Triplicate equipment blanks will be collected using the actual multilevel sampling equipment under field-representative conditions by filling and flushing samples though the sampling string and collecting an equipment rinsate.

If the multilevel monitoring well equipment associated with RHM(b) (9) is determined to meet the project DQOs for PFAS decision-making, then the sampling zone straddling the water table will be used to collect basal groundwater from this location to provide the information required for PFAS definition greater than the PSLs at the southeast boundary of Area B. Groundwater sampling from multilevel wells will be performed in accordance with fluid sampling procedures in Appendix F.

Table 17-2: Area B Sampling Locations and Rationale

Sample Type	Location ID	Location Rationale/Justification
Soil Samples [a] and Groundwater Grab Samples [b]		
(b) (3) *and OWDFMW08B Area*		
Soil Borings and Groundwater Grab Samples (Max sample Depth ~45 ft bgs)	RHB-BS-S01	Evaluate the extent of PFAS in soil and groundwater in the upslope perched unit.
	RHB-BS-S03 to RHB-BS-S06	Determine groundwater flow direction near OWDFMW08B (upslope perched unit).
	RHB-BS-S02	Step out for RHB-BS-S01. If perched water is not encountered at RHB-BS-S01, step to the west. If perched water is encountered, step to the east.
(b) (3) *and Former OWDF Area*		
Soil Borings and Groundwater Grab Samples (Max sample Depth ~35 ft bgs)	RHB-BS-S07	Sample PFAS in soil and perched groundwater around the center of the former OWDF and excavation area. Further refine perched groundwater flow near OWDFMW02B.
	RHB-BS-S08	
	RHB-BS-S09	Sample PFAS in soil and perched groundwater around the center of the former OWDF and excavation area. Further define perched groundwater elevation near OWDFMW03B and OWDFWM05B.
	RHB-BS-S13	
	RHB-BS-S15	
	RHB-BS-S17	
	RHB-BS-S21	Sample PFAS in soil and perched groundwater around the center of the former OWDF. Further refine the downslope perched groundwater flow direction at the former OWDF.
Soil Borings (Max sample Depth ~45 ft bgs)	RHB-BS-S10	Sample PFAS in soil around the center of the former OWDF and excavation area.
	RHB-BS-S11	Sample PFAS in soil around the center of the former OWDF.
	RHB-BS-S12	
	RHB-BS-S14	
	RHB-BS-S15	Sample PFAS in soil at the former OWDF wells and along the Facility boundary.
	RHB-BS-S16	Sample PFAS in soil around the center of the former OWDF.
	RHB-BS-S17	Sample PFAS in soil at the former OWDF wells and along the Facility boundary.
	RHB-BS-S18	Sample PFAS in soil around the center of the former OWDF and excavation area.
	RHB-BS-S19	Sample PFAS in soil at the former OWDF wells and along the Facility boundary.
	RHB-BS-S20	
(b) (3) *Area*		
Soil Borings and Groundwater Grab Samples (Max sample Depth ~40 ft bgs)	RHB-BS-S22	Evaluate the extent of PFAS in soil and groundwater west of the OWDF. Further refine perched groundwater flow near OWDFMW05B.
	RHB-BS-S23	
	RHB-BS-S25	
	RHB-BS-S24	Step in 100 ft west of OWDF if PFAS does not exceed the PSLs at RHB-BS-S22.
		Step out 300 ft west of OWDF if PFAS does exceed the PSLs at RHB-BS-S22.
	RHB-BS-S26	Step out 100 ft west of OWDF if PFAS does not exceed the PSLs at RHB-BS-S23.
	RHB-BS-S40	Step in near the CHT if PFAS does not exceed the PSLs at RHB-BS-S21 and RHB-BS-S07.
Selected RHP Wells and Boundary Area		
Soil Borings (Max sample Depth 18 ft bgs)	RHB-BS-S27 to RHB-BS-S39	Sample PFAS at the RHP locations and at the edge of the Facility boundary to identify potential off-site sources.

Sample Type	Location ID	Location Rationale/Justification
Groundwater Samples [c]		
Perched Groundwater Grab Samples Off-site	PFMW05B [b]	Identify potential off-site sources with perched temporary well and groundwater grab samples.
	PFMW06B [b]	
Perched Groundwater Samples On-site	PFMW04B	Evaluate PFAS in perched groundwater to the east and identify potential sources.
	OWDFMW02B	Existing upslope former OWDF perched groundwater monitoring well. Often there is not enough volume to sample.
	OWDFMW03B	Existing downslope former OWDF perched groundwater monitoring well in the former OWDF.
	OWDFMW04B	Existing upslope former OWDF perched groundwater monitoring well. Often there is not enough volume to sample.
	OWDFMW05B to OWDFMW07B	Existing downslope former OWDF perched groundwater monitoring well in the former OWDF.
	OWDFMW07C	Existing, deeper, downslope former OWDF perched groundwater monitoring well in the former OWDF.
	OWDMFW08B	Existing upslope former OWDF perched groundwater monitoring well.
Basal Groundwater Samples Off-site	PFMW05A	New off-site basal groundwater monitoring well to evaluate PFAS in basal groundwater off-site north of RHP01, RHP02, and RHP03. Identify potential off-site sources.
	PFMW06A	
Basal Groundwater Samples On-site	PFMW03A	New on-site basal groundwater monitoring well to evaluate PFAS in basal groundwater to the east of RHP01.
	RHP01 to RHP03, RHP04A, RHP04B, RHP04C, RHP05, RHP06	Existing plume delineation basal monitoring well.
	RHP07 [d]	Existing in-tunnel plume delineation basal monitoring well.
	RHP08	Existing plume delineation basal monitoring well.
	RHP08B	
	OWDFMW01, OWDFMW02A to OWDFMW08A	Existing former OWDF basal groundwater monitoring well.
	RHMW2254-01	(b) (3) water development tunnel sampling point, into the basal groundwater.
	RHMW15 [e]	RHMW15 Zone 5 potential existing monitoring well to be sampled. Sampling equipment contains material that could leach PFAS to sample. Will be sampled based on the results of the equipment rinsates.

[a] 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 intervals.
[b] Perched aquifer may not be encountered during drilling and well installation, and/or perched groundwater monitoring well may be dry during the sample event.
[c] Number of groundwater samples proposed for a single sampling event. Two rounds of groundwater sampling will be conducted.
[d] Sample depth at in-tunnel wells is measured from below tunnel floor (not bgs).
[e] Sampling will be determined based on evaluation of data.

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

18.1 AREA A

Sampling Locations and Matrix	Proposed Number of Sampling Locations	Location ID	Proposed Sample Depths (ft bgs) [a]	Analyses	Number of Proposed Samples [b]	Sampling SOP Reference
Soil Samples [a]						
Shallow Soil Boring: Surface and Subsurface Soil (Samples Collected to Refusal)	3	RHA-BS-S01, RHA-BS-S03, and RHA-BS-S05 (Sampled by Hand Auger)	0-0.5, 0.5-2, 2-10, and total depth	PFAS	9 Primary 1 Duplicates 1 MS/MSD 1 Equipment Blanks 1 Field Blanks	• Soil PFAS Sampling Guidance (MDEQ 2018a) • Procedure I-B-1, Soil Sampling (DON 2015) • Procedure III-B, Field QC Samples (Water, Soil) (DON 2015)
	3	RHA-BS-S02, RHA-BS-S04, and RHA-BS-S06	0-0.5, 0.5-2, 2-10, 10-20, 20-30 and total depth	PFAS	18 Primary 2 Duplicates 1 MS/MSD 1 Equipment Blanks 1 Field Blanks	
	7	RHA-BS-S07 to RHA-BS-S13 (Soil Beneath the excavation fill) [d]	0-0.5, 0.5-2, 2-10, 10-20, 20-30 and total depth	PFAS	42 Primary 4 Duplicates 2 MS/MSD 2 Equipment Blanks 2 Field Blanks	
Swale Surface Soil Samples	10	RHA-SD-S01 to RHA-SD-S10	0–0.5	PFAS	10 Primary 1 Field Duplicate	
Surface Soil Samples	10	RHA-SS-S01 to RHA-SS-S10	0–0.5	PFAS	10 Primary 1 Field Duplicate	• PFAS Sampling Guidance (MDEQ 2018a) • Procedure I-B-1, Soil Sampling (DON 2015) • Procedure III-B, Field QC Samples (Water, Soil) (DON 2015)
Deep Soil Borings: Surface and Subsurface Soil Samples (Samples Collected to Refusal)	10	RHA-BS-S14/PFMW04B to RHA-BS-S20	0-0.5, 0.5-2, 2-10, 10-20, 20-30 and capillary fringe or total depth	PFAS, VOCs, GRO, DRO/RRO, and PAHs	42 Primary 5 Duplicate 3 MS/MSD 3 Equipment Blanks 3 Field Blanks 7 Trip Blanks	• PFAS Sampling Guidance (MDEQ 2018a) • Procedure I-B, Soil Sampling (DON 2015) • Procedure III-B, Field QC Samples (Water, Soil) (DON 2015)
		RHA-BS-S21 to RHA-BS-S23		PFAS	18 Primary 2 Duplicate 1 MS/MSD 1 Equipment Blanks 1 Field Blanks	

Sampling Locations and Matrix	Proposed Number of Sampling Locations	Location ID	Proposed Sample Depths (ft bgs) [a]	Analyses	Number of Proposed Samples [b]	Sampling SOP Reference
Groundwater Samples [c]						
Perched Groundwater Samples	5	PFMW01B	35–65	PFAS, VOCs, GRO, DRO/RRO, and PAHs	5 Primary 1 Duplicate 1 Equipment Blanks 1 Field Blanks 5 Trip Blanks	• PFAS Sampling Guidance (MDEQ 2018a) • Procedure I-B-1, Soil Sampling (DON 2015) • Procedure III-B, Field QC Samples (Water, Soil) (DON 2015)
		RHMW17S	35–65			
		RHMW17D	41.5–51.5			
		RHMW07	175.0–190.0			
		PFMW04B [e]	35–65			
Basal Groundwater Samples	13	PFMW01A	220.0–250.0	PFAS, VOCs, GRO, DRO/RRO, and PAHs	4 Primary 1 Duplicate 9 Primary 1 Duplicate 1 MS/MSD 1 Equipment Blanks 1 Field Blanks	• PFAS Sampling Guidance (MDEQ 2018a) • Procedure I-C-3, Monitoring Well Sampling (DON 2015) • Procedure III-B, Field QC Samples (Water, Soil) (DON 2015)
		PFMW02A	220.0–250.0			
		RHMW17	220.0–250.0			
		RHMW06	223.0–253.0			
		RHMW01R [f]	230.0–260.0	PFAS	9 Primary 1 Duplicate 1 MS/MSD 1 Equipment Blanks 1 Field Blanks	
		RHMW02 [f]	74.0–94.0			
		RHMW03 [f]	84.0–99.0			
		RHMW04	102.3–117.3			
		RHMW05 [f]	290.0–305.0			
		RHMW08	78.0–93.0			
		RHMW18	281.4–311.4			
		RHMW20	592.0–622.0			
		RHMW21	223.0–253.0			

MS matrix spike
MSD matrix spike duplicate

[a] The proposed boring depth may be reduced if refusal is encountered. Final boring depths will be determined in the field, and samples will be collected either to the point of refusal or the proposed sample depth, whichever occurs first.

[b] The table reflects the maximum number of samples anticipated. The actual number of primary, duplicate, field QC samples, equipment blanks, field blanks, and trip blanks collected will be dependent on conditions in the field. Duplicate samples based on 10% of analytical samples per sampling event. MS/MSD samples based on 5% of analytical samples per sampling event. Equipment rinsate blanks based on 1 per event or alternatively they will be collected above 5% of analytical samples per sampling event. One field blank per water source. One trip blank per shipping cooler, trip blank analyses may differ from planned.

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

[d] 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 composited, as written.

[e] Perched aquifer may not be encountered during drilling and well installation, and/or perched groundwater monitoring well may be dry during the sample event.

[f] Sampling depth at in-tunnel wells is measured from below tunnel floor (not bgs).

18.2 AREA B

Sampling Locations and Matrix	Proposed Number of Sampling Locations [a,b]	Location ID	Proposed Sample Depths (ft bgs) [a]	Analyses	Number of Proposed Samples [b]	Sampling SOP Reference
Soil Samples [a] and Groundwater Grab Samples [b]						
(b) (3) *and OWDFMW08B Area*						
Surface and Subsurface Soil Samples	5	RHB-BS-S01, RHB-BS-S03 to RHB-BS-S06	0-0.5, 0.5-2, 2-10, 10-20, 20-30, and capillary fringe or total depth (~44-45)	PFAS	30 Primary 3 Duplicate 1 MS/MSD 1 Equipment Blank 1 Field Blank	• Soil PFAS Sampling Guidance (MDEQ 2018a) • Procedure I-B-1, Soil Sampling (DON 2015) • Procedure III-B, Field QC Samples (Water, Soil) (DON 2015)
	1	RHB-BS-S02			Potential step-out location 6 sample depths	
Groundwater Grab Samples [b]	5	RHB-BS-S01, RHB-BS-S03 to RHB-BS-S06	~45	PFAS	5 Primary 1 Duplicate 1 MS/MSD 1 Equipment Blank 1 Field Blank	• PFAS Sampling Guidance (MDEQ 2018a) • Procedure I-C-3, Monitoring Well Sampling (DON 2015) • Procedure III-B, Field QC Samples (Water, Soil) (DON 2015)
	1	RHB-BS-S02			Potential step-out location	
(b) (3) *and Former OWDF Area*						
Surface and Subsurface Soil Samples	15	RHB-BS-S07 to RHB-BS-S21	0-0.5, 0.5-2, 2-10, 10-20, 20-30, and capillary fringe or total depth (~34-35)	PFAS	90 Primary 9 Duplicate 5 MS/MSD 5 Equipment Blank 5 Field Blank	• Soil PFAS Sampling Guidance (MDEQ 2018a) • Procedure I-B-1, Soil Sampling (DON 2015) • Procedure III-B, Field QC Samples (Water, Soil) (DON 2015)
Groundwater Grab Samples	7	RHB-BS-S07 to RHB-BS-S09, RHB-BS-S13, RHB-BS-S15, RHB-BS-S17, RHB-BS-S21	~35	PFAS	7 Primary 1 Duplicate	• PFAS Sampling Guidance (MDEQ 2018a) • Procedure I-C-3, Monitoring Well Sampling (DON 2015) • Procedure III-B, Field QC Samples (Water, Soil) (DON 2015)

Sampling Locations and Matrix	Proposed Number of Sampling Locations [a,b]	Location ID	Proposed Sample Depths (ft bgs) [a]	Analyses	Number of Proposed Samples [b]	Sampling SOP Reference
(b) (3) *Area*						
Surface and Subsurface Soil Sample	3	RHB-BS-S22, RHB-BS-S23, RHB-BS-S25	0-0.5, 0.5-2, 2-10, 10-20, 20-30, and capillary fringe or total depth (~39-40)	PFAS	18 Primary 2 Duplicate 1 MS/MSD 1 Equipment Blank 1 Field Blank	• Soil PFAS Sampling Guidance (MDEQ 2018a) • Procedure I-B-1, Soil Sampling, (DON 2015) • Procedure III-B, Field QC Samples (Water, Soil) (DON 2015)
	2	RHB-BS-S24, RHB-BS-S26			Potential step-out location 6 sample depths	
Groundwater Grab Samples	3	RHB-BS-S22, RHB-BS-S23, RHB-BS-S25	~40	PFAS	3 Primary	• PFAS Sampling Guidance (MDEQ 2018a) • Procedure I-C-3, Monitoring Well Sampling (DON 2015) • Procedure III-B, Field QC Samples (Water, Soil) (DON 2015)
	3	RHB-BS-S24, RHB-BS-S26 RHB-BS-S40			Potential step-out location 6 sample depths	
Selected RHP Wells and Boundary Area						
Surface and Subsurface Soil Sample	13	RHB-BS-S27 to RHB-BS-S39, PFMW03A/PFMW03B, PFMW05A, PFMW06A	0-0.5, 0.5-2, 2-10, 10-20, 20-30, and total depth	PFAS	80 Primary 8 Duplicate 4 MS/MSD 4 Equipment Blank 4 Field Blank	• Soil PFAS Sampling Guidance (MDEQ 2018a) • Procedure I-B-1, Soil Sampling (DON 2015) • Procedure III-B, Field QC Samples (Water, Soil) (DON 2015)
Proposed Monitoring Well Locations						
Surface and Subsurface Soil Sample	3	PFMW03A/PFMW03B, PFMW05A, PFMW06A	0-0.5, 0.5-2, 2-10, 10-20, 20-30, and total depth and capillary fringe	PFAS	18 Primary 2 Duplicate 1 MS/MSD 1 Equipment Blank 1 Field Blank	• Soil PFAS Sampling Guidance (MDEQ 2018a) • Procedure I-B-1, Soil Sampling (DON 2015) • Procedure III-B, Field QC Samples (Water, Soil) (DON 2015)

Sampling Locations and Matrix	Proposed Number of Sampling Locations [a,b]	Location ID	Proposed Sample Depths (ft bgs) [a]	Analyses	Number of Proposed Samples [b]	Sampling SOP Reference
Groundwater Samples [c,d]						
Perched Groundwater Grab Samples Off-site	2	PFMW05 [c]	TBD	PFAS	34 Primary 4 Duplicate 2 MS/MSD 2 Equipment Blank 2 Field Blank	• PFAS Sampling Guidance (MDEQ 2018a) • Procedure I-C-3, Monitoring Well Sampling (DON 2015) • Procedure III-B, Field QC Samples (Water, Soil) (DON 2015)
		PFMW06 [c]				
Perched Groundwater Samples On-site	9	PFMW03B	TBD			
		OWDFMW02B [c]	42.5–62.6			
		OWDFMW03B	26.6–36.6			
		OWDFMW04B[c]	24–34			
		OWDFMW05B	29.9–39.9			
		OWDFMW06B	24.6–34.6			
		OWDFMW07B	29.8–39.8			
		OWDFMW07C	117.6–137.6			
		OWDMFW08B	28.2–38.2			
Basal Groundwater Samples Off-site	2	PFMW05A	TBD			
		PFMW06A				
Basal Groundwater Samples On-site	21	PFMW03A	TBD			
		RHP01	125.0–155.0			
		RHP02	109.75 to 139.75			
		RHP03	104.0–134.0			
		RHP04A	130.26–160.26			
		RHP04B	300.56–320.56			
		RHP04C	486.3–506.3			
		RHP05	203.85–233.91			
		RHP06	239.0–269.0			
		RHP07 [e]	73.7–93.7			
		RHP08	276.0–306.0			
		RHP08B	415.6–435.6			

Sampling Locations and Matrix	Proposed Number of Sampling Locations [a,b]	Location ID	Proposed Sample Depths (ft bgs) [a]	Analyses	Number of Proposed Samples [b]	Sampling SOP Reference
Basal Groundwater Samples On-site (cont'd)	21	OWDFMW01	131.66–142.76	PFAS	34 Primary 4 Duplicate 2 MS/MSD 2 Equipment Blank 2 Field Blank	• PFAS Sampling Guidance (MDEQ 2018a) • Procedure I-C-3, Monitoring Well Sampling (DON 2015) • Procedure III-B, Field QC Samples (Water, Soil) (DON 2015)
		OWDFMW02A	153.0–173.0			
		OWDMFW03A	138.5–158.5			
		OWDFMW04A	149.0–169.0			
		OWDFMW05A	119.9–139.9			
		OWDFMW06A	190.0–210.0			
		OWDFMW07A	223.6–243.6			
		OWDFMW08A	140.5–160.5			
		RHMW2254-01	N/A			
Multilevel Monitoring Well – Basal Groundwater	1	RHMW15 Zone 5	278–320	PFAS	Potential Multilevel Monitoring Well groundwater sample	• PFAS Sampling Guidance (MDEQ 2018a) • Procedure I-C-3, Monitoring Well Sampling (DON 2015) • Procedure III-B, Field QC Samples (Water, Soil) (DON 2015)
	N/A	Multilevel Monitoring Well Equipment Rinsates	N/A		3 Equipment Blanks 1 Field Blank	

N/A not applicable
TBD to be determined
[a] The proposed boring depth may be reduced if refusal is encountered and if perched water is not encountered, the actual number of samples collected may be less than the proposed. Final boring depths will be determined in the field, and samples will be collected either to the point of refusal or the proposed sample depth, whichever occurs first.
[b] The table reflects the maximum number of samples anticipated. The actual number of primary, duplicate, field QC samples, equipment blanks, field blanks, and trip blanks collected will be dependent on conditions in the field. Duplicate samples based on 10% of analytical samples per sampling event. MS/MSD samples based on 5% of analytical samples per sampling event. Equipment rinsate blanks based on 1 per event or alternatively they will be collected above 5% of analytical samples per sampling event. One field blank per water source. One trip blank per shipping cooler, trip blank analyses may differ from planned.
[c] Perched aquifer may not be encountered during drilling and well installation, and/or perched groundwater monitoring well may be dry during the sample event.
[d] Number of groundwater samples proposed for a single sampling event. Two rounds of groundwater sampling will be conducted from permanently install monitoring wells.
[e] Sampled depth at in-tunnel wells is measured from below tunnel floor (not bgs).

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 [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 1633A SOPs Eurofins Sacramento: Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids, and Tissue [Method1633/1633A] SAC-LC-SOP73084, Rev 2.8, 3/25/2025 SOP Eurofins Denver: Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Water, AFFF, Solid, Biosolids, and Tissues by LC/MS/MS [EPA Method 1633 & 1633A] DV-LC-0044 Rev. 5, 5/1/2025	(1) 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. Protected from light.	90 days to extraction. [c,e] 90 days extraction to analysis. [c,e]
	VOCs	Preparation Method: EPA 5035A and Analysis Method: EPA 8026D SOP: Determination of Volatile Organics by GC/MS [8260 C/D and 624/624.1] DV-MS-0010 Rev. 35, 6/20/2025	(2) 4-oz glass soil VOA amber glass with 25 mL of methanol, Teflon-lined lid	25 g per VOA vial	Methanol ratio of 1 g soil to 1 mL methanol.	Samples analyzed within 14 days of collection.
	GRO	Preparation Method: EPA 5035A and Analysis Method: EPA 8015D SOP: Gasoline Range Organics (GRO) by GC/FID [SW846 Method 8015 and State Methods] DV-GC-0010 Rev. 20, 2/2/2025	(2) 4-oz glass soil VOA amber glass with 25 mL of methanol, Teflon-lined lid	25 g per VOA vial	Methanol ratio of 1 g soil to 1 mL methanol and frozen.	14 days when shipped to laboratory.
	DRO/RRO	Preparation Method: EPA 3550 and Analysis Method: EPA 8015 SOP: Diesel and Residual Range Organics (DRO and RRO) by GC/FID [SW846 Method 8015 and Kansas MRH/HRH] SOP: DV-GC-0027 Rev. 18, 10/10/2025	(1) 4-oz glass soil jar, Teflon-lined lid	4 oz	Store in dark. Cool to ≤6°C.	Samples extracted within 14 days and analyzed within 40 days following extraction.
	PAH	Preparation Method: EPA 3550C and Analysis Method: EPA 8270E SIM SOP: Polycyclic Aromatic Hydrocarbons by GC/MS Selected Ion Monitoring (SIM) [SW-846 Method 8270D/E] DV-MS-0002 Rev. 21, 10/10/2025	(1) 4-oz glass soil jar, Teflon-lined lid	4 oz	Store in dark. Cool to ≤6°C. Frozen after extraction.	Samples extracted within 14 days and analyzed within 40 days following extraction.
Groundwater [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 1633A SOP: Eurofins Sacramento: Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids, and Tissue [Method1633/1633A] SAC-LC-SOP73084, Rev 2.8, 3/25/2025 SOP: Eurofins Denver: Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Water, AFFF, Solid, Biosolids, and Tissues by LC/MS/MS [EPA Method 1633 & 1633A] DV-LC-0044 Rev. 5, 5/1/2025	(3) 125-mL HDPE bottle with non-Teflon (PTFE) lined lid	125 mL	Sample stored at < 6°C. Extracts of water samples at < 6°C. Protected from light.	28 days to extraction. [c,d,e] 90 days extraction to analysis. [c]

Matrix	Analytical Group	Preparation Reference/Method SOP Analytical Reference/Method SOP	Containers	Sample Mass/ Volume	Preservation Requirement	Maximum Holding Time (preparation/analysis)
Groundwater [b] (cont'd)	VOC	Preparation Method: EPA 5030B and Analysis Method: EPA 8260D SOP: Determination of Volatile Organics by GC/MS [8260 C/D and 624/624.1] DV-MS-0010 Rev. 35, 6/20/2025	(3) 40-mL VOA vials, HCl-preserved, Teflon-lined septum caps	40 mL per VOA vial	Cool to ≤6°C and adjust to pH <2.	14 days when shipped to a laboratory within 48 hours at <6°C upon receipt. Headspace should not exceed 5–6 mm. If not preserved, samples are to be analyzed within 7 days of collection.
	GRO	Preparation Method: EPA 5030B and Analysis Method: EPA 8015C SOP: Gasoline Range Organics (GRO) by GC/FID [SW846 Method 8015 and State Methods] DV-GC-0010 Rev. 20, 2/2/2025	(3) 40-mL VOA vials, HCl-preserved, Teflon-lined septum caps	40 mL per VOA vial	Cool to ≤6°C and adjust to pH <2 using HCl.	14 days when shipped to a laboratory within 48 hours at <6°C upon receipt. Headspace should not exceed 5-6 mm. If not preserved, samples are to be analyzed within 7 days of collection.
	DRO/ RRO	Preparation Method: EPA 3510C and Analysis Method: EPA 8015C SOP: Diesel and Residual Range Organics (DRO and RRO) by GC/FID [SW846 Method 8015 and Kansas MRH/HRH] SOP: DV-GC-0027 Rev. 18, 10/10/2025	(2) 1-L amber glass, unpreserved, Teflon-lined lid	1 L	Store in dark. Cool to ≤6°C.	Samples extracted within 7 days and analyzed within 40 days following extraction.
	PAHs	Preparation Method: EPA 3510C and Analysis Method: EPA 8270E SIM SOP: Polycyclic Aromatic Hydrocarbons by GC/MS Selected Ion Monitoring (SIM) [SW-846 Method 8270D/E] DV-MS-0002 Rev 21, 10/10/2025	(2) 1-L amber glass, unpreserved, Teflon-lined lid	1 L	Store in dark. Cool to ≤6°C.	Samples extracted within 7 days and analyzed within 40 days following extraction.

°C	degree Celsius	mg	milligram
g	gram	mL	milliliter
GC	gas chromatography	mm	millimeter
HCl	hydrogen chloride	oz	ounce
HDPE	high-density polyethylene	PTFE	polytetrafluoroethylene
kg	kilogram	VOA	volatile organic analyte
L	liter		
LC-MS/MS	liquid chromatography tandem mass spectrometry		

[a] Sample results will be reported on a dry weight basis. Solid samples (soils 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) will be analyzed as soon as practicable; 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 1633A and caveats DoD Environmental Data Quality Workgroup memo dated March 27, 2025 (DoD 2025a).
[e] Per the DoD Environmental Data Quality Workgroup memo dated March 27, 2025, the Navy does not expect laboratories to prepare or analyze samples within the shortened holding time specified in Method 1633A. The Navy is willing to accept any additional uncertainty associated with missing the shortened hold times. Qualification of the results can appear along with the result or in the case narrative. Currently, none of the PFAS with shortened holding time considerations have DoD-accepted toxicity factors or corresponding EPA RSLs, thus any additional uncertainty associated with a holding time exceedance for these analytes will not affect current decision-making. Narrating or qualifying results will allow any uncertainty to be considered in future decision-making (DoD 2025a).

Worksheet #20: Field Quality Control Sample Summary Table

Matrix	Analytical Group	Sample Depth (ft bgs)	No. of Samples [a]	No. of Field Duplicates [a]	No. of MS/MSD [b]	No. of Field Blanks [c]	No. of Equipment Blanks [d]/ Trip Blanks [e]
Area A (Surface Only)							
Surface Soil	PFAS	0–0.5	10	1	1	0	0
Swale Surface Soil		0–0.5	10	1	1	0	0
Area A (Shallow Boring)							
Surface Soil	PFAS	0–0.5	13	1	1	1	1
Subsurface Soil		0.5-2	13	2	0	1	1
		2-10	13	1	1	1	1
		10-20	10	1	1	0	0
		20-30	10	1	1	1	1
		Total Depth	10	1	0	0	0
		Soil Totals:	69	7	4	4	4
Area A (Deep Borings)							
Surface Soil	PFAS	0–0.5	3	1	0	0	0
Subsurface Soil		0.5-2	3	1	1	1	1
		2-10	3	0	0	0	0
		10-20	3	0	0	0	0
		20-30	3	0	0	0	0
		Capillary Fringe or Total Depth	3	0	0	0	0
		Soil Totals:	18	2	1	1	1
Area A (Deep Boring Select Samples)							
Surface Soil	PFAS, DRO/RRO, and PAHs [h]	0–0.5	7	1	1	1	1/0
Subsurface Soil	PFAS, VOCs, GRO, DRO/RRO, and PAHs [h]	0.5-2	7	1	0	0	0/1 [d]
		2-10	7	1	1	1	1/1 [d]
		10-20	7	0	0	0	0/1 [d]
		20-30	7	1	0	0	0/1 [d]
		Capillary Fringe or Total Depth	7	1	1	1	1/1 [d]
		Soil Totals:	42	5	3	3	3/5 [d]

Matrix	Analytical Group	Sample Depth (ft bgs)	No. of Samples [a]	No. of Field Duplicates [a]	No. of MS/MSD [b]	No. of Field Blanks [c]	No. of Equipment Blanks [d]/ Trip Blanks [e]
Area B (b) (3) and OWDFMW08B Area)							
Surface Soil	PFAS	0–0.5	5	1	0	0	0
Subsurface Soil		0.5-2	5	0	0	0	0
		2-10	5	1	1	1	1
		10-20	5	0	0	0	0
		20-30	5	1	0	0	0
		Capillary Fringe or Total Depth	5	0	0	0	0
		Soil Totals:	30	3	1	1	1
Grab Groundwater [f]	PFAS	~45	5	1	1	1	1
Area B (b) (3) and Former OWDF Area)							
Surface Soil	PFAS	0–0.5	15	2	1	1	1
Subsurface Soil		0.5-2	15	1	1	1	1
		2-10	15	2	1	1	1
		10-20	15	1	0	0	0
		20-30	15	2	1	1	1
		Capillary Fringe or Total Depth	15	1	1	1	1
		Soil Totals:	90	9	5	5	5
Grab Groundwater [a]	PFAS	~45	7	1	0	0	0
(b) (3) Facility Area (Step outs excluded)							
Surface Soil	PFAS	0–0.5	3	1	0	0	0
Subsurface Soil		0.5-2	3	1	0	0	0
		2-10	3	0	1	1	1
		10-20	3	0	0	0	0
		20-30	3	0	0	0	0
		Capillary Fringe or Total Depth	3	0	0	0	0
		Soil Totals:	18	2	1	1	1
Grab Groundwater [f]	PFAS	Potential Perched Off-site wells	3	1	0	0	0
Selected RHP Wells and Boundary Area							
Surface Soil	PFAS	0–0.5	13	2	1	1	1
Subsurface Soil		0.5-2	13	2	1	1	1

Matrix	Analytical Group	Sample Depth (ft bgs)	No. of Samples [a]	No. of Field Duplicates [a]	No. of MS/MSD [b]	No. of Field Blanks [c]	No. of Equipment Blanks [d]/ Trip Blanks [e]
Subsurface Soil (cont'd)	PFAS (cont'd)	2-10	13	1	1	1	1
		10-20	13	1	1	1	1
		20-30	13	1	0	0	0
		Total Depth	13	1	0	0	0
		Soil Totals:	78	8	4	4	4
3 proposed monitoring well locations							
Surface Soil	PFAS	0–0.5	3	1	0	0	0
Subsurface Soil		0.5-2	3	1	0	0	0
		2-10	3	0	1	1	1
		10-20	3	0	0	0	0
		20-30	3	0	0	0	0
		Capillary Fringe or Total Depth	3	0	0	0	0
		Soil Totals:	18	2	1	1	1
Grab Groundwater [f]	PFAS	Perched off-site	2	1	1	1	1
Two Quarters of Groundwater Sampling for PFAS for Installed and Proposed Monitoring Wells							
Groundwater [g]	VOCs, GRO, DRO/RRO, and PAHs	Area A Wells	8	1	1	1	1/8 [d]
	PFAS	Area A Wells	51	6	3	3	3
		Area B Wells					
		Off-site Wells					
Multilevel Monitoring Well Equipment Blank Evaluation							
Sampling Equipment	PFAS	N/A	—	—	—	1	3

— no data
N/A not applicable
[a] The proposed boring depth may be reduced if refusal is encountered the actual number of primary samples collected may be less than the proposed. Duplicate samples based on 10% of analytical samples per sampling event.
[b] MS/MSD extra sample volume will be collected based on 5 percent of analytical samples per sampling event. Actual MS/MSD analysis number will be dependent on Worksheet 28 requirements.
[c] Once per source of decontamination water per sampling event or alternatively they will be collected above 5% of analytical samples per sampling event. Field blank sample collection may differ from that planned depending on field sampling schedule and source water used for decontamination.
[d] Collected 5% of primary samples collected per matrix per analytical method.
[e] One trip blank per shipping cooler, actual trip blank analyses may differ from planned.
[f] Number of groundwater grab samples proposed. Perched aquifer may not be encountered during drilling at all locations.
[g] 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 monitoring wells maybe be dry during the sampling event.
[h] Volatiles (VOCs and GRO) will not be analyzed in exposed surface soil. Number of samples analyzed for DRO and RRO with SGC will be contingent on positive detections of DRO and RRO in non-silica-gel-cleaned samples.

Worksheet #21: Project Sampling SOP References Table

Reference Number (Appendix C)	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 2023p)	NAVFAC	N/A	N/A.
N/A	EGLE PFAS Sampling Quick Reference Field Guide (MDEQ 2018a)	MDEQ	PFAS-free sampling equipment and general guidance	Avoid specific items (e.g., Teflon) and follow best management practices listed in Worksheet #14 to prevent introducing COPCs with samples.
N/A	Michigan Department of Environmental Quality General PFAS Sampling Guidance (MDEQ 2018a)	MDEQ	PFAS-free sampling equipment and general guidance	Avoid specific items (e.g., Teflon) and follow best management practices listed in Worksheet #14 to prevent introducing COPCs with samples.
N/A	Sampling Guidance, Soil, Water, and Sediment Sampling for PFAS Analysis (MDEQ 2018a)	MDEQ	PFAS-free sampling equipment and general guidance	Avoid specific items (e.g., Teflon) and follow best management practices listed in Worksheet #14 to prevent introducing COPCs with samples.
I-A-1	Development of PQOs (DON 2015)	NAVFAC Pacific	N/A	N/A.
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-7	Analytical Data Validation Planning and Coordination (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 COPCs 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 COPCs 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 COPCs 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-H	Direct-Push Sampling Techniques (DON 2015)	NAVFAC Pacific	Stainless steel split-tube sampler and polytetrafluoroethylene or acetate sleeves	Avoid specific items (e.g., Teflon) listed in Worksheet #14 to prevent introducing COPCs with samples.

Reference Number (Appendix C)	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 2023p)	NAVFAC	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 ft; vertical accuracy for ground surface elevations shall be ± 0.1 ft; monitoring wellheads shall be ± 0.01 ft.
II-S	Data Quality Assessment Report (DON 2015)	NAVFAC Pacific	N/A	N/A.
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.
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 COPCs 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 COPCs with samples.

EGLE Michigan Department of Environment, Great Lakes, and Energy
MDEQ Michigan Department of Environmental Quality
N/A not applicable
WGS World Geodetic System
[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 light-emitting diode 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	ICAL 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 drawdown (i.e., ≤0.2 feet)	Reduce pumping rate and continue to monitor drawdown 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.

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.
Pressure Transducer	Calibrated by vendor prior to shipping to site	According to the manufacturer's recommendations.	Bump check on calibration parameters.	Visually inspect for damage.	Every time the device is deployed or removed from a monitoring location	Stable and acceptable readings achieved per manufacturer's instructions	Return to manufacturer for recalibration.	Field Manager	Manufacturer's specifications for all inspection, testing, maintenance, and calibrations.
Gyroscopic Alignment Instrumentation	Calibrated by vendor	According to the manufacturer's recommendations.	Accuracy and precision per manufacturer's specifications.	Visually inspect balance for wear or damage before calibration.	Prior to deploying down a monitoring well	Stable and acceptable readings achieved per manufacturer's instructions	Return to manufacturer for recalibration.	Operator	Manufacturer's specifications for all inspection, testing, maintenance, and calibrations.

dB decibel
ICAL initial calibration
mL milliliter
N/A not applicable
ppm part per million
[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 DO.

Worksheet #23: Analytical SOP References Table

Laboratory: Eurofins Environment Testing America – Sacramento, 880 Riverside Parkway, West Sacramento, CA 95605
Laboratory Project Point of Contact: Jill Kellmann, Project Manager, 916-374-4402, jill.kellmann@et.eurofinsus.com

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: Eurofins Environment Testing America						
SAC-LC-SOP72084	EPA Method 1633, Analysis of PFAS in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS Lab SOP: Preparation and Extractions for Aqueous, AFFF, Solid, and Biota PFAS Samples by EPA Method 1633, Rev. 5. 2/21/2024	Definitive	PFAS (Soil and Water)	Preparation of Extracts	No	No
SAC-LC-SOP72084	EPA Method 1633, Analysis of PFAS in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS Lab SOP: Instrumental Analysis by EPA Method 1633, Rev. 6. 2/21/24	Definitive	PFAS (Soil 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 WP. 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).

Laboratory: Eurofins Environment Denver, 955 Yarrow St Suite 100, Arvada, CO 80002
Laboratory Project Point of Contact: Jill Kellmann, Project Manager, 916-374-4402, jill.kellmann@et.eurofinsus.com and Patrick McEntee, Project Manager, 303-736-0107

Lab SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Variance to QSM (Yes/No)	Modified for Project Work? (Yes/No)
Preparatory Methods						
DV-LC-0044	Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Water, AFFF, Solid, Biosolids, and Tissues by LC/MS/MS [EPA Method 1633 & 1633A] DV-LC-0044 Rev. 5, 5/1/2025	Definitive	PFAS (soil and water)	Preparation of Extracts	No	No
DV-MS-0010	Determination of Volatile Organics by GC/MS [8260 C/D and 624/624.1] DV-MS-0010 Rev. 35. 6/20/2025 (Purge and Trap 5030C and 5035A)	Definitive	VOCs and GRO (soil and water)	Preparation	No	No
DV-OP-0015	Microwave Extraction of Solid Samples by Method SW-846 3546 SOP DV-OP-0015 Rev. 17. Effective Date: 1/20/2025	Definitive	DRO/ORO (soil)	Preparation	No	No
DV-OP-0007	Concentration and Clean-up of Organic Extracts (Method 3630C, Silica Gel Cleanup)	Definitive	DRO/ORO (Silica Gel Clean up) (soil and water)	Preparation	No	No
DV-OP-0015	Microwave Extraction of Solid Samples by Method SW-846 3546 SOP DV-OP-0015 Rev. 17. Effective Date: 1/20/2025	Definitive	PAHs (soil)	Preparation	No	No
Analytical Methods						
DV-LC-0044	Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Water, AFFF, Solid, Biosolids, and Tissues by LC/MS/MS [EPA Method 1633 & 1633A] DV-LC-0044 Rev. 5, 5/1/2025	Definitive	PFAS (soil and water)	LC-MS/MS	No	No
DV-MS-0010	Determination of Volatile Organics by GC/MS [8260 C/D and 624/624.1] DV-MS-0010 Rev. 35, 6/20/2025	Definitive	VOC (soil and water)	GC-MS	No	No
DV-GC-0010	Gasoline Range Organics (GRO) by GC/FID [SW846 Method 8015 and State Methods] DV-GC-0010 Rev. 20, 2/2/2025	Definitive	GRO (soil and water)	GC-FID	No	No
DV-GC-0027	Diesel and Residual Range Organics (DRO and RRO) by GC/FID [SW846 Method 8015 and Kansas MRH/HRH] SOP: DV-GC-0027 Rev. 18, 10/10/2025	Definitive	DRO/ORO (soil and water)	GC-FID	No	No
DV-MS-0002	Polycyclic Aromatic Hydrocarbons by GC/MS Selected Ion Monitoring (SIM) [SW-846 Method 8270D/E] DV-MS-0002 Rev. 21, 10/10/2025	Definitive	PAHs (soil and water)	GC-MS-SIM	No	No

Note: The laboratory SOPs listed in the table are the most current revisions at the time of publication of this WP. The Navy consultant will review the laboratory SOPs immediately prior to sample submittal to ensure that the laboratory uses SOPs that are in compliance with the DoD QSM annual review requirement.
GC-FID gas chromatography-flame ionization detector
GC-MS gas chromatography-mass spectrometry
ORO oil range organics

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.	If problem found, correct as appropriate, then recalibrate.	Lab Manager/ Analyst	SAC-LC-SOP73084, DV-LC-0044
	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 after any major maintenance is performed.	As recommended or required by the instrument manufacturer and EPA Method 1633 requirements. Mass spectrometers are recalibrated every 3–6 months or as needed. Range must bracket the ion masses of interest. Mass calibration verified to 0.5 Da of true value by acquiring a full scan continuum of mass spectrum of PFAS stock standard.	Correct the problem, then repeat mass calibration.	Lab Manager/ Analyst	SAC-LC-SOP73084, DV-LC-0044
	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	SAC-LC-SOP73084, DV-LC-0044

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 midpoint ICAL standard. If sample concentration reported is below the LOQ, the IAR must fall within +/-50% of the IAR observed in either the midpoint ICAL 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	SAC-LC-SOP73084, DV-LC-0044
	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	SAC-LC-SOP73084, DV-LC-0044
	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	SAC-LC-SOP73084, DV-LC-0044
	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. 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 ± 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	SAC-LC-SOP73084, DV-LC-0044

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 for all analytes.	At instrument setup and when needed, based on EPA Method 1633 requirements of QC results, before sample analysis.	ICAL 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	SAC-LC-SOP73084, DV-LC-0044
	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 ≥ 3:1 for the quantitation ions and the confirmation ions or ≥ 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 RSD of the response ratio or response factor values for each target analyte and isotopically labeled compound must be ≤ 20%. Option 2: The %RSE for each target analyte and EIS compound must be ≤ 20%.	Flagging is not appropriate. Perform instrument maintenance and recalibrate.	Lab Manager/ Analyst	SAC-LC-SOP73084, DV-LC-0044
	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 +/- 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	SAC-LC-SOP73084, DV-LC-0044

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)	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-impacted media.	Lab Manager/ Analyst	SAC-LC-SOP73084, DV-LC-0044
	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	SAC-LC-SOP73084, DV-LC-0044
	Bile salt interference check.	After ICAL 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 ICAL must be repeated before any field samples are analyzed.	Lab Manager/ Analyst	SAC-LC-SOP73084, DV-LC-0044
GC-FID EPA Method 8015D	Minimum 5-point ICAL for linear calibration. Minimum 6-point ICAL for quadratic calibration.	Prior to sample analysis.	Minimum 5 levels for when using evaluation by %RSD or linear regression and 6 levels for evaluation by quadratic regression. Each analyte shall meet one of the three options below: *Option 1:* %RSD for each analyte ≤ 20%, unless the specific method referenced has tighter criteria, in which case the method shall be followed. *Option 2:* linear least squares regression for each analyte: $r^2 \geq 0.99$. *Option 3:* non-linear least squares regression (quadratic) for each analyte: $r^2 \geq 0.99$. Quantitation for multicomponent analytes such as chlordane, toxaphene, and Aroclors shall be performed using a 5-point (minimum) calibration. Results shall not be quantitated using a single point.	Correct problem then repeat ICAL.	Lab Manager/ Analyst	DV-GC-0010, DV-GC-0027

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference [a]
GC-FID EPA Method 8015D	Evaluation %RE or %RSE.	Each ICAL using options 2 or 3 above shall also be evaluated for %RE either by determination of the %RE at or near the mid-range of the ICAL and at less than or equal to the LOQ, or by the determination of the %RSE.	The laboratory shall meet the criteria listed in the reference method revision used for analysis and reporting. If no criteria are listed, the laboratory shall develop its own criteria; however, the maximum allowable %RE at or near the mid-range and low level of the calibration shall be 20% and 50%, respectively. The maximum allowable %RSE shall be 30%.	Correct problem, then repeat ICAL. Qualification of data is not appropriate.	Lab Manager/ Analyst	DV-GC-0010, DV-GC-0027
	RT window width no IS used.	At method setup and after major maintenance (e.g., column change). Calculated for each analyte and surrogate.	RT width is ± 3 times standard deviation for each analyte RT from the 72-hour study or 0.03 minutes, whichever is greater. For analytes reported across a RT range (e.g., DRO/RRO variations, chlordane), the RT window of the method- defined marker compounds are established as stated above. The RT range is calculated based on the lower limit of the RT window for the first marker compound and the upper limit of the RT window for the last marker compound.	N/A.	Lab Manager/ Analyst	DV-GC-0010, DV-GC-0027
	RT or RRT establishment.	Once per ICAL and at the beginning of the analytical batch. Established for each analyte and surrogate.	RT or RRT shall be set using the midpoint standard of the ICAL when ICAL is performed or on days when ICAL is not performed, the initial CCV for the batch shall be used.	N/A.	Lab Manager/ Analyst	DV-GC-0010, DV-GC-0027
	CCV.	At the beginning of each analytical batch before sample analysis when ICAL is not performed, after every 10 field samples, and at the end of the analytical batch.	All reported analytes and surrogates within established RT windows. All reported analytes and surrogates within ± 20% of true value, unless the specific reference method has tighter criteria, in which case the reference method shall be followed.	Where an assignable cause isolated to only the CCV is identified, one CCV may be reanalyzed immediately (i.e., within one hour and no samples analyzed). If the immediate CCV is acceptable, proceed with analysis. Sample reanalysis is not required. Otherwise, correct problem and analyze passing CCV or recalibrate. All affected samples since last passing CCV shall be reanalyzed. If the samples cannot be reanalyzed, apply qualifier to affected analyte results and explain in the case narrative.	Lab Manager/ Analyst	DV-GC-0010, DV-GC-0027

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference [a]
GC-FID EPA Method 8015D (cont'd)	LOD determination and verification.	At initial setup and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each.	The apparent signal-to-noise ratio must be at least 3 and the results must meet all method requirements for analyte identification.	If the LOD verification fails, the laboratory must: 1) Repeat the DL determination and LOD verification at a higher concentration; or 2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration.	Lab Manager/ Analyst	DV-GC-0010, DV-GC-0027
	LOQ establishment and verification.	At initial setup: 1) Verify LOQ. 2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each.	1) The LOQ and associated precision and bias must meet client requirements and must be reported; or 2) In the absence of client requirements, must meet control limits of the LCS. 3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Module 4, Section 5.2.4d of the DoD QSM (DoD and DOE 2023).	If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias.	Lab Manager/ Analyst	DV-GC-0010, DV-GC-0027
	Other performance checks. If the reference method includes additional performance checks such as peak tailing evaluation, the checks shall be performed and evaluated as described in the reference method.	Retention times must be verified at the beginning of each 12-hour work shift.	As recommended or required in the reference method.	Correct problem, then repeat performance checks. Qualification of data is not appropriate.	Lab Manager/ Analyst	DV-GC-0010, DV-GC-0027

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference [a]
GC-MS EPA Methods 8260D, 8720E SIM	Tune check.	Prior to ICAL and at the beginning of each 12-hour period	Specific ion abundance criteria from the reference method revision used for analysis and reporting.	Retune instrument and verify. If the method requires an ICAL after a change in tuning parameters, follow the reference method as written Qualification of data is not appropriate.	Lab Manager/ Analyst	DV-MS-0002, DV-MS-0010
	Minimum 5-point ICAL for linear calibration. Minimum 6-point ICAL for quadratic calibration.	Prior to sample analysis.	Minimum 5 levels when using evaluation by %RSD or linear regression and 6 levels for evaluation by quadratic regression. Each analyte shall meet one of the three options below: *Option 1:* %RSD for each analyte ≤ 20%, unless the specific method referenced has tighter criteria, in which case the method shall be followed: *Option 2:* Linear least squares regression for each analyte: $r^2 \geq 0.99$. *Option 3:* Non-linear least squares regression (quadratic) for each analyte: $r^2 \geq 0.99$. If the specific version of a reference method requires additional evaluation (e.g., RFs or low calibration standard analysis and recovery criteria), these additional requirements shall also be met.	Correct problem then repeat ICAL.	Lab Manager/ Analyst	DV-MS-0002, DV-MS-0010
	Evaluation of %RE or %RSE.	Each ICAL using options 2 or 3 above shall also be evaluated for %RE either by determination of the %RE at or near the mid-range of the ICAL and at less than or equal to the LOQ, or by the determination of the %RSE.	The laboratory shall meet the criteria listed in the reference method revision used for analysis and reporting. If no criteria are listed, the laboratory shall develop its own criteria; however, the maximum allowable %RE at or near the mid-range and low level of the calibration shall be 20% and 50%, respectively. The maximum allowable %RSE shall be 30%.	Correct problem, then repeat ICAL. Qualification of data is not appropriate.	Lab Manager/ Analyst	DV-MS-0002, DV-MS-0010
	RT window position for each analyte and surrogate.	Once per ICAL.	Position will be set using the midpoint standard for the ICAL.	N/A.	Lab Manager/ Analyst	DV-MS-0002, DV-MS-0010
	RRT.	With each sample.	RRT of each target analyte in each calibration standard within ±0.06 RRT units of ICAL.	Correct problem, then reanalyze all samples analyzed since the last RT check. If fails, then rerun ICAL and samples.	Lab Manager/ Analyst	DV-MS-0002, DV-MS-0010

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference [a]
GC-MS EPA Methods 8260D, 8720E SIM (cont'd)	CCV.	Daily, before sample analysis, unless ICAL performed same day and after every 10 samples and at the end of the analysis sequence.	All analytes within ±20% of expected value (%D). All reported analytes and surrogates within ± 50% for end of analytical batch CCV.	Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and recalibrate; then reanalyze all affected samples since the last acceptable CCV.	Lab Manager/ Analyst	DV-MS-0002, DV-MS-0010
	IS.	Each CCV and sample	RT ± 10 seconds from RT of the ICAL midpoint standard. EICP area within -50% to +100% of area from IS in ICAL midpoint standard.	Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed during failure is mandatory.	Lab Manager/ Analyst	DV-MS-0002, DV-MS-0010
	LOD determination and verification.	At initial setup and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each.	The apparent signal-to-noise ratio must be at least 3 and the results must meet all method requirements for analyte identification.	If the LOD verification fails, the laboratory must: 1) Repeat the DL determination and LOD verification at a higher concentration; or 2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration.	Lab Manager/ Analyst	DV-MS-0002, DV-MS-0010
	LOQ establishment and verification.	At initial setup: 1) Verify LOQ. 2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each.	1) The LOQ and associated precision and bias must meet client requirements and must be reported; or 2) In the absence of client requirements, must meet control limits of the LCS. 3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Module 4, Section 5.2.4d of the DoD QSM (DoD and DOE 2023).	If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias.	Lab Manager/ Analyst	DV-MS-0002, DV-MS-0010
	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 method 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.	Correct problem, then repeat mass calibration. Qualification of data is not appropriate.	Lab Manager/ Analyst	DV-MS-0002, DV-MS-0010

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	SOP Reference [a]
GC-MS EPA Methods 8260D, 8720E SIM (cont'd)	Mass accuracy verification (according to manufacturer instructions).	Before each ICAL.	Masses within the mass range to be monitored shall be within ± 0.2 Da of the target mass.	Correct problem, then repeat verification. Qualification of data is not appropriate.	Lab Manager/ Analyst	DV-MS-0002, DV-MS-0010
	ISC.	Daily. The ISC standard shall be less than or equal to the LOQ.	S/N ≥ 10:1 for all quantitation ions and S/N ≥ 3:1 for all other characteristic ions. All reported analytes and surrogates within ± 35% of true value.	Correct problem, then repeat ISC. If problem persists, repeat ICAL, raising LOQ to a concentration where criteria are met. Qualification of data is not appropriate.	Lab Manager/ Analyst	DV-MS-0002, DV-MS-0010
	Characteristic ions.	Minimum of 3 structurally significant ions that are not isotopic clusters, when possible. IS and surrogates may use fewer ions.	The relative intensities of the characteristic ions of target analytes agree within 30% of the relative intensities in the reference spectrum and the relative intensities shall be >0.	Qualification of data is not appropriate.	Lab Manager/ Analyst	DV-MS-0002, DV-MS-0010

%D percent difference
%RE relative error
%RSD relative standard deviation
%RSE relative standard error
CCV continuing calibration verification
CV calibration verification
Da dalton
EICP extracted ion current profile
EIS extracted internal standard
IAR ion abundance ratio
IS internal standard
ISC instrument sensitivity check
LCS laboratory control sample
N/A not applicable
NIS non-extracted internal standards
r^2 coefficient of determination
RF response factor
RRT relative retention time
RSD relative standard deviation
RT retention time
S/N signal-to-noise ratio
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
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 ICAL and/or as necessary	ICAL or calibration verification passes method specifications	Perform additional maintenance prior to instrument calibration or calibration verification.	Analyst	SAC-LC-SOP73084, DV-LC-0044
	Clean curtain and orifice front plate.	Maintain sensitivity	Visually inspect and clean.	As needed	CCV/ICV pass criteria	Refer to the manufacturer's operating manual.	Analyst	SAC-LC-SOP73084, DV-LC-0044
	Roughing pump oil.	Maintenance check	Fill.	4–6 months	Maintain vacuum	Refer to the manufacturer's operating manual.	Analyst	SAC-LC-SOP73084, DV-LC-0044
	Manual tune if not within 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 ICAL and/or as necessary	CCV pass criteria	Recalibrate.	Analyst	SAC-LC-SOP73084, DV-LC-0044
	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 ICAL and/or as necessary	CCV pass criteria	Recalibrate.	Analyst	SAC-LC-SOP73084, DV-LC-0044
	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	Passing ICAL and CCV	Replace with another analytical column and recalibrate.	Analyst	SAC-LC-SOP73084, DV-LC-0044
	Create all eluents.	N/A	Check the stability of the base line.	As needed	Minimum noise in the base line	Prepare fresh mobile phase solution.	Analyst	SAC-LC-SOP73084, DV-LC-0044

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
LC-MS-MS (cont'd)	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	SAC-LC-SOP73084, DV-LC-0044
GC-FID GC-MS	Change gas purifier.	N/A	Visually inspect if traps are changing color.	Every 6–12 months	No moisture	Replace indicating traps.	Analyst	DV-MS-002, DV-MS-0010, DV-GC-0010, DV-GC-0027
	Change syringes/syringe needles.	N/A	Visually inspect for wear or damage.	Every 3 months	N/A	Replace syringe if dirt is noticeable in the syringe.	Analyst	DV-MS-002, DV-MS-0010, DV-GC-0010, DV-GC-0027
	Change inlet liner, liner O-rings, and inlet septum.	N/A	Visually inspect for dirt or deterioration.	As Needed	N/A	Replace and check often.	Analyst	DV-MS-002, DV-MS-0010, DV-GC-0010, DV-GC-0027
	Change front-end column.	Sensitivity check	Instrument performance and sensitivity.	Daily or as needed	Tune and CCV pass criteria	Reinspect injector port, cut additional column, reanalyze CCV, recalibrate instrument.	Analyst	DV-MS-002, DV-MS-0010, DV-GC-0010, DV-GC-0027
GC-FID	Clean injector ports or cleaning of the collector.	Detector signals and chromatogram review	Instrument performance and sensitivity.	As needed	CCV passes criteria	Reinspect injector port. Replace collector assembly if rusted and unable to be cleaned.	Analyst	DV-GC-0010, DV-GC-0027D
	Replace trap on purge-and-trap systems.	N/A	N/A.	Bi-monthly or as needed	N/A	N/A.	Analyst	DV-GC-0010, DV-GC-0027D
	Replace detector jets.	N/A	N/A.	As needed	N/A	N/A.	Analyst	DV-GC-0010, DV-GC-0027D
	Replace hydrocarbon traps and oxygen traps on helium and hydrogen gas lines.	N/A	N/A.	Every 4–6 months	N/A	N/A.	Analyst	DV-GC-0010, DV-GC-0027D
	Replace chemical trap.	N/A	N/A	Yearly or as needed	N/A	N/A.	Analyst	DV-GC-0010, DV-GC-0027D
	Replace converter tube in gas purifier system.	N/A	N/A.	Yearly or as needed	N/A	N/A.	Analyst	DV-GC-0010, DV-GC-0027D

Instrument/ Equipment	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
GC-MS	Run tuning program to determine if source is functioning properly.	N/A	N/A.	Daily	N/A	Cool system, vent, disassemble and clean.	Analyst	DV-MS-0002, DV-MS-0010
	N/A.	Tune instrument	N/A.	Daily or every 12 hours	Per method	Liner and septa are replaced; tune file used is manually adjusted.	Analyst	DV-MS-0002, DV-MS-0010
	Change septum, clean injection port, change or clip column, install new liner, change trap.	Sensitivity check	Instrument performance and sensitivity.	Daily or as needed	Tune and CCV pass criteria	Reinspect injector port, cut additional column, reanalyze CCV, recalibrate instrument.	Analyst	DV-MS-0002, DV-MS-0010
	Vacuum rough pump oil level is checked.	N/A	N/A.	Every 4–6 weeks	N/A	Add oil if needed.	Analyst	DV-MS-0002, DV-MS-0010
	Replace/refill carrier gas line oxygen and moisture traps.	N/A	N/A.	Yearly or as needed	N/A	N/A.	Analyst	DV-MS-0002, DV-MS-0010
	Clean sources, maintain vacuum pumps.	Tuning	Instrument performance and sensitivity.	Service vacuum pumps twice per year, other maintenance as needed	Tune and CCV pass criteria	Recalibrate instrument.	Analyst	DV-MS-0002, DV-MS-0010

ICC initial calibration check
ICV initial calibration verification
ISC instrument sensitivity check
N/A not applicable

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
Sample Disposal	
Personnel/Organization	Sample custodian/Designated analytical laboratory
Number of Days from Analysis	90 days

Worksheet #27: Sample Custody Requirements

Each sample will be assigned a COC sample 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:

JVzzz

Where:

J	=	Designating the sampling team's home office (e.g., Honolulu office)
V	=	Designating CTO ____ (assigned for each CTO)
zzz	=	Chronological number, starting with 001

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 (i.e., 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:

AA-bbcc-dee-Dff.f

Where:

AA	=	Red Hill Site location identifier 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). These are excluded if the location number or full name is provided in the AA identifier.
d	=	Field QC sample type (Table 27-3).
ee	=	Chronological sample number from a particular sampling location, as well as the number of field or equipment blanks collected on the specified date (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: MMDDYYYY.

For example, the sample number RHA-BS06-SS-D0.5 would indicate that the sample is a surface soil sample collected at boring location numbered RHA-BS-S06, at 0.5 feet bgs. The duplicate sample would be designated as RHA-BS06-SS-D01-D0.5. The first subsurface soil sample from this location would be denoted by RHA-BS06-BS-S01-D3.0. Similarly, a groundwater sample number will be RHP03-GW-S01-DMMDDYYYY. This sample will represent a primary groundwater sample collected from existing well RHP03 on the date MMDDYYYY. These characters will establish a unique descriptive identifier that will be used during data evaluation.

Table 27-1: Area/Location Identifiers

Area/Location ID	Site Area
Area A	
RHA-BS01 to RHA-BS23	Soil boring locations of Area A of Red Hill PFAS investigation (surface and subsurface) (RHA-BS-S01 to RHA-BS-S23).
RHA-SS01 to RHA-SS05	Surface soil boring locations of (RHA-SS01 to RHA-SS05) Area A of Red Hill PFAS investigation (RHA-SS-S01 to RHA-SS-S05).
RHA-SD01 to RHA-SD05	Swale surface soil sampling location (RHA-SD-S01 to RHA-SD-S05).
RHMW01R	Samples collected from existing well RHMW01R.
RHMW02	Samples collected from existing well RHMW02.
RHMW03	Samples collected from existing well RHMW03.
RHMW04	Samples collected from existing well RHMW04.
RHMW05	Samples collected from existing well RHMW05.
RHMW06	Samples collected from existing well RHMW06.
RHMW07	Samples collected from existing well RHMW07.
RHMW18	Samples collected from existing well RHMW18.
RHMW20	Samples collected from existing well RHMW20.
RHMW21	Samples collected from existing well RHMW21.
RHMW17	Samples collected from existing well RHMW17.
RHMW17D	Samples collected from existing well RHMW17D.
RHMW17S	Samples collected from existing well RHMW17S.
PFMW01A	Samples collected from newly installed groundwater monitoring location PFMW01A (basal and boring).
PFMW01B	Samples collected from newly installed groundwater monitoring location PFMW01B (perched).
PFMW02A	Samples collected from newly installed groundwater monitoring location PFMW02A (basal and boring).
PFMW02B	Samples collected from PFMW02B boring (boring only; no perched groundwater monitoring well installed).
PFMW04B	Area A samples collected from proposed groundwater monitoring location PFMW04B (perched and boring).

Area/Location ID	Site Area
Area B	
RHB-BS01 to RHB-BS40	Soil and grab groundwater locations of Area B of Red Hill PFAS investigation (RHB-BS-S01 to RHB-BS-S40).
RHP01	Samples collected from existing well RHP01.
RHP02	Samples collected from existing well RHP02.
RHP03	Samples collected from existing well RHP03.
RHP04A	Samples collected from existing well RHP04A.
RHP04B	Samples collected from existing well RHP04B.
RHP04C	Samples collected from existing well RHP04C.
RHP06	Samples collected from existing well RHP06.
RHP07	Samples collected from existing well RHP07.
RHP08	Samples collected from existing well RHP08.
RHP08B	Samples collected from existing well RHP08B.
RHMW15Z5	Samples collected from existing multilevel well RHMW15 Zone number 5.
PFMW03A	Area B samples collected from proposed groundwater monitoring location PFMW03A (basal and boring).
PFMW03B	Area B samples collected from proposed groundwater monitoring location PFMW03AB (perched).
PFMW05A	Area B samples collected from proposed groundwater monitoring location PFMW05A (basal and boring).
PFMW05B	Area B samples collected from proposed groundwater monitoring location PFMW05B (perched boring).
PFMW06A	Area B samples collected from proposed groundwater monitoring location PFMW06A (basal and boring).
PFMW06B	Area B samples collected from proposed groundwater monitoring location PFMW06B (perched boring).
OWDFMW01	Samples collected from existing well OWDFMW01 (basal).
OWDFMW02A	Samples collected from existing well OWDFMW02A (basal).
OWDFMW02B	Samples collected from existing well OWDFMW02B (perched).
OWDFMW03A	Samples collected from existing well OWDFMW03A (basal).
OWDFMW03B	Samples collected from existing well OWDFMW03B (perched).
OWDFMW04A	Samples collected from existing well OWDFMW04A (basal).
OWDFMW04B	Samples collected from existing well OWDFMW04B (perched).
OWDFMW05A	Samples collected from existing well OWDFMW05A (basal).
OWDFMW05B	Samples collected from existing well OWDFMW05B (perched).
OWDFMW06A	Samples collected from existing well OWDFMW06A (basal).
OWDFMW06B	Samples collected from existing well OWDFMW06B (perched).
OWDFMW07A	Samples collected from existing well OWDFMW07A (basal).
OWDFMW07B	Samples collected from existing well OWDFMW07B (perched).
OWDFMW07C	Samples collected from existing well OWDFMW07C (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	Swale Surface Soil	Swale Surface Soil
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
T	Trip 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 QSM (DoD and DOE 2023).

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: SAC-LC-SOP73084
Analytical Organization	Eurofins Sacramento

QC Sample	Frequency and Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	MPC
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 Method 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 Section 9.4 of EPA Method 1633. 2) The lower limit of in-house 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 15.3.2). 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.	Lab Manager/ Analyst	Accuracy/Bias	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 Synonymously: Injected Internal Standard(s)	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 ICAL.	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.	Lab Manager/ Analyst	Accuracy	Meet EPA Method 1633 limits. Results within acceptance limits.

Matrix	All matrices
Analytical Group	PFAS
Analytical Method/SOP Reference	Analytical Method: EPA Method 1633 Preparation Method: EPA Method 1633 Laboratory SOPs: SAC-LC-SOP73084
Analytical Organization	Eurofins Sacramento

QC Sample	Frequency and Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	MPC
Instrument Blank	At the beginning of the analytical sequence and after the analysis of high concentration samples and standards (e.g., customer samples, highest calibration standard, calibration verification standard).	No analytes detected >1/2 LOQ.	If acceptance criteria are not met after the highest calibration standard, calibration shall be performed using a lower concentration for the highest standard until acceptance criteria is met. If field sample analyte concentrations exceed the highest calibration standard and the same analytes in the following field sample or in consecutive following field samples also exceed the instrument blank acceptance criteria (i.e., >1/2 LOQ), the affected samples shall be reanalyzed using a fresh aliquot of the sample extract. If the extract cannot be reanalyzed and re-extraction is not possible, apply qualifier to affected results and explain in the case narrative.	Lab Manager/ Analyst	Accuracy/ Contamination/ Bias	No analytes detected >1/2 LOQ.
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 1/3 the regulatory limit, whichever is greater.	1) Correct problem. If required, re-extract and reanalyze MB 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.	Lab Manager/ Analyst	Accuracy/ Contamination/ Bias	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/3 the regulatory limit, whichever is greater.

Matrix	All matrices
Analytical Group	PFAS
Analytical Method/SOP Reference	Analytical Method: EPA Method 1633 Preparation Method: EPA Method 1633 Laboratory SOPs: SAC-LC-SOP73084
Analytical Organization	Eurofins Sacramento

QC Sample	Frequency and Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	MPC
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 the EPA Method 1633 analyte list must meet the acceptance criteria stated in EPA Method 1633 (Tables 5, 6, 7, and 8). The recoveries of analytes not included in the 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.	Lab Manager/ Analyst	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.
Ion Ratio	Each detected analyte (except PFBA, PFPeA, NMeFOSE, NEtFOSE, PFMPA, and PFMBA).	Acceptance window of 50%–150% of the ratio in the midpoint calibration standard or daily CCV standard.	Reanalyze affected sample(s) once. If acceptable, report. If not, verify instrument performance, and verify that all sample prep steps to alleviate matrix taken (e.g., cleanups, dilutions). If no improvement, report with qualifier and narrate ion transition ratios outside criteria.	Lab Manager/ Analyst	Accuracy/ Contamination	50%–150% of daily CCV or ICAL midpoint for compounds with sufficient secondary transitions.
MS/MSD	One MS/MSD pair per preparatory batch.	The MS/MSD must be in accordance with the recommendations in EPA Method 1663, dependent on the analysis of a screening sample. The recoveries of analytes included in the EPA Method 1633 analyte list must meet the acceptance criteria stated in EPA Method 1633. The recoveries of analytes not included in the EPA Method 1633 analyte list must meet in-house limits. Analyte recoveries must be within in-house blank spike (BS) limits. RPD ≤ 30% (between MS and MSD).	Examine the project-specific requirements. Contact the client as to additional measures to be taken. Apply a flag to specific analyte(s) in the parent sample if acceptance criteria are not met and explain in the case narrative.	Lab Manager/ Analyst	Precision and Bias	For analytes included in the EPA Method 1633 analyte list, meet EPA Method 1633 limits. For analytes not included in the EPA Method 1633 analyte list, meet laboratory-derived limits.

LLLCS low-level laboratory control sample
MB method blank
NIS non-extracted internal standards
PFMBA perfluoro-4-methoxybutanoic acid
PFMPA Perfluoro-3-methoxypropanoic acid

Matrix	Soil and Water
Analytical Group	VOCs
Analytical Method/SOP Reference	Analytical Method: SW-846 8260D Preparation Method: EPA 5035A and EPA 5030B, respectively Laboratory SOPs: DV-MS-0010
Analytical Organization	Eurofins Denver

QC Sample	Frequency and Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	MPC
MB	Each time samples are extracted and one per matrix per analytical method for each batch of at most 20 samples.	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common lab contaminants, no analytes detected >LOQ.	Correct problem. If required, reprepare and reanalyze MB and all samples processed with the contaminated blank.	Lab Manager/ Analyst	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 higher. For common laboratory contaminants, no analytes detected >LOQ.
LCS	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	Per DoD QSM Appendix C Limits, Method SW-846 8260D and Lab SOP DV-MS-0010.	Correct problem. If required, reprepare and reanalyze the LCS and all samples processed in the associated preparatory batch for the failed analytes. Results may not be reported without a valid LCS.	Lab Manager/ Analyst	Precision and Accuracy/Bias	QC acceptance criteria at least as stringent as specified by DoD QSM (DoD and DOE 2023).
LCSD	If sufficient sample is not available for either a MSD or MD, one LCSD shall be included in the preparatory batch. Shall contain all surrogates and all reported analytes.	*Recovery:* Same as LCS acceptance criteria. *Precision:* RPD of all analytes ≤ 30% between LCS and LCSD.	Where an assignable cause isolated to only the LCSD is identified, the LCSD may be reanalyzed. Otherwise, reprepare and analyze the LCSD and all affected QC and field samples in the associated preparatory batch for the analytes outside acceptance criteria if sufficient sample material is available. If the samples cannot be reprepared and analyzed, apply qualifier to affected analyte results of all samples in the associated preparatory batch and explain in the case narrative.	Lab Manager/ Analyst	Precision and Accuracy/Bias	QC acceptance criteria at least as stringent as specified by DoD QSM (DoD and DOE 2023).

Matrix	Soil and Water
Analytical Group	VOCs
Analytical Method/SOP Reference	Analytical Method: SW-846 8260D Preparation Method: EPA 5035A and EPA 5030B, respectively Laboratory SOPs: DV-MS-0010
Analytical Organization	Eurofins Denver

QC Sample	Frequency and Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	MPC
MS	One per analytical method for each batch of at most 20 samples. Shall contain all surrogates and all reported analytes.	Per DoD QSM Appendix C Limits, Method SW-846 8260D and Lab SOP DV-MS-0010. MSD or Matrix Duplicate: RPD of all analytes ≤30%.	If an assignable cause isolated to only the MS is identified, reanalyze the MS or reprepare and analyze the MS if sufficient sample material is available, as indicated by the cause. Otherwise, apply qualifier to affected analyte results in the parent sample and explain in the case narrative.	Lab Manager/ Analyst	Precision and Accuracy/Bias	For matrix evaluation, use QC acceptance criteria at least as stringent as specified by DoD QSM (DoD and DOE 2023). for LCS.
MSD or MD	One per preparatory batch if sufficient material is provided. MSD: Shall contain all surrogates and all reported analytes. MD: Shall be analyzed for all surrogates and all reported analytes.	*Recovery:* Same as the LCS recovery acceptance criteria. *Precision:* RPD of all analytes ≤ 30% between MS and MSD or sample and MD. RPD does not apply if both results are below the LOQ.	If an assignable cause isolated to only the MSD or MD is identified, reanalyze the MSD or MD or reprepare and analyze the MSD or MD if sufficient sample material is available, as indicated by the cause. Otherwise, apply qualifier to affected analyte results in the parent sample and explain in the case narrative.	Lab Manager/ Analyst	Precision and Accuracy/Bias	Recovery: Use QC acceptance criteria at least as stringent as specified by DoD QSM (DoD and DOE 2023). for LCS. Precision: RPD ≤ 30% RPD does not apply if both results are below the LOQ
Surrogate spike	All field and QC samples.	Per DoD QSM (DoD and DOE 2023), Method SW-846 8260D and Lab SOP DV-MS-0010.	For QC and field samples, correct problem then reprepare and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Lab Manager/ Analyst	Accuracy/Precision/ Representativeness	QC acceptance criteria at least as stringent as specified by DoD QSM (DoD and DOE 2023).
Trip blank	One per cooler.	Target analytes ≤1/2 LOQ.	Reanalyze for confirmation through a second analysis of the trip blank. Identify MPC and determine if acceptance criteria are met.	Lab Manager/ Analyst	Accuracy/Bias/ Representativeness/ Contamination	Target analytes ≤1/2 LOQ.

LCSD laboratory control sample duplicate

Matrix	Soil and Water
Analytical Group	GRO and DRO/RRO
Analytical Method/SOP Reference	Analytical Method: EPA Method 8015D Preparation Methods: EPA 5030C/5035A and EPA 35/463510C, respectively Laboratory SOPs: DV-GC-0010 and DV-GC-0027
Analytical Organization	Eurofins Denver

QC Sample	Frequency and Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	MPC
MB	Each time samples are extracted and one per matrix per analytical method for each batch of at most 20 samples.	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common lab contaminants, no analytes detected >LOQ.	Correct problem. If required, reprepare and reanalyze MB and all samples processed with the contaminated blank.	Analyst Lab QA Officer Project Chemist	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 higher. For common laboratory contaminants, no analytes detected >LOQ.
LCS	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	Per DoD QSM Appendix C Limits, Method 8015C and lab SOP DV-GC-0027.	Correct problem. If required, reprepare and reanalyze the LCS and all samples processed in the associated preparatory batch for the failed analytes.	Analyst Lab QA Officer Project Chemist	Accuracy	QC acceptance criteria at least as stringent as specified by DoD QSM (DoD and DOE 2023).
MS	One per analytical method for each batch of at most 20 samples.	Per DoD QSM Appendix C Limits, Method 8015C and lab SOP DV-GC-0027.	Identify MPC and determine if acceptance criteria are met. Notify lab QA officer and project chemist about additional measures to be taken.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision	For matrix evaluation, use QC acceptance criteria at least as stringent as specified by DoD QSM (DoD and DOE 2023).
MSD or MD	One per preparatory batch if sufficient material is provided. MSD: Shall contain all surrogates and all reported analytes. MD: Shall be analyzed for all surrogates and all reported analytes.	*Recovery:* Same as the LCS recovery acceptance criteria. *Precision:* RPD of all analytes ≤ 30% between MS and MSD or sample and MD. RPD does not apply if both results are below the LOQ.	If an assignable cause isolated to only the MSD or MD is identified, reanalyze the MSD or MD or reprepare and analyze the MSD or MD if sufficient sample material is available, as indicated by the cause. Otherwise, apply qualifier to affected analyte results in the parent sample and explain in the case narrative.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision	For matrix evaluation, use QC acceptance criteria at least as stringent as specified by DoD QSM (DoD and DOE 2023).

Matrix	Soil and Water
Analytical Group	GRO and DRO/RRO
Analytical Method/SOP Reference	Analytical Method: EPA Method 8015D Preparation Methods: EPA 5030C/5035A and EPA 35/463510C, respectively Laboratory SOPs: DV-GC-0010 and DV-GC-0027
Analytical Organization	Eurofins Denver

QC Sample	Frequency and Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	MPC
Surrogate spike	All field and QC samples.	Per DoD QSM (DoD and DOE 2023), Method 8015C and lab SOP DV-GC-0027.	If an assignable cause isolated to only the surrogates is identified in a field sample, reprepare and analyze the field sample if sufficient sample material is available. If obvious chromatographic interference is present, repreparation and analysis may not be necessary, but the customer shall be notified before reporting data. If samples with surrogate recoveries outside acceptance criteria cannot be reprepared and analyzed, apply qualifier to analyte results associated with the surrogates outside acceptance criteria and explain in the case narrative.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision/ Representativeness	QC acceptance criteria at least as stringent as specified by DoD QSM (DoD and DOE 2023).

MD matrix duplicate

Matrix	Soil and Water
Analytical Group	PAHs
Analytical Method/SOP Reference	Analytical Method: EPA Method 8270D SIM Preparation Method: EPA 3550C and EPA 3510C, respectively Laboratory SOPs: DV-MS-0002.
Analytical Organization	Eurofins Denver

QC Sample	Frequency and Number	Method/SOP QC Acceptance Limits	Corrective Action	Personnel Responsible for Corrective Action	DQI	MPC
MB	Each time samples are extracted and one per matrix per analytical method for each batch of at most 20 samples.	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common lab contaminants, no analytes detected >LOQ.	Correct problem. If required, reprepare and reanalyze MB and all samples processed with the contaminated blank.	Analyst Lab QA Officer Project Chemist	Sensitivity/Bias	No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ.
LCS	One per batch of at most 20 samples analyzed of similar matrix per analytical method.	Per DoD QSM Appendix C Limits, Method 8270DSIM and Lab SOP DV-MS-0002.	Correct problem. If required, reprepare and reanalyze the LCS and all samples processed in the associated preparatory batch for the failed analytes.	Analyst Lab QA Officer Project Chemist	Accuracy	QC acceptance criteria at least as stringent as specified by DoD QSM (DoD and DOE 2023).
IS verification	Every field sample, standard, and QC sample.	RT ± 10 seconds from RT of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard.	Inspect mass spectrometer and gas chromatographer for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision/ Representativeness	Laboratory in-house method manual to be followed for acceptance criteria.
Surrogate spike	All field and QC samples.	Per DoD QSM Appendix C Limits, Method 8270DSIM and Lab SOP Lab SOP DV-MS-0002.	For QC and field samples, correct problem then reprepare and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision/ Representativeness	QC acceptance criteria at least as stringent as specified by DoD QSM (DoD and DOE 2023).
MS/MSD pair	One per analytical method for each batch of at most 20 samples.	Per DoD QSM Appendix C Limits, Method 8270DSIM and Lab SOP Lab SOP DV-MS-0002. MSD or Matrix Duplicate: RPD of all analytes ≤20%.	Identify MPC and determine if acceptance criteria are met. Notify Lab QA officer and project chemist about additional measures to be taken.	Analyst Lab QA Officer Project Chemist	Accuracy/Precision	For matrix evaluation, use QC acceptance criteria at least as stringent as specified by DoD QSM (DoD and DOE 2023).

EICP extracted ion current profile
IS internal standard
RT retention time

Worksheet #29: Project Documents and Records Table

Document [a]	Storage/Archive Location
Sample Collection Documents and Records	Storage: AECOM Technical Services, Inc. 1001 Bishop Street Suite 1600 Honolulu, HI 96813 Telephone: 808-523-8874 Once NIRIS uploads are complete, hard copies of pertinent documents shall be managed at the direction of NAVFAC Hawaii.
Field logbook (and sampling notes)	
Field sample forms (e.g., boring logs, sample log sheets, drilling logs)	
COC records	
Air Bills	
Photographs	
Field task modification forms	
Field sampling SOPs	
Laboratory documents and records	
Sample collection logs	
Health and safety sign in sheets	
Accident Prevention Plan acknowledgement	
Surveyed locations	
Communication logs	
Documentation of deviation from methods	
Excavation permits	
Corrective action forms/documentation of the audits	
Documentation of internal QA review	
Identification of QC samples	
Meteorological data from field	
Sampling instrument calibration logs	
Sampling location and sampling plan	
Sampling report	
Analytical Records	
COC records	
Sample receipt forms and sample tracking forms	
Preparation and analysis forms and/or logbooks	
Tabulated data summary forms and raw data for field samples, standards, QC checks, and QC samples	
Case narrative	
Sample chronology (time of receipt, extraction, and analysis)	
Identification of QC samples	
Communication logs	
Corrective action reports	
Definitions of laboratory qualifiers	
Documentation of corrective action results	
Documentation of laboratory method deviations	
Electronic data deliverables	
Instrument calibration reports	
Laboratory sample ID numbers	
Reporting forms, completed with actual results	
Signatures for laboratory sign-off (e.g., laboratory QA manager)	
Standards traceability records	

Document [a]	Storage/Archive Location
Project Data Assessment Records	Storage: AECOM Technical Services, Inc. 1001 Bishop Street Suite 1600 Honolulu, HI 96813 Telephone: 808-523-8874 Once NIRIS uploads are complete, hard copies of pertinent documents shall be managed at the direction of NAVFAC Hawaii.
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	
Off-site Analysis Documents and Records	
COC documents	
Laboratory Data Reports	
Third-Party Data Validation Reports	

NIRIS Naval Installation Restoration Information Solution

[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 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	Primary Laboratory/ Organization [a] (name and address, contact person and telephone number)	Secondary Laboratory/ Organization [a] (name and address, contact person and telephone number)
Area A (PFAS)						
Surface Soil	RHA-SS-S01 to RHA-SS-S10, RHA-BS-S01 to RHA-BS-S20, and PFMW04B.	PFAS	EPA Method 1633 Lab SOP: SAC-LC-SOP73084	21 days	Eurofins Environment Sacramento 880 Riverside Parkway West Sacramento, CA 95605 Jill Kellmann 916-374-4402	Eurofins Environment Denver 955 Yarrow Street Suite 100 Arvada, CO 80002 Jill Kellmann 916-374-4402 Patrick McEntee 303-736-0107
Swale Surface Soil	RHA-SD-S01 to RHA-SD-S10.					
Subsurface Soil	RHA-BS-S01 to RHA-BS0-S20, and PFMW04B.					
Groundwater	Area A proposed monitoring well PFMW03B (perched and basal aquifers), RHMW06, RHMW17, RHMW17D, RHMW17S, PFMW01A, PFMW01B, and PFMW01B.					
Field QC	N/A.					
Area A (PHCs)						
Surface Soil	RHA-BS-S14 to RHA-BS-S20, and PFMW03B.	VOCs GRO DRO/RRO PAH DRO/RRO w/ SGC on select samples)	EPA Method 8260D Lab SOP: 8260D_DOD6_LL EPA Method 8015B Lab SOP: 8015D_GRO_DOD6 and 8015D_DRO_DOD6 EPA Method 8270E SIM Lab SOP: 8270E_SIM_DOD6	21 days	Eurofins Environment Denver 955 Yarrow Street Suite 100 Arvada, CO 80002 Jill Kellmann 916-374-4402 Patrick McEntee 303-736-0107	N/A
Subsurface Soil	RHA-BS-S14 to RHA-BS-S20, and PFMW03B.					
Groundwater	Area A proposed monitoring well PFMW03B (perched and basal aquifers), RHMW06, RHMW17, RHMW17D, RHMW17S, PFMW01A, PFMW01B, and PFMW01B.					
Area B						
Surface Soil	RHB-BS-S01 to RHB-BS-S40, PFMW04B, and PFMW04A to PFMW06A.	PFAS	EPA Method 1633 Lab SOP: SAC-LC-SOP73084	21 days	Eurofins Environment Sacramento 880 Riverside Parkway West Sacramento, CA 95605 Jill Kellmann 916-374-4402	Eurofins Environment Denver 955 Yarrow Street Suite 100 Arvada, CO 80002 Jill Kellmann 916-374-4402 Patrick McEntee 303-736-0107
Subsurface Soil	RHB-BS-S01 to RHB-BS-S39, PFMW04B, and PFMW04A to PFMW06A.					
Potential Grab Groundwater	RHB-BS-S01 to RHB-BS-S09, RHB-BS-S13, RHB-BS-S15, RHB-BS-S17, and RHB-BS-S21 to RHB-BS-S26					
Groundwater	Area B proposed monitoring well PFMW04B, and PFMW04A to PFMW06A. Temporary wells RHB-GW07 to RHB-GW09, RHB-GW13, and RHB-GW21.					
Field QC	N/A.					

Matrix	Sampling Locations	Analytical Group	Analytical SOP	Data Package Turnaround Time	Primary Laboratory/ Organization [a] (name and address, contact person and telephone number)	Secondary Laboratory/ Organization [a] (name and address, contact person and telephone number)
Quarterly Monitoring						
Groundwater	RHMW2254-01, RHP01, RHP02, RHP03, RHP04A, RHP04B, RHP04C, RHP05, RHP06, RHP07, RHP08, RHP08B, RHMW01R, RHMW02, RHMW03, RHMW04, RHMW05, RHMW06, RHMW07, RHMW08, RHMW17, RHMW17D, RHMW17S, RHMW18, RHMW20, RHMW21, OWDFMW01, OWDFMW02A, OWDFMW02B, OWDFMW03A, OWDFMW03B, OWDFMW04A, OWDFMW04B, OWDFMW05A, OWDFMW05B, OWDFMW07A, OWDFMW07B, OWDFMW07C, OWDFMW08A, OWDFMW08B, PFMW01A, PFMW01B, PFMW02A, and proposed wells PFMW03B, PFMW04B, and PFMW04A to PFMW06A.	PFAS	EPA Method 1633 Lab SOP: SAC-LC-SOP73084	21 days	Eurofins Environment Sacramento 880 Riverside Parkway West Sacramento, CA 95605 Jill Kellmann 916-374-4402	Eurofins Environment Denver 955 Yarrow Street Suite 100 Arvada, CO 80002 Jill Kellmann 916-374-4402 Patrick McEntee 303-736-0107

N/A not applicable
[a] Laboratory meets accreditation requirements to support project needs.

All samples will be sent to a DoD ELAP–accredited laboratory: Eurofins Environment – Sacramento 880 Riverside Parkway West Sacramento, CA 95605. Samples for other area COPCs will be shipped to Eurofins Environment Denver, 955 Yarrow Street, Suite 100, Arvada, CO 80002.

Data packages will be due 21 days after samples are received at the laboratory. Data packages will be prepared according to NAVFAC Pacific ER 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):

- Cover sheet
- Table of contents
- Case narrative
- Analytical results
- Sample management records
- QA/QC information
- All raw data and information for third-party review to conduct Stage 4 validation as outlined in Section 4.2 of *DoD General Data Validation Guidelines* (DoD 2020b)

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	QA Manager	CTO Manager/ Field Manager	Field Manager	CTO Manager/ Field Manager
Laboratory data assessment	Once per SDG	External/ Internal	Environmental Data Services/ AECOM	Third-Party Data Validator/ Project Chemist	Laboratory Project Manager	Laboratory Project Manager	Third-Party Data Validator/ Project Chemist

SDG sample delivery group

Worksheet #32: Assessment Findings and Corrective Action Responses

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

[a] Copies of all assessment findings and corrective action responses will be provided to the Navy RPM.

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, Environmental Data Services	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, Environmental Data Services	CTO Manager (AECOM) and RPM (Navy)
Field Audit Report	Once, during the initial 3 weeks of the field work	5 days after field audit is completed	QA Manager, AECOM	CTO Manager (AECOM), CTO Field Manager (AECOM), and QA Manager (Navy)

DQAR data quality assessment report

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 (Brant Landers, AECOM)	Step I	Internal
Field procedures	Determine whether field procedures are performed in accordance with this WP 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 (Tyler Nishikawa, 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 requirements. Determine whether instrument ICALs were performed in accordance with WP requirements.	Project Chemist (Brant Landers, AECOM) and Data Validator (Diane Waldschmidt, Environmental Data Services)	Step I	Internal and 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 (Brant Landers, 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 (Jill Kellmann, Eurofins)	Step I	External
Analytes	Determine whether all analytes specified in Worksheet #15 were analyzed and reported on by the laboratory.	Project Chemist (Brant Landers, AECOM)	Step IIa	Internal
COC and field QC logbook	Examine data traceability from sample collection to project data generation.	Project Chemist (Brant Landers, AECOM)	Step IIa	Internal
Laboratory data and WP 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 Data Validation Guidelines 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 (Diane Waldschmidt, Environmental Data Services) and Project Chemist (Brant Landers, AECOM)	Steps IIa and IIb	Internal and External
DoD Validation Guidelines	*Department of Defense General Data Validation Guidelines* (DoD 2019b).	Data Validator (Diane Waldschmidt, Environmental Data Services)	Step IIa	External
PFAS	*DoD Data Validation Guidelines Module 6: Data Validation Procedure for Per and Polyfluoroalkyl Substances Analysis* by QSM Table B-24 (DoD 2022), according to current version of DoD QSM Table B-24 (DoD and DOE 2023).	Data Validator (Diane Waldschmidt, Environmental Data Services)	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 (Brant Landers, AECOM) and Field Manager (Tyler Nishikawa, AECOM)	Step IIb	Internal
VOC, SVOCs, PAHs,	DoD Module 1 Data Validation Guidelines: *Data Validation Procedure for Organic Analysis by GC/MS* (DoD 2020a).	Data Validator (Diane Waldschmidt, Environmental Data Services)	Step IIa	External

Data Review Input	Description	Responsible for Verification (name, organization)	Step I/IIa/IIb [a]	Internal/External
GRO and DRO/RRO	DoD Module 4 Data Validation Guidelines: *Data Validation Procedure for Organic Analysis by GC* (DoD 2021).	Data Validator (Diane Waldschmidt, Environmental Data Services)	Step IIa	External
Field QC samples	Establish that the number of QC samples specified in Worksheet #20 were collected and analyzed.	Project Chemist (Brant Landers, AECOM)	Step IIb	Internal
Project quantitation limits and data qualifiers	Establish that sample results met the project quantitation limits and qualify the data in accordance with DoD General Data Validation Guidelines (DoD 2019b).	Data Validator (Diane Waldschmidt, Environmental Data Services) and Project Chemist (Brant Landers, AECOM)	Step IIb	Internal and External
Validation report	Summarize outcome of data comparison to MPC in the WP. Include qualified data and an explanation of all data qualifiers.	Data Validator (Diane Waldschmidt, Environmental Data Services)	Step IIa	External

SVOC semivolatile organic compound
UFP Uniform Federal Policy
[a] IIa Compliance with methods, procedures, and contracts. See Table 10, page 117, UFP-QAPP manual, V.1 (IDQTF 2005).
IIb Comparison with MPC in the WP. See Table 11, page 118, UFP-QAPP manual, V.1 (IDQTF 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 RI. The evaluation will consider any deviations from proposed field activities or sampling and handling procedures. The analytical results of the water and soil sampling will be compared to the PQOs presented in Worksheets #12 and #28 to determine whether the 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 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 WP. 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 WP requirements for completeness and accuracy per Worksheet #22 (SOP requirements for calibration, maintenance, and testing). In addition, the review process will verify that SOPs for field sampling and analysis were followed.

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

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

37.2 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). The remaining 90 percent of the analytical data will be validated according to 2B Validation (Electronic and Manual, [S2BVEM]) as outlined in the following procedures:

- DoD *Data Validation Guidelines Module 6; Data Validation Procedure for Per- and Polyfluoroalkyl Substances Analysis by QSM Table B-24* (DoD 2022)
- DoD *Data Validation Guidelines Module 1 Data Validation Guidelines: Data Validation Procedure for Organic Analysis by GC/MS* (DoD 2020a)
- DoD *Data Validation Guidelines Module 4 Data Validation Guidelines: Data Validation Procedure for Organic Analysis by GC* (DoD 2021)

The analytical data will be evaluated for QA and QC based on the DoD Data Validation Guidelines Modules 1, 4, and 6 and the DoD QSM (DoD and DOE 2023). The RI will use the DoD *Data Validation Guidelines* and supporting modules to evaluate and qualify data (DoD 2019a).

Sample data that do not meet the DoD Validation Guidance Procedures (DoD 2019a) and the DoD 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 NDs as U-qualified at the LOD and requires reporting detects between the DL and LOQ 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 NDs) 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.

Table 37-2: Reporting Requirements

Reporting Requirements	NDs or Results Below (<) DL	Results Below (<) LOD	Results Below (<) LOQ
DoD QSM Reporting	LOD Value U	Reported Result J	Reported Result J

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 QA/QC evaluation of the data according to the PARCCS criteria relative to the MPCs or PQOs in accordance with NAVFAC, Pacific ER 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 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 DLs, LODs, and LOQs are verified for the target analytes presented in Worksheet #15 to ensure they are detected at concentrations necessary to support the DQOs.

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 analysis as a whole.

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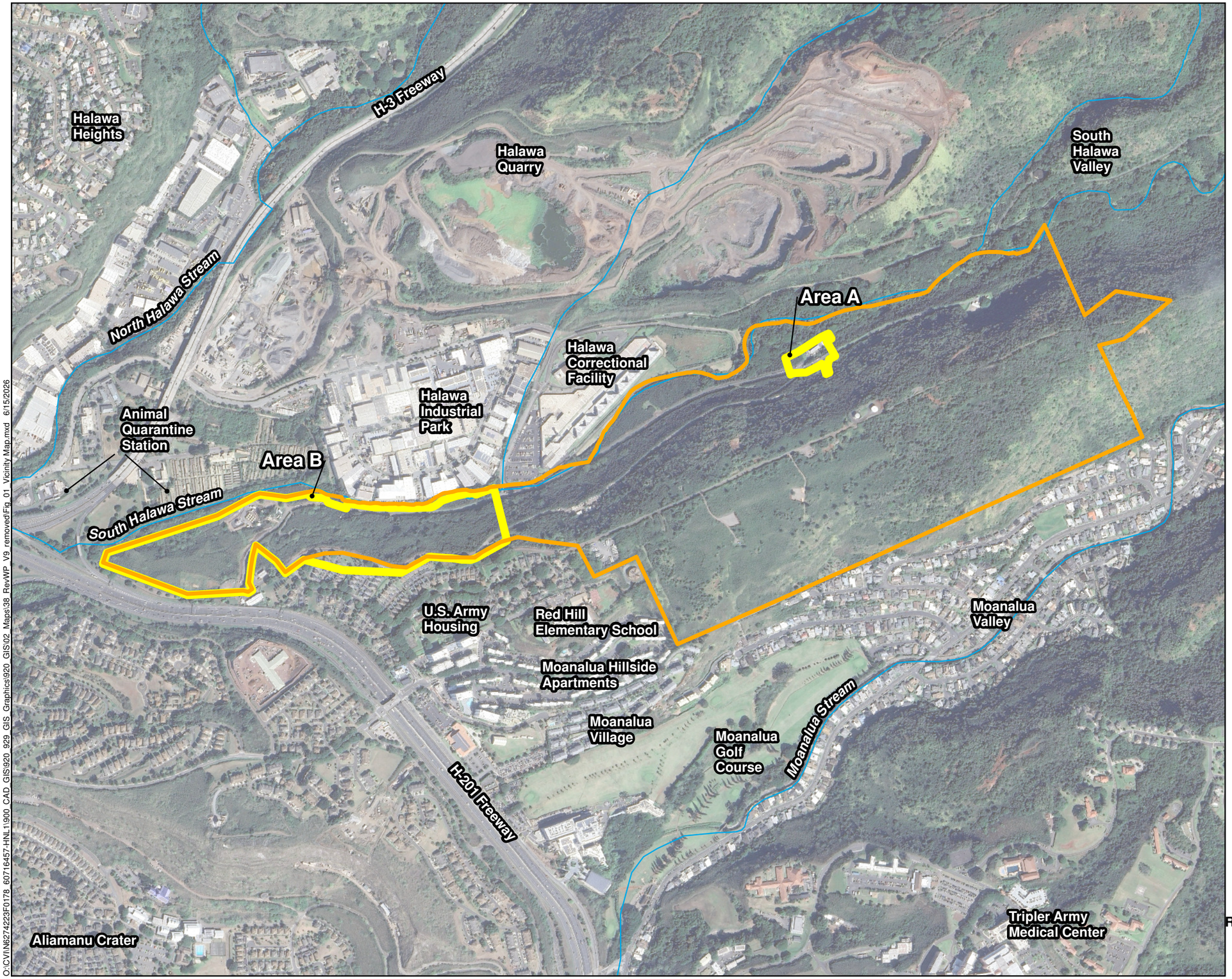
Appendix A:
Figures



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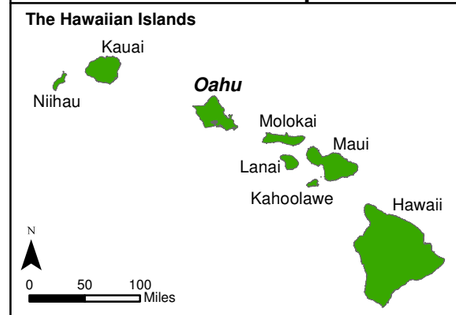

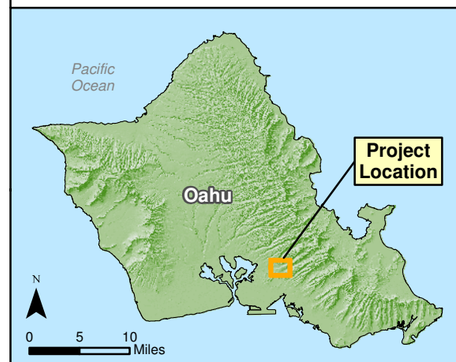

Legend

- Stream
- Red Hill Facility Boundary
- Potential Source Area

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft.
2. Basemap: Google Earth, downloaded on January 2025.
3. Sensitive infrastructure has been removed fom the figure for public dissemination.

N

0 750 1,500 Feet

Figure 1
Vicinity Map
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substance
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

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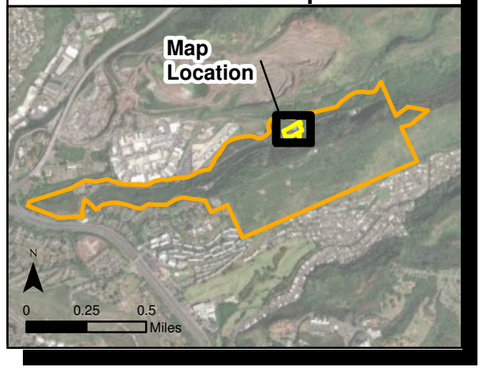
Location Map



Legend

- Existing Perched Monitoring Well
- Existing Basal Aquifer Monitoring
- 2022 Release Response Excavated
- Approximate Location of AFFF Concentrate
- Fence
- Stream
- Red Hill Facility Boundary
- Potential Source

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft.
2. Base Map: Google Earth, downloaded on January 2025.
3. Sensitive infrastructure has been removed from the figure for public dissemination.

N

0 30 60 120 Feet

Figure 2
Area A - Current Site Features
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substance
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

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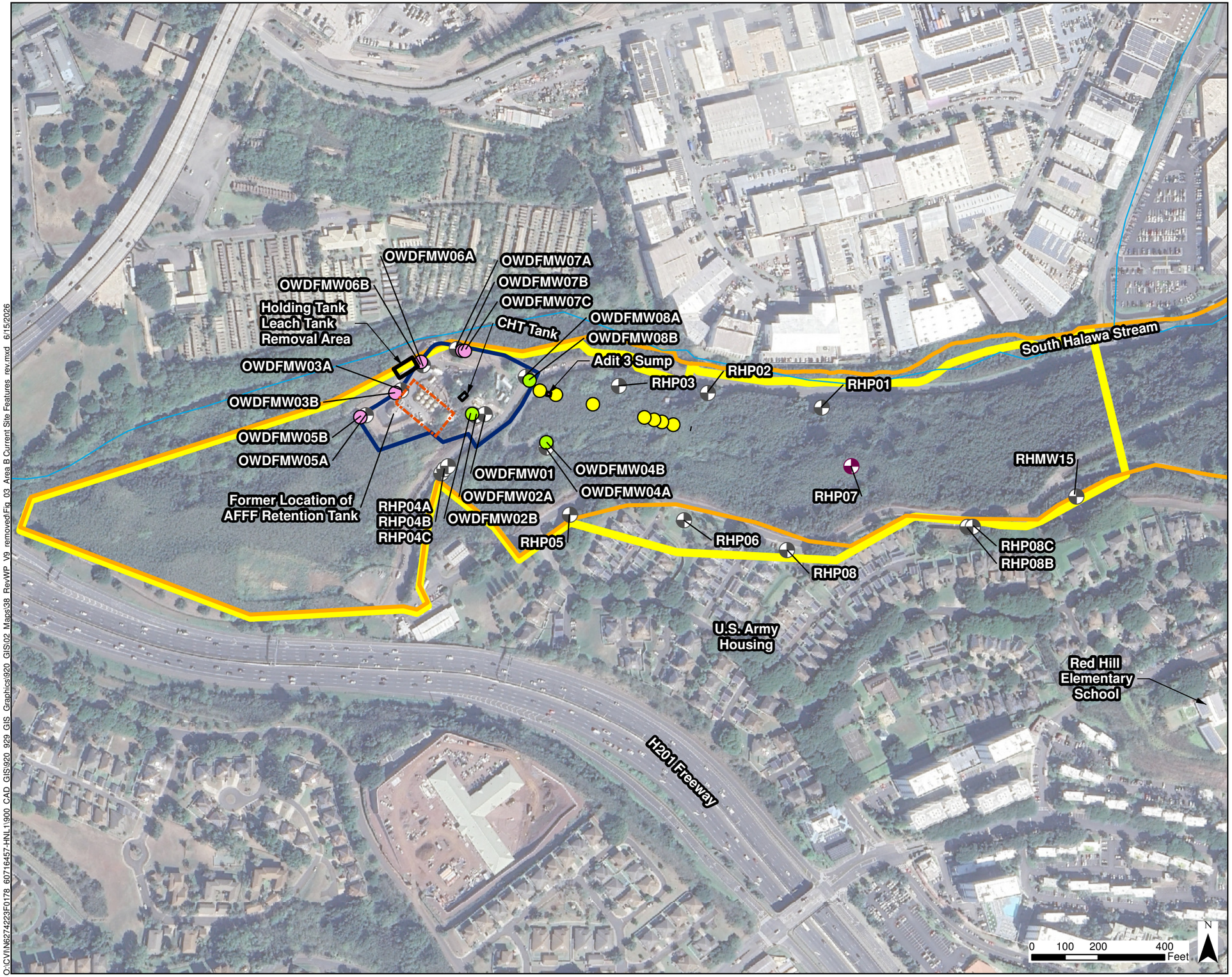
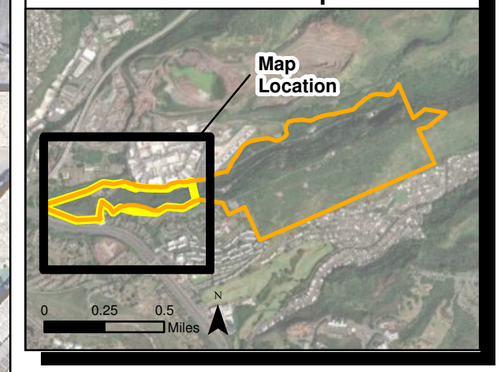


Location Map



Legend

- Approximate Extent of Containment Cap
- Adit 3 Temporary Well
- Down-Slope Perched Monitoring Well
- Up-Slope Perched Monitoring Well
- Existing Basal Aquifer Monitoring Well
- Existing Basal Aquifer Monitoring Well in Tunnel
- Stream
- Former OWDF Boundary
- Red Hill Facility Boundary
- Potential Source Area

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft.
2. Base Map Source: Google Earth, downloaded on December 9, 2025.
3. Sensitive infrastructure has been removed from the figure for public dissemination.

Figure 3
Area B - Current Site Features
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

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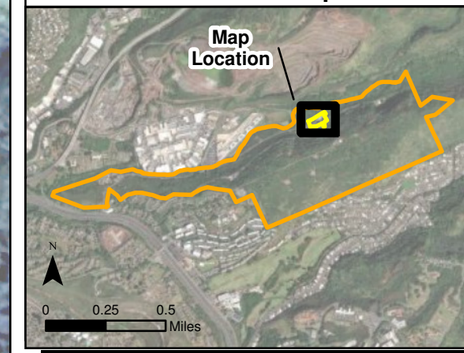
Location Map



Legend

- Fence
- Stream
- Red Hill Facility Boundary
- Potential Source Area

Notes

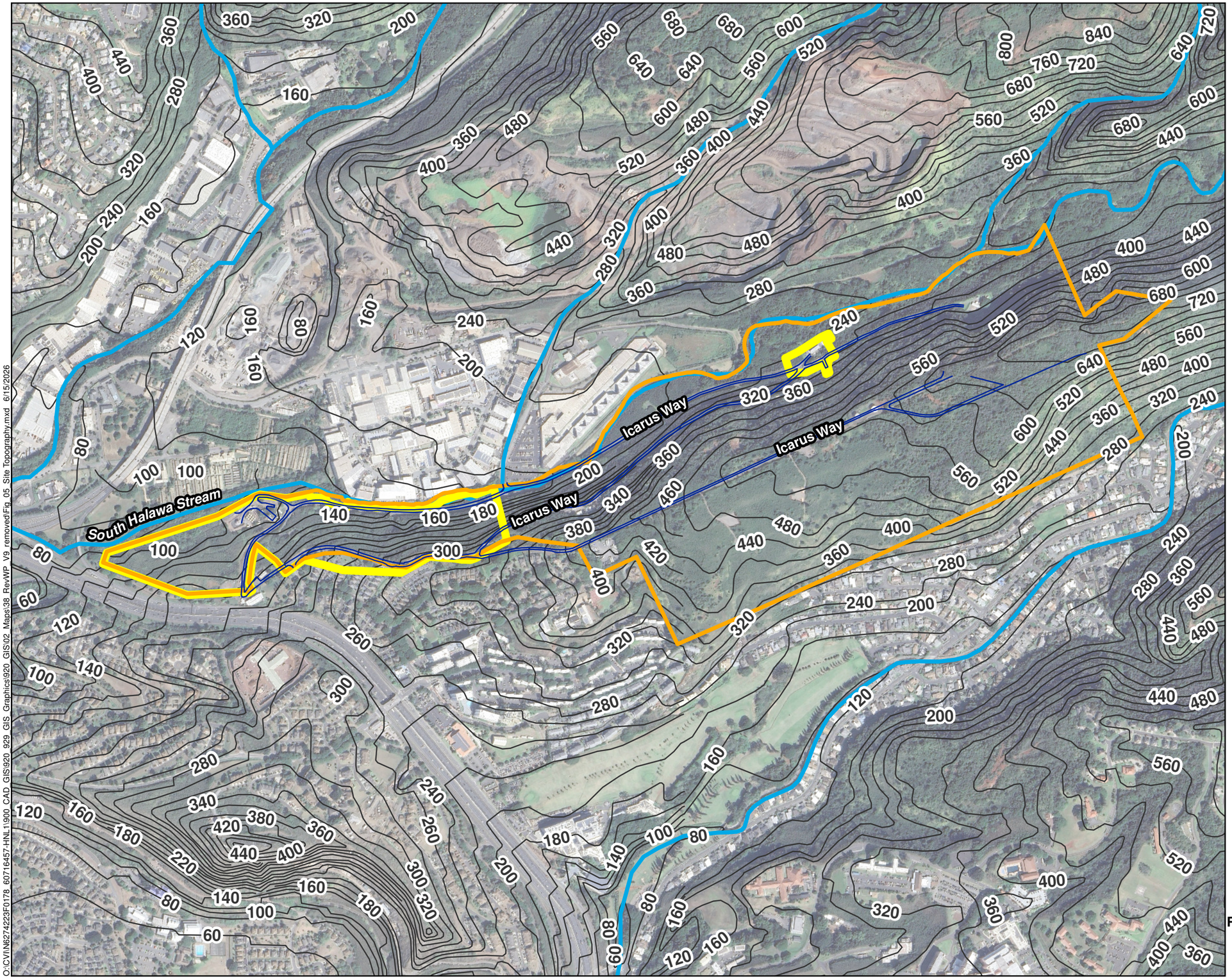
1. Map projection: NAD 1983 Hawaii State Plane Z3 ft.
2. Basemap: Google Earth, downloaded on January 2025.
3. Sensitive infrastructure has been removed from the figure for public dissemination.

N

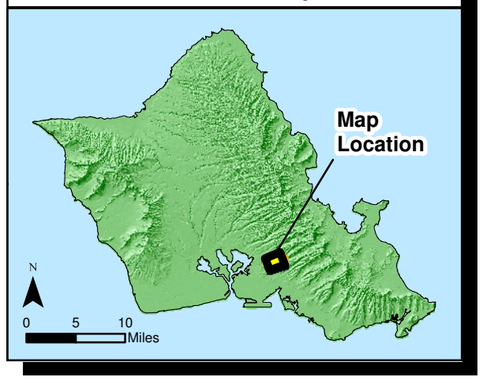
0 30 60 120 Feet

Figure 4
Area A - Historical Site Features
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substance
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

O:\CVIN\6274223F0178_60716457-HNL1\900_CAD_GIS\920_929_GIS_Graphics\920_GIS\02_Maps\38_RevWP_V9_removed\Fig_04_Area A Historical Site Features_rev.mxd 6/15/2026



Location Map



Legend

- −440− Approximate Elevation Contour (ft msl)
- Stream
- Facility Roads
- Red Hill Facility Boundary
- Potential Source Area

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft.
2. Base Map Source: Google Earth downloaded on January 2025.
3. Elevation contours from: State of Hawaii Office of Planning and Sustainable Development, Statewide GIS Program, July 2010.
4. Acronyms and Abbreviations:
   ft Feet
   msl Mean sea level

N

0 750 1,500 Feet

Figure 5
Site Topography
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substance
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

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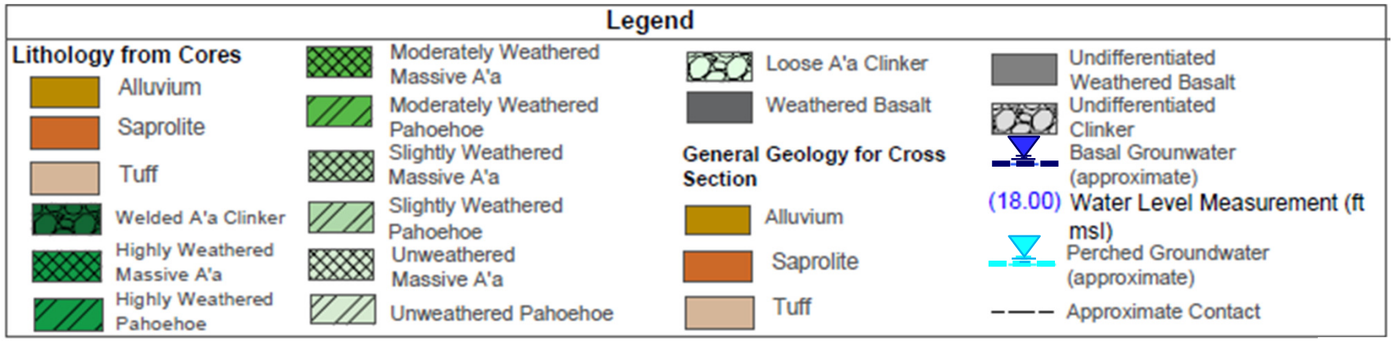
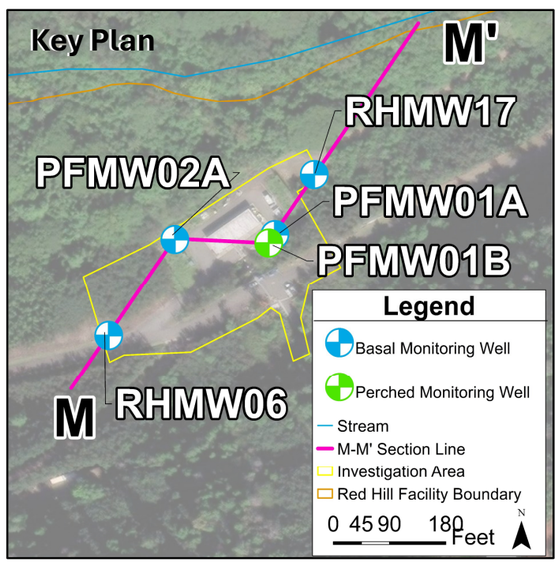
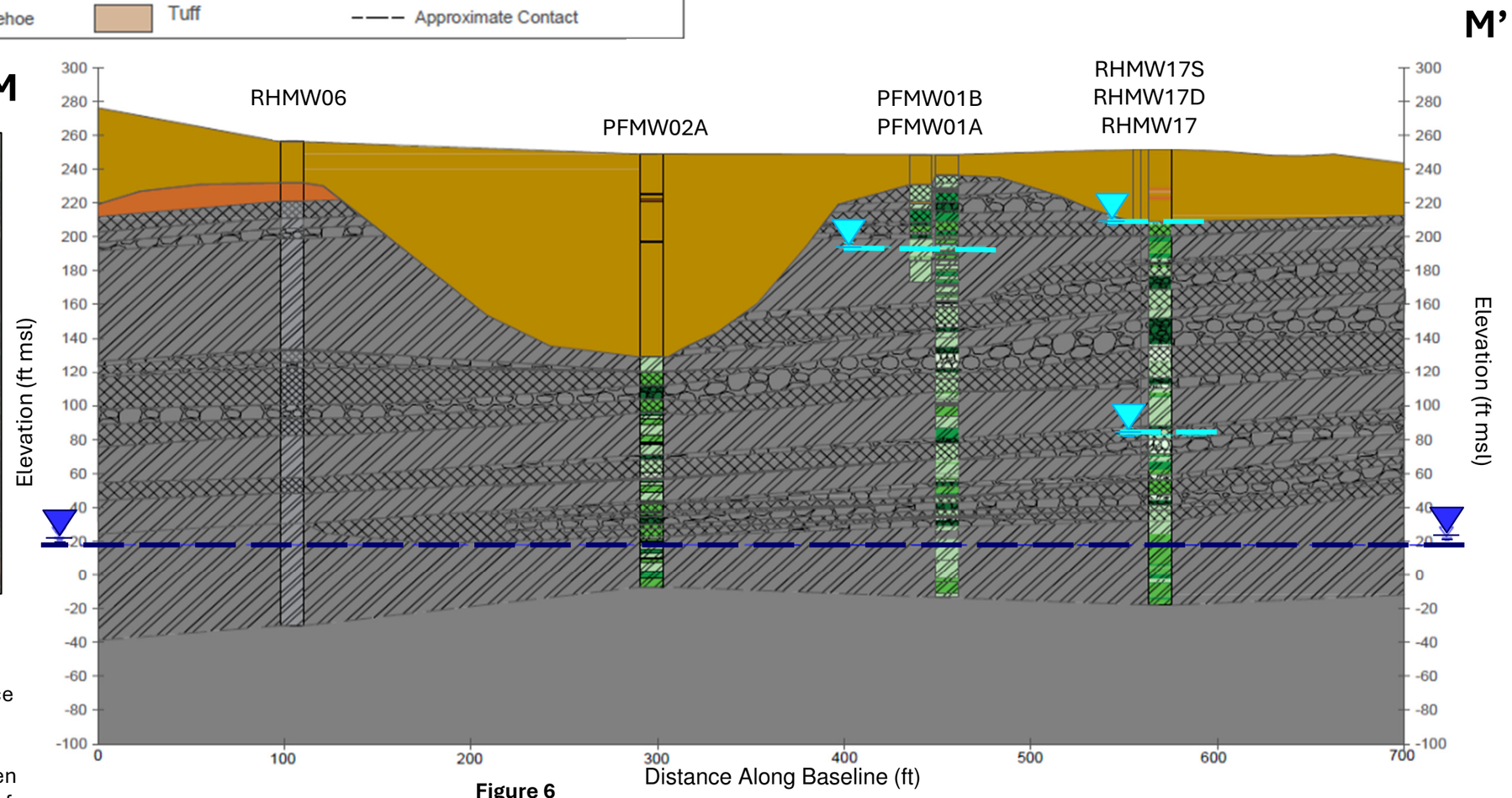






Notes:

1. RHMW17S and RHMW17D are 2-inch PVC "piezometers" installed in the annular space of RHMW17.
2. RHMW06 was logged by Parsons in 2014. Although their log does differentiate between basalt types it does not specify the degree of weathering, as indicated by the green shading in the other borings on this cross section.

Figure 6
Area A – Lithologic Cross Section
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

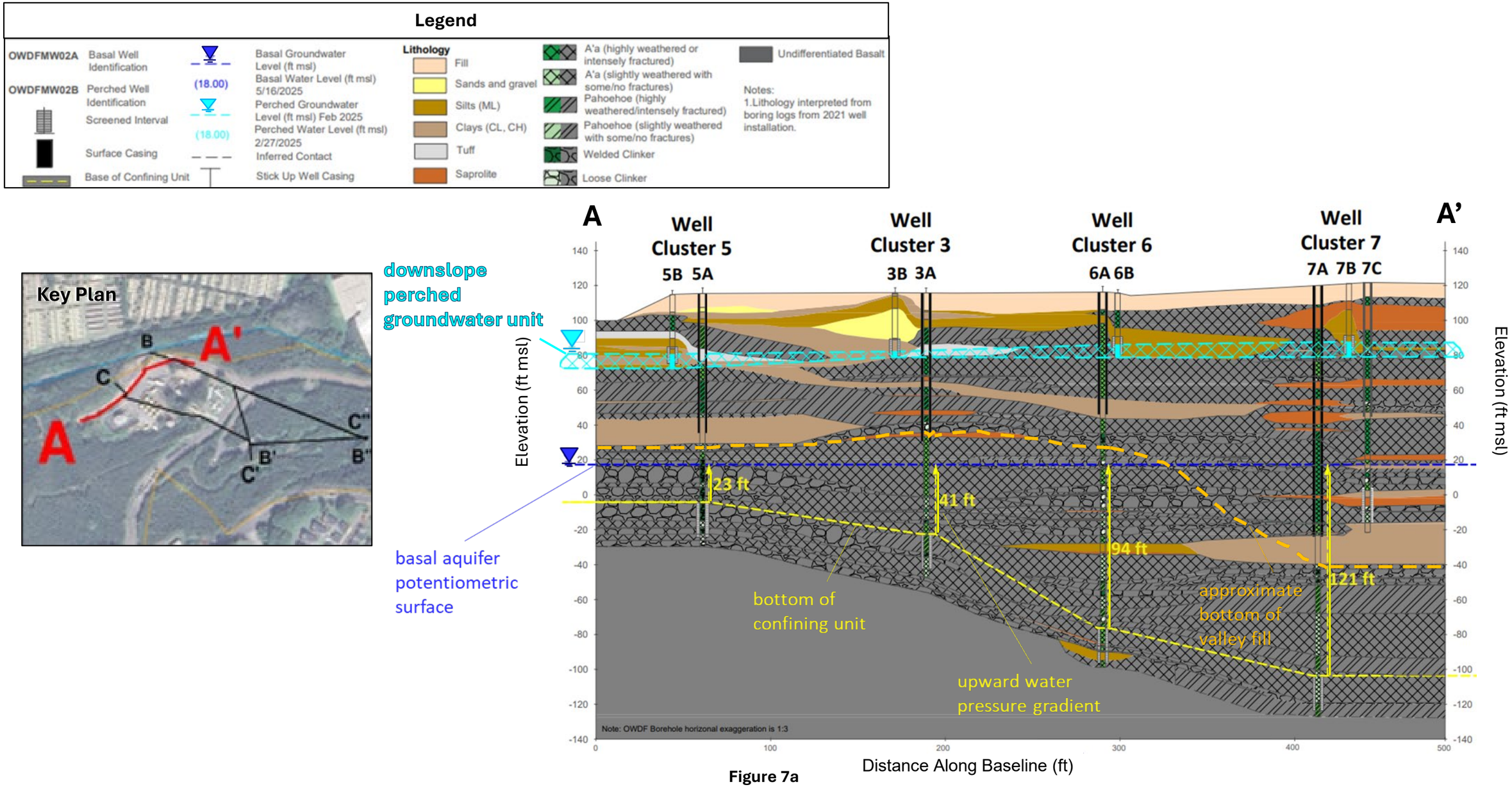
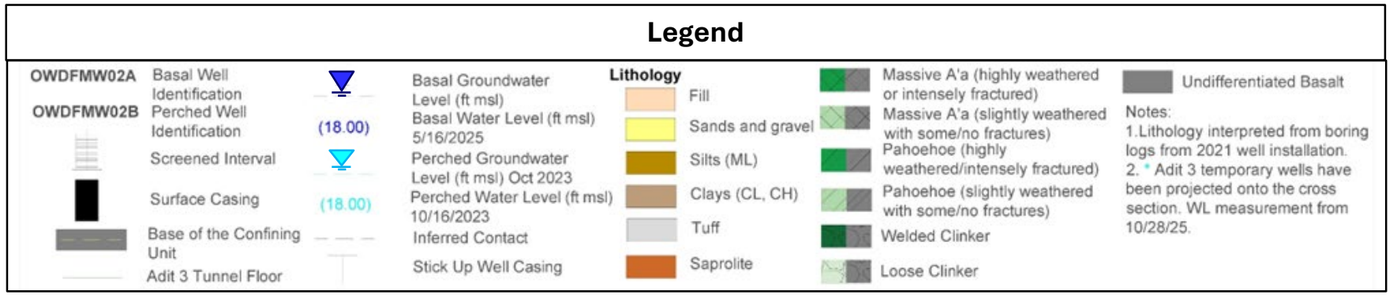
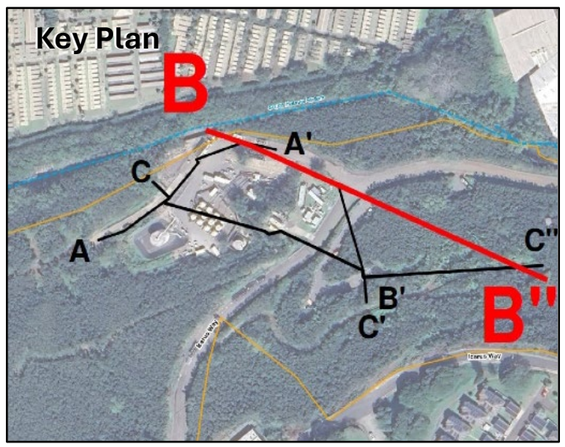


Figure 7a
OWDF Geological Cross Section A-A'
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii





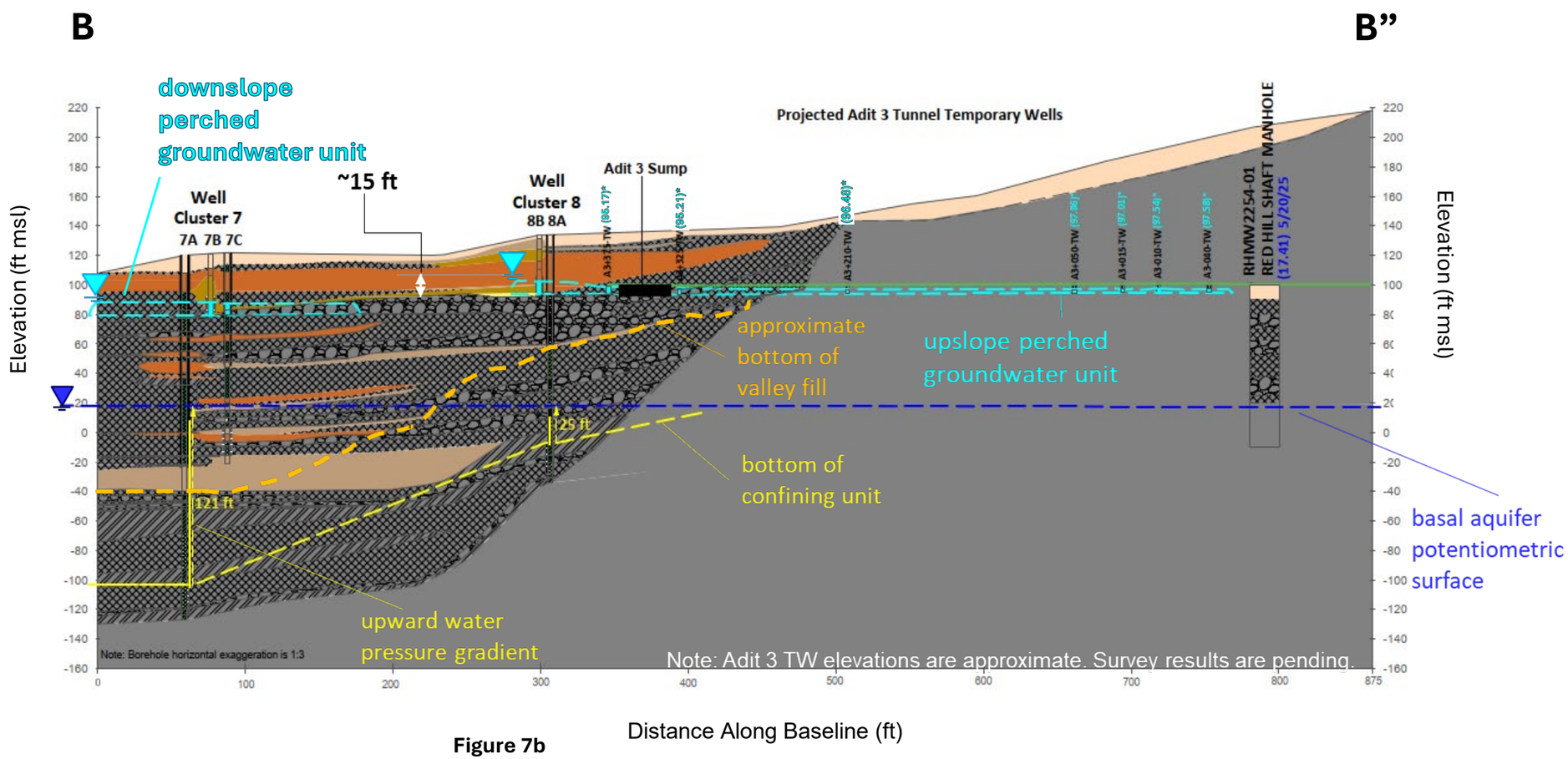
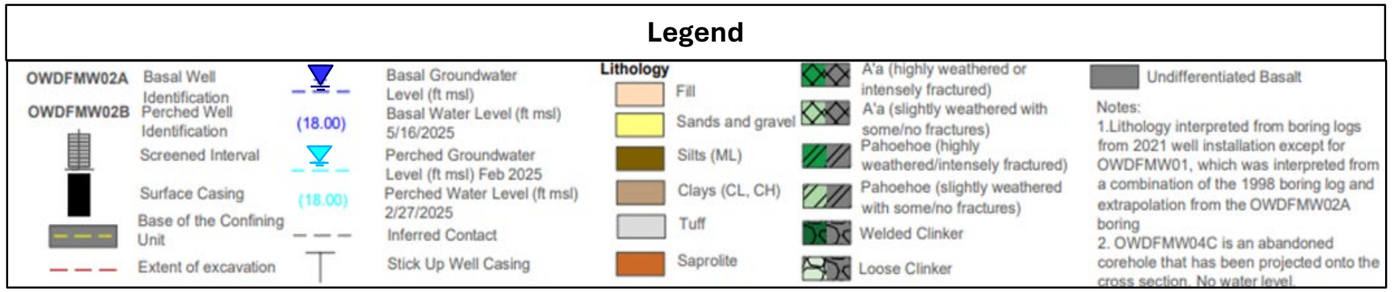


Figure 7b
OWDF Geological Cross Section B-B"
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii



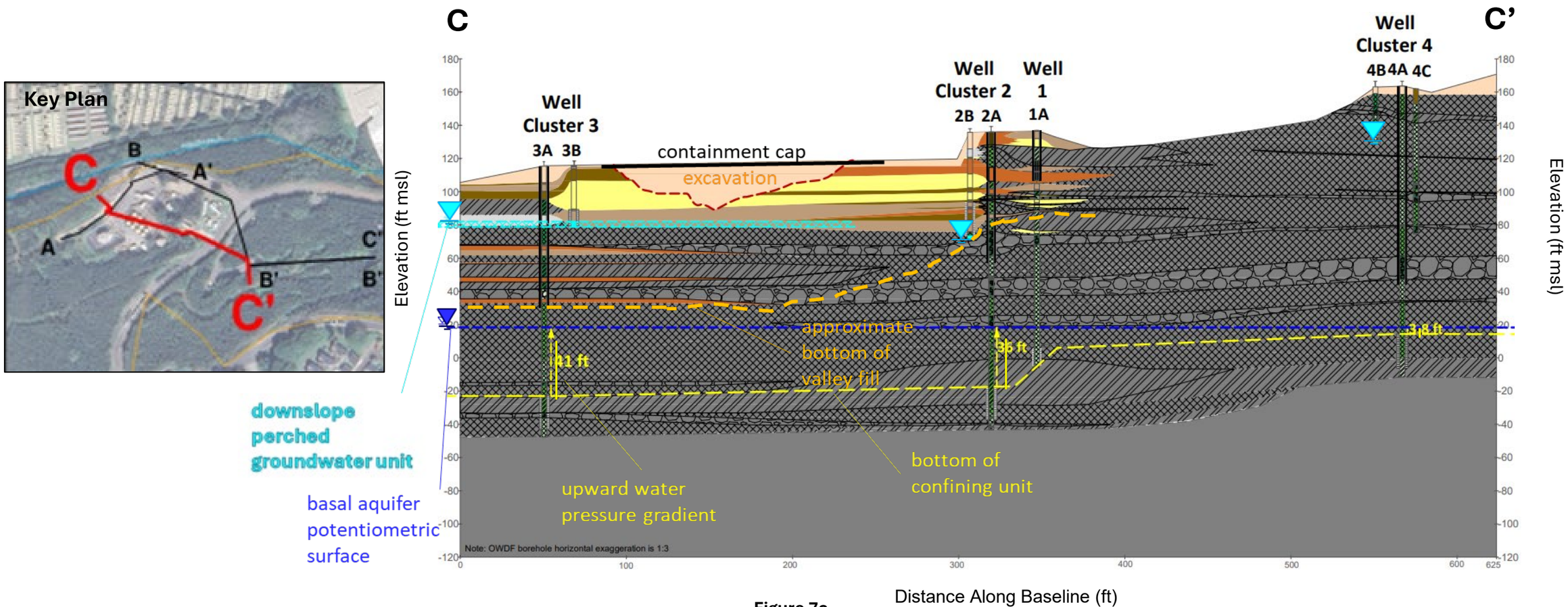
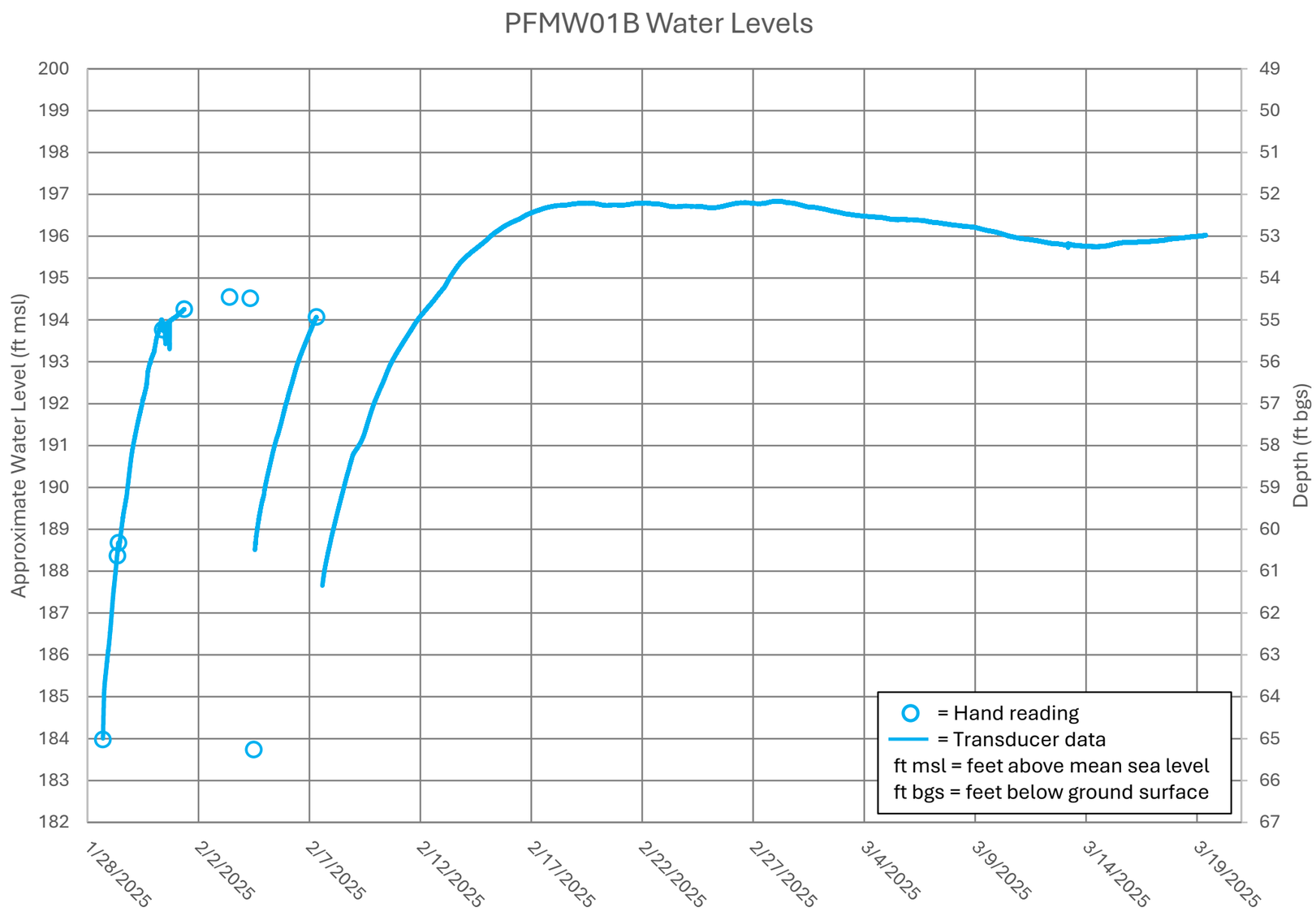
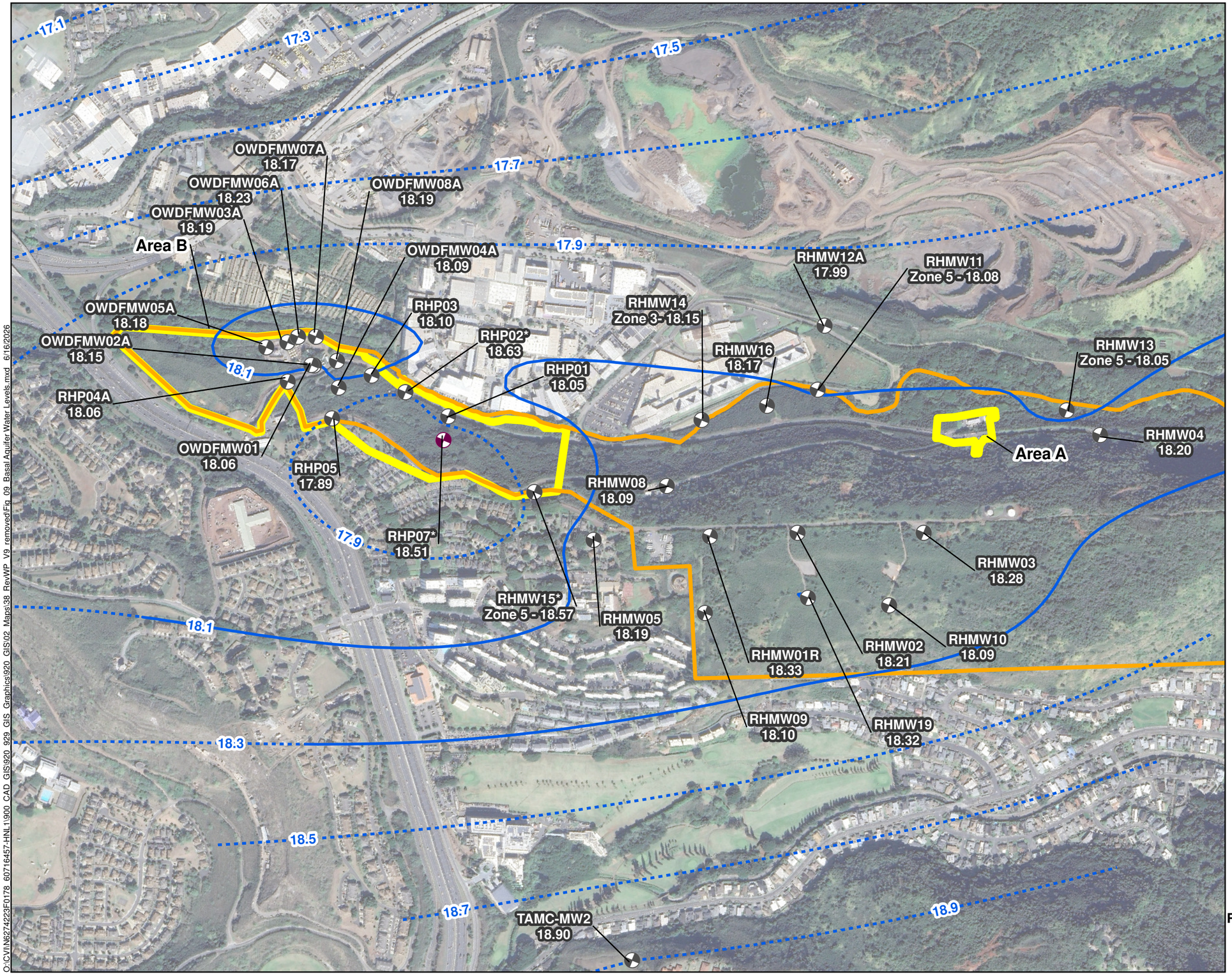


Figure 7c
OWDF Geological Cross Section C-C'
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

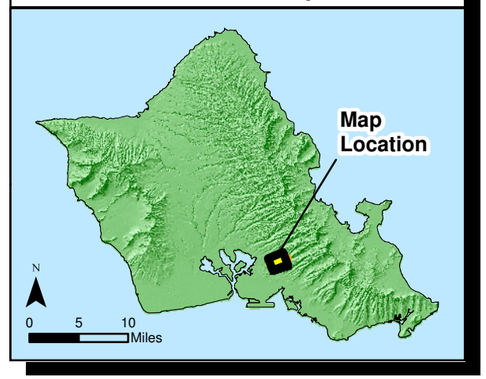


Note: Data gaps were during monitoring well development.

Figure 8
Area A – PFMW01B Perched Water Levels
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii



Location Map



Legend

- Existing Basal Aquifer Monitoring Well in Tunnel
- Existing Basal Aquifer Monitoring
- Water Level Contours (ft msl)
- Estimated Water Level Contours (ft msl)
- Red Hill Facility Boundary
- Potential Source Area

Notes

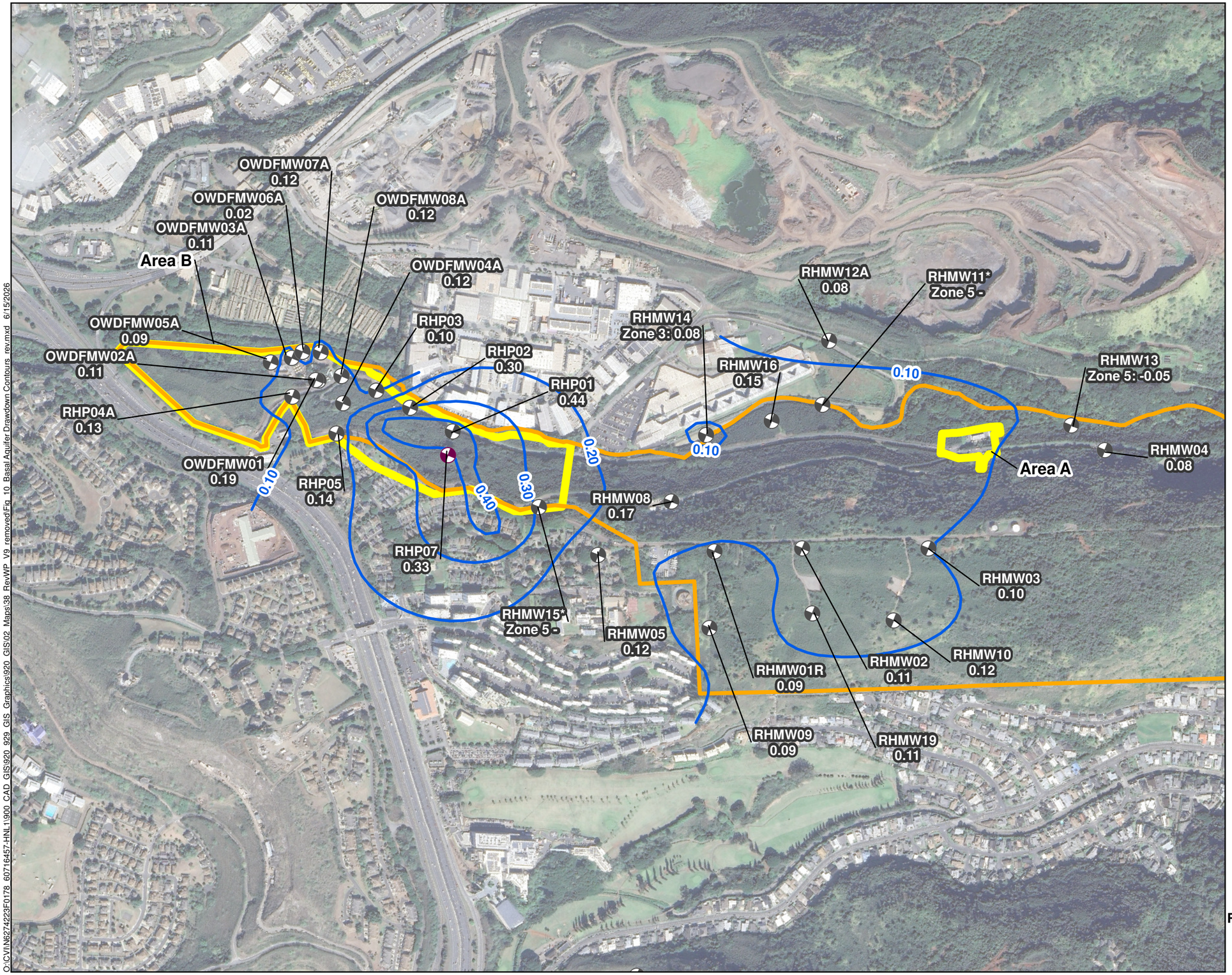
1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Base Map Source: Google Earth, downloaded on January 2025.
3. Coordinates: NAD 1983 Hawaii State Plane Z3 ft
4. Based off of Flow Optimization Study, September 2023.
5. *Value was not used in contouring.
6. Acronyms and Abbreviations:
   MGD Million gallons per day
   ft Feet
   msl mean sea level
7. Sensitive infrastructure has been removed from the figure for public dissemination.

N

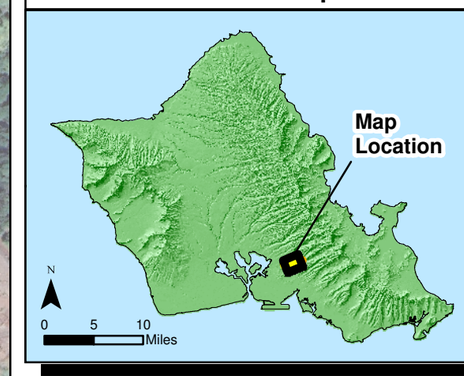
0 400 800 1,600 Feet

Figure 9
Basal Aquifer Water Levels
RHS Pumping at 1.7 MGD
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

O:\CVI\N6274223F0178 60716457-HNL1\900 CAD GIS\920 929 GIS Graphics\920 GIS\02 Maps\38 RevWP V9 removed\Fig 09 Basal Aquifer Water Levels.mxd 6/16/2026



Location Map



Legend

- Existing Basal Aquifer Monitoring Well in Tunnel
- Existing Basal Aquifer Monitoring Well
- Drawdown Contours (ft msl)
- Red Hill Facility Boundary
- Potential Source Area

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Base Map Source: Google Earth, downloaded on January 2025.
3. Coordinates: NAD 1983 Hawaii State Plane Z3 ft
4. Based off of Flow Optimization Study, September 2023.
5. *RSB box malfunctioned. Data not recorded.
6. Acronyms and Abbreviations:
   MGD Million gallons per day
   ft Feet
   msl mean sea level
7. Sensitive infrastructure has been removed from the figure for public dissemination.

N

0 400 800 1,600 Feet

Figure 10
Basal Aquifer Drawdown Contours
RHS Pumping at 1.7 MGD
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

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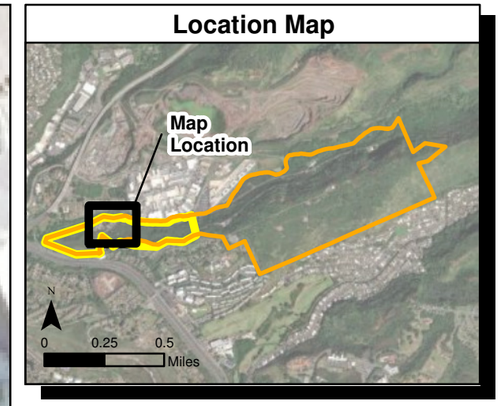
Location Map



Legend

- OWDFMW01
- OWDF Basal Well
- OWDF Perched Well
- Adit 3 Temporary Well
- 6-inch Pump Station Cooling Water Drain
- Downgradient Perched Groundwater Contour (ft msl)
- Upgradient Perched Groundwater Contour (ft msl)
- Former OWDF Boundary
- Adit 3 Sump
- Red Hill Facility Boundary
- Potential Source Area

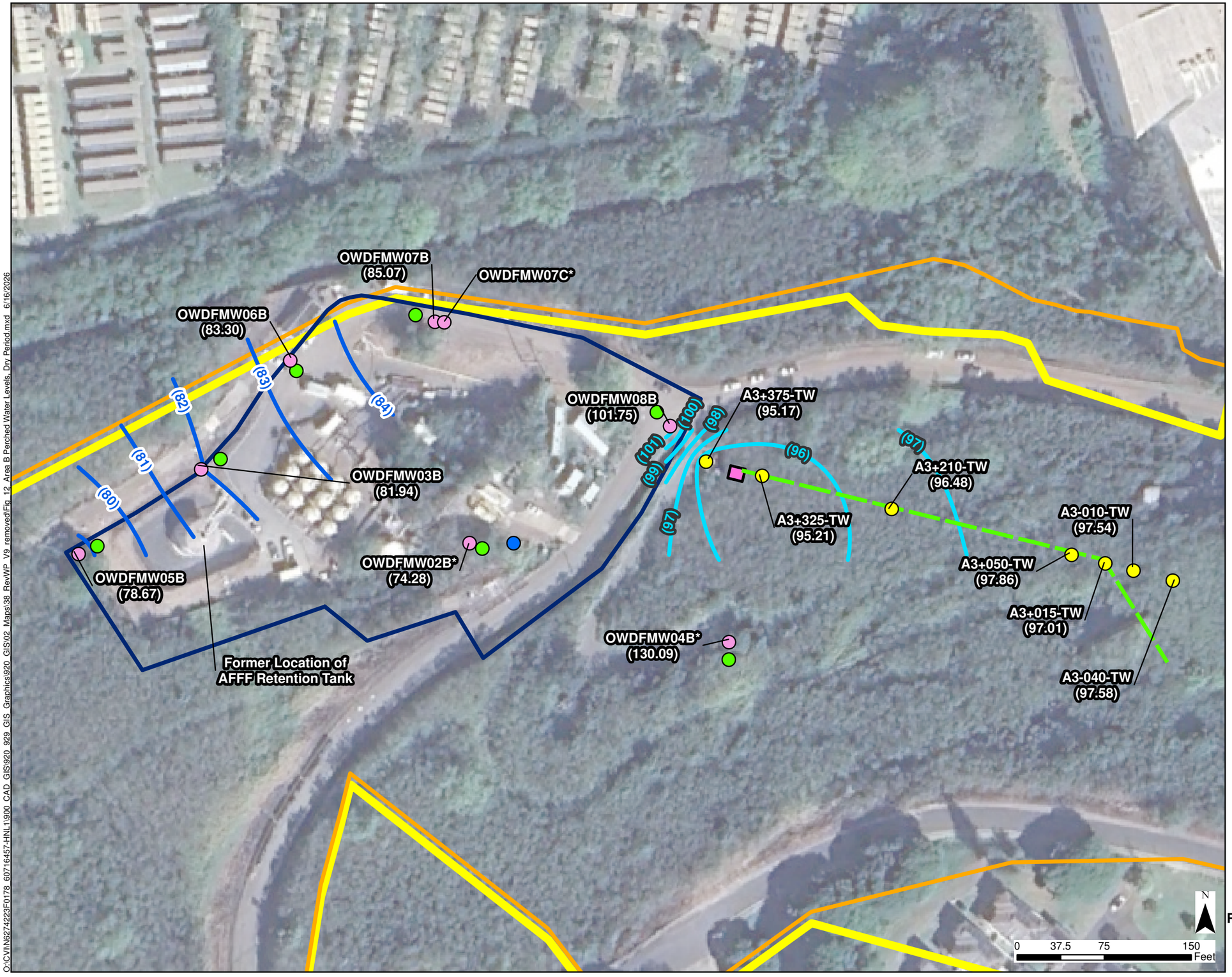
OWDFMW02B (73.00) — Well ID (Water Level [ft msl])

Notes

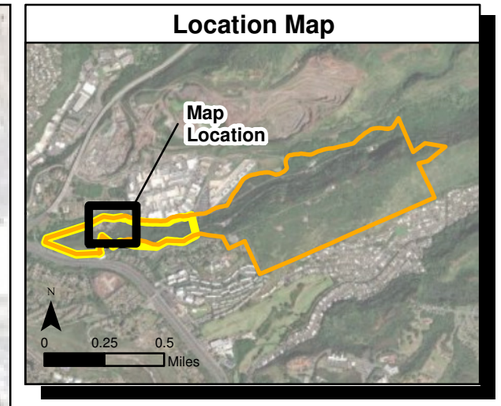
1. Map projection: NAD 1983 Hawaii State Plane Z3 ft.
2. Base Map Source: Google Earth, downloaded on January 2025.
3. Water levels were recorded on March 10, 2023 between 10:00 and 12:05.
4. *Well not screened in either the upper or lower perched zones and therefore not included in the contour.
5. Acronyms and Abbreviations:
   ID Identification
   TW Temporary Well
   ft msl feet above mean sea level
6. Sensitive infrastructure has been removed from the figure for public dissemination.

Figure 11
Area B - Perched Water Levels, Rainy Period
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

O:\CVIN\6274223F0178_60716457-HNL1\900_CAD_GIS\920_929_GIS_Graphics\920_GIS\02_Maps\38_RevWP_V9_removed\Fig_11_Area B Perched Water Levels, Rainy Period.mxd 6/16/2026



Location Map



Legend

- OWDFMW01
- OWDF Basal Well
- OWDF Perched Well
- Adit 3 Temporary Well
- 6-inch Pump Station Cooling Water Drain
- Downgradient Perched Groundwater Contour (ft msl)
- Upgradient Perched Groundwater Contour (ft msl)
- Former OWDF Boundary
- Adit 3 Sump
- Red Hill Facility Boundary
- Potential Source Area

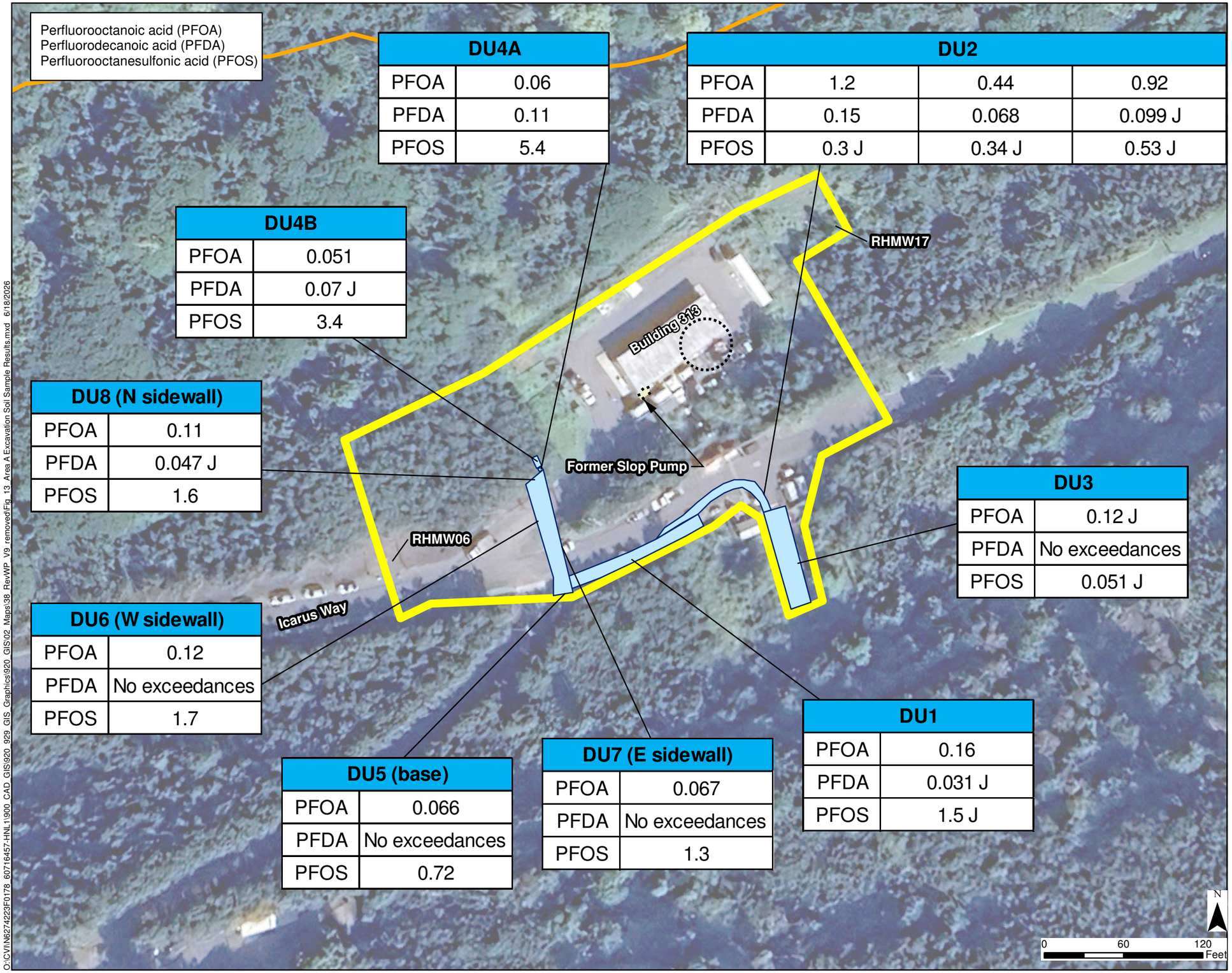
OWDFMW02B (74.28) — Well ID (Water Level [ft msl])

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft.
2. Basemap: Google Earth, downloaded on January 2025.
3. Water levels were recorded on July 31, 2023 between 10:00 and 12:05.
4. *Well not screened in either the upper or lower perched zones and therefore not included in the contour.
5. Acronyms and Abbreviations:
   ID Identification
   TW Temporary Well
   ft msl feet above mean sea level
6. Sensitive infrastructure has been removed from the figure for public dissemination.

Figure 12
Area B - Perched Water Levels, Dry Period
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

O:\CVI\N6274223F0178_60716457-HNL1\900_CAD_GIS\920_929_GIS_Graphics\920_GIS\02_Maps\38_RevWP_V9_removed\Fig_12_Area B Perched Water Levels, Dry Period.mxd 6/16/2026



DU4A	
PFOA	0.06
PFDA	0.11
PFOS	5.4

DU2			
PFOA	1.2	0.44	0.92
PFDA	0.15	0.068	0.099 J
PFOS	0.3 J	0.34 J	0.53 J

DU4B	
PFOA	0.051
PFDA	0.07 J
PFOS	3.4

DU8 (N sidewall)	
PFOA	0.11
PFDA	0.047 J
PFOS	1.6

DU3	
PFOA	0.12 J
PFDA	No exceedances
PFOS	0.051 J

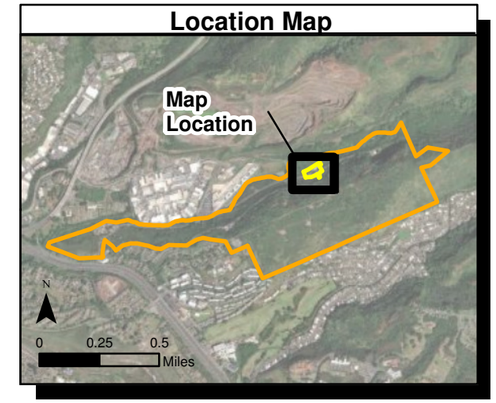
DU6 (W sidewall)	
PFOA	0.12
PFDA	No exceedances
PFOS	1.7

DU1	
PFOA	0.16
PFDA	0.031 J
PFOS	1.5 J

DU5 (base)	
PFOA	0.066
PFDA	No exceedances
PFOS	0.72

DU7 (E sidewall)	
PFOA	0.067
PFDA	No exceedances
PFOS	1.3

Location Map



Legend

- Existing Basal Monitoring Well
- Former 5,000 Barrel Slop Tank S-355
- Fence
- Stream
- Topographic Contour (ft msl)
- Former Decision Unit / Excavated Area
- Red Hill Facility Boundary
- Potential Source Area

Notes

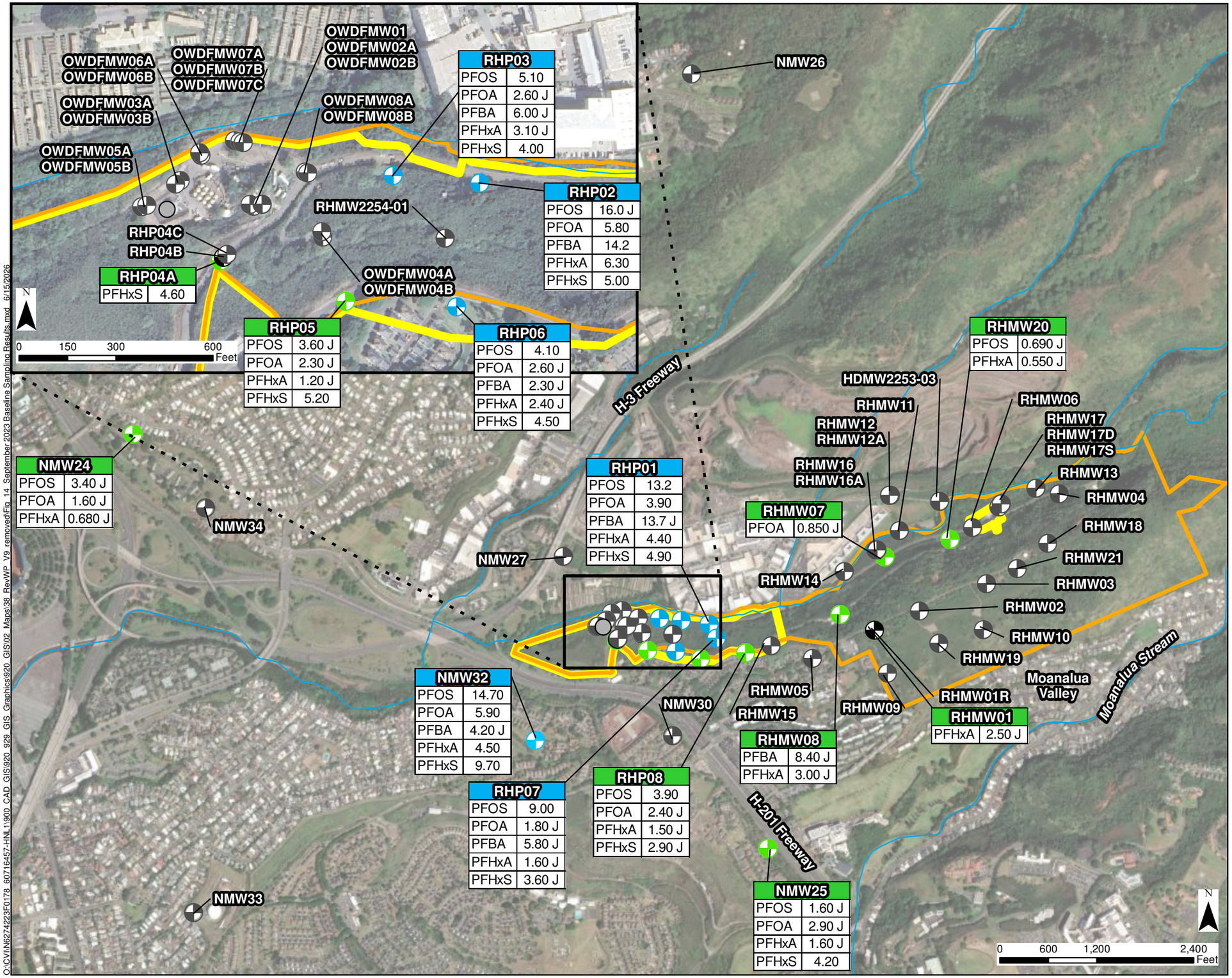
1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Basemap: Google Earth, downloaded on January 2025.
3. Screening levels from ASD Memorandum, Investigating PFAS within the DoD Cleanup Program (ASD 2025).
4. Acronyms and Abbreviations
   - DU Decision Unit
   - EPA Environmental Protection Agency, United States
   - RSL record screening limit
   - J estimated concentration
   - µg/kg micrograms per kilogram
6. Screening Criteria

ASD 2025	
PFOA	0.07
PFDA	0.06
PFOS	0.63

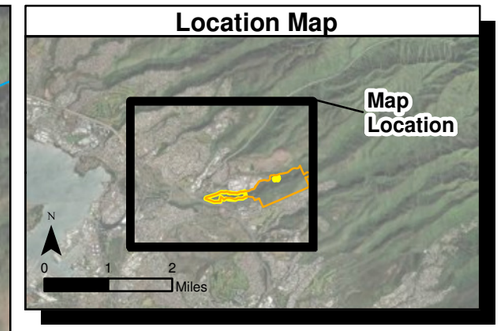
7. Sensitive infrastructure has been removed from the figure for public dissemination.

Figure 13
Area A - Excavation Soil Sample Result Exceedances
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substance
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

O:\CVI\N62742 23F0178 60716457-HNL1\900 CAD GIS\920 929 GIS Graphics\920 GIS\02 Maps\38 RevWP V9 removed\Fig 13 Area A Excavation Soil Sample Results.mxd 6/18/2026



Location Map



Legend

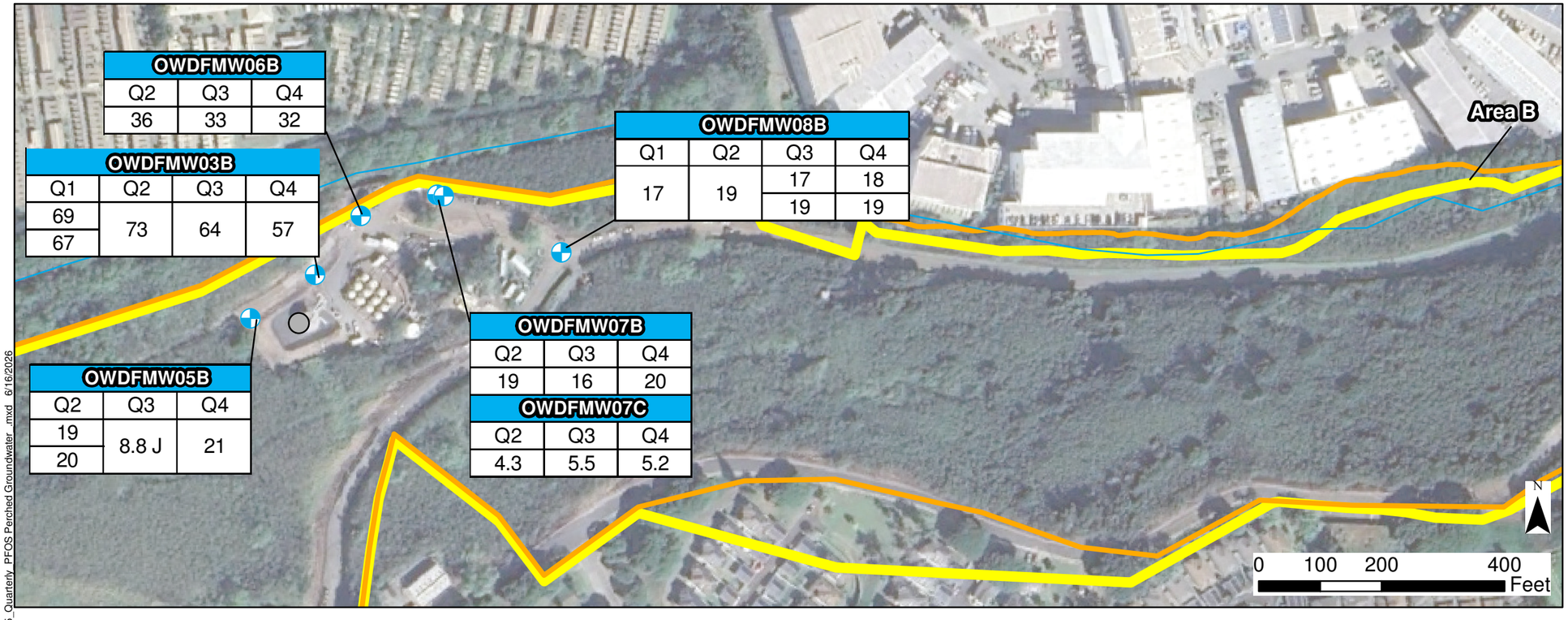
- Former Location of AFFF Drain Line Retention Tank
- Monitoring Location with PFAS Detected Above the PSL
- Monitoring Location with PFAS Detected Below the PSL
- Monitoring Location with no PFAS Detection
- Existing Monitoring Location Not Sampled for PFAS
- Stream
- Red Hill Facility Boundary
- Potential Source Area

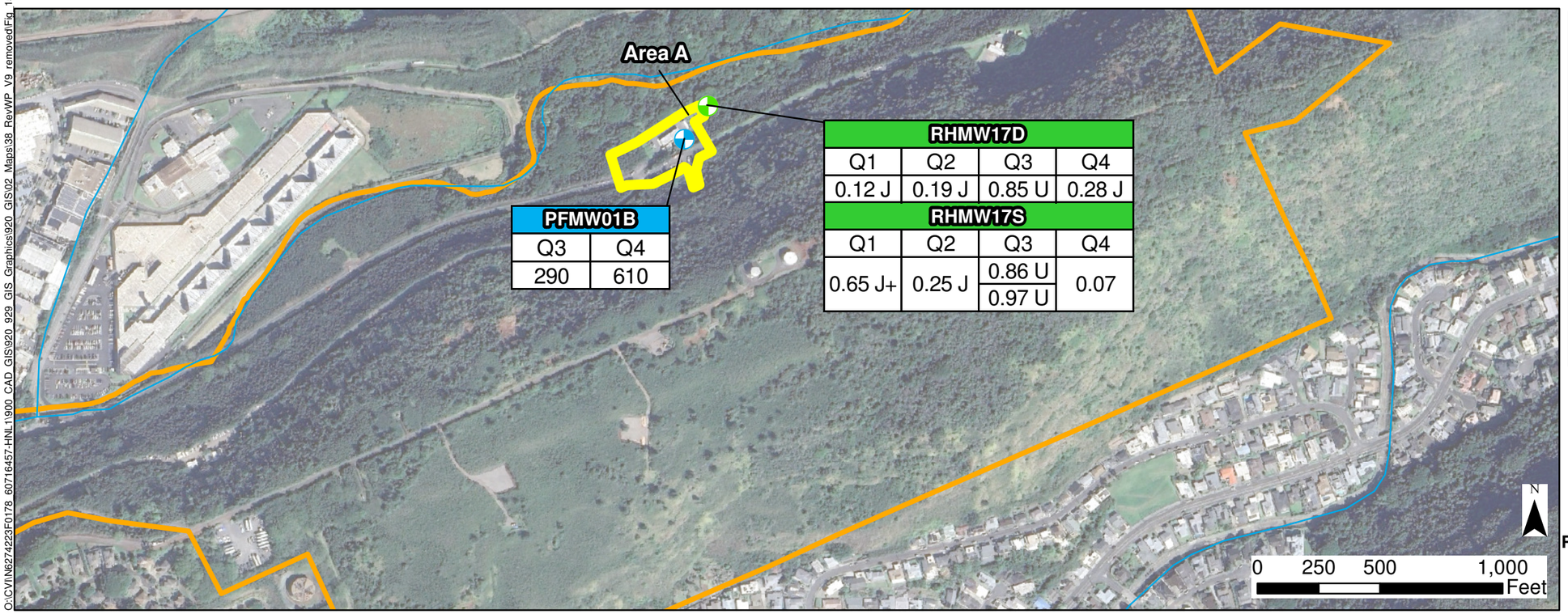
Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Basemap: Google Earth, downloaded on January 2025.
3. Only those PFAS with PSLs that were detected during Baseline Sampling are shown.
4. Units are in nanograms per liter (ng/L)
5. Abbreviation Definition
   - UST underground storage tank
   - PSL project screening level
   - 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 low
   - J+ the result was an estimated quantity, but the result may be biased high
   - U the analyte was not detected and was reported as less than the LOD
   - UJ the analyte was not detected and was reported as less than the LOD. However, the associated numerical value is approximate.
6. Sensitive infrastructure has been removed from the figure for public dissemination.

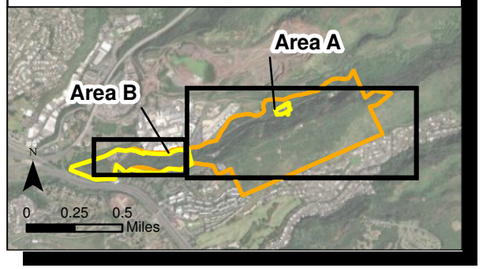
Figure 14
Summary of September 2023 Baseline Sampling
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

O:\CVI\N6274223F0178 60716457-HNL\1900 CAD GIS\920 929 GIS Graphics\920 GIS\02 Maps\38 RevWP V9 removed\Fig 14 September 2023 Baseline Sampling Results.mxd 6/15/2026





Location Map



Legend

- Former Location of AFFF Drain Line Retention Tank
- Perched Monitoring Location with PFOS Exceedance
- Perched Monitoring Location with PFOS Detected Below the PSL
- Stream
- Red Hill Facility Boundary
- Potential Source Area

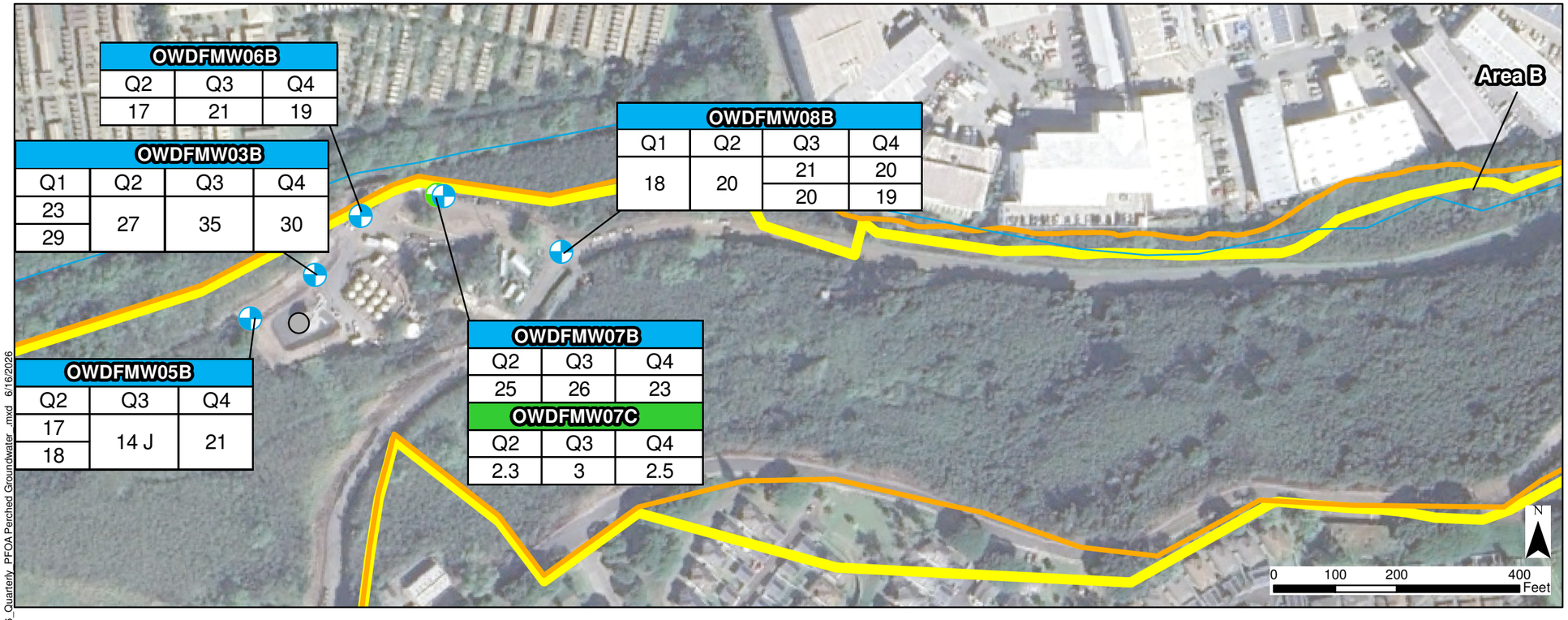
Well Name			
Q1 Concentration (ng/L)	Q2 Concentration (ng/L)	Q3 Concentration (ng/L)	Q4 Concentration (ng/L)

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Basemap: Google Earth, downloaded on January 2025.
3. Units are in nanograms per liter (ng/L)
4. Abbreviation Definition
   - PSL project screening level
   - UST underground storage tank
   - PFOS perfluorooctane sulfonate
   - 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
   - U the analyte was not detected
   - Q1 First Quarter
   - Q2 Second Quarter
   - Q3 Third Quarter
   - Q4 Fourth Quarter
5. PFOS PSL = 4 ng/L
6. Sensitive infrastructure has been removed from the figure for public dissemination.

Figure 15
Expedited Quarterly Sampling Results - PFOS Perched Groundwater
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

O:\CVIN\60274223\F0178_60716457-HNL11900_CAD_GIS\920_929_GIS_Graphics\920_GIS\02_Maps\38_RevWP_V9_removed\Fig_15_Quarterly_PFOS Perched Groundwater_.mxd 6/16/2026



OWDFMW06B

Q2	Q3	Q4
17	21	19

OWDFMW03B

Q1	Q2	Q3	Q4
23	27	35	30
29			

OWDFMW08B

Q1	Q2	Q3	Q4
18	20	21	20
		20	19

OWDFMW05B

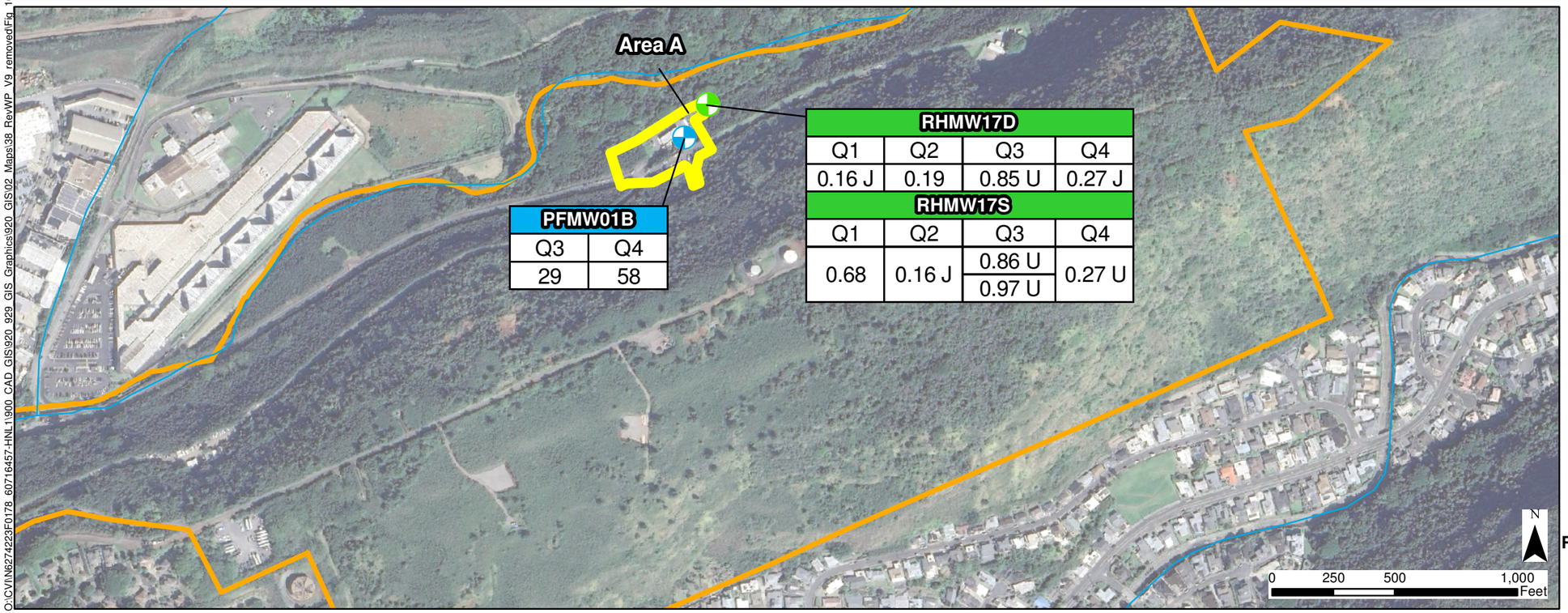
Q2	Q3	Q4
17	14 J	21
18		

OWDFMW07B

Q2	Q3	Q4
25	26	23

OWDFMW07C

Q2	Q3	Q4
2.3	3	2.5



PFMW01B

Q3	Q4
29	58

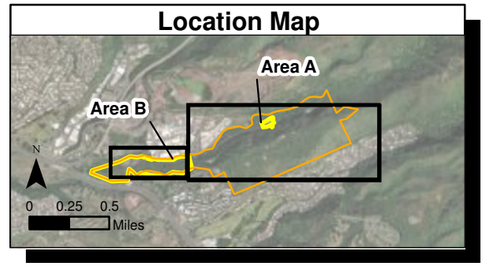
RHMW17D

Q1	Q2	Q3	Q4
0.16 J	0.19	0.85 U	0.27 J

RHMW17S

Q1	Q2	Q3	Q4
0.68	0.16 J	0.86 U	0.27 U
		0.97 U	

Location Map



Legend

- Former Location of AFFF Drain Line Retention Tank
- Perched Monitoring Location with PFOA PSL Exceedance
- Perched Monitoring Location with PFOA Detected Below the PSL
- Stream
- Red Hill Facility Boundary
- Potential Source Area

Well Name			
Q1 Concentration (ng/L)	Q2 Concentration (ng/L)	Q3 Concentration (ng/L)	Q4 Concentration (ng/L)

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Basemap: Google Earth, downloaded on January 2025.
3. Units are in nanograms per liter (ng/L)
4. Abbreviation Definition
   - PSL project screening level
   - UST underground storage tank
   - PFOA perfluorooctanoic acid
   - 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
   - U the analyte was not detected
   - Q1 First Quarter
   - Q2 Second Quarter
   - Q3 Third Quarter
   - Q4 Fourth Quarter
5. PFOA PSL = 4 ng/L
6. Sensitive infrastructure has been removed from the figure for public dissemination.

Figure 16
Expedited Quarterly Sampling Results - PFOA Perched Groundwater
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

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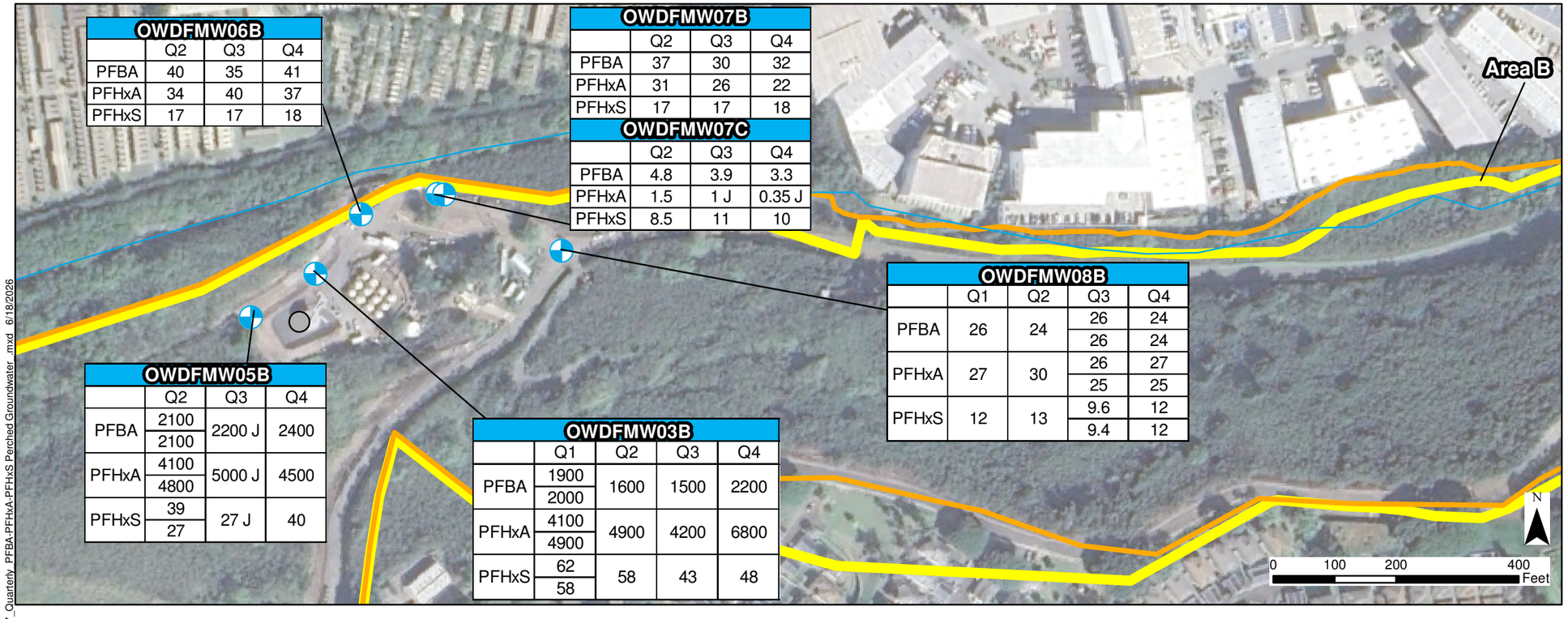


OWDFMW06B

	Q2	Q3	Q4
PFBA	40	35	41
PFHxA	34	40	37
PFHxS	17	17	18

OWDFMW07B

	Q2	Q3	Q4
PFBA	37	30	32
PFHxA	31	26	22
PFHxS	17	17	18

OWDFMW07C

	Q2	Q3	Q4
PFBA	4.8	3.9	3.3
PFHxA	1.5	1 J	0.35 J
PFHxS	8.5	11	10

OWDFMW08B

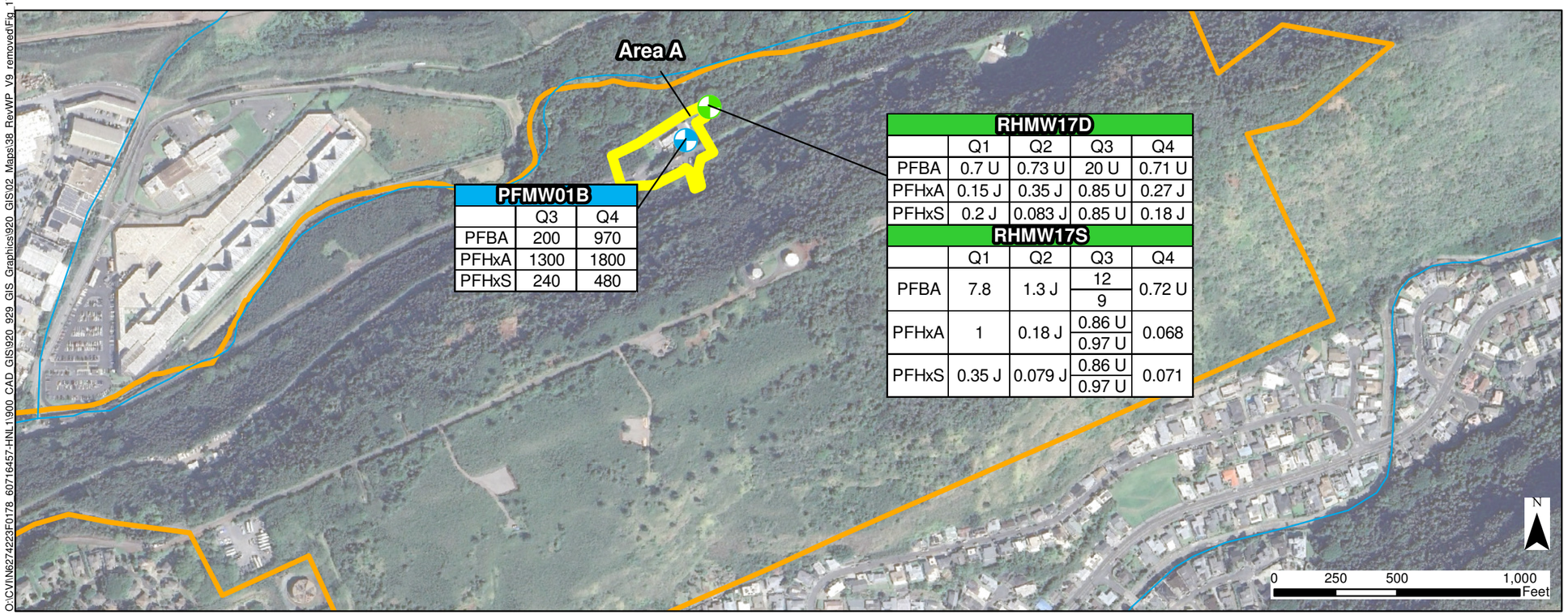
	Q1	Q2	Q3	Q4
PFBA	26	24	26	24
			26	24
PFHxA	27	30	26	27
			25	25
PFHxS	12	13	9.6	12
			9.4	12

OWDFMW05B

	Q2	Q3	Q4
PFBA	2100	2200 J	2400
	2100		
PFHxA	4100	5000 J	4500
	4800		
PFHxS	39	27 J	40
	27		

OWDFMW03B

	Q1	Q2	Q3	Q4
PFBA	1900	1600	1500	2200
	2000			
PFHxA	4100	4900	4200	6800
	4900			
PFHxS	62	58	43	48
	58			



PFMW01B

	Q3	Q4
PFBA	200	970
PFHxA	1300	1800
PFHxS	240	480

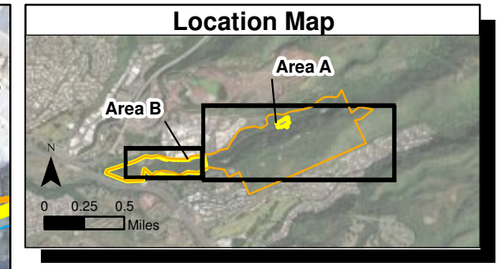
RHMW17D

	Q1	Q2	Q3	Q4
PFBA	0.7 U	0.73 U	20 U	0.71 U
PFHxA	0.15 J	0.35 J	0.85 U	0.27 J
PFHxS	0.2 J	0.083 J	0.85 U	0.18 J

RHMW17S

	Q1	Q2	Q3	Q4
PFBA	7.8	1.3 J	12	0.72 U
			9	
PFHxA	1	0.18 J	0.86 U	0.068
			0.97 U	
PFHxS	0.35 J	0.079 J	0.86 U	0.071
			0.97 U	

Location Map



Legend

- Former Location of AFFF Drain Line Retention Tank
- Perched Monitoring Location with PFBA, PFHxA, and/or PFHxS PSL Exceedance
- Perched Monitoring Location with PFBA, PFHxA, and/or PFHxS Detected Below the PSL
- Stream
- Red Hill Facility Boundary
- Potential Source Area

Well Name			
Q1 Concentration (ng/L)	Q2 Concentration (ng/L)	Q3 Concentration (ng/L)	Q4 Concentration (ng/L)

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Basemap: Google Earth, downloaded on January 2025.
3. Units are in nanograms per liter (ng/L)
4. Abbreviation Definition
   - PSL project screening level
   - UST underground storage tank
   - PFBA perfluorobutanoic acid
   - PFHxA perfluorohexanoic acid
   - PFHxS perfluorohexanesulfonic acid
   - J the reported result was an estimated value with an unknown bias
   - J+ the reported result was an estimated quantity, but the result may be biased high
   - U the analyte was not detected
   - Q1 First Quarter
   - Q2 Second Quarter
   - Q3 Third Quarter
   - Q4 Fourth Quarter
5. PFBA PSL = 1800 ng/L
   PFHxA PSL = 990 ng/L
   PFHxS PSL = 10 ng/L
6. Sensitive infrastructure has been removed from the figure for public dissemination.

Figure 17
Expedited Quarterly Sampling Results - PFBA, PFHxA, and PFHxS Perched Groundwater
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

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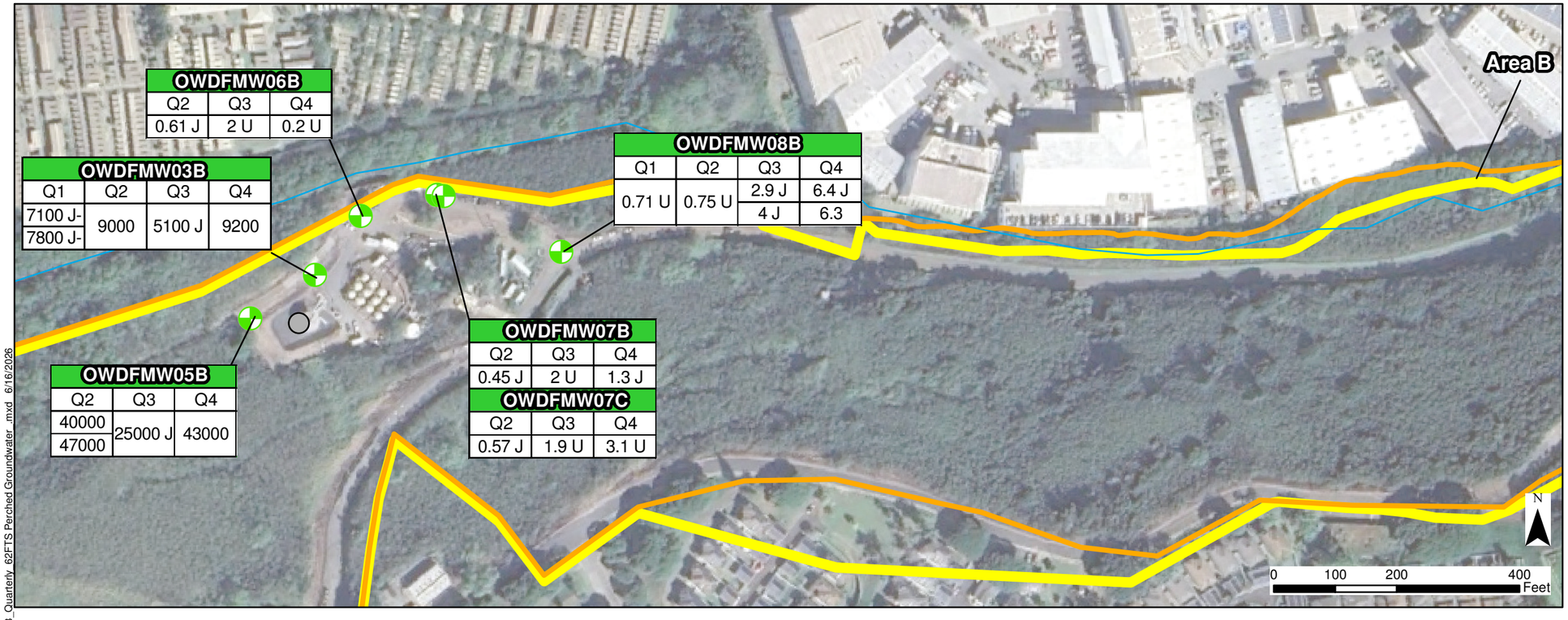


OWDFMW06B

Q2	Q3	Q4
0.61 J	2 U	0.2 U

OWDFMW03B

Q1	Q2	Q3	Q4
7100 J- 7800 J-	9000	5100 J	9200

OWDFMW08B

Q1	Q2	Q3	Q4
0.71 U	0.75 U	2.9 J 4 J	6.4 J 6.3

OWDFMW07B

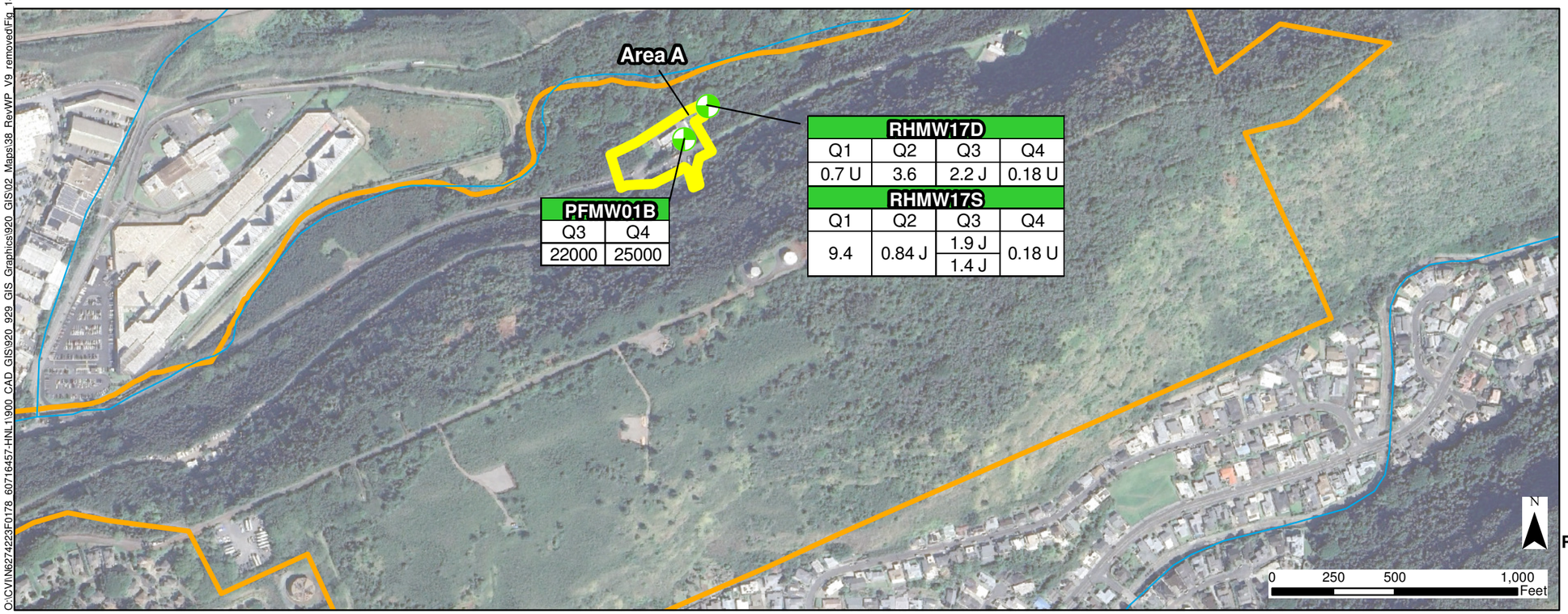
Q2	Q3	Q4
0.45 J	2 U	1.3 J

OWDFMW07C

Q2	Q3	Q4
0.57 J	1.9 U	3.1 U

OWDFMW05B

Q2	Q3	Q4
40000 47000	25000 J	43000



RHMW17D

Q1	Q2	Q3	Q4
0.7 U	3.6	2.2 J	0.18 U

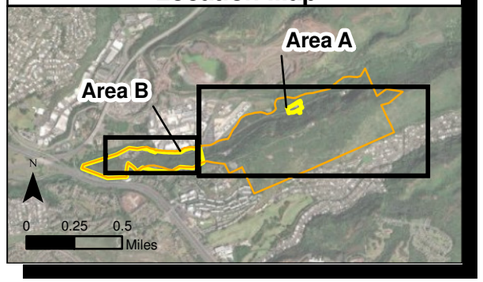
RHMW17S

Q1	Q2	Q3	Q4
9.4	0.84 J	1.9 J 1.4 J	0.18 U

PFMW01B

Q3	Q4
22000	25000

Location Map



Legend

- Former Location of AFFF Drain Line Retention Tank
- Perched Monitoring Location with 6:2 FTS Detected
- Stream
- Red Hill Facility Boundary
- Potential Source Area

Well Name			
Q1 Concentration (ng/L)	Q2 Concentration (ng/L)	Q3 Concentration (ng/L)	Q4 Concentration (ng/L)

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Basemap: Google Earth, downloaded on January 2025.
3. Units are in nanograms per liter (ng/L)
4. Abbreviation Definition
   - PSL project screening level
   - UST underground storage tank
   - 6:2 FTS 1H,1H, 2H, 2H-perfluorooctane sulfonic acid
   - 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 low
   - U the analyte was not detected
   - Q1 First Quarter
   - Q2 Second Quarter
   - Q3 Third Quarter
   - Q4 Fourth Quarter
5. There is no PSL for 6:2 FTS
6. Sensitive infrastructure has been removed from the figure for public dissemination.

Figure 18
Expedited Quarterly Sampling Results - 6:2 FTS Perched Groundwater
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

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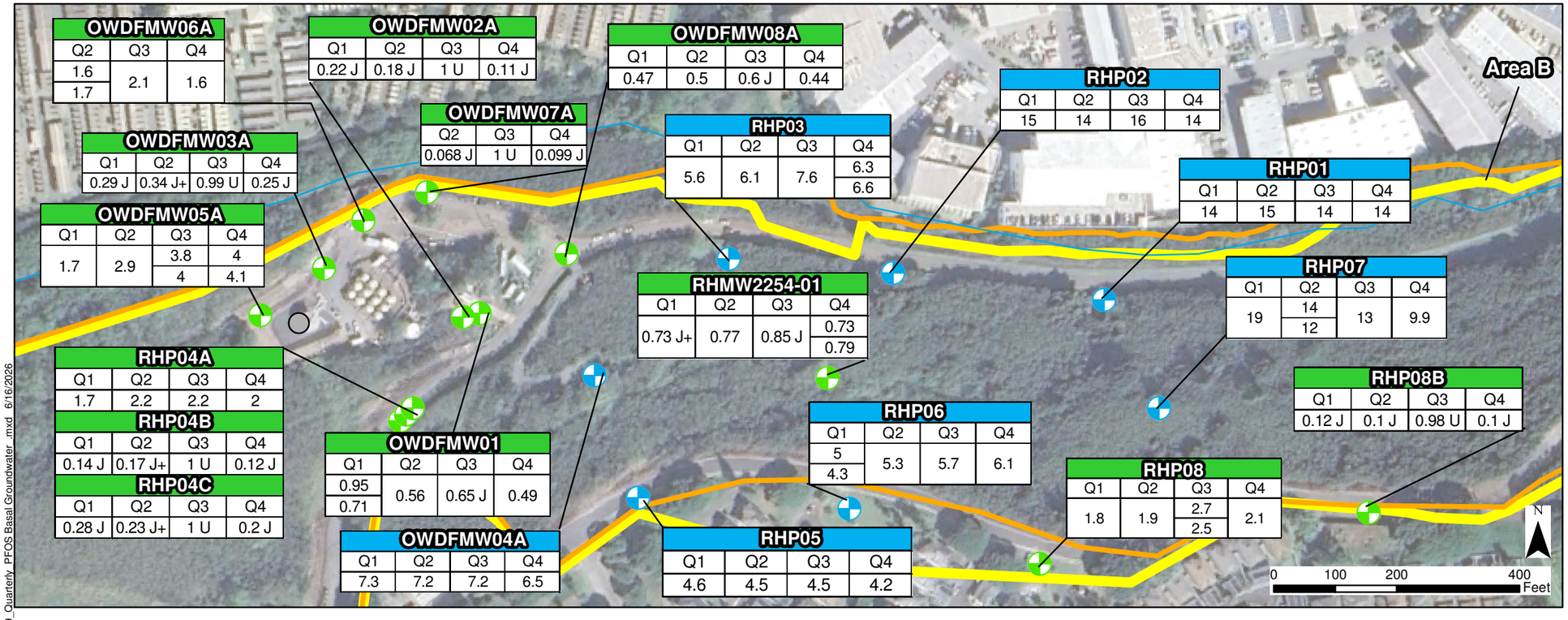

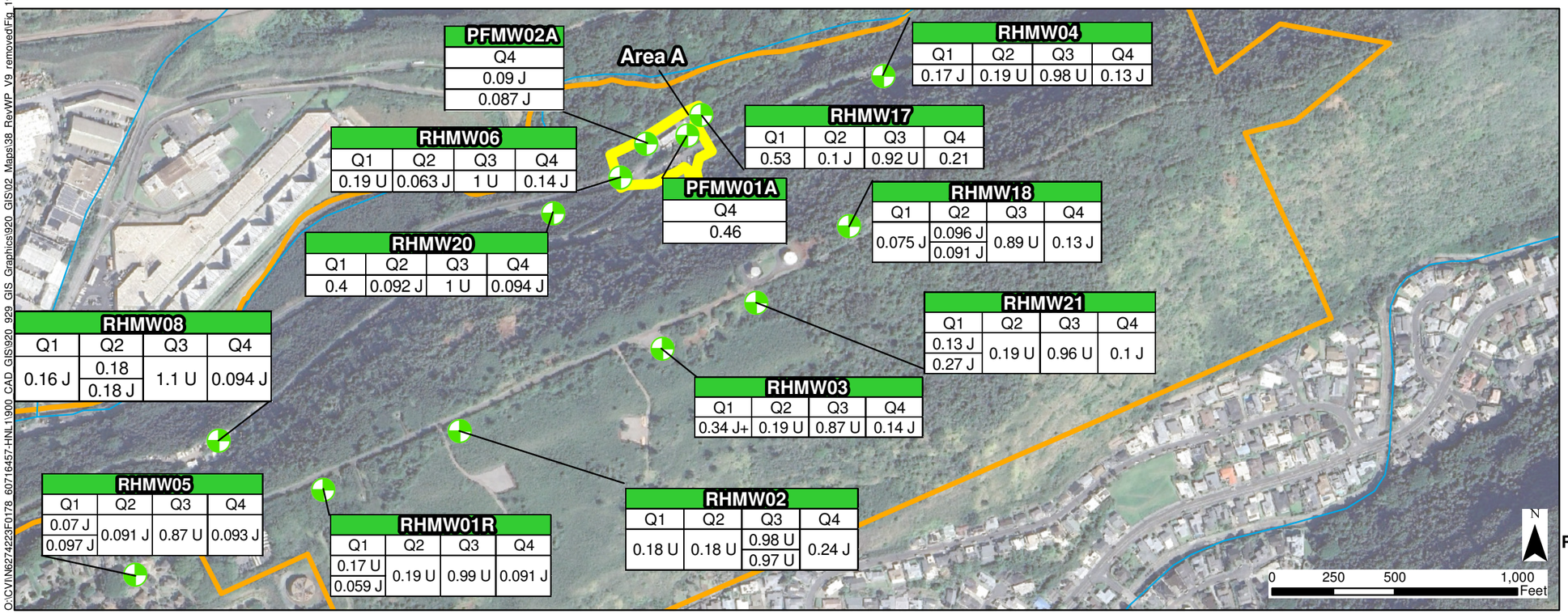

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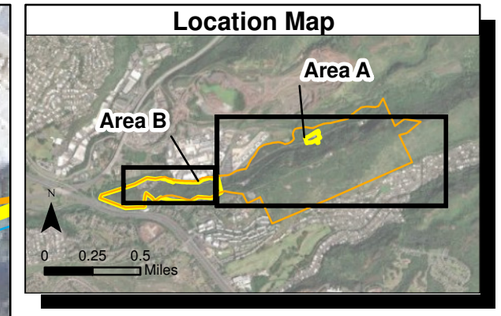
Location Map



Legend

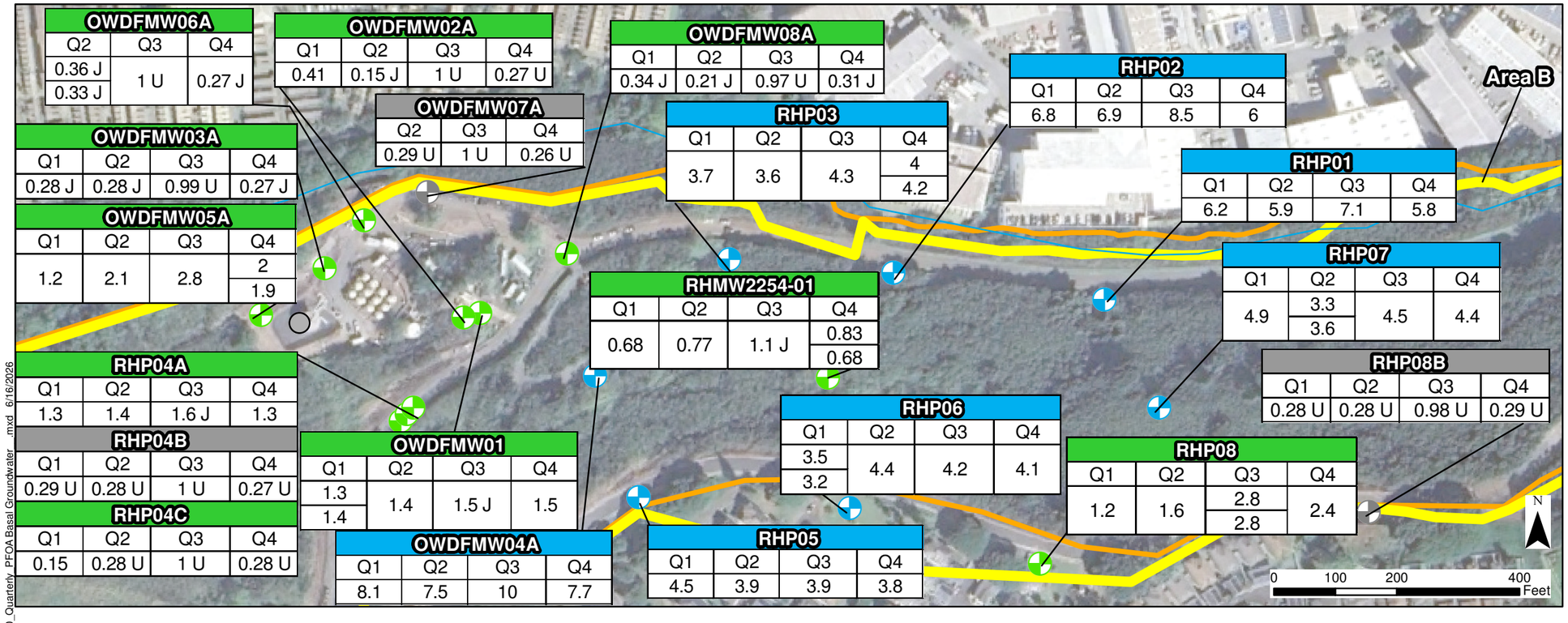
- Former Location of AFFF Drain Line Retention Tank
- Basal Monitoring Location with PFOS PSL Exceedance
- Basal Monitoring Location with PFOS Detected Below the PSL
- Stream
- Red Hill Facility Boundary
- Potential Source Area

Well Name			
Q1 Concentration (ng/L)	Q2 Concentration (ng/L)	Q3 Concentration (ng/L)	Q4 Concentration (ng/L)

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Basemap: Google Earth, downloaded on January 2025.
3. Units are in nanograms per liter (ng/L)
4. Abbreviation Definition
   - PSL project screening level
   - UST underground storage tank
   - PFOS perfluorooctane sulfonate
   - 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
   - U the analyte was not detected
   - Q1 First Quarter
   - Q2 Second Quarter
   - Q3 Third Quarter
   - Q4 Fourth Quarter
5. PFOS PSL = 4 ng/L
6. Sensitive infrastructure has been removed from the figure for public dissemination.

Figure 19
Expedited Quarterly Sampling Results - PFOS Basal Groundwater
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii



OWDFMW06A

Q2	Q3	Q4
0.36 J 0.33 J	1 U	0.27 J

OWDFMW02A

Q1	Q2	Q3	Q4
0.41	0.15 J	1 U	0.27 U

OWDFMW08A

Q1	Q2	Q3	Q4
0.34 J	0.21 J	0.97 U	0.31 J

OWDFMW07A

Q2	Q3	Q4
0.29 U	1 U	0.26 U

OWDFMW03A

Q1	Q2	Q3	Q4
0.28 J	0.28 J	0.99 U	0.27 J

RHP03

Q1	Q2	Q3	Q4
3.7	3.6	4.3	4 4.2

RHP02

Q1	Q2	Q3	Q4
6.8	6.9	8.5	6

RHP01

Q1	Q2	Q3	Q4
6.2	5.9	7.1	5.8

OWDFMW05A

Q1	Q2	Q3	Q4
1.2	2.1	2.8	2 1.9

RHMW2254-01

Q1	Q2	Q3	Q4
0.68	0.77	1.1 J	0.83 0.68

RHP07

Q1	Q2	Q3	Q4
4.9	3.3 3.6	4.5	4.4

RHP08B

Q1	Q2	Q3	Q4
0.28 U	0.28 U	0.98 U	0.29 U

RHP04A

Q1	Q2	Q3	Q4
1.3	1.4	1.6 J	1.3

RHP06

Q1	Q2	Q3	Q4
3.5 3.2	4.4	4.2	4.1

RHP04B

Q1	Q2	Q3	Q4
0.29 U	0.28 U	1 U	0.27 U

OWDFMW01

Q1	Q2	Q3	Q4
1.3 1.4	1.4	1.5 J	1.5

RHP08

Q1	Q2	Q3	Q4
1.2	1.6	2.8 2.8	2.4

RHP04C

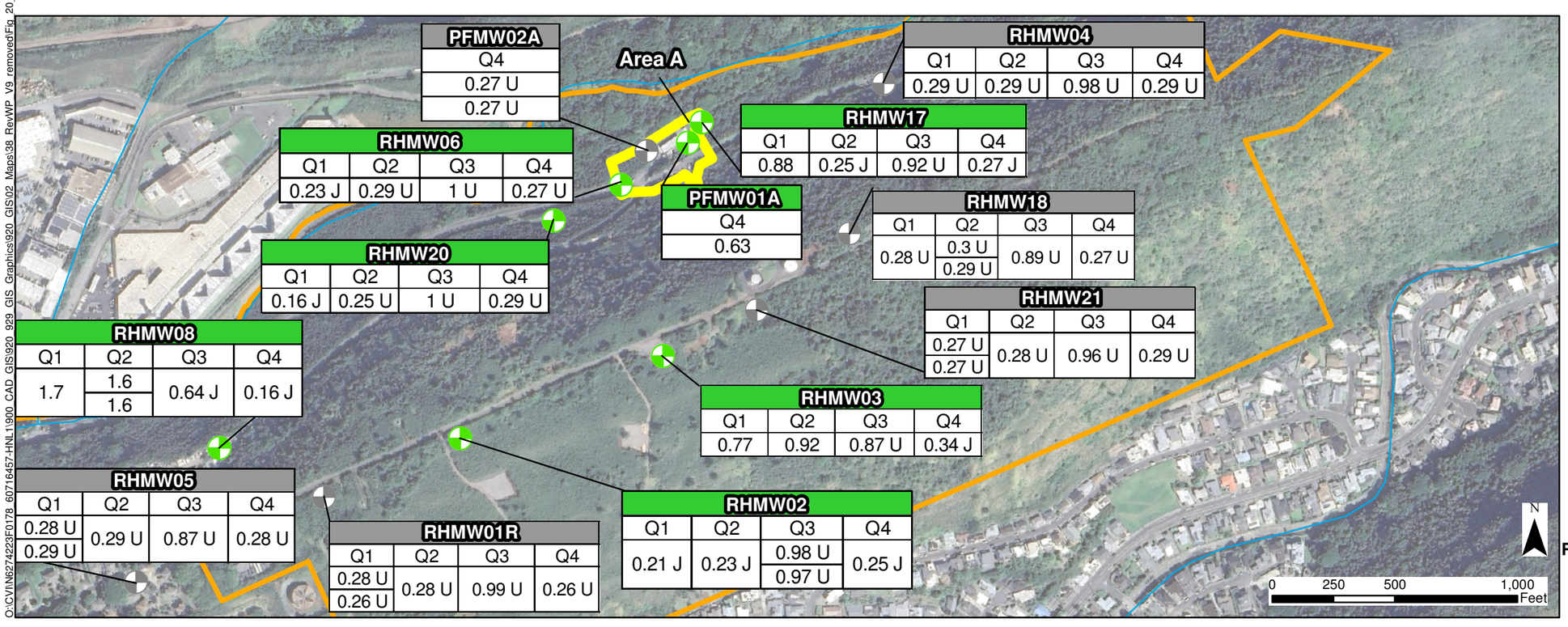
Q1	Q2	Q3	Q4
0.15	0.28 U	1 U	0.28 U

OWDFMW04A

Q1	Q2	Q3	Q4
8.1	7.5	10	7.7

RHP05

Q1	Q2	Q3	Q4
4.5	3.9	3.9	3.8



PFMW02A

Q4
0.27 U
0.27 U

RHMW04

Q1	Q2	Q3	Q4
0.29 U	0.29 U	0.98 U	0.29 U

RHMW17

Q1	Q2	Q3	Q4
0.88	0.25 J	0.92 U	0.27 J

RHMW06

Q1	Q2	Q3	Q4
0.23 J	0.29 U	1 U	0.27 U

PFMW01A

Q4
0.63

RHMW18

Q1	Q2	Q3	Q4
0.28 U	0.3 U 0.29 U	0.89 U	0.27 U

RHMW20

Q1	Q2	Q3	Q4
0.16 J	0.25 U	1 U	0.29 U

RHMW21

Q1	Q2	Q3	Q4
0.27 U 0.27 U	0.28 U	0.96 U	0.29 U

RHMW08

Q1	Q2	Q3	Q4
1.7	1.6 1.6	0.64 J	0.16 J

RHMW03

Q1	Q2	Q3	Q4
0.77	0.92	0.87 U	0.34 J

RHMW05

Q1	Q2	Q3	Q4
0.28 U 0.29 U	0.29 U	0.87 U	0.28 U

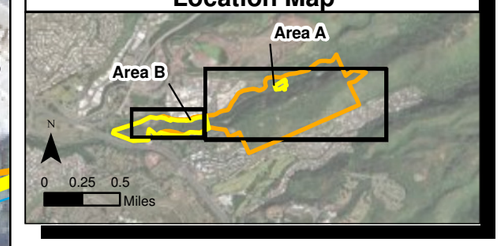
RHMW01R

Q1	Q2	Q3	Q4
0.28 U 0.26 U	0.28 U	0.99 U	0.26 U

RHMW02

Q1	Q2	Q3	Q4
0.21 J	0.23 J	0.98 U 0.97 U	0.25 J

Location Map



Legend

- Former Location of AFFF Drain Line Retention Tank
- Basal Monitoring Location with PFOA PSL Exceedance
- Basal Monitoring Location with PFOA Detected Below the PSL
- Basal Monitoring Location with No PFOA Detections
- Stream
- Red Hill Facility Boundary
- Potential Source Area

Well Name			
Q1 Concentration (ng/L)	Q2 Concentration (ng/L)	Q3 Concentration (ng/L)	Q4 Concentration (ng/L)

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Basemap: Google Earth, downloaded on January 2025.
3. Units are in nanograms per liter (ng/L)
4. Abbreviation Definition
   - PSL — project screening level
   - UST — underground storage tank
   - PFOA — perfluorooctanoic acid
   - 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
   - U — the analyte was not detected
   - Q1 — First Quarter
   - Q2 — Second Quarter
   - Q3 — Third Quarter
   - Q4 — Fourth Quarter
5. PFOA PSL = 4 ng/L
6. Sensitive infrastructure has been removed from the figure for public dissemination.

Figure 20
Expedited Quarterly Sampling Results - PFOA Basal Groundwater
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

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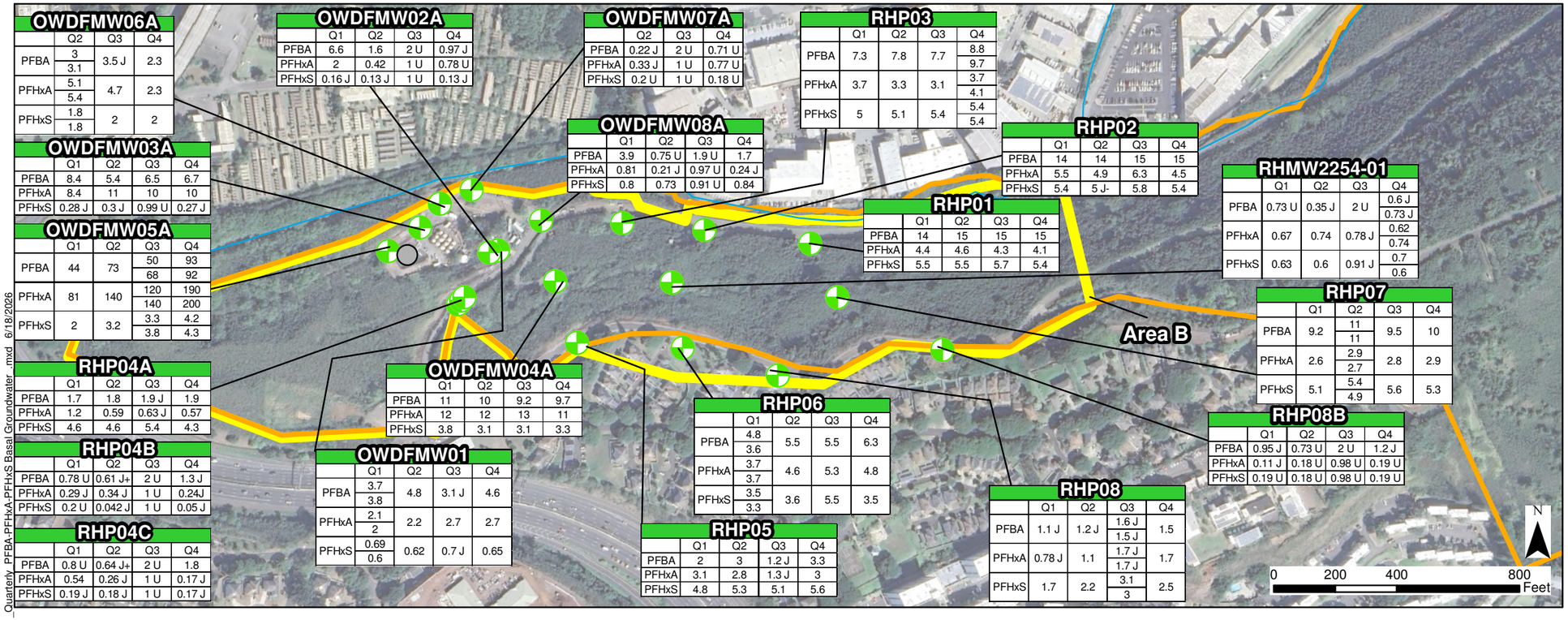


OWDFMW06A

	Q2	Q3	Q4
PFBA	3	3.5 J	2.3
	3.1		
PFHxA	5.1	4.7	2.3
	5.4		
PFHxS	1.8	2	2
	1.8		

OWDFMW02A

	Q1	Q2	Q3	Q4
PFBA	6.6	1.6	2 U	0.97 J
PFHxA	2	0.42	1 U	0.78 U
PFHxS	0.16 J	0.13 J	1 U	0.13 J

OWDFMW07A

	Q2	Q3	Q4
PFBA	0.22 J	2 U	0.71 U
PFHxA	0.33 J	1 U	0.77 U
PFHxS	0.2 U	1 U	0.18 U

RHP03

	Q1	Q2	Q3	Q4
PFBA	7.3	7.8	7.7	8.8
				9.7
PFHxA	3.7	3.3	3.1	3.7
				4.1
PFHxS	5	5.1	5.4	5.4
				5.4

OWDFMW08A

	Q1	Q2	Q3	Q4
PFBA	3.9	0.75 U	1.9 U	1.7
PFHxA	0.81	0.21 J	0.97 U	0.24 J
PFHxS	0.8	0.73	0.91 U	0.84

RHP02

	Q1	Q2	Q3	Q4
PFBA	14	14	15	15
PFHxA	5.5	4.9	6.3	4.5
PFHxS	5.4	5 J-	5.8	5.4

OWDFMW03A

	Q1	Q2	Q3	Q4
PFBA	8.4	5.4	6.5	6.7
PFHxA	8.4	11	10	10
PFHxS	0.28 J	0.3 J	0.99 U	0.27 J

RHP01

	Q1	Q2	Q3	Q4
PFBA	14	15	15	15
PFHxA	4.4	4.6	4.3	4.1
PFHxS	5.5	5.5	5.7	5.4

RHMW2254-01

	Q1	Q2	Q3	Q4
PFBA	0.73 U	0.35 J	2 U	0.6 J
				0.73 J
PFHxA	0.67	0.74	0.78 J	0.62
				0.74
PFHxS	0.63	0.6	0.91 J	0.7
				0.6

OWDFMW05A

	Q1	Q2	Q3	Q4
PFBA	44	73	50	93
			68	92
PFHxA	81	140	120	190
			140	200
PFHxS	2	3.2	3.3	4.2
			3.8	4.3

RHP07

	Q1	Q2	Q3	Q4
PFBA	9.2	11	9.5	10
		11		
PFHxA	2.6	2.9	2.8	2.9
		2.7		
PFHxS	5.1	5.4	5.6	5.3
		4.9		

RHP04A

	Q1	Q2	Q3	Q4
PFBA	1.7	1.8	1.9 J	1.9
PFHxA	1.2	0.59	0.63 J	0.57
PFHxS	4.6	4.6	5.4	4.3

OWDFMW04A

	Q1	Q2	Q3	Q4
PFBA	11	10	9.2	9.7
PFHxA	12	12	13	11
PFHxS	3.8	3.1	3.1	3.3

RHP06

	Q1	Q2	Q3	Q4
PFBA	4.8	5.5	5.5	6.3
	3.6			
PFHxA	3.7	4.6	5.3	4.8
	3.7			
PFHxS	3.5	3.6	5.5	3.5
	3.3			

RHP08B

	Q1	Q2	Q3	Q4
PFBA	0.95 J	0.73 U	2 U	1.2 J
PFHxA	0.11 J	0.18 U	0.98 U	0.19 U
PFHxS	0.19 U	0.18 U	0.98 U	0.19 U

RHP04B

	Q1	Q2	Q3	Q4
PFBA	0.78 U	0.61 J+	2 U	1.3 J
PFHxA	0.29 J	0.34 J	1 U	0.24J
PFHxS	0.2 U	0.042 J	1 U	0.05 J

OWDFMW01

	Q1	Q2	Q3	Q4
PFBA	3.7	4.8	3.1 J	4.6
	3.8			
PFHxA	2.1	2.2	2.7	2.7
	2			
PFHxS	0.69	0.62	0.7 J	0.65
	0.6			

RHP08

	Q1	Q2	Q3	Q4
PFBA	1.1 J	1.2 J	1.6 J	1.5
			1.5 J	
PFHxA	0.78 J	1.1	1.7 J	1.7
			1.7 J	
PFHxS	1.7	2.2	3.1	2.5
			3	

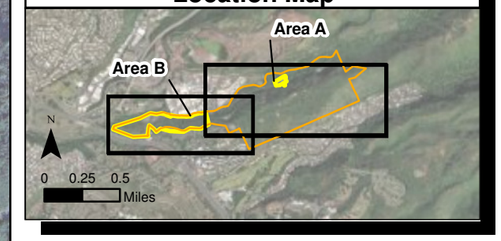
RHP04C

	Q1	Q2	Q3	Q4
PFBA	0.8 U	0.64 J+	2 U	1.8
PFHxA	0.54	0.26 J	1 U	0.17 J
PFHxS	0.19 J	0.18 J	1 U	0.17 J

RHP05

	Q1	Q2	Q3	Q4
PFBA	2	3	1.2 J	3.3
PFHxA	3.1	2.8	1.3 J	3
PFHxS	4.8	5.3	5.1	5.6

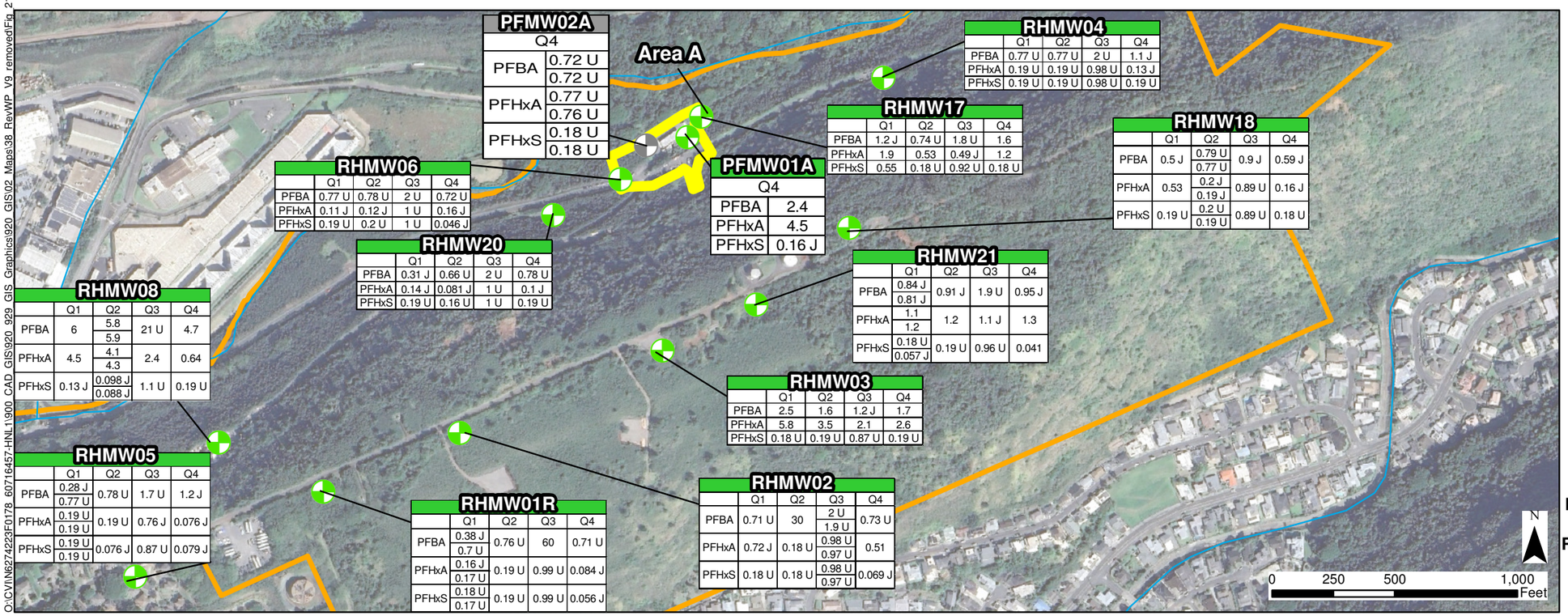
Location Map



Legend

- Former Location of AFFF Drain Line Retention Tank
- Basal Monitoring Location with PFBA, PFHxA, and/or PFHxS Detected Below the PSL
- Basal Monitoring Well with No PFBA, PFHxA, and/or PFHxS Detections for All Quarterly Sampling Events
- Stream
- Red Hill Facility Boundary
- Potential Source

Well Name			
Q1 Concentration (ng/L)	Q2 Concentration (ng/L)	Q3 Concentration (ng/L)	Q4 Concentration (ng/L)



PFMW02A

	Q4
PFBA	0.72 U
	0.72 U
PFHxA	0.77 U
	0.76 U
PFHxS	0.18 U
	0.18 U

RHMW04

	Q1	Q2	Q3	Q4
PFBA	0.77 U	0.77 U	2 U	1.1 J
PFHxA	0.19 U	0.19 U	0.98 U	0.13 J
PFHxS	0.19 U	0.19 U	0.98 U	0.19 U

RHMW17

	Q1	Q2	Q3	Q4
PFBA	1.2 J	0.74 U	1.8 U	1.6
PFHxA	1.9	0.53	0.49 J	1.2
PFHxS	0.55	0.18 U	0.92 U	0.18 U

RHMW18

	Q1	Q2	Q3	Q4
PFBA	0.5 J	0.79 U	0.9 J	0.59 J
		0.77 U		
PFHxA	0.53	0.2 J	0.89 U	0.16 J
		0.19 J		
PFHxS	0.19 U	0.2 U	0.89 U	0.18 U
		0.19 U		

RHMW06

	Q1	Q2	Q3	Q4
PFBA	0.77 U	0.78 U	2 U	0.72 U
PFHxA	0.11 J	0.12 J	1 U	0.16 J
PFHxS	0.19 U	0.2 U	1 U	0.046 J

PFMW01A

	Q4
PFBA	2.4
PFHxA	4.5
PFHxS	0.16 J

RHMW20

	Q1	Q2	Q3	Q4
PFBA	0.31 J	0.66 U	2 U	0.78 U
PFHxA	0.14 J	0.081 J	1 U	0.1 J
PFHxS	0.19 U	0.16 U	1 U	0.19 U

RHMW21

	Q1	Q2	Q3	Q4
PFBA	0.84 J	0.91 J	1.9 U	0.95 J
	0.81 J			
PFHxA	1.1	1.2	1.1 J	1.3
	1.2			
PFHxS	0.18 U	0.19 U	0.96 U	0.041
	0.057 J			

RHMW08

	Q1	Q2	Q3	Q4
PFBA	6	5.8	21 U	4.7
		5.9		
PFHxA	4.5	4.1	2.4	0.64
		4.3		
PFHxS	0.13 J	0.098 J	1.1 U	0.19 U
		0.088 J		

RHMW03

	Q1	Q2	Q3	Q4
PFBA	2.5	1.6	1.2 J	1.7
PFHxA	5.8	3.5	2.1	2.6
PFHxS	0.18 U	0.19 U	0.87 U	0.19 U

RHMW05

	Q1	Q2	Q3	Q4
PFBA	0.28 J	0.78 U	1.7 U	1.2 J
	0.77 U			
PFHxA	0.19 U	0.19 U	0.76 J	0.076 J
	0.19 U			
PFHxS	0.19 U	0.076 J	0.87 U	0.079 J
	0.19 U			

RHMW01R

	Q1	Q2	Q3	Q4
PFBA	0.38 J	0.76 U	60	0.71 U
	0.7 U			
PFHxA	0.16 J	0.19 U	0.99 U	0.084 J
	0.17 U			
PFHxS	0.18 U	0.19 U	0.99 U	0.056 J
	0.17 U			

RHMW02

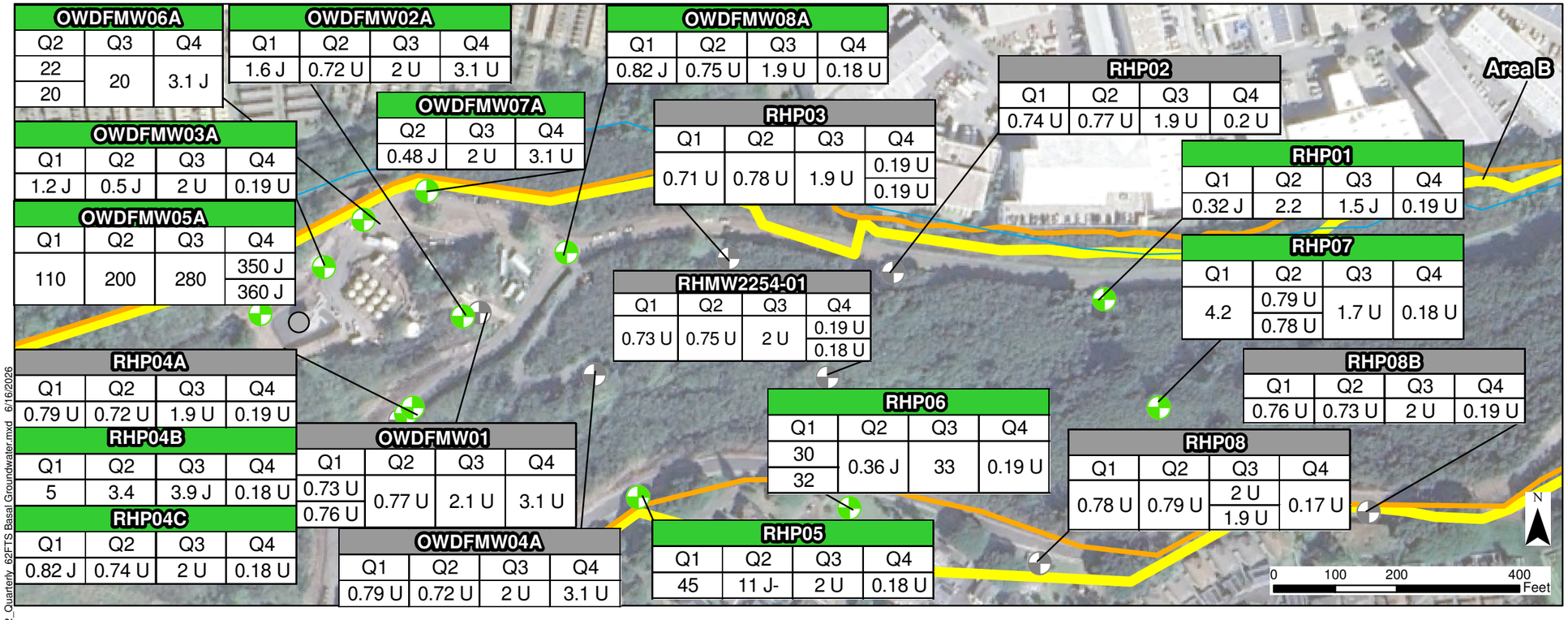
	Q1	Q2	Q3	Q4
PFBA	0.71 U	30	2 U	0.73 U
			1.9 U	
PFHxA	0.72 J	0.18 U	0.98 U	0.51
			0.97 U	
PFHxS	0.18 U	0.18 U	0.98 U	0.069 J
			0.97 U	

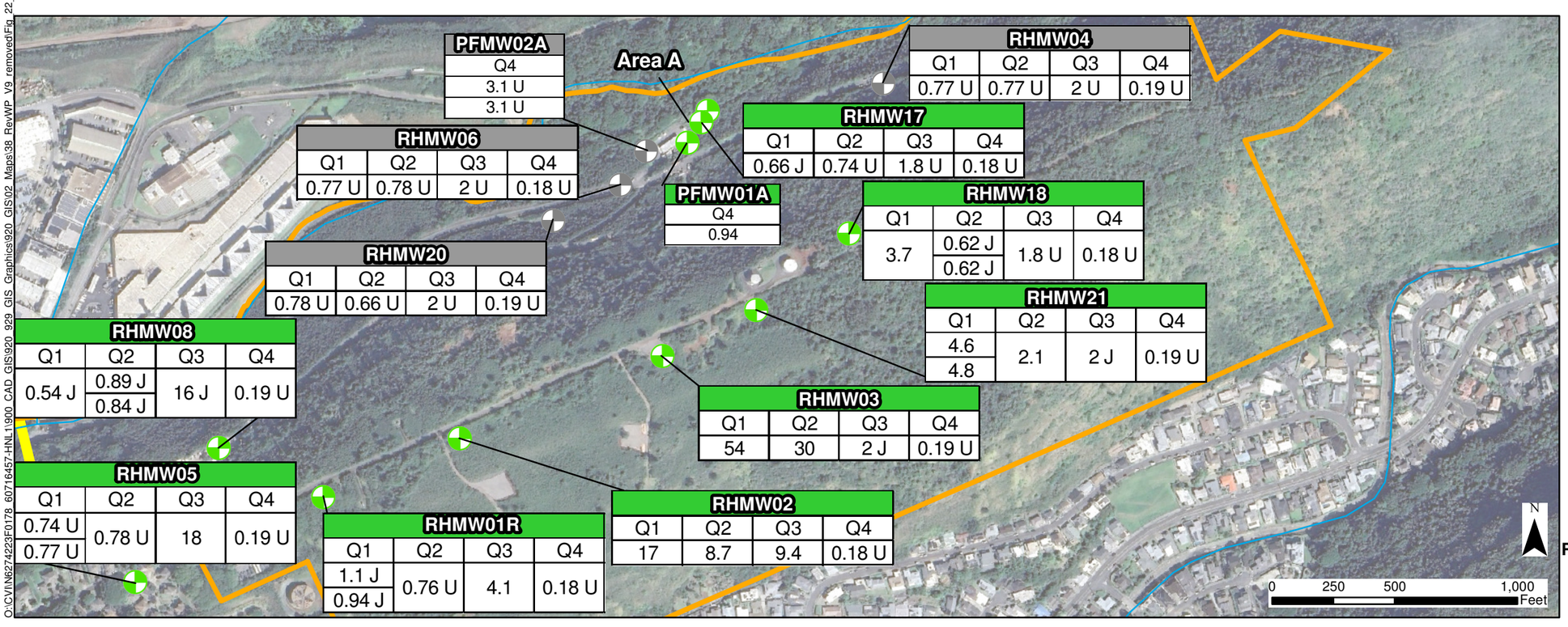
Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Basemap: Google Earth, downloaded on January 2025.
3. Units are in nanograms per liter (ng/L)
4. Abbreviation Definition
   - PSL project screening level
   - UST underground storage tank
   - PFBA perfluorobutanoic acid
   - PFHxA perfluorohexanoic acid
   - PFHxS perfluorohexanesulfonic acid
   - J the reported result was an estimated value with an unknown bias
   - J+ the reported result was an estimated quantity, but the result may be biased high
   - U the analyte was not detected
   - Q1 First Quarter
   - Q2 Second Quarter
   - Q3 Third Quarter
   - Q4 Fourth Quarter
5. PFBA PSL = 1800 ng/L
   PFHxA PSL = 990 ng/L
   PFHxS PSL = 10 ng/L
6. Sensitive infrastructure has been removed from the figure for public dissemination.

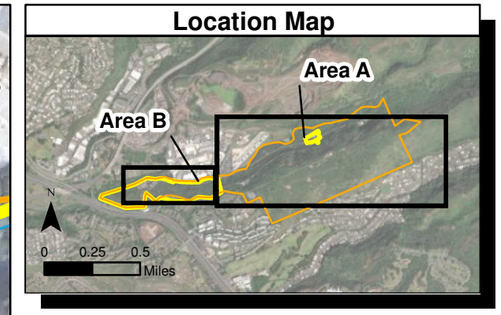
Figure 21
Expedited Quarterly Sampling Results - PFBA, PFHxA, and PFHxS Basal Groundwater
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oah, Hawaii

O:\CVI\N6274223F0178_60716457-HNL11900_CAD_GIS\920_929_GIS_Graphics\920_GIS\02_Maps\38_RevWP_V9_removed\Fig 21_Quarterly_PFBA-PFHxA-PFHxS Basal Groundwater_.mxd 6/18/2026





Location Map



Legend

- Former Location of AFFF Drain Line Retention Tank
- Basal Monitoring Location with 6:2 FTS Detections
- Basal Monitoring Well with No 6:2 FTS Detections for All Quarterly Sampling Events
- Stream
- Red Hill Facility Boundary
- Potential Source Area

Well Name			
Q1 Concentration (ng/L)	Q2 Concentration (ng/L)	Q3 Concentration (ng/L)	Q4 Concentration (ng/L)

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Basemap: Google Earth, downloaded on January 2025.
3. Units are in nanograms per liter (ng/L)
4. Abbreviation Definition
   - PSL project screening level
   - UST underground storage tank
   - 6:2 FTS 1H,1H, 2H, 2H-perfluorooctane sulfonic acid
   - 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 low
   - U the analyte was not detected
   - Q1 First Quarter
   - Q2 Second Quarter
   - Q3 Third Quarter
   - Q4 Fourth Quarter
5. There is no PSL for 6:2 FTS
6. Sensitive infrastructure has been removed from the figure for public dissemination.

Figure 22
Expedited Quarterly Sampling Results - 6:2 FTS Basal Groundwater
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

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(b) (3)

[redacted]

Figure 23
Geostatistical Interpretation of Expedited Quarterly Results- PFOS Area B
Perched Groundwater
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

(b) (3)

[redacted]

Figure 24
Geostatistical Interpretation of Expedited Quarterly Results- PFOA Area B
Perched Groundwater
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

(b) (3)

[redacted]

Figure 25
Geostatistical Interpretation of Expedited Quarterly Results- PFOS Area B
Basal Groundwater
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

(b) (3)

[redacted]

Figure 26
Geostatistical Interpretation of Expedited Quarterly Results- PFOA Area B
Basal Groundwater
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

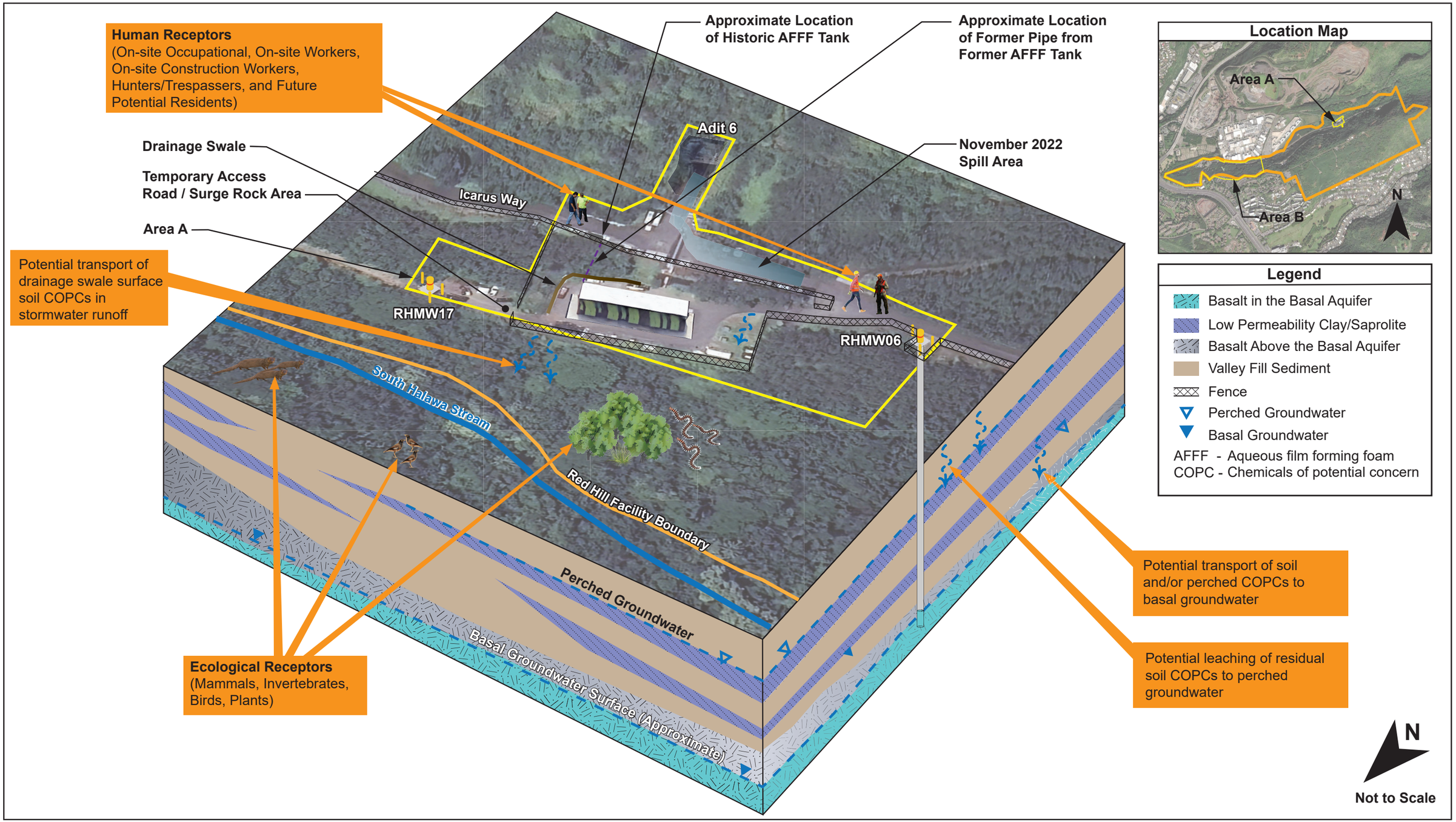

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Figure 27
Area A - Pictorial Conceptual Site Model
Draft Remedial Investigation Work Plan
Per-and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

Contributing Source	Transport Mechanism	Exposure Route	Scenario	Onsite Occupational Worker	Onsite Construction Worker	Onsite Resident (Adult/Child)	Hunter/ Trespasser (Adult/Child)
AFFF and TPH Release							
Surface Soil	Direct Contact	Incidental Ingestion: Dermal Contact:	Current:	Potentially Complete	Incomplete	N/A	Potentially Complete
			Future:	Potentially Complete	Potentially Complete	Potentially Complete	Potentially Complete
	Air Transport	Inhalation of Particulates:	Current:	Potentially Complete	Incomplete	N/A	Potentially Complete
			Future:	Potentially Complete	Potentially Complete	Potentially Complete	Potentially Complete
	Bio-uptake	Ingestion of Plants/ Animals:	Current:	Incomplete	Incomplete	N/A	Potentially Complete [a]
			Future:	Incomplete	Incomplete	Potentially Complete [a]	Potentially Complete [a]
	Sediment in Halawa Stream [b]	Incidental Ingestion and Dermal Contact:	Current:	Incomplete	Incomplete	N/A	Potentially Complete [b]
			Future:	Incomplete	Incomplete	Potentially Complete [b]	Potentially Complete [b]
Subsurface Soil	Direct Contact	Incidental Ingestion and Dermal Contact:	Current:	Incomplete	Incomplete	N/A	Incomplete
			Future:	Potentially Complete	Potentially Complete	Potentially Complete	Potentially Complete
	Air Transport	Inhalation of Particulates:	Current:	Incomplete	Incomplete	N/A	Incomplete
			Future:	Potentially Complete	Potentially Complete	Potentially Complete	Potentially Complete
	Groundwater	Ingestion:	Current:	Potentially Complete [a]	Incomplete	N/A	Incomplete
			Future:	Potentially Complete	Incomplete	Potentially Complete	Incomplete
		Dermal Contact:	Current:	Potentially Complete [a]	Incomplete	N/A	Incomplete
			Future:	Potentially Complete	Incomplete	Potentially Complete	Incomplete

Note: Shaded value indicates pathway to be evaluated in the risk assessment.
JBPHH Joint Base Pearl Harbor-Hickam
N/A not applicable
[a] Considered a potentially complete exposure pathway but exposure pathway is considered limited (no quantitative evaluation).
[b] Pathways are potentially complete but will only be evaluated if PFAS is detected in soil in the drainage ditches. If PFAS are found in the site soils, then an evaluation will be made to determine if off-site sampling in South Halawa Stream is necessary.

Figure 28
Area A – Human Health Exposure Pathway Evaluation
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

Historical Releases	Affected Media	Exposure Route	Terrestrial Receptors: Plants	Soil Invertebrates	Omnivorous Mammals	Omnivorous Birds	Insectivorous Birds
Slop Tank Discharge							
AFFF and TPH Release	Surface Soil	Direct Contact:	Potentially Complete	Potentially Complete	Potentially Complete [a]	Potentially Complete [a]	Potentially Complete [a]
		Incidental Ingestion:	N/A	Potentially Complete	Potentially Complete	Potentially Complete	Potentially Complete
		Food Web Transfer:	N/A	N/A	Potentially Complete	Potentially Complete	Potentially Complete
	Subsurface Soil	All Pathways:	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete
	Groundwater	All Pathways:	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete

Aquatic Receptors: Aquatic Life (incl. Plankton)	Sediment Biota	Fish	Water Birds
Stormwater Runoff to Halawa Stream — Direct Contact/ Ingestion:	Potentially Complete [b]	Potentially Complete [b]	Potentially Complete [b]	Potentially Complete [b]
Stormwater Runoff to Halawa Stream — Food Web Transfer:	N/A	Potentially Complete [b]	Potentially Complete [b]	Potentially Complete [b]

Note: Shaded value indicates pathway to be evaluated in the risk assessment
COPC chemical of potential concern
N/A not applicable (exposure route does not exist or is not normally evaluated as such in ecological risk assessment)
[a] Because of the presence of fur and feathers, direct contact to surface soil is very limited and does not warrant quantitative evaluation.
[b] pathways are potentially complete but will only be evaluated quantitatively if PFAS is detected in soil in drainage ditches. If PFAS are found in site surface soils, then an evaluation will be made to determine if off-site sampling in South Halawa Stream is necessary.

Figure 29
Area A – Ecological Exposure Pathway Evaluation
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

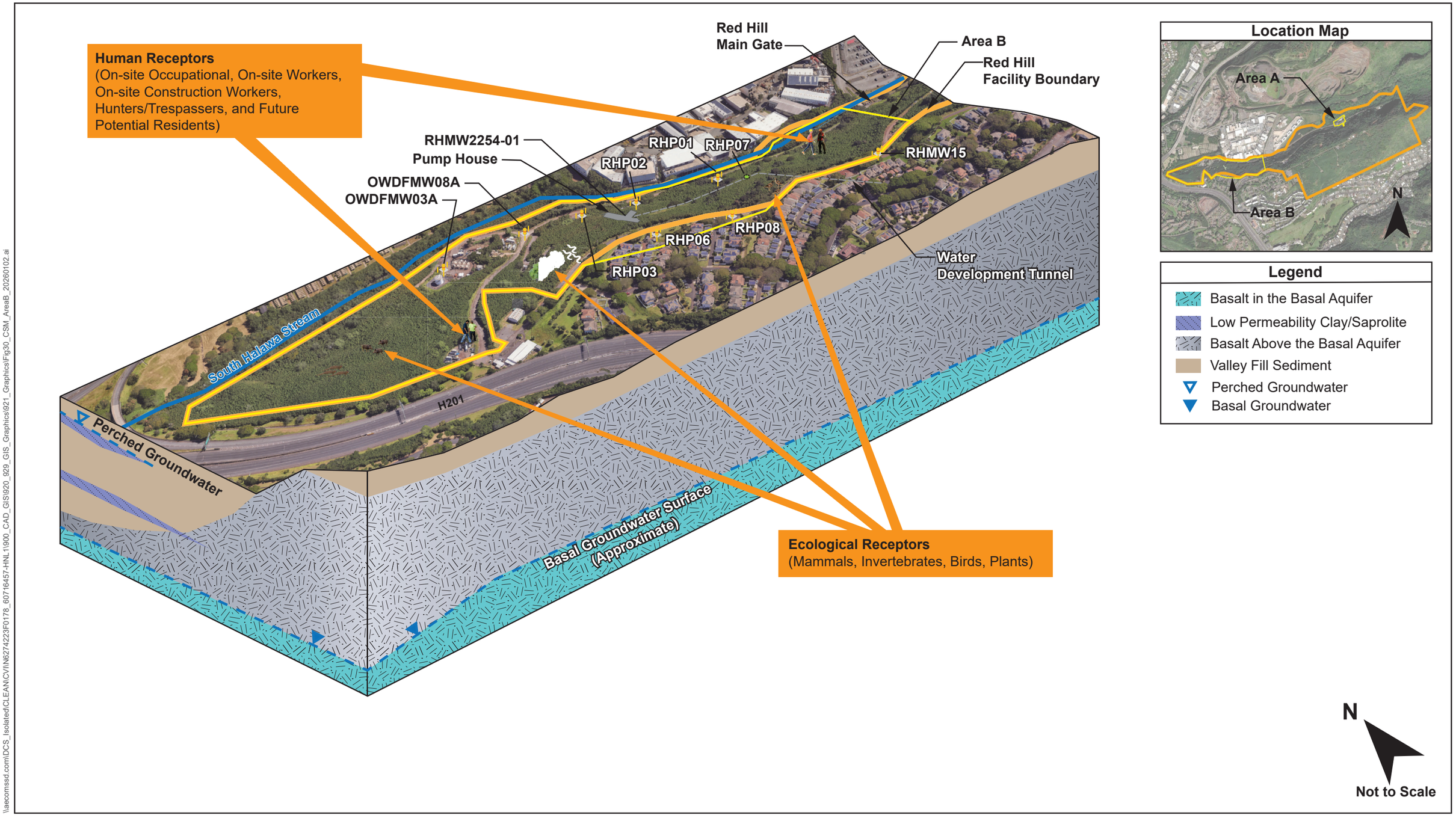

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Figure 30
Area B - Pictorial Conceptual Site Model
Draft Remedial Investigation Work Plan
Per-and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

Contributing Source	Transport Mechanism	Exposure Route	Scenario	Receptors: Onsite Occupational Worker	Onsite Construction Worker	Onsite Resident (Adult/Child)	Hunter/ Trespasser (Adult/Child)
AFFF and TPH Release							
Surface Soil	Direct Contact	Incidental Ingestion: Dermal Contact:	Current:	**Potentially Complete**	Incomplete	N/A	**Potentially Complete**
			Future:	**Potentially Complete**	**Potentially Complete**	**Potentially Complete**	**Potentially Complete**
	Air Transport	Inhalation of Particulates:	Current:	**Potentially Complete**	Incomplete	N/A	**Potentially Complete**
			Future:	**Potentially Complete**	**Potentially Complete**	**Potentially Complete**	**Potentially Complete**
	Bio-uptake	Ingestion of Plants/ Animals:	Current:	Incomplete	Incomplete	N/A	**Potentially Complete** [a]
			Future:	Incomplete	Incomplete	**Potentially Complete** [a]	**Potentially Complete** [a]
	Sediment in Halawa Stream	Incidental Ingestion and Dermal Contact:	Current:	Incomplete	Incomplete	N/A	**Potentially Complete** [b]
			Future:	Incomplete	Incomplete	**Potentially Complete** [b]	**Potentially Complete** [b]
Subsurface Soil	Direct Contact	Incidental Ingestion and Dermal Contact:	Current:	Incomplete	Incomplete	N/A	Incomplete
			Future:	**Potentially Complete**	**Potentially Complete**	**Potentially Complete**	**Potentially Complete**
	Air Transport	Inhalation of Particulates:	Current:	Incomplete	Incomplete	N/A	Incomplete
			Future:	**Potentially Complete**	**Potentially Complete**	**Potentially Complete**	**Potentially Complete**
	Groundwater	Ingestion:	Current:	**Potentially Complete** [a]	Incomplete	N/A	Incomplete
			Future:	**Potentially Complete**	Incomplete	**Potentially Complete**	Incomplete
		Dermal Contact:	Current:	**Potentially Complete** [a]	Incomplete	N/A	Incomplete
			Future:	**Potentially Complete**	Incomplete	**Potentially Complete**	Incomplete

Note: Shaded value indicates pathway to be evaluated in the risk assessment.
JBPHH Joint Base Pearl Harbor-Hickam
N/A not applicable
[a] Considered a potentially complete exposure pathway but exposure pathway is considered limited (no quantitative evaluation).
[b] Pathways are potentially complete but will only be evaluated if PFAS is detected in soil in the drainage ditches. If PFAS are found in the site soils, then an evaluation will be made to determine if off-site sampling in South Halawa Stream is necessary.

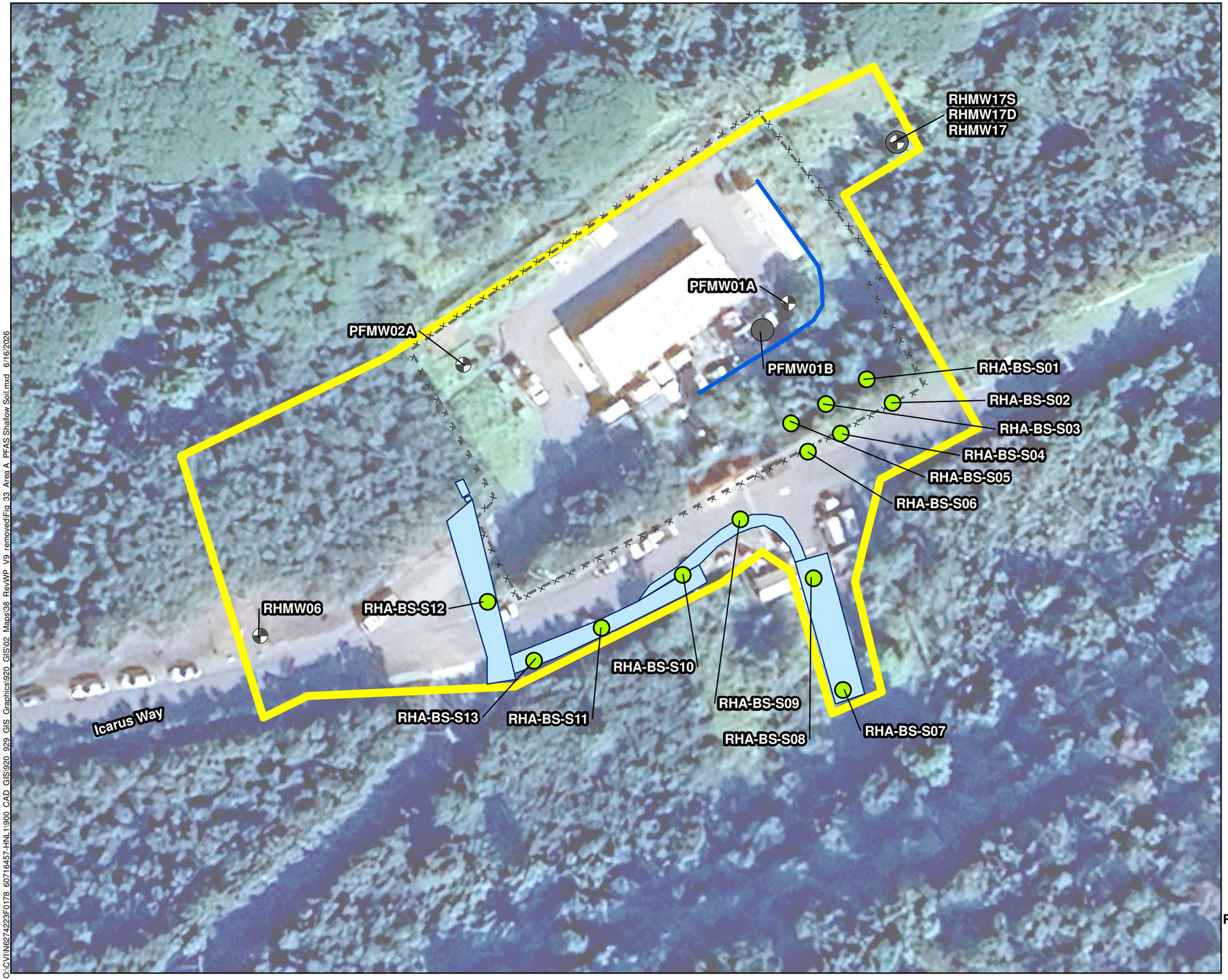
Figure 31
Area B – Human Health Exposure Pathway Evaluation
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

Historical Releases	Affected Media	Exposure Route	Terrestrial Receptors: Plants	Soil Invertebrates	Omnivorous Mammals	Omnivorous Birds	Insectivorous Birds
AFFF Release	Surface Soil – Vegetated Areas	Direct Contact:	Potentially Complete	Potentially Complete	Potentially Complete [a]	Potentially Complete [a]	Potentially Complete [a]
		Incidental Ingestion:	N/A	Potentially Complete	Potentially Complete	Potentially Complete	Potentially Complete
		Food Web Transfer:	N/A	N/A	Potentially Complete	Potentially Complete	Potentially Complete
	Subsurface Soil	All Pathways:	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete
	Groundwater	All Pathways:	Incomplete	Incomplete	Incomplete	Incomplete	Incomplete

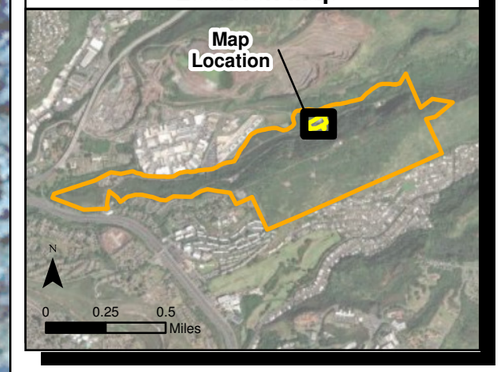
Historical Releases	Affected Media	Exposure Route	Aquatic Receptors: Aquatic Life (incl. Plankton)	Sediment Biota	Fish	Water Birds
AFFF Release	Stormwater Runoff to Surface Water	Direct Contact/ Ingestion:	Incomplete [b]	Incomplete [b]	Incomplete [b]	Incomplete [b]
		Food Web Transfer:	N/A	Incomplete [b]	Incomplete [b]	Incomplete [b]

Note: Shaded value indicates pathway to be evaluated in the risk assessment.
AFFF aqueous film-forming foam
COPC chemical of potential concern
N/A not applicable (exposure route does not exist or is not normally evaluated as such in ecological risk assessment)
[a] Because of the presence of fur and feathers, direct contact to surface soil is very limited and does not warrant quantitative evaluation.
[b] The stream is concrete-lined and impaired for the support of aquatic life, it is not considered potential ecological habitat for this Site. The preliminary risk evaluation concluded that there were no significant exposure pathways for ecological receptors.

Figure 32
Area B – Ecological Exposure Pathway Evaluation
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii



Location Map



Legend

- Proposed Shallow PFAS Soil Boring
- Existing Perched Monitoring Well
- Existing Basal Monitoring Well
- Fence
- Drainage Swale
- 2022 Release Response Excavated
- Red Hill Facility Boundary
- Potential Source Area

Notes

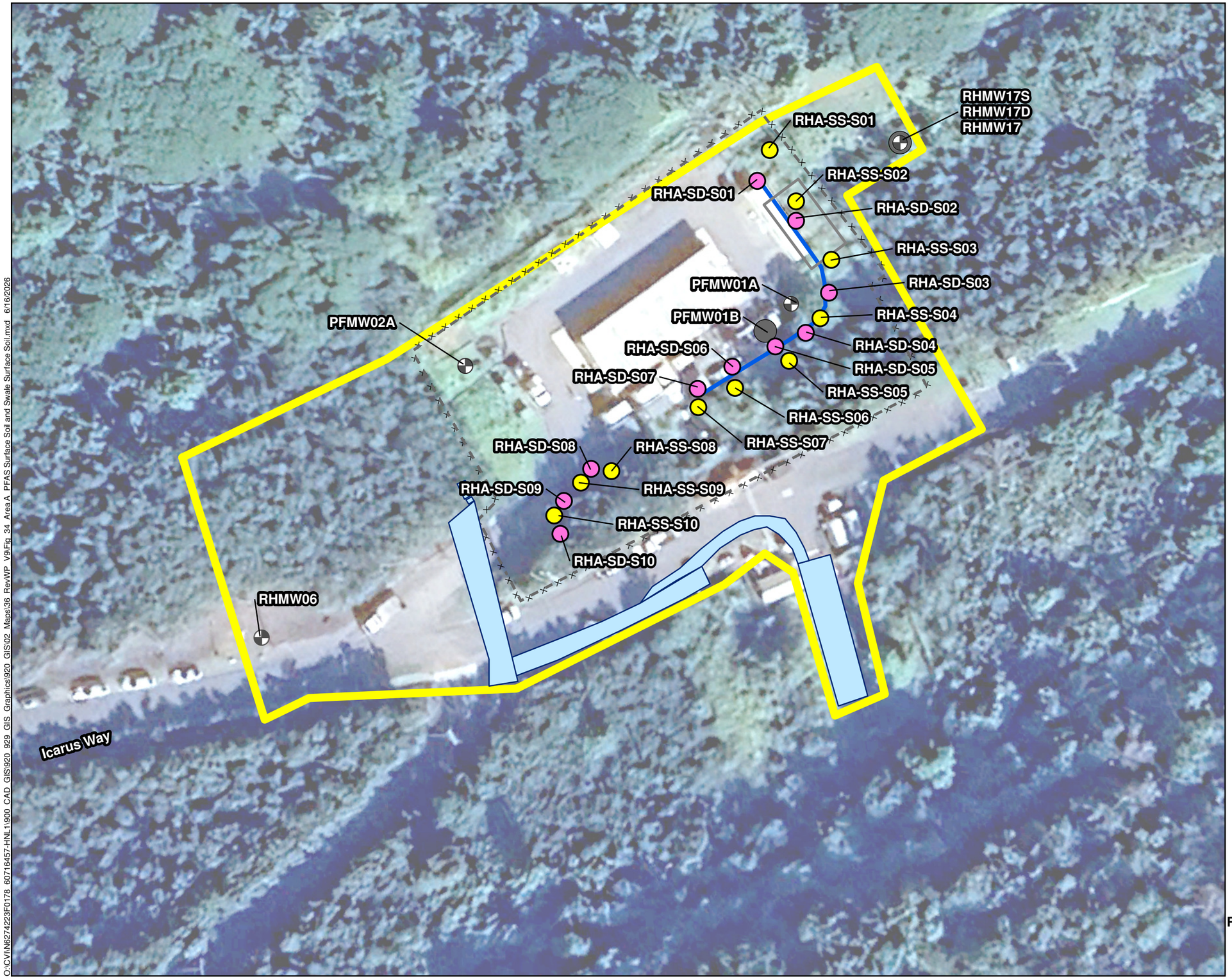
1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Base Map Source: Google Earth downloaded on January 2025.
3. Exact sampling locations will be verified in the field based on site conditions at the time the field work is conducted. All intrusive locations will be adjusted based on utility surveys.
4. Sensitive infrastructure has been removed from the figure for public dissemination.

N

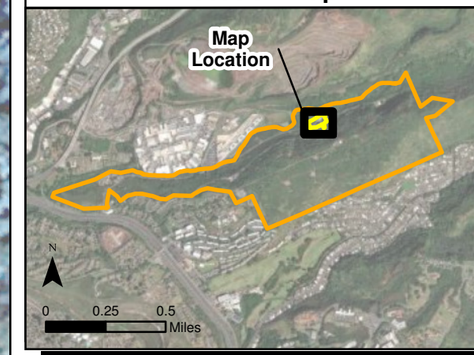
0 50 100 Feet

Figure 33
Area A – Proposed PFAS Shallow Soil Sampling Locations
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substance
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

O:\CVIN\6274223F0178 60716457-HNL1900 CAD GIS\920 929 GIS Graphics\920 GIS\02 Maps\38 RevWP V9 removed\Fig 33 Area A PFAS Shallow Soil.mxd 6/16/2026



Location Map



Legend

- Proposed Swale Surface Soil Sample
- Proposed Surface Soil
- Existing Perched Monitoring Well
- Existing Basal Monitoring Well
- Fence
- Drainage Swale
- Office Trailer
- 2022 Release Response Excavated
- Red Hill Facility Boundary
- Potential Source Area

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Base Map Source: Google Earth downloaded on January 2025.
3. Exact sampling locations will be verified in the field based on site conditions at the time the field work is conducted. All intrusive locations will be adjusted based on utility surveys.
4. Sensitive infrastructure has been removed from the figure for public dissemination.

N

0 50 100 Feet

Figure 34
Area A – Proposed PFAS Surface Soil and Swale Surface Soil Sampling Locations
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substance
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

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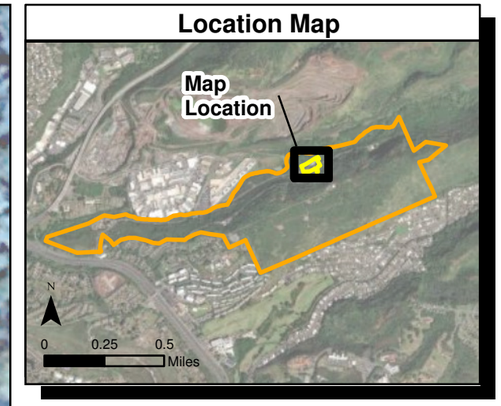
Location Map



Legend

- Proposed Deep PFAS and Petroleum Soil Boring
- Proposed Deep PFAS Soil Boring*
- Existing Perched Monitoring
- Existing Basal Monitoring
- Fence
- Drainage Swale
- 2022 Release Response Excavated
- Red Hill Facility Boundary
- Potential Source Area

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Base Map Source: Google Earth downloaded on January 2025.
3. *If evidence of petroleum is observed during drilling, petroleum samples may also be collected.
4. Exact sampling locations will be verified in the field based on site conditions at the time the field work is conducted. All intrusive locations will be adjusted based on utility surveys.
5. Sensitive infrastructure has been removed from the figure for public dissemination.

Figure 35
Area A – Proposed PFAS and Petroleum Deep Soil Boring Locations
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substance
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

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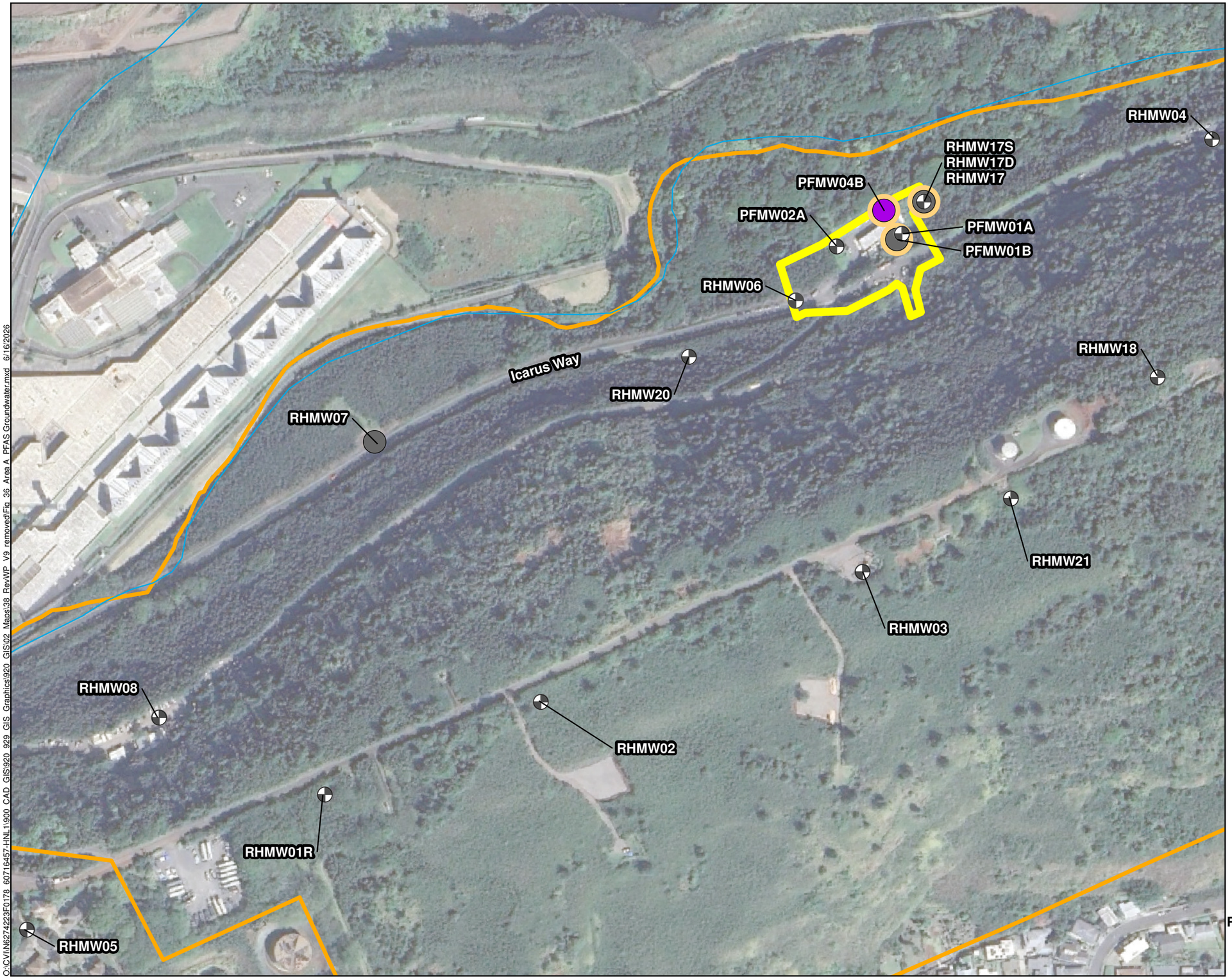
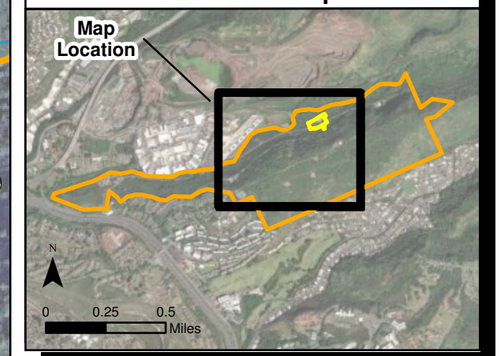


Location Map



Legend

- Proposed Perched Monitoring Well
- Existing Perched Monitoring Well
- Existing Basal Monitoring Well
- Proposed Synoptic Water Level Monitoring Location
- Stream
- Red Hill Facility Boundary
- Potential Source Area

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Base Map Source: Google Earth downloaded on January 2025.
3. RHMW07 is an elevated head well.
4. Sensitive infrastructure has been removed from the figure for public dissemination.

N

0 250 500 Feet

Figure 36
Area A – Proposed PFAS Groundwater Sampling Locations
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substance
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

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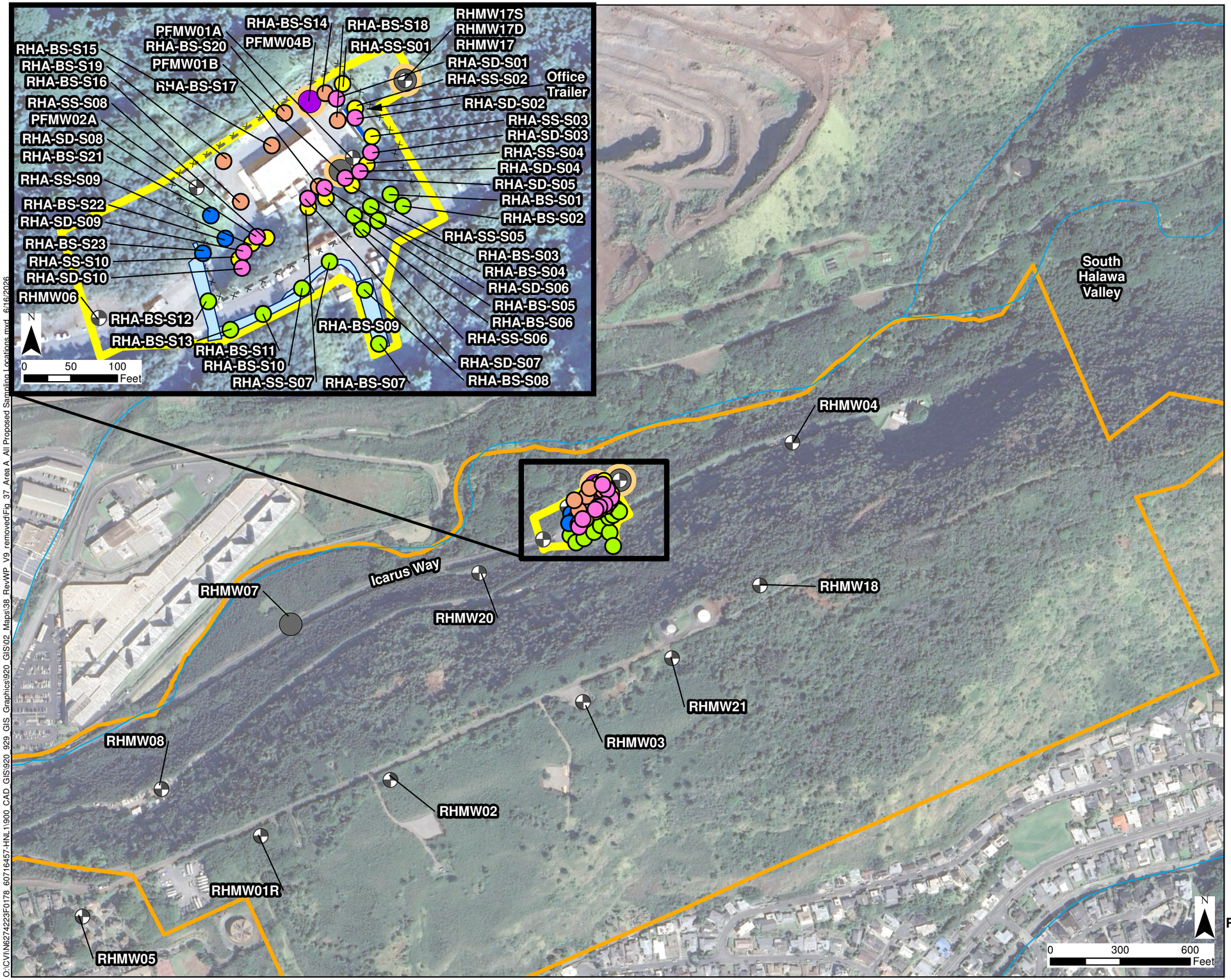
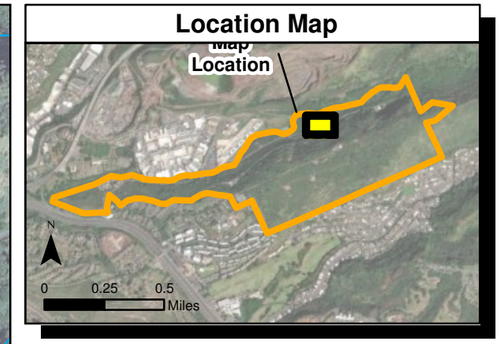


Location Map



Legend

- Proposed Swale Surface Soil Sample
- Proposed Surface Soil
- Proposed Deep PFAS and Petroleum Soil Boring
- Proposed Deep PFAS Soil Boring*
- Proposed Shallow PFAS Soil Boring
- Proposed PFAS Perched Monitoring
- Existing Perched Monitoring Well
- Existing Basal Monitoring Well
- Proposed Synoptic Water Level Monitoring Location
- Fence
- Drainage Swale
- 2022 Release Response Excavated
- Red Hill Facility Boundary
- Potential Source Area

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Base Map Source: Google Earth downloaded on January 2025.
3. RHMW07 is an elevated head well.
4. *If evidence of petroleum is observed during drilling, petroleum samples may also be collected.
5. Exact sampling locations will be verified in the field based on site conditions at the time the field work is conducted. All intrusive locations will be adjusted based on utility surveys.
6. Sensitive infrastructure has been removed from the figure for public dissemination.

Figure 37
Area A – All Proposed Sampling Locations
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substance
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

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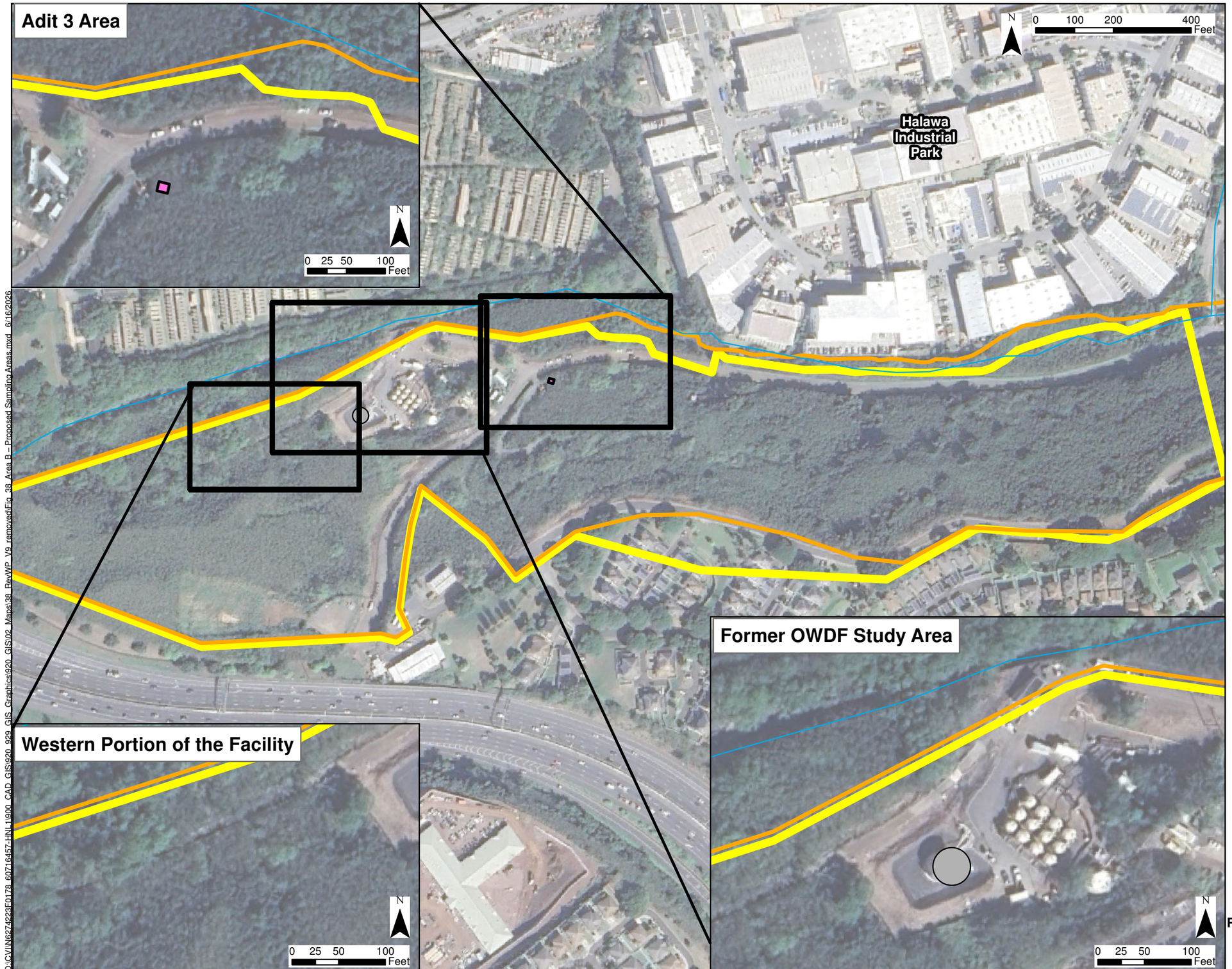
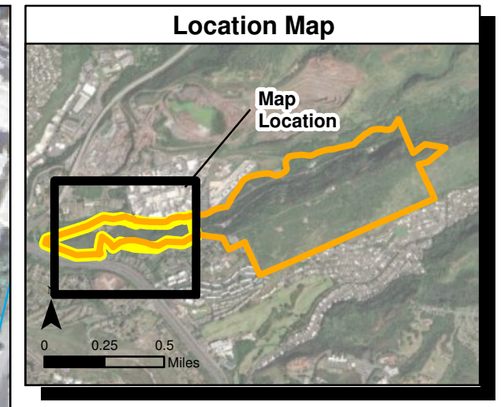


Location Map



Legend

- Former Location of AFFF Drain Line Retention Tank
- Stream
- Adit 3 Sump
- Red Hill Facility Boundary
- Potential Source Area

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Base Map Source: Google Earth, downloaded on January 2025.
3. Area B sampling area details are shown in Figures 39 through 41.
4. Sensitive infrastructure has been removed from the figure for public dissemination.

Figure 38
Area B – Proposed Sampling Areas
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

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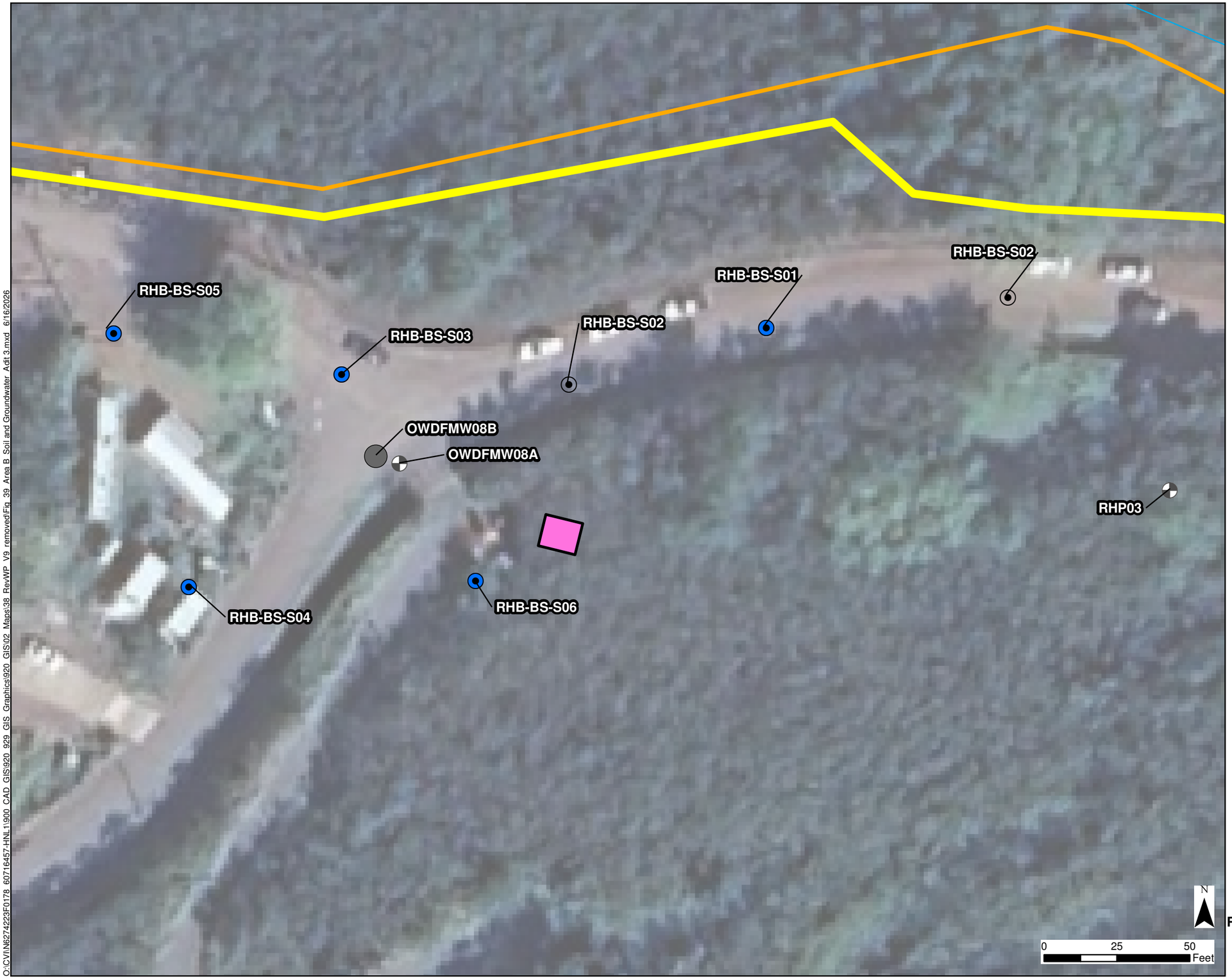
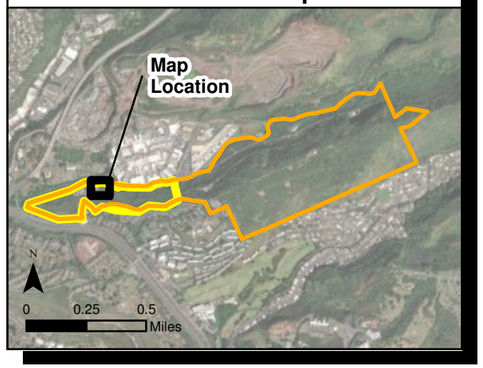


Location Map



Legend

- Proposed Soil Boring with Temporary Groundwater Well
- Potential Step-out Soil Boring with Temporary Groundwater Well Perched Groundwater Grab Sampling Location
- Existing Perched Monitoring Well
- Existing Basal Monitoring Well
- Adit 3 Sump
- Stream
- Red Hill Facility Boundary
- Potential Source Area

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Base Map Source: Google Earth, downloaded on January, 2025.
3. Exact sampling locations will be verified in the field based on site conditions at the time the field work is conducted. All intrusive locations will be adjusted based on utility surveys.
4. Only one of the two step-out borings labelled RHB-BS-S02 will be advanced based on the results at RHB-BS-S01.
5. Acronyms and Abbreviations:
   - OWDF — Oily Waste Disposal Facility
   - PFAS — per- and polyfluoroalkyl substances
6. Sensitive infrastructure has been removed from the figure for public dissemination.

Figure 39
Area B – Proposed Soil and Groundwater Grab Sampling Locations – Adit 3 Area
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

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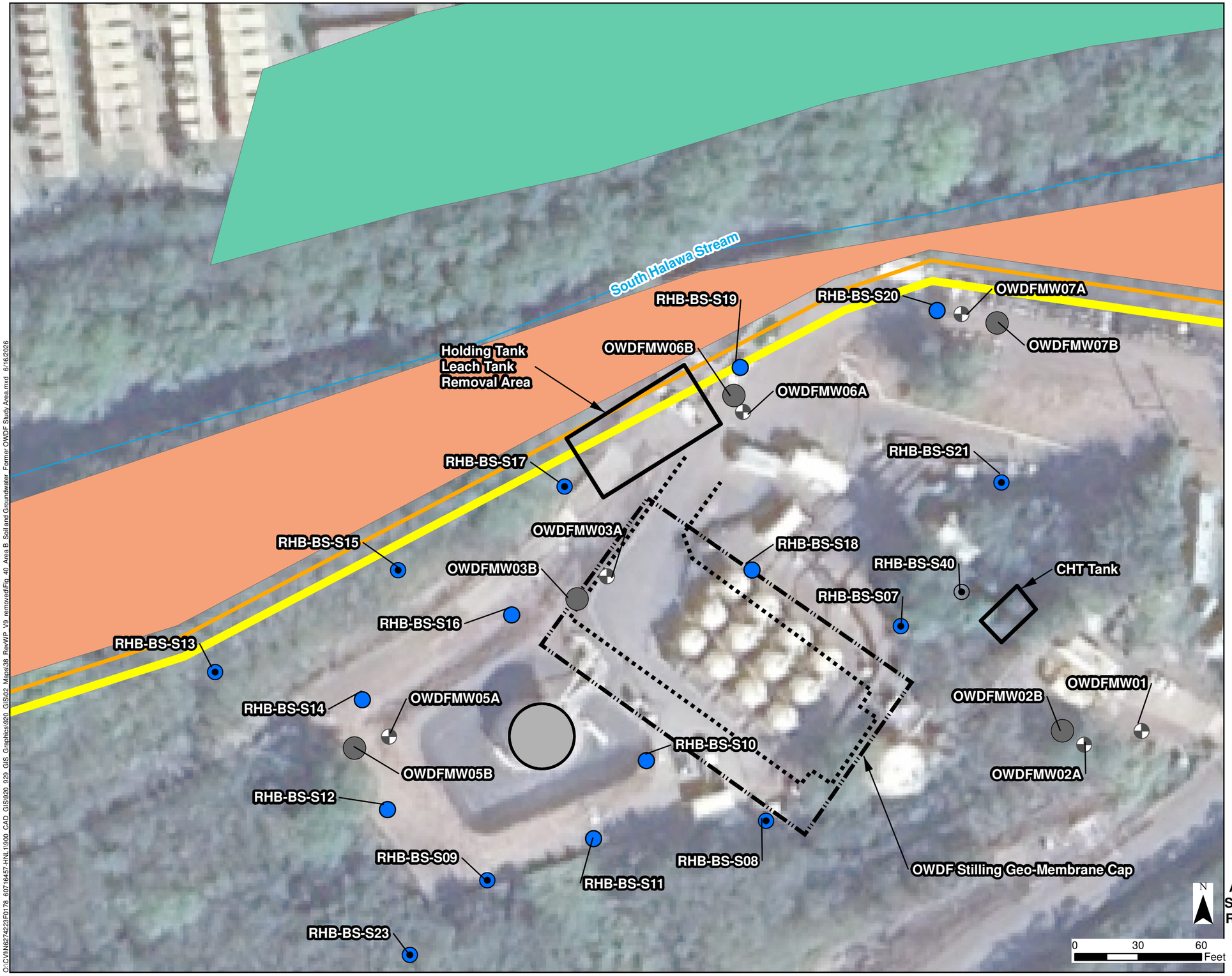
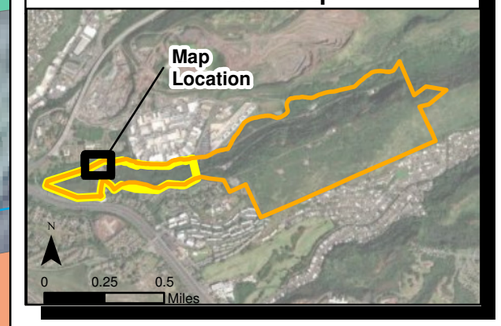


Location Map



Legend

- Former Location of AFFF Drain Line Retention Tank
- Proposed Soil Boring
- Proposed Soil Boring with Temporary Groundwater Well
- Optional Step-Out Soil Boring with Temporary Groundwater Well
- Existing Perched Monitoring Well
- Existing Basal Monitoring Well
- OWDF Stilling Basin Asphalt
- Stream
- Red Hill Facility Boundary
- Potential Source Area
- Phase 2 - Sampling South of South Halawa Stream, If Necessary
- Phase 3 - Sampling North of South Halawa Stream, If Necessary

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Base Map Source: Google Earth, downloaded on January 2025.
3. FY21 P-716 Red Hill Water Treatment Facility Phase 2, Western Portion of the Facility. NAVFAC Drawing No. CG101. Preliminary, Not for Construction, undated
4. Exact sampling locations will be verified in the field based on site conditions at the time the field work is conducted. All intrusive locations will be adjusted based on utility surveys.
5. Acronyms and Abbreviations:
   - OWDF — Oily Waste Disposal Facility
   - PFAS — per- and polyfluoroalkyl substances

Figure 40
Area B – Proposed Soil and Groundwater Grab Sampling Locations – Former OWDF Study Area
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

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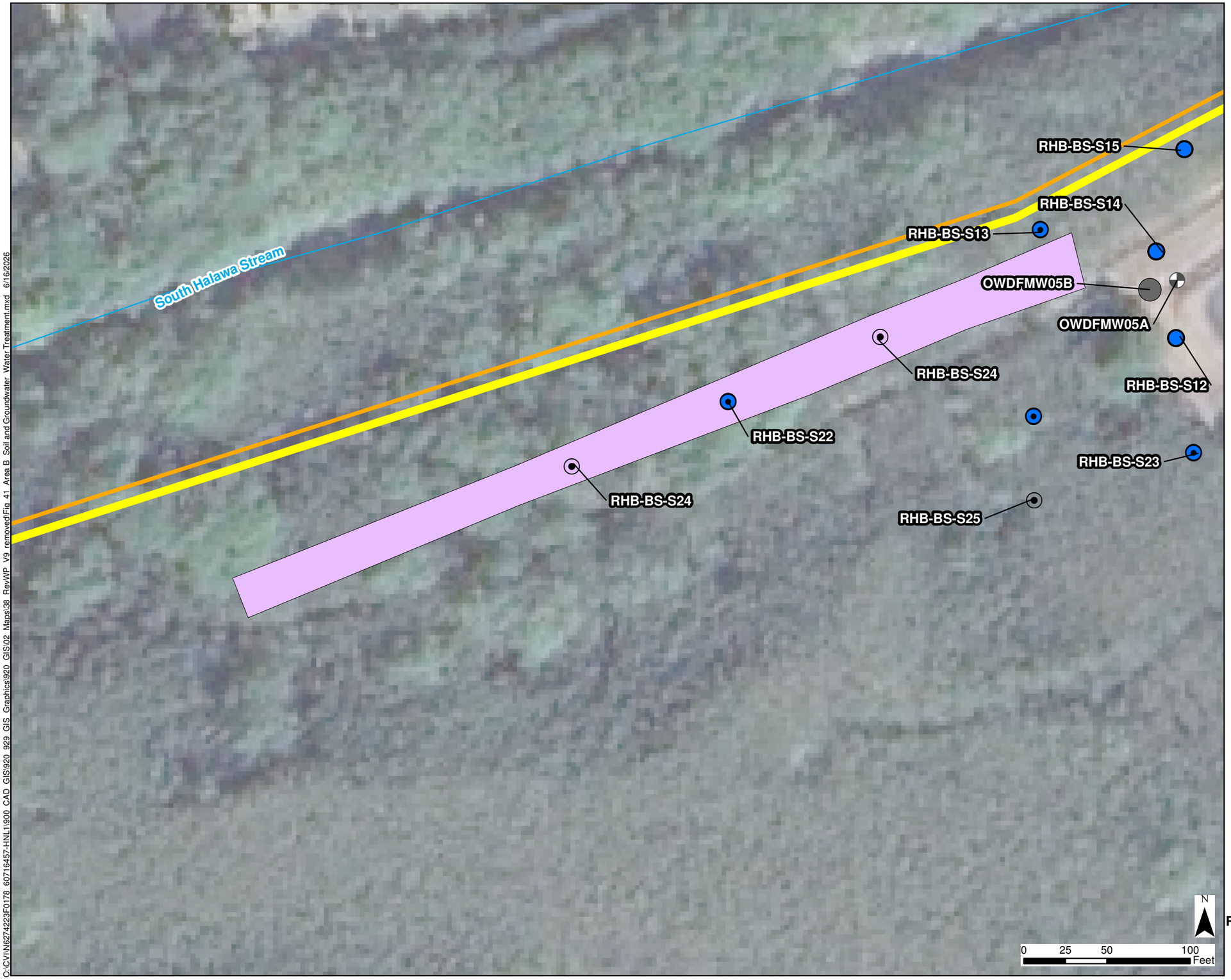
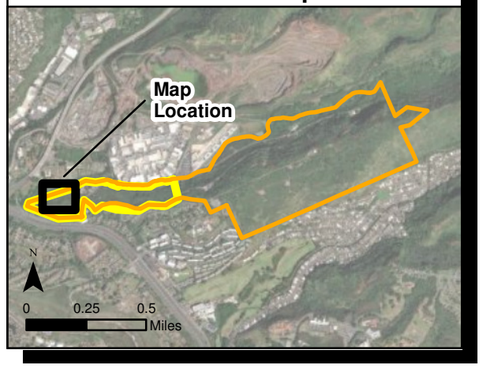


Location Map



Legend

- Proposed Soil Boring
- Proposed Soil Boring with Temporary Groundwater Well
- Potential Step-out Soil Boring and Perched Groundwater Grab Sample Location
- Existing Perched Monitoring Well
- Existing Basal Monitoring Well
- Stream
- Water Treatment Facility Western Lower Access Road
- Red Hill Facility Boundary
- Potential Source Area

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Base Map Source: Google Earth, downloaded on January 2025.
3. Exact sampling locations will be verified in the field based on site conditions at the time the field work is conducted. All intrusive locations will be adjusted based on utility surveys.
4. Only one of the two step-out borings labelled RHB-BS-S24 will be advanced based on the results at RHB-BS-S22.
5. Acronyms and Abbreviations:
   PFAS per- and polyfluoroalkyl substances
   WTF Water Treatment Facility

Figure 41
Area B – Proposed Soil and Groundwater Grab Sampling Locations – Western Portion of the Facility
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

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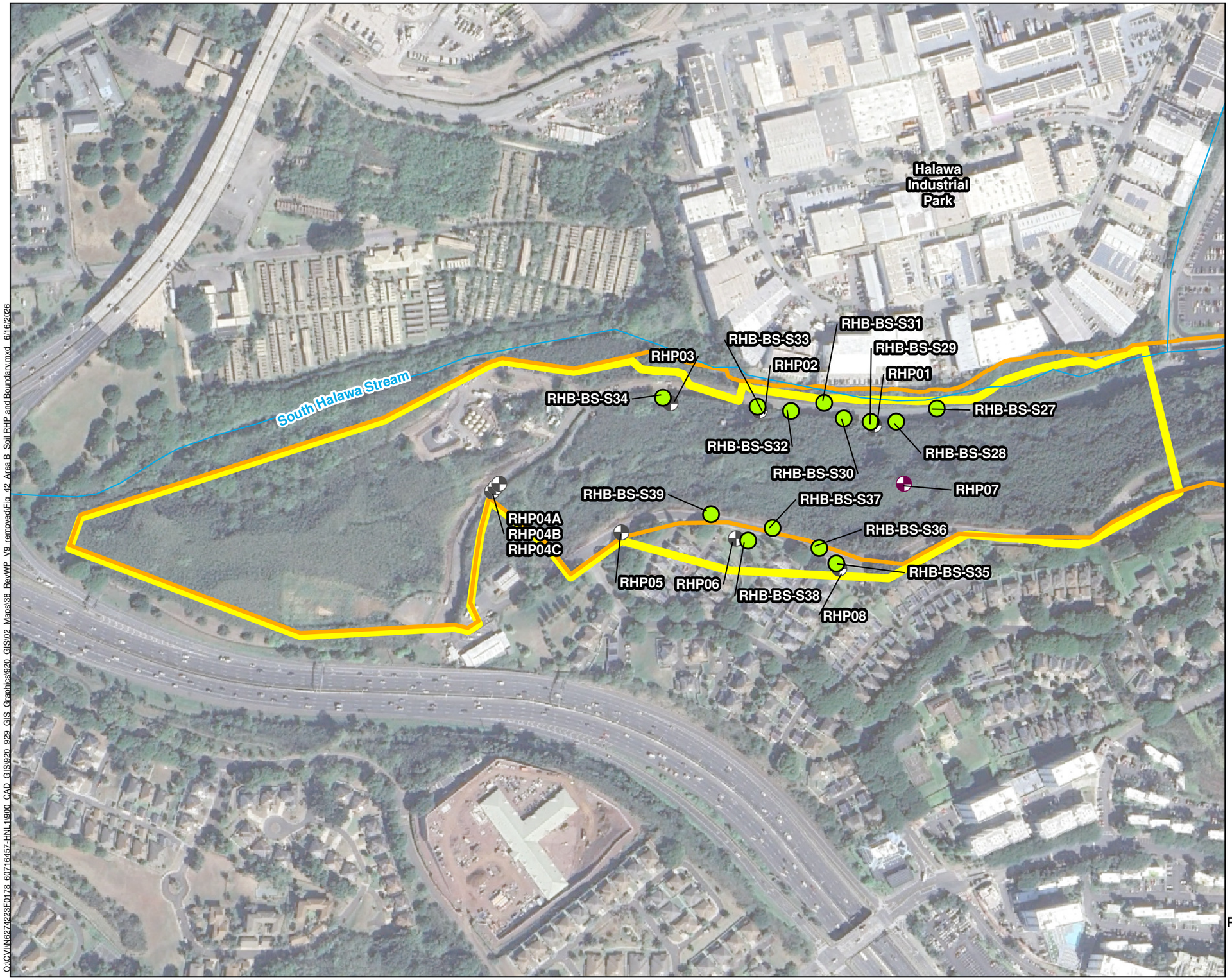
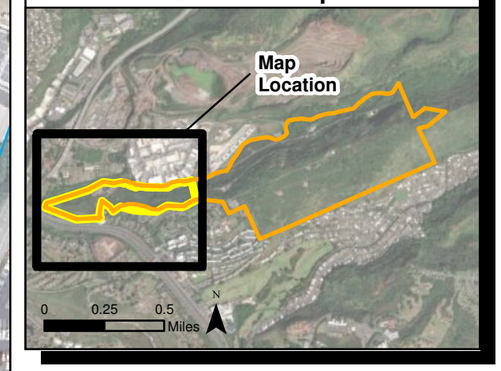


Location Map



Legend

- Proposed Surface / Subsurface Soil Boring
- Existing Basal Monitoring Well
- Existing Basal Aquifer Monitoring Well in Tunnel
- Stream
- Red Hill Facility Boundary
- Potential Source Area

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Base Map Source: Google Earth, downloaded on January 2025.
3. Exact sampling locations will be verified in the field based on site conditions at the time the field work is conducted. All intrusive locations will be adjusted based on utility surveys.
4. Sensitive infrastructure has been removed from the figure for public dissemination.

N

0 300 600 Feet

Figure 42
Area B – Proposed Soil Sampling Locations – Plume Delineation Wells and the Area B Boundary
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substance
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

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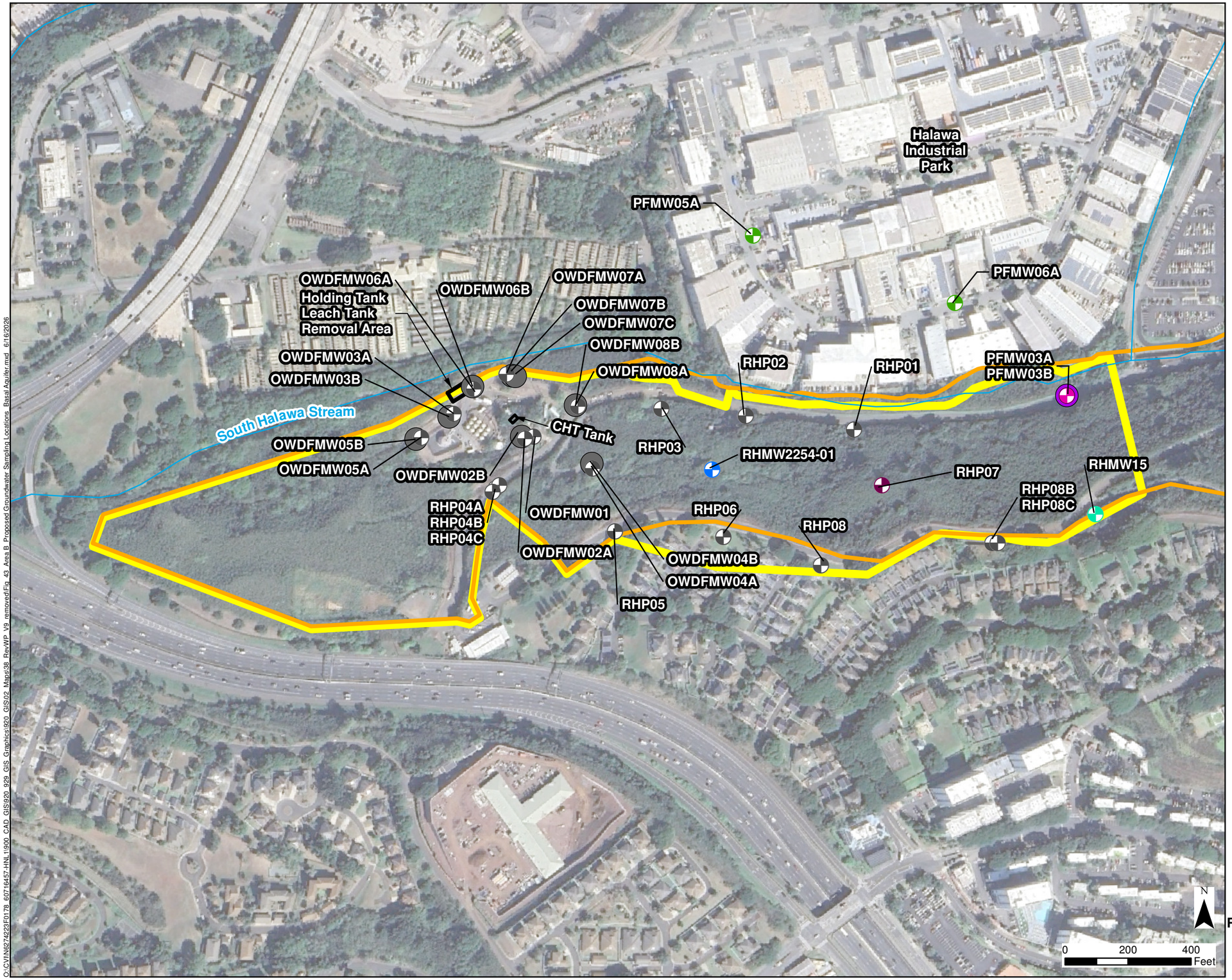
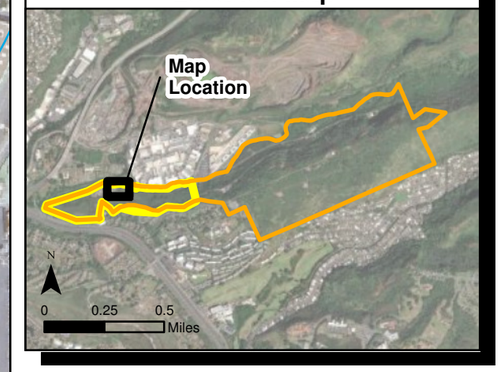


Location Map



Legend

- Proposed Offsite Basal Monitoring Well
- Proposed On Site Basal Monitoring Well
- Proposed Perched Monitoring Well
- Existing PFAS Perched Monitoring Well
- Existing Basal Monitoring Well
- Existing Water Development Tunnel Monitoring Location
- Existing Basal Aquifer Monitoring Well in Tunnel
- Multi-level Basal Monitoring Well
- Stream
- Red Hill Facility Boundary
- Potential Source Area

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Base Map Source: Google Earth, downloaded on January 2025.
3. Sensitive infrastructure has been removed from the figure for public dissemination.

Figure 43
Area B – Proposed Groundwater Monitoring Well Sampling Locations
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

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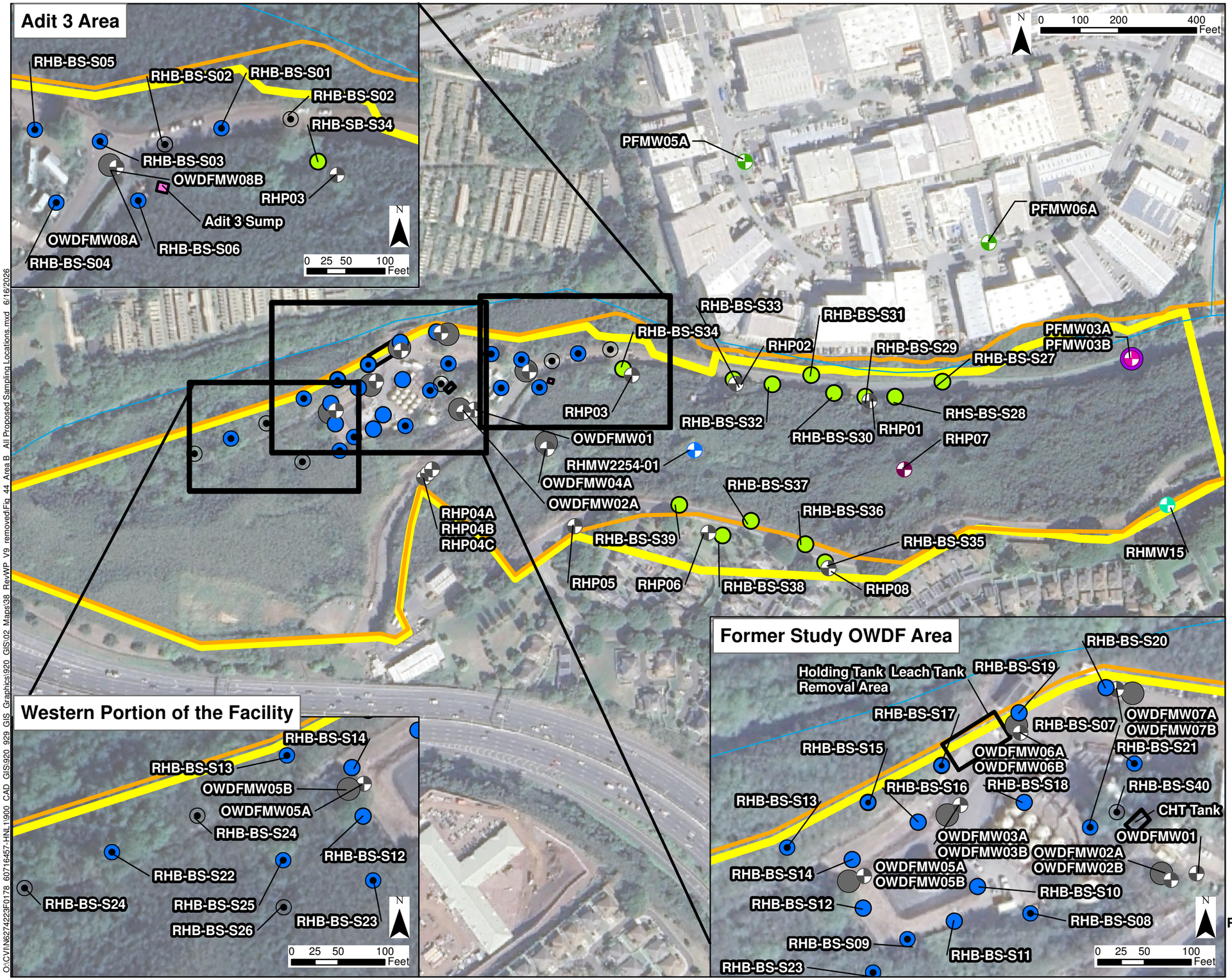
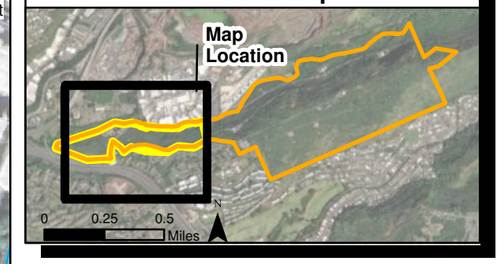


Location Map



Legend

- Existing Basal Monitoring Well
- Existing Water Development Tunnel Monitoring Location
- Existing Basal Aquifer Monitoring Well in Tunnel
- Multi-level Basal Monitoring Well
- Proposed Surface / Subsurface Soil
- Proposed Soil Boring with Temporary Groundwater Well
- Potential Step-out Soil Boring with Temporary Groundwater Well Perched Groundwater Grab Sampling Location
- Proposed Soil Boring
- Proposed Onsite Basal Monitoring Well and Proposed Co-located Perched Monitoring Well
- Proposed Offsite Basal Monitoring
- Existing Perched Monitoring Well
- Stream
- Red Hill Facility Boundary
- Potential Source Area

Notes

1. Map projection: NAD 1983 Hawaii State Plane Z3 ft
2. Base Map Source: Google Earth, downloaded on January 2025.
3. Exact sampling locations will be verified in the field based on site conditions at the time the field work is conducted. All intrusive locations will be adjusted based on utility surveys.
4. Only one of each step-out boring RHB-BS-S02 and RHB-BS-S24 will be advanced based on the results at RHB-BS-S01 and RHB-BS-22, respectively.
5. Sensitive infrastructure has been removed from the figure for public dissemination.

Figure 44
Area B – All Proposed Sampling Locations
Revised Draft Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances
Red Hill Bulk Fuel Storage Facility
JBPHH, Oahu, Hawaii

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Appendix B:
Analytical Data Tables

Table B-1: Detected Results for Soil, PFAS Samples Collected in December 2022

PFAS	CAS No.	2024 Nov. EPA Residential Soil (µg/kg) [b]	2025 ASD Memorandum SL (µg/kg) [c]	Maximum Concentration (µg/kg)	Maximum Concentration. Exceeds ASD 2025 SL	Location of Maximum Detected Concentration	Maximum Concentration Exceeds ASD 2025
PFBA	375-22-4	7,800	7,800	5.8	No	DU2	No
PFPeA	2706-90-3	—	—	5.6	—	DU4A	—
PFHxA	307-24-4	3,200	3,200	17	No	DU2	No
PFHpA	375-85-9	—	—	1.5	—	DU4A	—
PFOA	335-67-1	0.019	0.07	1.2	Yes	DU2	Yes
PFNA	375-95-1	19	19	0.054	No	DU4A	No
PFDA	335-76-2	0.013	0.06 [e]	0.15	Yes	DU2	Yes
PFUnA	2058-94-8	1,900 [d]	—	0.18	—	DU4B	—
PFDoA	307-55-1	320 [d]	—	0.096	—	DU4A	—
PFTrDA	72629-94-8	—	—	0.075	—	DU4A	—
PFTeDA	376-06-7	6,300 [d]	—	0.0370 J	—	DU4B	—
PFBS	375-73-5	1,900	1,900	0.0240 J	No	DU7	No
PFPeS	2706-91-4	—	—	0.0230 J	—	DU7	—
PFHxS	355-46-4	130	130	0.21	No	DU7	No
PFHpS	375-92-8	—	—	0.0170 J	—	DU4A	—
PFOS	1763-23-1	0.63	0.63	5.4	Yes	DU4A	Yes
PFNS	68259-12-1	—	—	0.094	—	DU4A	—
PFDS	335-77-3	—	—	0.16	—	DU4A	—
PFDoS	79780-39-5	—	—	0.140 J	—	DU2, DU4A	—
4:2 FTS	757124-72-4	—	—	1.00 J	—	DU2	—
6:2 FTS	27619-97-2	—	—	150 J	—	DU2	—
NEtFOSA	4151-50-2	—	—	0.0350 J	—	DU4A	—
PFOSA	754-91-6	—	—	0.0280 J	—	DU4A	—
NMeFOSE	24448-09-7	—	—	0.73	—	DU2	—
3:3FTCA	356-02-5	—	—	0.087 J	—	DU4A	—
5:3FTCA	914637-49-3	—	—	1.6	—	DU4A	—
2,2-BEE [a]	112-34-5	190,000	190,000	210	No	DU3	No

Note: All concentrations are reported in µg/kg.
— not applicable
J estimated concentration
[a] Solvent (2-(2-butoxyethoxy)ethanol) component of the AFFF concentrate.
[b] EPA RSL table values for residential soil using a THQ of 0.1 and target cancer risk of 1E-06 (EPA 2024c).
[c] Soil and groundwater SLs are identified in the ASD Memorandum, *Investigating Per- and Polyfluoroalkyl Substances within the DoD Cleanup Program* (ASD 2025).
[d] The November 2024 EPA RSL for this analyte is not yet approved for use within the DoD Cleanup Program (ASD 2025).
[e] The November 2024 EPA RSL for this analyte is above the method's pooled MDL; therefore, the method's pooled MDL is used as the screening value to establish consistent and measurable values (ASD 2025; EPA 2024d).

Table B-2: November 2022 Release Response Detected Groundwater PFAS Results

PFAS	Cas No.	November 2024 EPA Tap Water RSL [a] (ng/L)	ASD Memorandum 2025 SL [b] (ng/L)	Maximum Detected Concentration (ng/L)	Maximum Concentration Exceeding ASD Memorandum 2025	Location of Maximum Detected Concentration	Number of Detections [c]
PFBA	375-22-4	1,800	1,800	66.5	No	RHMW02	89
PFPeA	2706-90-3	—	—	60.9 J	—	RHMW02	190
PFHxA	307-24-4	990	990	7.7	No	RHMW12A	192
PFHpA	375-85-9	—	—	4.9	—	RHMW06	153
PFOA	335-67-1	0.0027	4 [d]	1.8	No	RHMW2254-01	95
PFNA	375-95-1	5.9	5.9	2.2	No	RHMW10	35
PFDA	335-76-2	0.004	0.52 [e]	0.79 J	Yes	RHMW10	17
PFUnA	2058-94-8	600 [c]	—	0.99	—	RHMW10	7
PFDoA	307-55-1	100 [c]	—	1.10 J	—	RHMW03	8
PFTrDA	72629-94-8	—	—	0.48 J	—	RHMW10	2
PFTeDA	376-06-7	2000 [c]	—	0.23 J	—	RHMW17D	1
PFBS	375-73-5	600	600	4.3	No	RHMW17S	62
PFPeS	2706-91-4	—	—	0.23 J	—	RHMW2254-01	9
PFHxS	355-46-4	39	10 [d]	1.6 J	No	RHMW2254-01	54
PFHpS	375-92-8	—	—	7.1 J	—	RHMW17D	4
PFOS	1763-23-1	0.2	4 [d]	2.8 J	No	RHMW12A	71
PFNS	68259-12-1	—	—	0.17 J	—	RHMW17J	1
PFDoS	79780-39-5	—	—	0.16 J	—	RHMW12A	1
4:2 FTS	757124-72-4	—	—	0.53 J	—	RHMW10	1
6:2 FTS	27619-97-2	—	—	269	—	RHMW17	137
8:2 FTS	39108-34-4	—	—	0.31 J	—	RHMW10	1
PFOSA	754-91-6	—	—	1.2	—	RHMW03	19
5:3FTCA	914637-49-3	—	—	0.83 J	—	RHMW17	1
PFMBA	863090-89-5	—	—	0.11 J	—	RHMW10	1
PFMPA	377-73-1	—	—	0.53 J	—	RHMW10	4

Note: All concentrations are reported in ng/L.
— not applicable
J estimated concentration
[a] EPA RSL table values for tap water using a THQ of 0.1 and target cancer risk of 1E-06 (EPA 2024c).
[b] Groundwater SLs are identified in the ASD Memorandum, *Investigating Per- and Polyfluoroalkyl Substances within the DoD Cleanup Program* (ASD 2025).
[c] A total of 421 samples analyzed.
[d] The November 2024 EPA RSL for this analyte is below the EPA analytical MDL; therefore, the MCL is used as the screening value. Alternatively, when the MCL is less the EPA RSL, the MCL is applied as the SL (ASD 2025; EPA 2024d).
[e] The November 2024 EPA RSL for this analyte is below the EPA analytical MDL and the analyte does not have a MCL; therefore, the EPA method's pooled MDL is used as the screening value to establish consistent and measurable values (ASD 2025; EPA 2024d).

Table B-3: September 2023 Baseline Detected Groundwater PFAS Results

PFAS	Cas No.	November 2024 EPA Tap Water RSL [a] (ng/L)	ASD Memorandum 2025 SL [b] (ng/L)	Maximum Detected Concentration (ng/L)	Samples Exceeding ASD Memorandum 2025	Location of Maximum Detected Concentration	Sample Count with Detected Concentration
PFBA	375-22-4	1,800	1,800	14.2	No	RHP02	9/23
PFPeA	2706-90-3	—	—	9.5	—	RHP01	16/23
PFHxA	307-24-4	990	990	6.3	No	RHP02	15/23
PFHpA	375-85-9	—	—	5.2	—	RHP02	15/23
PFOA	335-67-1	0.0027	4 [c]	5.9	Yes	NMW32	13/23
PFNA	375-95-1	5.9	5.9	1.60 J	No	RHP02	3/23
PFBS	375-73-5	600	600	4.3	No	RHP02	8/23
PFPeS	2706-91-4	—	—	1.7	—	NMW32	2/23
PFHxS	355-46-4	39	10 [c]	9.7	No	NMW32	12/23
PFHpS	375-92-8	—	—	4.8	—	RHP08	2/23
PFOS	1763-23-1	0.20	4 [c]	16.0 J	Yes	RHP02	13/23
6:2 FTS	27619-97-2	—	—	128	—	RHMW01	2/23

Note: All concentrations are reported in ng/L. The September 2023 one-time baseline sampling event results are included in the above table. Detected baseline sampling event results are shown on Figure 5.

— not applicable

J estimated concentration

[a] EPA RSL table values for tap water using a THQ of 0.1 and target cancer risk of 1E-06 (EPA 2024c).

[b] Groundwater SLs are identified in the ASD Memorandum, *Investigating Per- and Polyfluoroalkyl Substances within the DoD Cleanup Program* (ASD 2025).

[c] The November 2024 EPA RSL for this analyte is below the method's pooled MDL; therefore, the MCL is used as the screening value. Alternatively, when the MCL is less than the EPA RSL, the MCL is applied as the SL (ASD 2025; EPA 2024d).

Table B-4: Summary of Area A Perched Groundwater Quarterly Expedited Sampling Analytical Data
RI WP PFAS Release RHBFSF JBPHH Oahu HI

			Location	PFMW01B				RHMW07								RHMW17D								RHMW17S									
			COC ID	JV191		JV252		JV035		JV115		JV151		JV233		JV042		JV111		JV154		JV230		JV041		JV112		JV155		JV156		JV231	
			Matrix	WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG	
			Sample Type	N		N		N		N		N		N		N		N		N		N		N		N		N		FD		N	
			Sample Date	4/4/2025		7/31/2025		10/18/2024		1/28/2025		4/3/2025		7/29/2025		10/21/2024		1/24/2025		4/25/2025		7/21/2025		10/28/2024		1/24/2025		4/25/2025		4/25/2025		7/21/2025	
Chemical	Cas No.	PSL [a,b]	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Perfluoropropanoic acid (PFPrA)	422-64-0	980	ng/L	50	U		R	—		—		5.1	U	**0.58**	J	—		—		50	U	0.71	U	—		—		4.3	U	4.8	U	0.72	U
Perfluorobutanoic Acid (PFBA)	375-22-4	1800	ng/L	**200**		**970**		**0.47**	J	**0.45**	J+	2	U	0.75	U	0.7	U	0.73	U	20	U	0.71	U	**7.8**		**1.3**	J	**12**		**9**		0.72	U
Perfluoropentanoic Acid (PFPeA)	2706-90-3	—	ng/L	**760**		**650**		**0.18**	J	**0.1**	J	1	U	**0.92**	J+	0.35	U	0.37	U	0.85	U	0.35	U	0.38	U	0.37	U	0.86	U	0.97	U	0.36	U
Perfluorohexanoic Acid (PFHxA)	307-24-4	990	ng/L	**1300**		**1800**		**0.083**	J	**0.068**	J	1	U	0.77	U	**0.15**	J	**0.35**	J	0.85	U	**0.27**	J	**1**		**0.18**	J	0.86	U	0.97	U	**0.068**	J
Perfluoroheptanoic Acid (PFHpA)	375-85-9	—	ng/L	**150**	J	**470**		**0.092**	J	**0.053**	J	1	U	0.77	U	**0.054**	J	**0.084**	J	0.85	U	**0.16**	J	**0.52**		**0.065**	J	0.86	U	0.97	U	0.18	U
Perfluorooctanoic Acid (PFOA)	335-67-1	4	ng/L	**29**		**58**		0.26	U	0.27	U	1	U	0.28	U	**0.16**	J	**0.19**	J	0.85	U	**0.27**	J	**0.68**		**0.16**	J	0.86	U	0.97	U	0.27	U
Perfluorononanoic Acid (PFNA)	375-95-1	5.9	ng/L	10	U	**0.77**		0.17	U	0.18	U	1	U	0.19	U	0.17	U	0.18	U	0.85	U	0.18	U	**0.23**	J	**0.096**	J	0.86	U	0.97	U	0.18	U
Perfluorodecanoic Acid (PFDA)	335-76-2	0.52	ng/L	10	U	**0.14**	J	0.17	U	0.18	U	1	U	0.19	U	0.17	U	0.18	U	0.85	U	0.18	U	**0.1**	J	**0.11**	J	0.86	U	0.97	U	0.18	U
Perfluoroundecanoic Acid (PFUnA)	2058-94-8	—	ng/L	10	U	0.28	U	0.26	U	0.27	U	1	U	0.28	U	0.26	U	0.27	U	0.85	U	0.27	U	0.29	U	0.28	U	0.86	U	0.97	U	0.27	U
Perfluorododecanoic Acid (PFDoA)	307-55-1	—	ng/L	10	U	0.18	U	0.17	U	0.18	U	1	U	0.19	U	0.17	U	0.18	U	0.85	U	0.18	U	0.19	U	0.18	U	0.86	U	0.97	U	0.18	U
Perfluorotridecanoic Acid (PFTrDA)	72629-94-8	—	ng/L	10	U	0.28	U	0.26	U	0.27	U	1	U	0.28	U	0.26	U	0.27	U	0.85	U	0.27	U	0.29	U	0.28	U	0.86	U	0.97	U	0.27	U
Perfluorotetradecanoic Acid (PFTA)	376-06-7	—	ng/L	10	U	0.28	U	0.26	U	0.27	U	1	U	0.28	U	0.26	U	0.27	U	0.85	U	0.27	U	0.29	U	0.28	U	0.86	U	0.97	U	0.27	U
Perfluorohexadecanoic Acid (PFHxDA)	67905-19-5	—	ng/L	10	U	0.28	U					1	U	0.28	U					0.85	U	0.27	U					0.86	U	0.97	U	0.27	U
Perfluorooctadecanoic Acid (PFODA)	16517-11-6	—	ng/L	14	U	0.28	UJ					1.4	U	0.28	UJ					1.2	U	0.27	U					1.2	U	1.4	U	0.27	U
Perfluorobutanesulfonic Acid (PFBS)	375-73-5	600	ng/L	**34**		**140**		**0.04**	J	**0.047**	J	1	U	**0.041**	J	**0.068**	J	**0.049**	J	0.85	U	0.18	U	**0.38**	J	**0.24**	J	0.86	U	0.97	U	0.18	U
Perfluoropentanesulfonic Acid (PFPeS)	2706-91-4	—	ng/L	**46**		**140**		0.17	U	0.18	U	1	U	0.19	U	0.17	U	0.18	U	0.85	U	0.18	U	0.19	U	0.18	U	0.86	U	0.97	U	0.18	U
Perfluorohexanesulfonic Acid (PFHxS)	355-46-4	10	ng/L	**240**		**480**		**0.084**	J	**0.072**	J	1	U	**0.079**	J	**0.2**	J	**0.083**	J	0.85	U	**0.18**	J	**0.35**	J	**0.079**	J	0.86	U	0.97	U	**0.071**	J
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	—	ng/L	**9.8**	J	**18**		0.17	U	0.18	U	1	U	0.19	U	0.17	U	0.18	U	0.85	U	0.18	U	0.19	U	0.18	U	0.86	U	0.97	U	0.18	U
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	4	ng/L	**290**		**610**		**0.16**	J	**0.072**	J+	1	U	0.19	U	**0.12**	J	**0.19**	J	0.85	U	**0.28**	J	**0.65**	J+	**0.25**	J	0.86	U	0.97	U	0.18	U
Perfluoro-1-nonanesulfonic acid (PFNS)	68259-12-1	—	ng/L	10	U	0.18	U	0.17	U	0.18	U	1	U	0.19	U	0.17	U	0.18	U	0.85	U	0.18	U	0.19	U	0.18	U	0.86	U	0.97	U	0.18	U
Perfluorodecanesulfonic Acid (PFDS)	335-77-3	—	ng/L	10	U	0.28	U	0.26	U	0.27	U	1	U	0.28	U	0.26	U	0.27	U	0.85	U	0.27	U	0.29	U	0.28	U	0.86	U	0.97	U	0.27	U
Perfluorododecanesulfonic Acid (PFDoS)	79780-39-5	—	ng/L	10	U	0.18	U	0.17	U	0.18	U	1	U	0.19	U	0.17	U	0.18	U	0.85	U	0.18	U	0.19	U	0.18	U	0.86	U	0.97	U	0.18	U
1H,1H,2H,2H-Perfluorohexane Sulfonic Acid (4:2 FTS)	757124-72-4	—	ng/L	**42**		**150**		0.69	U	0.71	U	2	U	0.75	U	0.7	U	0.73	U	1.7	U	0.71	U	0.76	U	0.74	U	1.7	U	1.9	U	0.72	U
1H,1H, 2H, 2H-Perfluorooctane Sulfonic Acid (6:2 FTS)	27619-97-2	—	ng/L	**22000**		**25000**		0.69	U	0.71	U	2	U	3.1	U	0.7	U	**3.6**		**2.2**	J	**2.6**		**9.4**		**0.84**	J	**1.9**	J	**1.4**	J	**1.3**	J
1H,1H, 2H, 2H-Perfluorodecane Sulfonic Acid (8:2 FTS)	39108-34-4	—	ng/L	20	U	0.74	U	0.69	U	0.71	U	2	U	0.75	U	0.7	U	0.73	U	1.7	U	0.71	U	0.76	U	0.74	U	1.7	U	1.9	U	0.72	U
1H,1H,2H,2H-perfluorododecane Sulfonic Acid (10:2 FTS)	120226-60-0	—	ng/L	—		0.74	U	—		—		—		0.75	U	—		—		—		0.71	U	—		—		—		—		0.72	U
N-Methyl Perfluorooctane Sulfonamide (NMeFOSA)	31506-32-8	—	ng/L	10	U	0.74	U	0.69	U	0.71	U	1	U	0.75	U	0.7	U	0.73	U	0.85	U	0.71	U	0.76	U	0.74	U	0.86	U	0.97	U	0.72	U
N-Ethyl Perfluorooctane Sulfonamide (NEtFOSA)	4151-50-2	—	ng/L	10	U	0.74	U	0.69	U	0.71	U	1	U	0.75	U	0.7	U	0.73	U	0.85	U	0.71	U	0.76	U	0.74	U	0.86	U	0.97	U	0.72	U
Perfluorobutane Sulfonamide (PFBSA)	30334-69-1	—	ng/L	—		**8.6**		—		—		—		0.19	U	—		—		—		0.18	U	—		—		—		—		0.18	U
Perfluorohexane Sulfonamide (PFHxSA)	41997-13-1	—	ng/L	—		**15**		—		—		—		0.19	U	—		—		—		0.18	U	—		—		—		—		0.18	U
Perfluorooctane Sulfonamide (PFOSA)	754-91-6	—	ng/L	10	U	0.18	U	0.17	U	0.18	U	1	U	0.19	U	0.17	U	0.18	U	0.85	U	0.18	U	0.19	U	0.18	U	0.86	U	0.97	U	0.18	U
N-Methyl Perfluorooctane Sulfonamidoacetic Acid	2355-31-9	—	ng/L	10	U	0.18	U	0.17	U	0.18	U	1	U	0.19	U	0.17	U	0.18	U	0.85	U	0.18	U	0.19	U	0.18	U	0.86	U	0.97	U	0.18	U
N-Ethyl Perfluorooctane Sulfonamidoacetic Acid (NEtFOSAA)	2991-50-6	—	ng/L	10	U	0.18	U	0.17	U	0.18	U	1	U	0.19	U	0.17	U	0.18	U	0.85	U	0.18	U	0.19	U	0.18	U	0.86	U	0.97	U	0.18	U
N-Methyl Perfluorooctane Sulfonamidoethanol (NMeFOSE)	24448-09-7	—	ng/L	50	U	1.1	U	1	U	1.1	U	5.1	U	1.1	U	1	U	1.1	U	4.2	U	1.1	U	1.1	U	1.1	U	4.3	U	4.8	U	1.1	U
N-Ethyl Perfluorooctane Sulfonamidoethanol (NEtFOSE)	1691-99-2	—	ng/L	50	U	1.1	U	1	U	1.1	U	5.1	U	1.1	U	1	U	1.1	U	4.2	U	1.1	U	1.1	U	1.1	U	4.3	U	4.8	U	1.1	U
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	1.5	ng/L	7	U	0.37	UJ	0.35	U	0.36	U	0.71	U	0.38	U	0.35	U	0.37	U	0.59	U	0.35	U	0.38	U	0.37	U	0.6	U	0.68	U	0.36	U
4,8-dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	—	ng/L	10	U	0.37	U	0.35	U	0.36	U	1	U	0.38	U	0.35	U	0.37	U	0.85	U	0.35	U	0.38	U	0.37	U	0.86	U	0.97	U	0.36	U
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	—	ng/L	10	U	0.37	U	0.35	U	0.36	U	1	U	0.38	U	0.35	U	0.37	U	0.85	U	0.35	U	0.38	U	0.37	U	0.86	U	0.97	U	0.36	U
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	—	ng/L	10	U	0.37	U	0.35	U	0.36	U	1	U	0.38	U	0.35	U	0.37	U	0.85	U	0.35	U	0.38	U	0.37	U	0.86	U	0.97	U	0.36	U
3:3 Fluorotelomer carboxylic acid	356-02-5	—	ng/L	**42**		**55**		0.69	U	0.71	U	2	U	0.75	U	0.7	U	0.73	U	1.7	U	0.71	U	0.76	U	0.74	U	1.7	U	1.9	U	0.72	U
5:3 Fluorotelomer carboxylic acid	914637-49-3	—	ng/L	**1900**		**4000**		0.69	U	0.71	U	5.1	U	0.75	U	0.7	U	0.73	U	4.2	U	0.71	U	0.76	U	0.74	U	4.3	U	4.8	U	0.72	U
7:3 Fluorotelomer carboxylic acid	812-70-4	—	ng/L	50	U	0.74	U	0.69	U	0.71	U	5.1	U	0.75	U	0.7	U	0.73	U	4.2	U	0.71	U	0.76	U	0.74	U	4.3	U	4.8	U	0.72	U
2H-Perfluoro-2-octenoic acid (6:2 FTUCA)	70887-88-6	—	ng/L	—		**16**		—		—		—		0.19	U	—		—		—		0.18	U	—		—		—		—		0.18	U
2H-Perfluoro-2-decenoic acid (8:2 FTUCA)	70887-84-2	—	ng/L	—		0.18	U	—		—		—		0.19	U	—		—		—		0.18	U	—		—		—		—		0.18	U
Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	—	ng/L	10	U	0.37	U	0.35	U	0.36	U	1	U	0.38	U	0.35	U	0.37	U	0.85	U	0.35	U	0.38	U	0.37	U	0.86	U	0.97	U	0.36	U
Perfluoro(4-ethylcyclohexane)sulfonic acid (PFEtCHxS)	646-83-3	—	ng/L	—		**0.85**		—		—		—		0.36	U	—		—		—		0.34	U	—		—		—		—		0.34	U
Perfluoro(4-Methyoxybutanoic) Acid (PFMBA)	863090-89-5	—	ng/L	10	U	0.37	U	0.35	U	0.36	U	1	U	0.38	U	0.35	U	0.37	U	0.85	U	0.35	U	0.38	U	0.37	U	0.86	U	0.97	U	0.36	U
Perfluoro-3-methoxypropanoic acid	377-73-1	—	ng/L	10	U	**1.1**		0.35	U	0.36	U	1	U	0.38	U	0.35	U	**5.3**		**5.4**		0.35	U	0.38	U	0.37	U	0.86	U	0.97	U	0.36	U
Nonafluoro-3,6-Dioxaheptanoic Acid (NFDHA)	151772-58-6	—	ng/L	10	U	0.37	U	0.35	U	0.36	U	1	U	0.38	U	0.35	U	0.37	U	0.85	U	0.35	U	0.38	U	0.37	U	0.86	U	0.97	U	0.36	U
bis(trifluoromethylsulfonyl)amine (TFSI)	82113-65-3	590	ng/L	10	U	0.28	U					1	U	0.28	U					0.85	U	0.27	U					0.86	U	0.97	U	0.27	U

Notes:
Units are in ng/L. Analysis conducted using EPA Method 1633 (EPA 2024).
Bold and shaded text indicates analyte was detected above the PSLs
Bold text indicates analyte was detected
— = not applicable
abbr. = abbreviated chemical name
Cas No. = chemical abstracts service registry number
COC = chain of custody
EPA = Environmental Protection Agency, United States
FD = field duplicate sample
ID = identification
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 low
J+ = the result was an estimated quantity, but the result may be biased high
LOD = limit of detection
N = primary sample
ng/L = nanogram per liter
PSL = project screening level
Q = data qualifier
R = Rejected. The data is unusable (the analyte may or may not be present). Use of the "R" qualifier indicates a significant variance from guideline acceptance criteria. Either resampling or re-analysis is necessary to determine the presence or absence of the rejected analyte.
RSL = regional screening level
U = the analyte was not detected and was reported as less than the LOD
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.
WG = groundwater
[a] EPA tap water RSL using a THQ of 0.1 and a target cancer risk of 1E-06 – November 2024 (EPA 2024).
[b] PSLs consistent with DoD memorandum (ASD 2025). PSLs are identified in Worksheet #15.

References:
ASD 2025. Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program. Memorandum : Office of the Assistant Secretary of Defense January 21, 2025.
EPA 2024. EPA Method 1633: Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS. Environmental Protection Agency, United States, January 2024.

Table B-5: Summary of Area A Basal Groundwater Quarterly Expedited Sampling Analytical Data
RI WP PFAS Release RHBFSF JBPHH Oahu HI

			Location	PFMW01A		PFMW02A				RHMW01R										RHMW02									
			COC ID	JV255		JV253		JV254		JV037		JV062		JV089		JV144		JV208		JV017		JV090		JV145		JV146		JV209	
			Matrix	WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG	
			Sample Type	N		N		FD		N		FD		N		N		N		N		N		N		FD		N	
			Sample Date	7/31/2025		7/31/2025		7/31/2025		10/21/2024		10/21/2024		1/20/2025		4/18/2025		7/14/2025		9/26/2024		1/20/2025		4/18/2025		4/18/2025		7/14/2025	
Chemical	Cas No.	PSL [a,b]	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Perfluoropropanoic acid (PFPrA)	422-64-0	980	ng/L	**1**	J	**1**	J	**0.89**	J	—		—		—		4.9	U	0.71	U	—		—		**280**		**270**		0.73	U
Perfluorobutanoic Acid (PFBA)	375-22-4	1800	ng/L	**2.4**		0.72	U	0.72	U	**0.38**	J	0.7	U	0.76	U	**60**		0.71	U	0.71	U	**30**		2	U	1.9	U	0.73	U
Perfluoropentanoic Acid (PFPeA)	2706-90-3	—	ng/L	**3.3**		**0.97**	J+	**0.9**	J+	0.37	U	0.35	U	0.38	U	0.99	U	0.35	U	**4.1**		0.36	U	0.98	U	0.97	U	0.36	U
Perfluorohexanoic Acid (PFHxA)	307-24-4	990	ng/L	**4.5**	J-	0.77	U	0.76	U	**0.16**	J	0.17	U	0.19	U	0.99	U	**0.084**	J	**0.72**	J	0.18	U	0.98	U	0.97	U	**0.51**	
Perfluoroheptanoic Acid (PFHpA)	375-85-9	—	ng/L	**1.1**		0.77	U	0.76	U	**0.051**	J	0.17	U	0.19	U	0.99	U	**0.045**	J	**0.71**		**0.17**	J	0.98	U	0.97	U	**0.4**	
Perfluorooctanoic Acid (PFOA)	335-67-1	4	ng/L	**0.63**		0.27	U	0.27	U	0.28	U	0.26	U	0.28	U	0.99	U	0.26	U	**0.21**	J	**0.23**	J	0.98	U	0.97	U	**0.25**	J
Perfluorononanoic Acid (PFNA)	375-95-1	5.9	ng/L	**0.2**	J	0.18	U	0.18	U	0.18	U	0.17	U	0.19	U	0.99	U	0.18	U	**0.09**		0.18	U	0.98	U	0.97	U	**0.11**	J
Perfluorodecanoic Acid (PFDA)	335-76-2	0.52	ng/L	0.2	U	0.18	U	0.18	U	0.18	U	0.17	U	0.19	U	0.99	U	0.18	U	0.18	U	0.18	U	0.98	U	0.97	U	**0.092**	J
Perfluoroundecanoic Acid (PFUnA)	2058-94-8	—	ng/L	0.3	U	0.27	U	0.27	U	0.28	U	0.26	U	0.28	U	0.99	U	0.26	U	0.27	U	0.27	U	0.98	U	0.97	U	0.27	U
Perfluorododecanoic Acid (PFDoA)	307-55-1	—	ng/L	0.2	U	0.18	U	0.18	U	0.18	U	0.17	U	0.19	U	0.99	U	0.18	U	0.18	U	0.18	U	0.98	U	0.97	U	0.18	U
Perfluorotridecanoic Acid (PFTrDA)	72629-94-8	—	ng/L	0.3	U	0.27	U	0.27	U	0.28	U	0.26	U	0.28	U	0.99	U	0.26	U	0.27	U	0.27	U	0.98	U	0.97	U	0.27	U
Perfluorotetradecanoic Acid (PFTA)	376-06-7	—	ng/L	0.3	U	0.27	U	0.27	U	0.28	U	0.26	U	0.28	U	0.99	U	0.26	U	0.27	U	0.27	U	0.98	U	0.97	U	0.27	U
Perfluorohexadecanoic Acid (PFHxDA)	67905-19-5	—	ng/L	0.3	U	0.27	U	0.27	U							0.99	U	0.26	U					0.98	U	0.97	U		R
Perfluorooctadecanoic Acid (PFODA)	16517-11-6	—	ng/L		R	0.27	UJ	0.27	UJ							1.4	U	0.26	UJ					1.4	U	1.4	U	0.27	UJ
Perfluorobutanesulfonic Acid (PFBS)	375-73-5	600	ng/L	**0.11**	J	0.18	U	0.18	U	0.18	U	0.17	U	0.19	U	0.99	U	0.18	U	0.18	U	0.18	U	0.98	U	0.97	U	0.18	U
Perfluoropentanesulfonic Acid (PFPeS)	2706-91-4	—	ng/L	0.2	U	0.18	U	0.18	U	0.18	U	0.17	U	0.19	U	0.99	U	0.18	U	0.18	U	0.18	U	0.98	U	0.97	U	0.18	U
Perfluorohexanesulfonic Acid (PFHxS)	355-46-4	10	ng/L	**0.16**	J	0.18	U	0.18	U	0.18	U	0.17	U	0.19	U	0.99	U	**0.056**	J	0.18	U	0.18	U	0.98	U	0.97	U	**0.069**	J
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	—	ng/L	0.2	U	0.18	U	0.18	U	0.18	U	0.17	U	0.19	U	0.99	U	0.18	U	0.18	U	0.18	U	0.98	U	0.97	U	0.18	U
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	4	ng/L	**0.46**		0.18	U	0.18	U	**0.059**	J	0.17	U	0.19	U	0.99	U	0.18	U	0.18	U	0.18	U	0.98	U	0.97	U	**0.24**	J+
Perfluoro-1-nonanesulfonic acid (PFNS)	68259-12-1	—	ng/L	0.2	U	0.18	U	0.18	U	0.18	U	0.17	U	0.19	U	0.99	U	0.18	U	0.18	U	0.18	U	0.98	U	0.97	U	0.18	U
Perfluorodecanesulfonic Acid (PFDS)	335-77-3	—	ng/L	0.3	U	0.27	U	0.27	U	0.28	U	0.26	U	0.28	U	0.99	U	0.26	U	0.27	U	0.27	U	0.98	U	0.97	U	0.27	U
Perfluorododecanesulfonic Acid (PFDoS)	79780-39-5	—	ng/L	0.2	U	0.18	U	0.18	U	0.18	U	0.17	U	0.19	U	0.99	U	0.18	U	0.18	U	0.18	U	0.98	U	0.97	U	0.18	U
1H,1H,2H,2H-Perfluorohexane Sulfonic Acid (4:2 FTS)	757124-72-4	—	ng/L	0.8	U	0.72	U	0.72	U	0.74	U	0.7	U	0.76	U	2	U	0.71	U	0.71	U	0.71	U	2	U	1.9	U	0.73	U
1H,1H, 2H, 2H-Perfluorooctane Sulfonic Acid (6:2 FTS)	27619-97-2	—	ng/L	**73**	J-	3.1	U	3.1	U	**1.1**	J	**0.94**	J	0.76	U	**4.1**		**2.3**		**17**		**8.7**		**9.4**		**11**		**11**	
1H,1H, 2H, 2H-Perfluorodecane Sulfonic Acid (8:2 FTS)	39108-34-4	—	ng/L	0.8	U	0.72	U	0.72	U	0.74	U	0.7	U	0.76	U	2	U	0.71	U	0.71	U	0.71	U	2	U	1.9	U	0.73	U
1H,1H,2H,2H-perfluorododecane Sulfonic Acid (10:2 FTS)	120226-60-0	—	ng/L	0.8	U	0.72	U	0.72	U	—		—		—		—		0.71	U	—		—		—		—		0.73	U
N-Methyl Perfluorooctane Sulfonamide (NMeFOSA)	31506-32-8	—	ng/L	0.8	U	0.72	U	0.72	U	0.74	U	0.7	U	0.76	U	0.99	U	0.71	U	0.71	U	0.71	U	0.98	U	0.97	U	0.73	U
N-Ethyl Perfluorooctane Sulfonamide (NEtFOSA)	4151-50-2	—	ng/L	0.8	U	0.72	U	0.72	U	0.74	U	0.7	U	0.76	U	0.99	U	0.71	U	**0.38**	J	0.71	U	0.98	U	0.97	U	0.73	U
Perfluorobutane Sulfonamide (PFBSA)	30334-69-1	—	ng/L	0.2	U	0.18	U	0.18	U	—		—		—		—		0.18	U	—		—		—		—		0.18	U
Perfluorohexane Sulfonamide (PFHxSA)	41997-13-1	—	ng/L	0.2	U	0.18	U	0.18	U	—		—		—		—		0.18	U	—		—		—		—		0.18	U
Perfluorooctane Sulfonamide (PFOSA)	754-91-6	—	ng/L	0.2	U	0.18	U	0.18	U	0.18	U	0.17	U	0.19	U	0.99	U	0.18	U	0.18	U	0.18	U	0.98	U	0.97	U	0.18	U
N-Methyl Perfluorooctane Sulfonamidoacetic Acid	2355-31-9	—	ng/L	0.2	U	0.18	U	0.18	U	0.18	U	0.17	U	0.19	U	0.99	U	0.18	U	0.18	U	0.18	U	0.98	U	0.97	U	0.18	U
N-Ethyl Perfluorooctane Sulfonamidoacetic Acid (NEtFOSAA)	2991-50-6	—	ng/L	0.2	U	0.18	U	0.18	U	0.18	U	0.17	U	0.19	U	0.99	U	0.18	U	0.18	U	0.18	U	0.98	U	0.97	U	0.18	U
N-Methyl Perfluorooctane Sulfonamidoethanol (NMeFOSE)	24448-09-7	—	ng/L	1.2	U	1.1	U	1.1	U	1.1	U	1	U	1.1	U	4.9	U	1.1	U	1.1	U	1.1	U	4.9	U	4.9	U	1.1	U
N-Ethyl Perfluorooctane Sulfonamidoethanol (NEtFOSE)	1691-99-2	—	ng/L	1.2	U	1.1	U	1.1	U	1.1	U	1	U	1.1	U	4.9	U	1.1	U	1.1	U	1.1	U	4.9	U	4.9	U	1.1	U
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	1.5	ng/L	0.4	U	0.36	U	0.36	U	0.37	U	0.35	U	0.38	U	0.69	U	0.35	U	0.36	U	0.36	U	0.69	U	0.68	U	0.36	U
4,8-dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	—	ng/L	0.4	U	0.36	U	0.36	U	0.37	U	0.35	U	0.38	U	0.99	U	0.35	U	0.36	U	0.36	U	0.98	U	0.97	U	0.36	U
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	—	ng/L	0.4	U	0.36	U	0.36	U	0.37	U	0.35	U	0.38	U	0.99	U	0.35	U	0.36	U	0.36	U	0.98	U	0.97	U	0.36	U
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	—	ng/L	0.4	U	0.36	U	0.36	U	0.37	U	0.35	U	0.38	U	0.99	U	0.35	U	0.36	U	0.36	U	0.98	U	0.97	U	0.36	U
3:3 Fluorotelomer carboxylic acid	356-02-5	—	ng/L	0.8	U	0.72	U	0.72	U	0.74	U	0.7	U	0.76	U	2	U	0.71	U	0.71	U	0.71	U	2	U	1.9	U	0.73	U
5:3 Fluorotelomer carboxylic acid	914637-49-3	—	ng/L	**1.1**	J	0.72	U	0.72	U	0.74	U	0.7	U	0.76	U	4.9	U	0.71	U	0.71	U	0.71	U	4.9	U	4.9	U	0.73	U
7:3 Fluorotelomer carboxylic acid	812-70-4	—	ng/L	0.8	U	0.72	U	0.72	U	0.74	U	0.7	U	0.76	U	4.9	U	0.71	U	0.71	U	0.71	U	4.9	U	4.9	U	0.73	U
2H-Perfluoro-2-octenoic acid (6:2 FTUCA)	70887-88-6	—	ng/L	**0.94**	J+	0.18	U	0.18	U	—		—		—		—		0.18	U	—		—		—		—		0.18	U
2H-Perfluoro-2-decenoic acid (8:2 FTUCA)	70887-84-2	—	ng/L	0.2	U	0.18	U	0.18	U	—		—		—		—		0.18	U	—		—		—		—		0.18	U
Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	—	ng/L	0.4	U	0.36	U	0.36	U	0.37	U	0.35	U	0.38	U	0.99	U	0.35	U	0.36	U	0.36	U	0.98	U	0.97	U	0.36	U
Perfluoro(4-ethylcyclohexane)sulfonic acid (PFEtCHxS)	646-83-3	—	ng/L	0.38	U	0.34	U	0.34	U	—		—		—		—		0.34	U	—		—		—		—		0.35	U
Perfluoro(4-Methyoxybutanoic) Acid (PFMBA)	863090-89-5	—	ng/L	0.4	U	0.36	U	0.36	U	0.37	U	0.35	U	0.38	U	0.99	U	0.35	U	0.36	U	0.36	U	0.98	U	0.97	U	0.36	U
Perfluoro-3-methoxypropanoic acid	377-73-1	—	ng/L	0.4	U	0.36	U	0.36	U	0.37	U	0.35	U	0.38	U	0.99	U	0.35	U	0.36	U	0.36	U	0.98	U	0.97	U	0.36	U
Nonafluoro-3,6-Dioxaheptanoic Acid (NFDHA)	151772-58-6	—	ng/L	0.4	U	0.36	U	0.36	U	0.37	U	0.35	U	0.38	U	0.99	U	0.35	U	0.36	U	0.36	U	0.98	U	0.97	U	0.36	U
bis(trifluoromethylsulfonyl)amine (TFSI)	82113-65-3	590	ng/L	0.3	U	0.27	U	0.27	U							0.99	U	0.26	U					0.98	U	0.97	U	0.27	U

Table B-5: Summary of Area A Basal Groundwater Quarterly Expedited Sampling Analytical Data (cont'd)
RI WP PFAS Release RHBFSF JBPHH Oahu HI

			Location	RHMW03								RHMW04								RHMW05									
			COC ID	JV018		JV095		JV147		JV214		JV025		JV110		JV148		JV229		JV043		JV044		JV106		JV149		JV226	
			Matrix	WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG	
			Sample Type	N		N		N		N		N		N		N		N		N		FD		N		N		N	
			Sample Date	9/26/2024		1/21/2025		4/23/2025		7/16/2025		10/15/2024		1/24/2025		4/28/2025		7/22/2025		10/23/2024		10/23/2024		1/24/2025		4/23/2025		7/16/2025	
Chemical	Cas No.	PSL [a,b]	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Perfluoropropanoic acid (PFPrA)	422-64-0	980	ng/L	—		—		4.4	U	**1**	J	—		—		4.9	U	**0.89**	J	—		—		—		4.3	U	**0.98**	J
Perfluorobutanoic Acid (PFBA)	375-22-4	1800	ng/L	**2.5**		**1.6**		**1.2**	J	**1.7**		0.77	U	0.77	U	2	U	**1.1**	J	**0.28**	J	0.77	U	0.78	U	1.7	U	**1.2**	J
Perfluoropentanoic Acid (PFPeA)	2706-90-3	—	ng/L	**7.4**		**3.5**		**3.1**		**2.2**		0.38	U	0.39	U	0.98	U	**0.29**	J	0.37	U	0.38	U	0.39	U	**0.88**	J	0.38	U
Perfluorohexanoic Acid (PFHxA)	307-24-4	990	ng/L	**5.8**		**3.5**		**2.1**		**2.6**		0.19	U	0.19	U	0.98	U	**0.13**	J	0.19	U	0.19	U	0.19	U	**0.76**	J	**0.076**	J
Perfluoroheptanoic Acid (PFHpA)	375-85-9	—	ng/L	**3.5**		**2.4**		**1.3**	J	**0.91**		0.19	U	0.19	U	0.98	U	**0.13**	J	0.19	U	0.19	U	0.19	U	**0.49**	J	**0.05**	J
Perfluorooctanoic Acid (PFOA)	335-67-1	4	ng/L	**0.77**		**0.92**		0.87	UJ	**0.34**	J	0.29	U	0.29	U	0.98	UJ	0.29	U	0.28	U	0.29	U	0.29	U	0.87	U	0.28	U
Perfluorononanoic Acid (PFNA)	375-95-1	5.9	ng/L	**0.34**		**0.19**	J	0.87	U	**0.11**	J	0.19	U	0.19	U	0.98	U	0.19	U	0.19	U	0.19	U	0.19	U	0.87	U	0.19	U
Perfluorodecanoic Acid (PFDA)	335-76-2	0.52	ng/L	**0.36**	J	**0.15**	J	0.87	U	0.19	U	0.19	U	0.19	U	0.98	U	0.19	U	0.19	U	0.19	U	0.19	U	0.87	U	0.19	U
Perfluoroundecanoic Acid (PFUnA)	2058-94-8	—	ng/L	**0.26**	J	0.28	U	0.87	U	0.28	U	0.29	U	0.29	U	0.98	U	0.29	U	0.28	U	0.29	U	0.29	U	0.87	U	0.28	U
Perfluorododecanoic Acid (PFDoA)	307-55-1	—	ng/L	**0.16**	J	0.19	U	0.87	U	0.19	U	0.19	U	0.19	U	0.98	U	0.19	U	0.19	U	0.19	U	0.19	U	0.87	U	0.19	U
Perfluorotridecanoic Acid (PFTrDA)	72629-94-8	—	ng/L	0.28	U	0.28	U	0.87	U	0.28	U	0.29	U	0.29	U	0.98	U	0.29	U	0.28	U	0.29	U	0.29	U	0.87	U	0.28	U
Perfluorotetradecanoic Acid (PFTA)	376-06-7	—	ng/L	0.28	U	0.28	U	0.87	U	0.28	U	0.29	U	0.29	U	0.98	U	0.29	U	0.28	U	0.29	U	0.29	U	0.87	U	0.28	U
Perfluorohexadecanoic Acid (PFHxDA)	67905-19-5	—	ng/L					0.87	U	0.28	U					0.98	U	0.29	U							0.87	U	0.28	U
Perfluorooctadecanoic Acid (PFODA)	16517-11-6	—	ng/L					1.2	U	0.28	U					1.4	U	0.29	U							1.2	U	0.28	U
Perfluorobutanesulfonic Acid (PFBS)	375-73-5	600	ng/L	**0.49**	J	0.19	U	0.87	U	0.19	U	0.19	U	0.19	U	0.98	U	0.19	U	0.19	U	0.19	U	**0.055**	J	0.87	U	0.19	U
Perfluoropentanesulfonic Acid (PFPeS)	2706-91-4	—	ng/L	0.18	U	0.19	U	0.87	U	0.19	U	0.19	U	0.19	U	0.98	U	0.19	U	0.19	U	0.19	U	0.19	U	0.87	U	0.19	U
Perfluorohexanesulfonic Acid (PFHxS)	355-46-4	10	ng/L	0.18	U	0.19	U	0.87	U	0.19	U	0.19	U	0.19	U	0.98	U	0.19	U	0.19	U	0.19	U	**0.076**	J	0.87	U	**0.079**	J
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	—	ng/L	0.18	U	0.19	U	0.87	U	0.19	U	0.19	U	0.19	U	0.98	U	0.19	U	0.19	U	0.19	U	0.19	U	0.87	U	0.19	U
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	4	ng/L	**0.34**	J+	0.19	U	0.87	U	0.19	U	**0.17**	J	0.19	U	0.98	U	**0.13**	J	**0.07**	J	**0.097**	J	**0.091**	J	0.87	U	0.19	U
Perfluoro-1-nonanesulfonic acid (PFNS)	68259-12-1	—	ng/L	0.18	U	0.19	U	0.87	U	0.19	U	0.19	U	0.19	U	0.98	U	0.19	U	0.19	U	0.19	U	0.19	U	0.87	U	0.19	U
Perfluorodecanesulfonic Acid (PFDS)	335-77-3	—	ng/L	0.28	U	0.28	U	0.87	U	0.28	U	0.29	U	0.29	U	0.98	U	0.29	U	0.28	U	0.29	U	0.29	U	0.87	U	0.28	U
Perfluorododecanesulfonic Acid (PFDoS)	79780-39-5	—	ng/L	0.18	U	0.19	U	0.87	U	0.19	U	0.19	U	0.19	U	0.98	U	0.19	U	0.19	U	0.19	U	0.19	U	0.87	U	0.19	U
1H,1H,2H,2H-Perfluorohexane Sulfonic Acid (4:2 FTS)	757124-72-4	—	ng/L	0.74	U	0.75	U	1.7	U	0.75	U	0.77	U	0.77	U	2	U	0.77	U	0.74	U	0.77	U	0.78	U	1.7	U	0.75	U
1H,1H, 2H, 2H-Perfluorooctane Sulfonic Acid (6:2 FTS)	27619-97-2	—	ng/L	**54**		**30**		**2**	J	**19**		0.77	U	0.77	U	2	U	**3**		0.74	U	0.77	U	0.78	U	**18**		**1.1**	J
1H,1H, 2H, 2H-Perfluorodecane Sulfonic Acid (8:2 FTS)	39108-34-4	—	ng/L	0.74	U	0.75	U	1.7	U	0.75	U	0.77	U	0.77	U	2	U	0.77	U	0.74	U	0.77	U	0.78	U	1.7	U	0.75	U
1H,1H,2H,2H-perfluorododecane Sulfonic Acid (10:2 FTS)	120226-60-0	—	ng/L	—		—		—		0.75	U	—		—		—		0.77	U	—		—		—		—		0.75	U
N-Methyl Perfluorooctane Sulfonamide (NMeFOSA)	31506-32-8	—	ng/L	0.74	U	0.75	U	0.87	U	0.75	U	0.77	U	0.77	U	0.98	U	0.77	U	0.74	U	0.77	U	0.78	U	0.87	U	0.75	U
N-Ethyl Perfluorooctane Sulfonamide (NEtFOSA)	4151-50-2	—	ng/L	0.74	U	0.75	U	0.87	U	0.75	U	0.77	U	0.77	U	0.98	U	0.77	U	0.74	U	0.77	U	0.78	U	0.87	U	0.75	U
Perfluorobutane Sulfonamide (PFBSA)	30334-69-1	—	ng/L	—		—		—		0.19	U	—		—		—		0.19	U	—		—		—		—		0.19	U
Perfluorohexane Sulfonamide (PFHxSA)	41997-13-1	—	ng/L	—		—		—		0.19	U	—		—		—		0.19	U	—		—		—		—		0.19	U
Perfluorooctane Sulfonamide (PFOSA)	754-91-6	—	ng/L	0.18	U	0.19	U	0.87	U	0.19	U	0.19	U	0.19	U	0.98	U	0.19	U	0.19	U	0.19	U	0.19	U	0.87	U	0.19	U
N-Methyl Perfluorooctane Sulfonamidoacetic Acid	2355-31-9	—	ng/L	0.18	U	0.19	U	0.87	U	0.19	U	0.19	U	0.19	U	0.98	U	0.19	U	0.19	U	0.19	U	0.19	U	0.87	U	0.19	U
N-Ethyl Perfluorooctane Sulfonamidoacetic Acid (NEtFOSAA)	2991-50-6	—	ng/L	0.18	U	0.19	U	0.87	U	0.19	U	0.19	U	0.19	U	0.98	U	0.19	U	0.19	U	0.19	U	0.19	U	0.87	U	0.19	U
N-Methyl Perfluorooctane Sulfonamidoethanol (NMeFOSE)	24448-09-7	—	ng/L	1.1	U	1.1	U	4.4	U	1.1	U	1.2	U	1.2	U	4.9	U	1.2	U	1.1	U	1.2	U	1.2	U	4.3	U	1.1	U
N-Ethyl Perfluorooctane Sulfonamidoethanol (NEtFOSE)	1691-99-2	—	ng/L	1.1	U	1.1	U	4.4	U	1.1	U	1.2	U	1.2	U	4.9	U	1.2	U	1.1	U	1.2	U	1.2	U	4.3	U	1.1	U
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	1.5	ng/L	0.37	U	0.38	U	0.61	U	0.38	U	0.38	U	0.39	U	0.69	U	0.38	U	0.37	U	0.38	U	0.39	U	0.61	U	0.38	U
4,8-dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	—	ng/L	0.37	U	0.38	U	0.87	U	0.38	U	0.38	U	0.39	U	0.98	U	0.38	U	0.37	U	0.38	U	0.39	U	0.87	U	0.38	U
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	—	ng/L	0.37	U	0.38	U	0.87	U	0.38	U	0.38	U	0.39	U	0.98	U	0.38	U	0.37	U	0.38	U	0.39	U	0.87	U	0.38	U
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	—	ng/L	0.37	U	0.38	U	0.87	U	0.38	U	0.38	U	0.39	U	0.98	U	0.38	U	0.37	U	0.38	U	0.39	U	0.87	U	0.38	U
3:3 Fluorotelomer carboxylic acid	356-02-5	—	ng/L	0.74	U	0.75	U	1.7	U	0.75	U	0.77	U	0.77	U	2	U	0.77	U	0.74	U	0.77	U	0.78	U	1.7	U	0.75	U
5:3 Fluorotelomer carboxylic acid	914637-49-3	—	ng/L	**0.45**	J	0.75	U	4.4	U	0.75	U	0.77	U	0.77	U	4.9	U	0.77	U	0.74	U	0.77	U	0.78	U	4.3	U	0.75	U
7:3 Fluorotelomer carboxylic acid	812-70-4	—	ng/L	0.74	U	0.75	U	4.4	U	0.75	U	0.77	U	0.77	U	4.9	U	0.77	U	0.74	U	0.77	U	0.78	U	4.3	U	0.75	U
2H-Perfluoro-2-octenoic acid (6:2 FTUCA)	70887-88-6	—	ng/L	—		—		—		0.19	U	—		—		—		0.19	U	—		—		—		—		0.19	U
2H-Perfluoro-2-decenoic acid (8:2 FTUCA)	70887-84-2	—	ng/L	—		—		—		0.19	U	—		—		—		0.19	U	—		—		—		—		0.19	U
Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	—	ng/L	0.37	U	0.38	U	0.87	U	0.38	U	0.38	U	0.39	U	0.98	U	0.38	U	0.37	U	0.38	U	0.39	U	0.87	U	0.38	U
Perfluoro(4-ethylcyclohexane)sulfonic acid (PFEtCHxS)	646-83-3	—	ng/L	—		—		—		0.36	U	—		—		—		0.37	U	—		—		—		—		0.36	U
Perfluoro(4-Methyoxybutanoic) Acid (PFMBA)	863090-89-5	—	ng/L	0.37	U	0.38	U	0.87	U	0.38	U	0.38	U	0.39	U	0.98	U	0.38	U	0.37	U	0.38	U	0.39	U	0.87	U	0.38	U
Perfluoro-3-methoxypropanoic acid	377-73-1	—	ng/L	0.37	U	0.38	U	0.87	U	0.38	U	0.38	U	0.39	U	0.98	U	0.38	U	0.37	U	0.38	U	0.39	U	0.87	U	0.38	U
Nonafluoro-3,6-Dioxaheptanoic Acid (NFDHA)	151772-58-6	—	ng/L	0.37	U	0.38	U	0.87	U	0.38	U	0.38	U	0.39	U	0.98	U	0.38	U	0.37	U	0.38	U	0.39	U	0.87	U	0.38	U
bis(trifluoromethylsulfonyl)amine (TFSI)	82113-65-3	590	ng/L					0.87	U	**0.33**	J					0.98	U	0.29	U							0.87	U	0.28	U

Table B-5: Summary of Area A Basal Groundwater Quarterly Expedited Sampling Analytical Data (cont'd)
RI WP PFAS Release RHBFSF JBPHH Oahu HI

			Location	RHMW06								RHMW08										RHMW17							
			COC ID	JV019		JV102		JV150		JV222		JV006		JV091		JV092		JV152		JV210		JV024		JV109		JV153		JV228	
			Matrix	WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG	
			Sample Type	N		N		N		N		N		N		FD		N		N		N		N		N		N	
			Sample Date	10/10/2024		1/23/2025		4/21/2025		7/17/2025		10/1/2024		1/20/2025		1/20/2025		5/9/2025		7/18/2025		10/14/2024		1/24/2025		4/25/2025		7/21/2025	
Chemical	Cas No.	PSL [a,b]	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Perfluoropropanoic acid (PFPrA)	422-64-0	980	ng/L	—		—		5.1	U	**0.62**	J	—		—		—		53	UJ	0.77	U	—		—		**2.9**	J	**0.85**	J
Perfluorobutanoic Acid (PFBA)	375-22-4	1800	ng/L	0.77	U	0.78	U	2	U	0.72	U	**6**		**5.8**		**5.9**		21	U	**4.7**		**1.2**	J	0.74	U	1.8	U	**1.6**	
Perfluoropentanoic Acid (PFPeA)	2706-90-3	—	ng/L	**0.23**	J	**0.24**	J	1	U	0.36	U	**10**		**9.7**		**10**		**4.3**		**1.7**	J+	**2.4**		**0.98**		**0.77**	J	**1.7**	
Perfluorohexanoic Acid (PFHxA)	307-24-4	990	ng/L	**0.11**	J	**0.12**	J	1	U	**0.16**	J	**4.5**		**4.1**		**4.3**		**2.4**	J	**0.64**	J+	**1.9**		**0.53**		**0.49**	J	**1.2**	
Perfluoroheptanoic Acid (PFHpA)	375-85-9	—	ng/L	**0.23**	J	**0.27**	J	1	U	**0.22**	J	**4.2**		**3.7**		**4**		11	U	**0.68**		**1.6**		**0.46**		0.92	U	**0.58**	
Perfluorooctanoic Acid (PFOA)	335-67-1	4	ng/L	**0.23**	J	0.29	U	1	U	0.27	U	**1.7**		**1.6**		**1.6**		**0.64**	J	**0.16**		**0.88**		**0.25**	J	0.92	U	**0.27**	J
Perfluorononanoic Acid (PFNA)	375-95-1	5.9	ng/L	0.19	U	0.2	U	1	U	0.18	U	**0.14**	J	**0.19**	J	**0.18**	J	1.1	U	**0.38**	J	**0.14**	J	0.18	U	0.92	U	0.18	U
Perfluorodecanoic Acid (PFDA)	335-76-2	0.52	ng/L	0.19	U	0.2	U	1	U	0.18	U	**0.14**	J	**0.18**	J	**0.16**	J	1.1	U	**0.19**	J	0.18	U	0.18	U	0.92	U	0.18	U
Perfluoroundecanoic Acid (PFUnA)	2058-94-8	—	ng/L	0.29	U	0.29	U	1	U	0.27	U	0.3	U	0.27	U	0.27	U	1.1	U	0.29	U	0.28	U	0.28	U	0.92	U	0.27	U
Perfluorododecanoic Acid (PFDoA)	307-55-1	—	ng/L	0.19	U	0.2	U	1	U	0.18	U	0.2	U	0.18	U	0.18	U	1.1	U	0.19	U	0.18	U	0.18	U	0.92	U	0.18	U
Perfluorotridecanoic Acid (PFTrDA)	72629-94-8	—	ng/L	0.29	U	0.29	U	1	U	0.27	U	0.3	U	0.27	U	0.27	U	1.1	U	0.29	U	0.28	U	0.28	U	0.92	U	0.27	U
Perfluorotetradecanoic Acid (PFTA)	376-06-7	—	ng/L	0.29	U	0.29	U	1	U	0.27	U	0.3	U	0.27	U	0.27	U	1.1	U	0.29	U	0.28	U	0.28	U	0.92	U	0.27	U
Perfluorohexadecanoic Acid (PFHxDA)	67905-19-5	—	ng/L					1	U	0.27	U							1.1	U	0.29	U					0.92	U	0.27	U
Perfluorooctadecanoic Acid (PFODA)	16517-11-6	—	ng/L					1.4	U	0.27	U							1.5	U	0.29	U					1.3	U	0.27	U
Perfluorobutanesulfonic Acid (PFBS)	375-73-5	600	ng/L	0.19	U	0.2	U	1	U	0.18	U	**0.098**	J	**0.16**	J	**0.13**	J	1.1	U	**0.23**	J	**0.081**	J	**0.088**	J	0.92	U	0.18	U
Perfluoropentanesulfonic Acid (PFPeS)	2706-91-4	—	ng/L	0.19	U	0.2	U	1	U	0.18	U	0.2	U	0.18	U	0.18	U	1.1	U	0.19	U	0.18	U	0.18	U	0.92	U	0.18	U
Perfluorohexanesulfonic Acid (PFHxS)	355-46-4	10	ng/L	0.19	U	0.2	U	1	U	**0.046**	J	**0.13**	J	**0.098**	J	**0.088**	J	1.1	U	0.19	U	**0.55**		0.18	U	0.92	U	0.18	U
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	—	ng/L	0.19	U	0.2	U	1	U	0.18	U	0.2	U	0.18	U	0.18	U	1.1	U	0.19	U	0.18	U	0.18	U	0.92	U	0.18	U
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	4	ng/L	0.19	U	**0.063**	J	1	U	0.18	U	**0.16**	J	0.18	U	0.18	U	1.1	U	**0.094**		**0.53**		**0.1**	J	0.92	U	**0.21**	J+
Perfluoro-1-nonanesulfonic acid (PFNS)	68259-12-1	—	ng/L	0.19	U	0.2	U	1	U	0.18	U	0.2	U	0.18	U	0.18	U	1.1	U	0.19	U	0.18	U	0.18	U	0.92	U	0.18	U
Perfluorodecanesulfonic Acid (PFDS)	335-77-3	—	ng/L	0.29	U	0.29	U	1	U	0.27	U	0.3	U	0.27	U	0.27	U	1.1	U	0.29	U	0.28	U	0.28	U	0.92	U	0.27	U
Perfluorododecanesulfonic Acid (PFDoS)	79780-39-5	—	ng/L	0.19	U	0.2	U	1	U	0.18	U	0.2	U	0.18	U	0.18	U	1.1	U	0.19	U	0.18	U	0.18	U	0.92	U	0.18	U
1H,1H,2H,2H-Perfluorohexane Sulfonic Acid (4:2 FTS)	757124-72-4	—	ng/L	0.77	U	0.78	U	2	U	0.72	U	0.79	U	0.73	U	0.73	U	2.1	U	0.77	UJ	0.74	U	0.74	U	1.8	U	0.72	U
1H,1H, 2H, 2H-Perfluorooctane Sulfonic Acid (6:2 FTS)	27619-97-2	—	ng/L	0.77	U	0.78	U	2	U	0.72	U	**0.54**	J	**0.89**	J	**0.84**	J	**16**	J	**1.2**	J	**0.66**	J	0.74	U	1.8	U	**1.1**	J
1H,1H, 2H, 2H-Perfluorodecane Sulfonic Acid (8:2 FTS)	39108-34-4	—	ng/L	0.77	U	0.78	U	2	U	0.72	U	0.79	U	0.73	U	0.73	U	2.1	U	0.77	U	0.74	U	0.74	U	1.8	U	0.72	U
1H,1H,2H,2H-perfluorododecane Sulfonic Acid (10:2 FTS)	120226-60-0	—	ng/L	—		—		—		0.72	U	—		—		—		—		0.77	U	—		—		—		0.72	U
N-Methyl Perfluorooctane Sulfonamide (NMeFOSA)	31506-32-8	—	ng/L	0.77	U	0.78	U	1	U	0.72	U	0.79	U	0.73	U	0.73	U	1.1	U	0.77	U	0.74	U	0.74	U	0.92	U	0.72	U
N-Ethyl Perfluorooctane Sulfonamide (NEtFOSA)	4151-50-2	—	ng/L	0.77	U	0.78	U	1	U	0.72	U	0.79	U	0.73	U	0.73	U	1.1	U	0.77	U	0.74	U	0.74	U	0.92	U	0.72	U
Perfluorobutane Sulfonamide (PFBSA)	30334-69-1	—	ng/L	—		—		—		0.18	U	—		—		—		—		0.19	U	—		—		—		0.18	U
Perfluorohexane Sulfonamide (PFHxSA)	41997-13-1	—	ng/L	—		—		—		0.18	U	—		—		—		—		0.19	U	—		—		—		0.18	U
Perfluorooctane Sulfonamide (PFOSA)	754-91-6	—	ng/L	0.19	U	0.2	U	1	U	0.18	U	0.2	U	0.18	U	0.18	U	1.1	U	0.19	U	0.18	U	0.18	U	0.92	U	0.18	U
N-Methyl Perfluorooctane Sulfonamidoacetic Acid	2355-31-9	—	ng/L	0.19	U	0.2	U	1	U	0.18	U	0.2	U	0.18	U	0.18	U	1.1	U	0.19	U	0.18	U	0.18	U	0.92	U	0.18	U
N-Ethyl Perfluorooctane Sulfonamidoacetic Acid (NEtFOSAA)	2991-50-6	—	ng/L	0.19	U	0.2	U	1	U	0.18	U	0.2	U	0.18	U	0.18	U	1.1	U	0.19	U	0.18	U	0.18	U	0.92	U	0.18	U
N-Methyl Perfluorooctane Sulfonamidoethanol (NMeFOSE)	24448-09-7	—	ng/L	1.2	U	1.2	U	5.1	U	1.1	U	1.2	U	1.1	U	1.1	U	5.3	U	1.1	U	1.1	U	1.1	U	4.6	U	1.1	U
N-Ethyl Perfluorooctane Sulfonamidoethanol (NEtFOSE)	1691-99-2	—	ng/L	1.2	U	1.2	U	5.1	U	1.1	U	1.2	U	1.1	U	1.1	U	5.3	U	1.1	U	1.1	U	1.1	U	4.6	U	1.1	U
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	1.5	ng/L	0.38	U	0.39	U	0.71	U	0.36	U	0.39	U	0.37	U	0.36	U	7.5	U	0.38	U	0.37	U	0.37	U	0.64	U	0.36	U
4,8-dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	—	ng/L	0.38	U	0.39	U	1	U	0.36	U	0.39	U	0.37	U	0.36	U	11	U	0.38	U	0.37	U	0.37	U	0.92	U	0.36	U
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	—	ng/L	0.38	U	0.39	U	1	U	0.36	U	0.39	U	0.37	U	0.36	U	11	UJ	0.38	U	0.37	U	0.37	U	0.92	U	0.36	U
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	—	ng/L	0.38	U	0.39	U	1	U	0.36	U	0.39	U	0.37	U	0.36	U	11	UJ	0.38	U	0.37	U	0.37	U	0.92	U	0.36	U
3:3 Fluorotelomer carboxylic acid	356-02-5	—	ng/L	0.77	U	0.78	U	2	U	0.72	U	0.79	U	0.73	U	0.73	U	2.1	UJ	0.77	U	0.74	U	0.74	U	1.8	U	0.72	U
5:3 Fluorotelomer carboxylic acid	914637-49-3	—	ng/L	0.77	U	0.78	U	5.1	U	0.72	U	0.79	U	0.73	U	0.73	U	5.3	U	0.77	U	0.74	U	0.74	U	4.6	U	0.72	U
7:3 Fluorotelomer carboxylic acid	812-70-4	—	ng/L	0.77	U	0.78	U	5.1	U	0.72	U	0.79	U	0.73	U	0.73	U	5.3	U	0.77	U	0.74	U	0.74	U	4.6	U	0.72	U
2H-Perfluoro-2-octenoic acid (6:2 FTUCA)	70887-88-6	—	ng/L	—		—		—		0.18	U	—		—		—		—		0.19	U	—		—		—		0.18	U
2H-Perfluoro-2-decenoic acid (8:2 FTUCA)	70887-84-2	—	ng/L	—		—		—		0.18	U	—		—		—		—		0.19	U	—		—		—		0.18	U
Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	—	ng/L	0.38	U	0.39	U	1	U	0.36	U	0.39	U	0.37	U	0.36	U	1.1	U	0.38	U	0.37	U	0.37	U	0.92	U	0.36	U
Perfluoro(4-ethylcyclohexane)sulfonic acid (PFEtCHxS)	646-83-3	—	ng/L	—		—		—		0.34	U	—		—		—		—		0.36	U	—		—		—		0.34	U
Perfluoro(4-Methyoxybutanoic) Acid (PFMBA)	863090-89-5	—	ng/L	0.38	U	0.39	U	1	U	0.36	U	0.39	U	0.37	U	0.36	U	1.1	UJ	0.38	U	0.37	U	0.37	U	0.92	U	0.36	U
Perfluoro-3-methoxypropanoic acid	377-73-1	—	ng/L	0.38	U	0.39	U	1	U	0.36	U	0.39	U	0.37	U	0.36	U	1.1	UJ	0.38	U	0.37	U	0.37	U	0.92	U	0.36	U
Nonafluoro-3,6-Dioxaheptanoic Acid (NFDHA)	151772-58-6	—	ng/L	0.38	U	0.39	U	1	U	0.36	U	0.39	U	0.37	U	0.36	U	1.1	UJ	0.38	U	0.37	U	0.37	U	0.92	U	0.36	U
bis(trifluoromethylsulfonyl)amine (TFSI)	82113-65-3	590	ng/L					1	U	0.27	U							11	U	0.29	U					0.92	U	0.27	U

Table B-5: Summary of Area A Basal Groundwater Quarterly Expedited Sampling Analytical Data (cont'd)
RI WP PFAS Release RHBFSF JBPHH Oahu HI

			Location	RHMW18										RHMW20								RHMW21									
			COC ID	JV073		JV113		JV114		JV157		JV232		JV032		JV124		JV158		JV244		JV038		JV039		JV093		JV159		JV211	
			Matrix	WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG	
			Sample Type	N		N		FD		N		N		N		N		N		N		N		FD		N		N		N	
			Sample Date	11/7/2024		1/27/2025		1/27/2025		4/24/2025		7/24/2025		10/16/2024		1/29/2025		4/29/2025		7/24/2025		10/21/2024		10/21/2024		1/20/2025		4/18/2025		7/14/2025	
Chemical	Cas No.	PSL [a,b]	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Perfluoropropanoic acid (PFPrA)	422-64-0	980	ng/L	—		—		—		50	U	0.72	U	—		—		5	U	0.78	U	—		—		—		4.8	U	**1**	J
Perfluorobutanoic Acid (PFBA)	375-22-4	1800	ng/L	**0.5**	J	0.79	U	0.77	U	**0.9**	J	0.72	U	**0.31**	J	0.66	U	2	U	0.78	U	**0.84**	J	**0.81**	J	**0.91**	J	1.9	U	**0.95**	J+
Perfluoropentanoic Acid (PFPeA)	2706-90-3	—	ng/L	**1.5**		**0.58**	J	**0.6**	J	**0.66**	J	0.36	U	**0.23**	J	**0.13**	J	1	U	0.39	U	**3.8**		**3.8**		**4.1**		**4**		**3.4**	
Perfluorohexanoic Acid (PFHxA)	307-24-4	990	ng/L	**0.53**		**0.2**	J	**0.19**	J	0.89	U	**0.16**	J	**0.14**	J	**0.081**	J	1	U	**0.1**	J	**1.1**		**1.2**		**1.2**		**1.1**	J	**1.3**	
Perfluoroheptanoic Acid (PFHpA)	375-85-9	—	ng/L	**0.15**	J	**0.13**	J	**0.084**	J	0.89	U	**0.099**	J	**0.092**	J	**0.084**	J	1	U	**0.085**	J	**0.22**	J	**0.23**	J	**0.2**	J	0.96	U	**0.38**	J
Perfluorooctanoic Acid (PFOA)	335-67-1	4	ng/L	0.28	U	0.3	U	0.29	U	0.89	U	0.27	U	**0.16**	J	0.25	U	1	UJ	0.29	U	0.27	U	0.27	U	0.28	U	0.96	U	0.29	U
Perfluorononanoic Acid (PFNA)	375-95-1	5.9	ng/L	0.19	U	0.2	U	0.19	U	0.89	U	0.18	U	0.19	U	0.16	U	1	U	0.19	U	0.18	U	0.18	U	0.19	U	0.96	U	0.19	U
Perfluorodecanoic Acid (PFDA)	335-76-2	0.52	ng/L	0.19	U	0.2	U	0.19	U	0.89	U	0.18	U	0.19	U	0.16	U	1	U	0.19	U	0.18	U	0.18	U	0.19	U	0.96	U	0.19	U
Perfluoroundecanoic Acid (PFUnA)	2058-94-8	—	ng/L	0.28	U	0.3	U	0.29	U	0.89	U	0.27	U	0.29	U	0.25	U	1	U	0.29	U	0.27	U	0.27	U	0.28	U	0.96	U	0.29	U
Perfluorododecanoic Acid (PFDoA)	307-55-1	—	ng/L	0.19	U	0.2	U	0.19	U	0.89	U	**0.27**	J	0.19	U	0.16	U	1	U	0.19	U	0.18	U	0.18	U	0.19	U	0.96	U	0.19	U
Perfluorotridecanoic Acid (PFTrDA)	72629-94-8	—	ng/L	0.28	U	0.3	U	0.29	U	0.89	U	0.27	U	0.29	U	0.25	U	1	U	0.29	U	0.27	U	0.27	U	0.28	U	0.96	U	0.29	U
Perfluorotetradecanoic Acid (PFTA)	376-06-7	—	ng/L	0.28	U	0.3	U	0.29	U	0.89	U	0.27	U	0.29	U	0.25	U	1	U	0.29	U	0.27	U	0.27	U	0.28	U	0.96	U	0.29	U
Perfluorohexadecanoic Acid (PFHxDA)	67905-19-5	—	ng/L							0.89	U	0.27	U					1	U	0.29	U							0.96	U	0.29	U
Perfluorooctadecanoic Acid (PFODA)	16517-11-6	—	ng/L							1.2	U	0.27	U					1.4	U	0.29	UJ							1.3	U	0.29	UJ
Perfluorobutanesulfonic Acid (PFBS)	375-73-5	600	ng/L	**0.047**	J	**0.036**		**0.041**	J	0.89	U	0.18	U	0.19	U	0.16	U	1	U	0.19	U	0.18	U	0.18	U	0.19	U	0.96	U	0.19	U
Perfluoropentanesulfonic Acid (PFPeS)	2706-91-4	—	ng/L	0.19	U	0.2	U	0.19	U	0.89	U	0.18	U	0.19	U	0.16	U	1	U	0.19	U	0.18	U	0.18	U	0.19	U	0.96	U	0.19	U
Perfluorohexanesulfonic Acid (PFHxS)	355-46-4	10	ng/L	0.19	U	0.2	U	0.19	U	0.89	U	0.18	U	0.19	U	0.16	U	1	U	0.19	U	0.18	U	**0.057**	J	0.19	U	0.96	U	0.19	U
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	—	ng/L	0.19	U	0.2	U	0.19	U	0.89	U	0.18	U	0.19	U	0.16	U	1	U	0.19	U	0.18	U	0.18	U	0.19	U	0.96	U	0.19	U
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	4	ng/L	**0.075**	J	**0.096**	J	**0.091**	J	0.89	U	0.18	U	**0.4**		**0.092**	J+	1	U	0.19	U	**0.13**	J	**0.27**	J	0.19	U	0.96	U	0.19	U
Perfluoro-1-nonanesulfonic acid (PFNS)	68259-12-1	—	ng/L	0.19	U	0.2	U	0.19	U	0.89	U	0.18	U	0.19	U	0.16	U	1	U	0.19	U	0.18	U	0.18	U	0.19	U	0.96	U	0.19	U
Perfluorodecanesulfonic Acid (PFDS)	335-77-3	—	ng/L	0.28	U	0.3	U	0.29	U	0.89	U	**0.15**	J	0.29	U	0.25	U	1	U	0.29	U	0.27	U	0.27	U	0.28	U	0.96	U	0.29	U
Perfluorododecanesulfonic Acid (PFDoS)	79780-39-5	—	ng/L	0.19	U	0.2	U	0.19	U	0.89	U	0.18	U	0.19	U	0.16	U	1	U	0.19	U	0.18	U	0.18	U	0.19	U	0.96	U	0.19	U
1H,1H,2H,2H-Perfluorohexane Sulfonic Acid (4:2 FTS)	757124-72-4	—	ng/L	0.75	U	0.79	U	0.77	U	1.8	U	0.72	U	0.78	U	0.66	U	2	U	0.78	U	0.72	U	0.73	U	0.76	U	1.9	U	0.77	U
1H,1H, 2H, 2H-Perfluorooctane Sulfonic Acid (6:2 FTS)	27619-97-2	—	ng/L	**3.7**		**0.62**	J	**0.62**	J	1.8	U	0.72	U	0.78	U	0.66	U	2	U	0.78	U	**4.6**		**4.8**		**2.1**		**2**	J	**2.8**	
1H,1H, 2H, 2H-Perfluorodecane Sulfonic Acid (8:2 FTS)	39108-34-4	—	ng/L	0.75	U	0.79	U	0.77	U	1.8	U	0.72	U	0.78	U	0.66	U	2	U	0.78	U	0.72	U	0.73	U	0.76	U	1.9	U	0.77	U
1H,1H,2H,2H-perfluorododecane Sulfonic Acid (10:2 FTS)	120226-60-0	—	ng/L	—		—		—		—		0.72	U	—		—		—		0.78	U	—		—		—		—		0.77	U
N-Methyl Perfluorooctane Sulfonamide (NMeFOSA)	31506-32-8	—	ng/L	0.75	U	0.79	U	0.77	U	0.89	U	**0.94**	J	0.78	U	0.66	U	1	U	0.78	U	0.72	U	0.73	U	0.76	U	0.96	U	0.77	U
N-Ethyl Perfluorooctane Sulfonamide (NEtFOSA)	4151-50-2	—	ng/L	0.75	U	0.79	U	0.77	U	0.89	U	0.72	U	0.78	U	0.66	U	1	U	0.78	U	0.72	U	0.73	U	0.76	U	0.96	U	0.77	U
Perfluorobutane Sulfonamide (PFBSA)	30334-69-1	—	ng/L	—		—		—		—		0.18	U	—		—		—		0.19	U	—		—		—		—		0.19	U
Perfluorohexane Sulfonamide (PFHxSA)	41997-13-1	—	ng/L	—		—		—		—		0.18	U	—		—		—		0.19	U	—		—		—		—		0.19	U
Perfluorooctane Sulfonamide (PFOSA)	754-91-6	—	ng/L	0.19	U	0.2	U	0.19	U	0.89	U	0.18	U	0.19	U	0.16	U	1	U	0.19	U	0.18	U	0.18	U	0.19	U	0.96	U	0.19	U
N-Methyl Perfluorooctane Sulfonamidoacetic Acid	2355-31-9	—	ng/L	0.19	U	0.2	U	0.19	U	0.89	U	0.18	U	0.19	U	0.16	U	1	U	0.19	U	0.18	U	0.18	U	0.19	U	0.96	U	0.19	U
N-Ethyl Perfluorooctane Sulfonamidoacetic Acid (NEtFOSAA)	2991-50-6	—	ng/L	0.19	U	0.2	U	0.19	U	0.89	U	**0.27**	J	0.19	U	0.16	U	1	U	0.19	U	0.18	U	0.18	U	0.19	U	0.96	U	0.19	U
N-Methyl Perfluorooctane Sulfonamidoethanol (NMeFOSE)	24448-09-7	—	ng/L	1.1	U	1.2	U	1.2	U	4.4	U	1.1	U	1.2	U	0.99	U	5	U	1.2	U	1.1	U	1.1	U	1.1	U	4.8	U	1.2	U
N-Ethyl Perfluorooctane Sulfonamidoethanol (NEtFOSE)	1691-99-2	—	ng/L	1.1	U	1.2	U	1.2	U	4.4	U	1.1	U	1.2	U	0.99	U	5	U	1.2	U	1.1	U	1.1	U	1.1	U	4.8	U	1.2	U
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	1.5	ng/L	0.38	U	0.4	U	0.38	U	0.62	U	0.36	U	0.39	U	0.33	U	0.71	U	0.39	U	0.36	U	0.36	U	0.38	U	0.67	U	0.39	U
4,8-dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	—	ng/L	0.38	U	0.4	U	0.38	U	0.89	U	0.36	U	0.39	U	0.33	U	1	U	0.39	U	0.36	U	0.36	U	0.38	U	0.96	U	0.39	U
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	—	ng/L	0.38	U	0.4	U	0.38	U	0.89	U	0.36	U	0.39	U	0.33	U	1	U	0.39	U	0.36	U	0.36	U	0.38	U	0.96	U	0.39	U
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	—	ng/L	0.38	U	0.4	U	0.38	U	0.89	U	0.36	U	0.39	U	0.33	U	1	U	0.39	U	0.36	U	0.36	U	0.38	U	0.96	U	0.39	U
3:3 Fluorotelomer carboxylic acid	356-02-5	—	ng/L	0.75	U	0.79	U	0.77	U	1.8	U	0.72	U	0.78	U	0.66	U	2	U	0.78	U	0.72	U	0.73	U	0.76	U	1.9	U	0.77	U
5:3 Fluorotelomer carboxylic acid	914637-49-3	—	ng/L	0.75	U	0.79	U	0.77	U	4.4	U	0.72	U	0.78	U	0.66	U	5	U	0.78	U	0.72	U	0.73	U	0.76	U	4.8	U	0.77	U
7:3 Fluorotelomer carboxylic acid	812-70-4	—	ng/L	0.75	U	0.79	U	0.77	U	4.4	U	0.72	U	0.78	U	0.66	U	5	U	0.78	U	0.72	U	0.73	U	0.76	U	4.8	U	0.77	U
2H-Perfluoro-2-octenoic acid (6:2 FTUCA)	70887-88-6	—	ng/L	—		—		—		—		0.18	U	—		—		—		0.19	U	—		—		—		—		0.19	U
2H-Perfluoro-2-decenoic acid (8:2 FTUCA)	70887-84-2	—	ng/L	—		—		—		—		0.18	U	—		—		—		0.19	U	—		—		—		—		0.19	U
Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	—	ng/L	0.38	U	0.4	U	0.38	U	0.89	U	0.36	U	0.39	U	0.33	U	1	U	0.39	U	0.36	U	0.36	U	0.38	U	0.96	U	0.39	U
Perfluoro(4-ethylcyclohexane)sulfonic acid (PFEtCHxS)	646-83-3	—	ng/L	—		—		—		—		0.34	U	—		—		—		0.37	U	—		—		—		—		0.37	U
Perfluoro(4-Methyoxybutanoic) Acid (PFMBA)	863090-89-5	—	ng/L	0.38	U	0.4	U	0.38	U	0.89	U	0.36	U	0.39	U	0.33	U	1	U	0.39	U	0.36	U	0.36	U	0.38	U	0.96	U	0.39	U
Perfluoro-3-methoxypropanoic acid	377-73-1	—	ng/L	0.38	U	0.4	U	0.38	U	0.89	U	0.36	U	0.39	U	0.33	U	1	U	0.39	U	0.36	U	0.36	U	0.38	U	0.96	U	0.39	U
Nonafluoro-3,6-Dioxaheptanoic Acid (NFDHA)	151772-58-6	—	ng/L	0.38	U	0.4	U	0.38	U	0.89	U	0.36	U	0.39	U	0.33	U	1	U	0.39	U	0.36	U	0.36	U	0.38	U	0.96	U	0.39	U
bis(trifluoromethylsulfonyl)amine (TFSI)	82113-65-3	590	ng/L							0.89	U	0.27	U					1	U	0.29	U							0.96	U	0.29	U

Notes:
Units are in ng/L.
Analysis conducted using EPA Method 1633 (EPA 2024).
Bold and shaded text indicates analyte was detected above the PSL
Bold text indicates analyte was detected
— = not applicable
abbr. = abbreviated chemical name
Cas No. = chemical abstracts service registry number
COC = chain of custody
EPA = Environmental Protection Agency, United States
FD = field duplicate sample
ID = identification
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 low
J+ = the result was an estimated quantity, but the result may be biased high
LOD = limit of detection
N = primary sample
ng/L = nanogram per liter
PSL = project screening level
Q = data qualifier
R = Rejected. The data is unusable (the analyte may or may not be present). Use of the "R" qualifier indicates a significant variance from guideline acceptance criteria. Either resampling or re-analysis is necessary to determine the presence or absence of the rejected analyte.
RSL = regional screening level
U = the analyte was not detected and was reported as less than the LOD
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.
WG = groundwater
[a] EPA tap water RSL using a THQ of 0.1 and a target cancer risk of 1E-06 – November 2024 (EPA 2024).
[b] PSLs consistent with DoD memorandum (ASD 2025). PSLs are identified in Worksheet #15.

References:

ASD 2025. Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program. Memorandum : Office of the Assistant Secretary of Defense January 21, 2025.
EPA 2024. EPA Method 1633: Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS. Environmental Protection Agency, United States, January 2024.

Table B-6: Summary of Area B Perched Groundwater Quarterly Expedited Sampling Analytical Data
RI WP PFAS Release RHBFSF JBPHH Oahu HI

			Location	OWDFMW03B										OWDFMW05B								OWDFMW06B						OWDFMW07B					
			COC ID	JV029		JV030		JV116		JV176		JV234		JV131		JV132		JV180		JV250		JV128		JV182		JV247		JV130		JV184		JV249	
			Matrix	WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG	
			Sample Type	N		FD		N		N		N		N		FD		N		N		N		N		N		N		N		N	
			Sample Date	10/15/2024		10/15/2024		1/28/2025		4/3/2025		7/28/2025		2/27/2025		2/27/2025		4/3/2025		8/1/2025		2/27/2025		4/1/2025		8/1/2025		2/27/2025		4/2/2025		7/29/2025	
Chemical	Cas No.	PSL[a,b]	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Perfluoropropanoic acid (PFPrA)	422-64-0	980	ng/L	—		—		—		1100	J	1100		—		—		1600	J		R	—		44		38		—		35		28	
Perfluorobutanoic Acid (PFBA)	375-22-4	1800	ng/L	1900		2000		1600		1500	J	2200		2100		2100		2200	J	2400		40		35		41		37		30		32	
Perfluoropentanoic Acid (PFPeA)	2706-90-3	—	ng/L	4800	J+	5800	J+	5700		5400	J	7500		3700		4100		7200	J	4100		65		51		68		49		49		32	
Perfluorohexanoic Acid (PFHxA)	307-24-4	990	ng/L	4100		4900		4900		4200	J	6800		4100		4800		5000	J	4500		34		40		37		31		26		22	
Perfluoroheptanoic Acid (PFHpA)	375-85-9	—	ng/L	1200		1400		930		980	J	1900		790		850		770	J	1100		25		26		27		25		23		17	
Perfluorooctanoic Acid (PFOA)	335-67-1	4	ng/L	23		29		27		35	J	30		17		18		14	J	21		17		21		19		25		26		23	
Perfluorononanoic Acid (PFNA)	375-95-1	5.9	ng/L	1.5		1.6		1.6		10	UJ	1.3		1.3		1.2		10	UJ	1.5		6.2		6		7.5		8.2		7.4		7.2	
Perfluorodecanoic Acid (PFDA)	335-76-2	0.52	ng/L	0.19	U	0.18	U	0.18	U	10	UJ	0.18	U	0.17	U	0.17	U	10	UJ	0.2	U	0.2	J	0.99	U	0.21	J	0.34	J	1	U	0.45	
Perfluoroundecanoic Acid (PFUnA)	2058-94-8	—	ng/L	0.28	U	0.27	U	0.27	U	10	UJ	0.27	U	0.26	U	0.26	U	10	UJ	0.29	U	0.26	U	0.99	U	0.31	U	0.41		1	U	1.1	
Perfluorododecanoic Acid (PFDoA)	307-55-1	—	ng/L	0.19	U	0.18	U	0.18	U	10	UJ	0.18	U	0.17	U	0.17	U	10	UJ	0.2	U	0.18	U	0.99	U	0.2	U	0.18	U	1	U	0.19	U
Perfluorotridecanoic Acid (PFTrDA)	72629-94-8	—	ng/L	0.28	U	0.27	U	0.27	U	10	UJ	0.27	U	0.26	U	0.26	U	10	UJ	0.29	U	0.26	U	0.99	U	0.31	U	0.27	U	1	U	0.29	U
Perfluorotetradecanoic Acid (PFTA)	376-06-7	—	ng/L	0.28	U	0.27	U	0.27	U	10	UJ	0.27	U	0.26	U	0.26	U	10	UJ	0.29	U	0.26	U	0.99	U	0.31	U	0.27	U	1	U	0.29	U
Perfluorohexadecanoic Acid (PFHxDA)	67905-19-5	—	ng/L							10	UJ	0.27	U					10	UJ	0.29	U			0.99	U	0.31	U			1	U	0.29	U
Perfluorooctadecanoic Acid (PFODA)	16517-11-6	—	ng/L							14	UJ	0.27	UJ					14	UJ	0.29	UJ			1.4	U	0.31	UJ			1.4	U	0.29	UJ
Perfluorobutanesulfonic Acid (PFBS)	375-73-5	600	ng/L	8		18		17		15	J	13		10		10		10	UJ	10		14		14		15		17		17		17	
Perfluoropentanesulfonic Acid (PFPeS)	2706-91-4	—	ng/L	9.6		8.9		8		9.4	J	7.2		3.4		3.6		10	UJ	5.4		1.3		1.4	J	1.3		1.2		1.3	J	1.2	
Perfluorohexanesulfonic Acid (PFHxS)	355-46-4	10	ng/L	62		58		58		43	J	48		39		27		27	J	40		17		17		18		17		17		18	
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	—	ng/L	1.9		2		2		10	UJ	1.8		0.75		0.76		10	UJ	0.92		0.53		0.52	J	0.45		0.35	J	1	U	0.36	J
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	4	ng/L	69		67		73		64	J	57		19		20		8.8	J	21		36		33		32		19		16		20	
Perfluoro-1-nonanesulfonic acid (PFNS)	68259-12-1	—	ng/L	0.19	U	0.18	U	0.18	U	10	UJ	0.18	U	0.17	U	0.17	U	10	UJ	0.2	U	0.18	U	0.99	U	0.2	U	0.18	U	1	U	0.19	U
Perfluorodecanesulfonic Acid (PFDS)	335-77-3	—	ng/L	0.28	U	0.27	U	0.27	U	10	UJ	0.27	U	0.26	U	0.26	U	10	UJ	0.29	U	0.26	U	0.99	U	0.31	U	0.27	U	1	U	0.29	U
Perfluorododecanesulfonic Acid (PFDoS)	79780-39-5	—	ng/L	0.19	U	0.18	U	0.18	U	10	UJ	0.18	U	0.17	U	0.17	U	10	UJ	0.2	U	0.18	U	0.99	U	0.2	U	0.18	U	1	U	0.19	U
1H,1H,2H,2H-Perfluorohexane Sulfonic Acid (4:2 FTS)	757124-72-4	—	ng/L	3.9		3.9		3.4		20	UJ	4.2		44		32		42	J	30		0.7	U	2	U	0.82	U	0.71	U	2	U	0.77	U
1H,1H, 2H, 2H-Perfluorooctane Sulfonic Acid (6:2 FTS)	27619-97-2	—	ng/L	7100	J-	7800	J-	9000		5100	J	9200		40000		47000		25000	J	43000		0.61	J	2	U	0.72	J	0.45	J	2	U	1.3	J
1H,1H, 2H, 2H-Perfluorodecane Sulfonic Acid (8:2 FTS)	39108-34-4	—	ng/L	0.096	J	0.093	J	0.12	J	20	UJ	0.18	U	0.2	J	0.18	J	20	UJ	0.18	J	0.7	U	2	U	0.82	U	0.71	U	2	U	0.77	U
1H,1H,2H,2H-perfluorododecane Sulfonic Acid (10:2 FTS)	120226-60-0	—	ng/L	—		—		—		—		0.71	U	—		—		—		0.79	U	—		—		0.82	U	—		—		0.77	U
N-Methyl Perfluorooctane Sulfonamide (NMeFOSA)	31506-32-8	—	ng/L	0.74	U	0.71	U	0.73	U	10	UJ	0.71	U	0.69	U	0.69	U	10	UJ	0.79	U	0.7	U	0.99	U	0.82	U	0.71	U	1	U	0.77	U
N-Ethyl Perfluorooctane Sulfonamide (NEtFOSA)	4151-50-2	—	ng/L	0.74	U	0.71	U	0.73	U	10	UJ	0.71	U	0.69	U	0.69	U	10	UJ	0.79	U	0.7	U	0.99	U	0.82	U	0.71	U	1	U	0.77	U
Perfluorobutane Sulfonamide (PFBSA)	30334-69-1	—	ng/L	—		—		—		—		0.2	J	—		—		—		0.2	U	—		—		0.63		—		—		0.28	J
Perfluorohexane Sulfonamide (PFHxSA)	41997-13-1	—	ng/L	—		—		—		—		0.18	U	—		—		—		0.2	U	—		—		0.2	U	—		—		0.19	U
Perfluorooctane Sulfonamide (PFOSA)	754-91-6	—	ng/L	0.19	U	0.18	U	0.18	U	10	UJ	0.18	U	0.17	U	0.17	U	10	UJ	0.2	U	0.18	U	0.99	U	0.2	U	0.18	U	1	U	0.19	U
N-Methyl Perfluorooctane Sulfonamidoacetic Acid	2355-31-9	—	ng/L	0.19	U	0.18	U	0.18	U	10	UJ	0.18	U	0.17	U	0.17	U	10	UJ	0.2	U	0.18	U	0.99	U	0.2	U	0.18	U	1	U	0.19	U
N-Ethyl Perfluorooctane Sulfonamidoacetic Acid (NEtFOSAA)	2991-50-6	—	ng/L	0.19	U	0.18	U	0.18	U	10	UJ	0.18	U	0.17	U	0.17	U	10	UJ	0.2	U	0.18	U	0.99	U	0.2	U	0.18	U	1	U	0.19	U
N-Methyl Perfluorooctane Sulfonamidoethanol (NMeFOSE)	24448-09-7	—	ng/L	1.1	U	1.1	U	1.1	U	50	UJ	1.1	U	1	U	1	U	50	UJ	1.2	U	1.1	U	4.9	U	1.2	U	1.1	U	5.1	U	1.2	U
N-Ethyl Perfluorooctane Sulfonamidoethanol (NEtFOSE)	1691-99-2	—	ng/L	1.1	U	1.1	U	1.1	U	50	UJ	1.1	U	1	U	1	U	50	UJ	1.2	U	1.1	U	4.9	U	1.2	U	1.1	U	5.1	U	1.2	U
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	1.5	ng/L	0.37	U	0.35	U	0.37	U	7	UJ	0.35	U	0.35	U	0.35	U	7	UJ	0.39	U	0.35	U	0.69	U	0.41	U	0.36	U	0.71	U	0.39	U
4,8-dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	—	ng/L	0.37	U	0.35	U	0.37	U	10	UJ	0.35	U	0.35	U	0.35	U	10	UJ	0.39	U	0.35	U	0.99	U	0.41	U	0.36	U	1	U	0.39	U
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	—	ng/L	0.37	U	0.35	U	0.37	U	10	UJ	0.35	U	0.35	U	0.35	U	10	UJ	0.39	U	0.35	U	0.99	U	0.41	U	0.36	U	1	U	0.39	U
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	—	ng/L	0.37	U	0.35	U	0.37	U	10	UJ	0.35	U	0.35	U	0.35	U	10	UJ	0.39	U	0.35	U	0.99	U	0.41	U	0.36	U	1	U	0.39	U
3:3 Fluorotelomer carboxylic acid	356-02-5	—	ng/L	3.9		6.8		0.73	U	20	UJ	21		0.69	UJ	0.69	UJ	20	UJ	0.79	U	0.7	U	20	U	0.82	U	0.71	U	2	U	0.77	U
5:3 Fluorotelomer carboxylic acid	914637-49-3	—	ng/L	7		11		2.2		50	UJ	46		3.4	J+	5	J+	50	UJ	2.2		0.7	U	4.9	U	0.82	U	0.71	U	5.1	U	0.77	U
7:3 Fluorotelomer carboxylic acid	812-70-4	—	ng/L	0.74	U	0.71	U	0.73	U	50	UJ	0.71	U	0.69	UJ	0.69	UJ	50	UJ	0.79	U	0.7	U	4.9	U	0.82	U	0.71	U	5.1	U	0.77	U
2H-Perfluoro-2-octenoic acid (6:2 FTUCA)	70887-88-6	—	ng/L	—		—		—		—		18		—		—		—		0.2	U	—		—		0.2	U	—		—		0.19	U
2H-Perfluoro-2-decenoic acid (8:2 FTUCA)	70887-84-2	—	ng/L	—		—		—		—		0.18	U	—		—		—		0.2	U	—		—		0.2	U	—		—		0.19	U
Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	—	ng/L	0.37	U	0.35	U	0.37	U	10	UJ	0.35	U	0.35	UJ	0.35	UJ	10	UJ	0.39	U	0.35	U	0.99	U	0.41	U	0.36	U	1	U	0.39	U
Perfluoro(4-ethylcyclohexane)sulfonic acid (PFEtCHxS)	646-83-3	—	ng/L	—		—		—		—		0.34	U	—		—		—		0.37	U	—		—		0.39	U	—		—		0.37	U
Perfluoro(4-Methyoxybutanoic) Acid (PFMBA)	863090-89-5	—	ng/L	0.37	U	0.35	U	0.37	U	10	UJ	0.35	U	0.35	UJ	0.35	UJ	10	UJ	0.39	U	0.35	U	9.9	U	0.41	U	0.36	U	1	U	0.39	U
Perfluoro-3-methoxypropanoic acid	377-73-1	—	ng/L	0.37	U	0.35	U	0.37	U	10	UJ	0.35	U	0.35	UJ	0.35	UJ	10	UJ	0.39	U	0.35	U	9.9	U	0.41	U	0.36	U	1	U	0.39	U
Nonafluoro-3,6-Dioxaheptanoic Acid (NFDHA)	151772-58-6	—	ng/L	0.37	U	0.35	U	0.37	U	10	UJ	0.35	U	0.35	UJ	0.35	UJ	10	UJ	0.39	U	0.35	U	0.99	U	0.41	U	0.36	U	1	UJ	0.39	U
bis(trifluoromethylsulfonyl)amine (TFSI)	82113-65-3	590	ng/L							10	UJ	0.27	U					10	UJ	0.29	U			0.99	U	0.31	U			1	U	0.29	U

Table B-6: Summary of Area B Perched Groundwater Quarterly Expedited Sampling Analytical Data (cont'd)
RI WP PFAS Release RHBFSF JBPHH Oahu HI

			Location	OWDFMW07C						OWDFMW08B											
			COC ID	JV133		JV185		JV251		JV036		JV117		JV187		JV188		JV235		JV236	
			Matrix	WG		WG		WG		WG		WG		WG		WG		WG		WG	
			Sample Type	N		N		N		N		N		N		FD		N		FD	
			Sample Date	2/28/2025		4/7/2025		7/30/2025		10/18/2024	10/18/2024	1/28/2025		4/3/2025		4/3/2025		7/28/2025		7/28/2025	
Chemical	Cas No.	PSL[a,b]	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Perfluoropropanoic acid (PFPrA)	422-64-0	980	ng/L	—		**9.8**		**6.3**		—		—		**28**	J	**32**	J	**23**		**23**	
Perfluorobutanoic Acid (PFBA)	375-22-4	1800	ng/L	**4.8**		**3.9**		**3.3**		**26**		**24**		**26**	J	**26**	J	**24**		**24**	
Perfluoropentanoic Acid (PFPeA)	2706-90-3	—	ng/L	**3.2**		**2.9**		**1.6**	J+	**43**		**44**		**39**	J	**45**	J	**34**		**35**	
Perfluorohexanoic Acid (PFHxA)	307-24-4	990	ng/L	**1.5**		**1**	J	**0.35**	J	**27**		**30**		**26**	J	**25**	J	**27**		**25**	
Perfluoroheptanoic Acid (PFHpA)	375-85-9	—	ng/L	**0.71**		**0.56**	J	**0.35**	J	**20**		**20**		**19**	J	**20**	J	**20**		**18**	
Perfluorooctanoic Acid (PFOA)	335-67-1	4	ng/L	**2.3**		**3**		**2.5**		**18**		**20**		**21**	J	**20**	J	**20**		**19**	
Perfluorononanoic Acid (PFNA)	375-95-1	5.9	ng/L	**0.75**		**0.96**	J	**0.86**		**2.9**		**3.4**		**3.7**	J	**3.7**	J	**3.9**		**3.9**	
Perfluorodecanoic Acid (PFDA)	335-76-2	0.52	ng/L	0.19	U	0.97	U	0.17	U	**0.18**	J	**0.14**	J	1	UJ	1	UJ	**0.19**	J	**0.22**	J
Perfluoroundecanoic Acid (PFUnA)	2058-94-8	—	ng/L	0.28	U	0.97	U	0.26	U	0.27	U	0.28	U	1	UJ	1	UJ	0.28	U	0.27	U
Perfluorododecanoic Acid (PFDoA)	307-55-1	—	ng/L	0.19	U	0.97	U	0.17	U	0.18	U	0.19	U	1	UJ	1	UJ	0.18	U	0.18	U
Perfluorotridecanoic Acid (PFTrDA)	72629-94-8	—	ng/L	0.28	U	0.97	U	0.26	U	0.27	U	0.28	U	1	UJ	1	UJ	0.28	U	0.27	U
Perfluorotetradecanoic Acid (PFTA)	376-06-7	—	ng/L	0.28	U	0.97	U	0.26	U	0.27	U	0.28	U	1	UJ	1	UJ	0.28	U	0.27	U
Perfluorohexadecanoic Acid (PFHxDA)	67905-19-5	—	ng/L			0.97	U	0.26	U					1	UJ	1	UJ	0.28	U	0.27	U
Perfluorooctadecanoic Acid (PFODA)	16517-11-6	—	ng/L			1.4	U	0.26	UJ					1.4	UJ	1.4	UJ	0.28	UJ	0.27	UJ
Perfluorobutanesulfonic Acid (PFBS)	375-73-5	600	ng/L	**1.7**		**1.9**		**2.2**		**12**		**13**		**12**	J	**11**	J	**12**		**11**	
Perfluoropentanesulfonic Acid (PFPeS)	2706-91-4	—	ng/L	**0.67**		**0.78**	J	**0.74**		**0.8**		**0.86**		**0.89**	J	**0.99**	J	**0.75**		**0.8**	
Perfluorohexanesulfonic Acid (PFHxS)	355-46-4	10	ng/L	**8.5**		**11**		**10**		**12**		**13**		**9.6**	J	**9.4**	J	**12**		**12**	
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	—	ng/L	**0.12**	J	0.97	U	**0.16**	J	**0.29**	J	**0.3**	J	1	UJ	1	UJ	**0.3**	J	**0.32**	J
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	4	ng/L	**4.3**		**5.5**		**5.2**		**17**		**19**		**17**	J	**19**	J	**18**		**19**	
Perfluoro-1-nonanesulfonic acid (PFNS)	68259-12-1	—	ng/L	0.19	U	0.97	U	0.17	U	0.18	U	0.19	U	1	UJ	1	UJ	0.18	U	0.18	U
Perfluorodecanesulfonic Acid (PFDS)	335-77-3	—	ng/L	0.28	U	0.97	U	0.26	U	0.27	U	0.28	U	1	UJ	1	UJ	0.28	U	0.27	U
Perfluorododecanesulfonic Acid (PFDoS)	79780-39-5	—	ng/L	0.19	U	0.97	U	0.17	U	0.18	U	0.19	U	1	UJ	1	UJ	0.18	U	0.18	U
1H,1H,2H,2H-Perfluorohexane Sulfonic Acid (4:2 FTS)	757124-72-4	—	ng/L	0.76	U	1.9	U	0.7	U	0.71	U	0.75	U	2	UJ	2	UJ	0.74	U	0.72	U
1H,1H, 2H, 2H-Perfluorooctane Sulfonic Acid (6:2 FTS)	27619-97-2	—	ng/L	**0.57**	J	1.9	U	3.1	U	0.71	U	0.75	U	**2.9**	J	**4**	J	**6.4**	J	**6.3**	
1H,1H, 2H, 2H-Perfluorodecane Sulfonic Acid (8:2 FTS)	39108-34-4	—	ng/L	0.76	U	1.9	U	0.7	U	0.71	U	0.75	U	2	UJ	2	UJ	0.74	U	0.72	U
1H,1H,2H,2H-perfluorododecane Sulfonic Acid (10:2 FTS)	120226-60-0	—	ng/L	—		—		0.7	U	—		—		—		—		0.74	U	0.72	U
N-Methyl Perfluorooctane Sulfonamide (NMeFOSA)	31506-32-8	—	ng/L	0.76	U	0.97	U	0.7	U	0.71	U	0.75	U	1	UJ	1	UJ	0.74	U	0.72	U
N-Ethyl Perfluorooctane Sulfonamide (NEtFOSA)	4151-50-2	—	ng/L	0.76	U	0.97	U	0.7	U	0.71	U	0.75	U	1	UJ	1	UJ	0.74	U	0.72	U
Perfluorobutane Sulfonamide (PFBSA)	30334-69-1	—	ng/L	—		—		0.17	U	—		—		—		—		**0.21**	J	**0.2**	J
Perfluorohexane Sulfonamide (PFHxSA)	41997-13-1	—	ng/L	—		—		0.17	U	—		—		—		—		0.18	U	0.18	U
Perfluorooctane Sulfonamide (PFOSA)	754-91-6	—	ng/L	0.19	U	0.97	U	0.17	U	0.18	U	0.19	U	1	UJ	1	UJ	0.18	U	0.18	U
N-Methyl Perfluorooctane Sulfonamidoacetic Acid	2355-31-9	—	ng/L	0.19	U	0.97	U	0.17	U	0.18	U	0.19	U	1	UJ	1	UJ	0.18	U	0.18	U
N-Ethyl Perfluorooctane Sulfonamidoacetic Acid (NEtFOSAA)	2991-50-6	—	ng/L	0.19	U	0.97	U	0.17	U	0.18	U	0.19	U	1	UJ	1	UJ	0.18	U	0.18	U
N-Methyl Perfluorooctane Sulfonamidoethanol (NMeFOSE)	24448-09-7	—	ng/L	1.1	U	4.8	U	1	U	1.1	U	1.1	U	5.1	UJ	5	UJ	1.1	U	1.1	U
N-Ethyl Perfluorooctane Sulfonamidoethanol (NEtFOSE)	1691-99-2	—	ng/L	1.1	U	4.8	U	1	U	1.1	U	1.1	U	5.1	UJ	5	UJ	1.1	U	1.1	U
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	1.5	ng/L	0.38	U	0.68	U	0.35	U	0.36	U	0.38	U	0.71	UJ	0.7	UJ	0.37	U	0.36	U
4,8-dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	—	ng/L	0.38	U	0.97	U	0.35	U	0.36	U	0.38	U	1	UJ	1	UJ	0.37	U	0.36	U
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	—	ng/L	0.38	U	0.97	U	0.35	U	0.36	U	0.38	U	1	UJ	1	UJ	0.37	U	0.36	U
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	—	ng/L	0.38	U	0.97	U	0.35	U	0.36	U	0.38	U	1	UJ	1	UJ	0.37	U	0.36	U
3:3 Fluorotelomer carboxylic acid	356-02-5	—	ng/L	0.76	U	1.9	U	0.7	U	0.71	U	0.75	U	2	UJ	2	UJ	0.74	U	0.72	U
5:3 Fluorotelomer carboxylic acid	914637-49-3	—	ng/L	0.76	U	4.8	U	0.7	U	0.71	U	0.75	U	5.1	UJ	5	UJ	0.74	U	0.72	U
7:3 Fluorotelomer carboxylic acid	812-70-4	—	ng/L	0.76	U	4.8	U	0.7	U	0.71	U	0.75	U	5.1	UJ	5	UJ	0.74	U	0.72	U
2H-Perfluoro-2-octenoic acid (6:2 FTUCA)	70887-88-6	—	ng/L	—		—		0.17	U	—		—		—		—		0.18	U	0.18	U
2H-Perfluoro-2-decenoic acid (8:2 FTUCA)	70887-84-2	—	ng/L	—		—		0.17	U	—		—		—		—		0.18	U	0.18	U
Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	—	ng/L	0.38	U	0.97	U	0.35	U	0.36	U	0.38	U	1	UJ	1	UJ	0.37	U	0.36	U
Perfluoro(4-ethylcyclohexane)sulfonic acid (PFEtCHxS)	646-83-3	—	ng/L	—		—		0.33	U	—		—		—		—		0.35	U	0.34	U
Perfluoro(4-Methyoxybutanoic) Acid (PFMBA)	863090-89-5	—	ng/L	0.38	U	0.97	U	0.35	U	0.36	U	0.38	U	1	UJ	1	UJ	0.37	U	0.36	U
Perfluoro-3-methoxypropanoic acid	377-73-1	—	ng/L	0.38	U	0.97	U	0.35	U	0.36	U	0.38	U	1	UJ	1	UJ	0.37	U	0.36	U
Nonafluoro-3,6-Dioxaheptanoic Acid (NFDHA)	151772-58-6	—	ng/L	0.38	U	0.97	UJ	0.35	U	0.36	U	0.38	U	1	UJ	1	UJ	0.37	U	0.36	U
bis(trifluoromethylsulfonyl)amine (TFSI)	82113-65-3	590	ng/L			0.97	U	0.26	U					1	UJ	1	UJ	**0.24**	J	**0.23**	J

Notes:
Units are in ng/L.
Analysis conducted using EPA Method 1633 (EPA 2024).
— = not applicable
Bold and shaded text indicates analyte was detected above the PSL
Bold text indicates analyte was detected
abbr. = abbreviated chemical name
Cas No. = chemical abstracts service registry number
COC = chain of custody
EPA = Environmental Protection Agency, United States
FD = field duplicate sample
ID = identification
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 low
J+ = the result was an estimated quantity, but the result may be biased high

LOD = limit of detection
N = primary sample
ng/L = nanogram per liter
OWDF = former oily waste disposal facility
PSL = project screening level
Q = data qualifier
RSL = regional screening level
R = Rejected. The data is unusable (the analyte may or may not be present). Use of the "R" qualifier indicates a significant variance from guideline acceptance criteria. Either resampling or re-analysis is necessary to determine the presence or absence of the rejected analyte.
U = the analyte was not detected and was reported as less than the LOD
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.
WG = groundwater
[a] EPA tap water RSL using a THQ of 0.1 and a target cancer risk of 1E-06 – November 2024 (EPA 2024).
[b] PSLs consistent with DoD memorandum (ASD 2025). PSLs are identified in Worksheet #15.

References:
ASD 2025. Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program. Memorandum : Office of the Assistant Secretary of Defense January 21, 2025.
EPA 2024. EPA Method 1633: Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS. Environmental Protection Agency, United States, January 2024.

Table B-7: Summary of Area B Basal Groundwater Quarterly Expedited Sampling Analytical Data
RI WP PFAS Release RHBFSF JBPHH Oahu HI

			Location	OWDFMW01		OWDFMW01		OWDFMW01		OWDFMW01		OWDFMW01		OWDFMW02A		OWDFMW02A		OWDFMW02A		OWDFMW02A		OWDFMW03A		OWDFMW03A		OWDFMW03A		OWDFMW03A		OWDFMW04A		OWDFMW04A	
			COC ID	JV022		JV064		JV104		JV173		JV224		JV065		JV105		JV174		JV225		JV033		JV120		JV175		JV239		JV023		JV121	
			Matrix	WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG	
			Sample Type	N		N		N		N		N		N		N		N		N		N		N		N		N		N		N	
			Sample Date	10/11/2024		10/29/2024		1/23/2025		3/31/2025		7/28/2025		10/29/2024		1/23/2025		3/31/2025		7/28/2025		10/16/2024		1/28/2025		4/2/2025		7/22/2025		10/11/2024		1/29/2025	
Chemical	Cas No.	PSL[a,b]	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Perfluoropropanoic acid (PFPrA)	422-64-0	980	ng/L	—		—		—		**6.7**	J	**7.9**		—		—		5	U	**1.2**	J	—		—		**4.5**	J	**4.6**		—		—	
Perfluorobutanoic Acid (PFBA)	375-22-4	1800	ng/L	**3.7**		**3.8**		**4.8**		**3.1**	J	**4.6**		**6.6**		**1.6**		2	U	**0.97**		**8.4**		**5.4**		**6.5**		**6.7**		**11**		**10**	
Perfluoropentanoic Acid (PFPeA)	2706-90-3	—	ng/L	**4.6**		**4.2**		**3.9**		**5.5**		**5.3**		**6.7**		**1.3**		1	U	**0.65**	J+	**18**		**18**		**20**		**17**		**19**		**17**	
Perfluorohexanoic Acid (PFHxA)	307-24-4	990	ng/L	**2.1**		**2**		**2.2**		**2.7**		**2.7**		**2**		**0.42**		1	UJ	0.78	U	**8.4**		**11**		**10**		**10**		**12**		**12**	
Perfluoroheptanoic Acid (PFHpA)	375-85-9	—	ng/L	**2.5**		**2.4**		**2.8**		**2.7**		**2.7**		**1.3**		**0.29**	J	1	U	0.78	U	**3.9**		**5.2**		**5.8**		**4.8**		**14**		**13**	
Perfluorooctanoic Acid (PFOA)	335-67-1	4	ng/L	**1.3**		**1.4**		**1.4**		**1.5**	J	**1.5**		**0.41**		**0.15**	J	1	U	0.27	U	**0.28**	J	**0.28**	J	0.99	U	**0.27**	J	**8.1**		**7.5**	
Perfluorononanoic Acid (PFNA)	375-95-1	5.9	ng/L	**0.41**		**0.41**		**0.27**	J	1.1	U	**0.21**	J	0.2	U	0.18	U	1	U	0.18	U	**0.18**	J	**0.098**	J	0.99	U	**0.14**	J	**2.9**		**2.6**	
Perfluorodecanoic Acid (PFDA)	335-76-2	0.52	ng/L	0.18	U	0.19	U	0.19	U	1.1	U	0.18	U	0.2	U	0.18	U	1	U	0.18	U	0.18	U	0.2	U	0.99	U	0.19	U	**0.26**	J	**0.2**	J
Perfluoroundecanoic Acid (PFUnA)	2058-94-8	—	ng/L	0.27	U	0.28	U	0.29	U	1.1	U	0.27	U	0.3	U	0.27	U	1	U	0.27	U	0.27	U	0.29	U	0.99	U	0.28	U	0.3	U	0.27	U
Perfluorododecanoic Acid (PFDoA)	307-55-1	—	ng/L	0.18	U	0.19	U	0.19	U	1.1	U	0.18	U	0.2	U	0.18	U	1	U	0.18	U	0.18	U	0.2	U	0.99	U	0.19	U	0.2	U	0.18	U
Perfluorotridecanoic Acid (PFTrDA)	72629-94-8	—	ng/L	0.27	U	0.28	U	0.29	U	1.1	U	0.27	U	0.3	U	0.27	U	1	U	0.27	U	0.27	U	0.29	U	0.99	U	0.28	U	0.3	U	0.27	U
Perfluorotetradecanoic Acid (PFTA)	376-06-7	—	ng/L	0.27	U	0.28	U	0.29	U	1.1	U	0.27	U	0.3	U	0.27	U	1	U	0.27	U	0.27	U	0.29	U	0.99	U	0.28	U	0.3	U	0.27	U
Perfluorohexadecanoic Acid (PFHxDA)	67905-19-5	—	ng/L	—		—		—		1.1	U	0.27	U					1	U	0.27	U					0.99	U	0.28	U				
Perfluorooctadecanoic Acid (PFODA)	16517-11-6	—	ng/L	—		—		—		1.5	U	0.27	UJ					1.4	U	0.27	UJ					1.4	U	0.28	U				
Perfluorobutanesulfonic Acid (PFBS)	375-73-5	600	ng/L	**0.29**	J	**0.34**	J	**0.33**	J	1.1	U	**0.45**		**0.067**	J	**0.044**	J	1	U	0.18	U	**0.13**	J	**0.17**	J	0.99	U	**0.21**	J	**2.7**		**2.7**	
Perfluoropentanesulfonic Acid (PFPeS)	2706-91-4	—	ng/L	0.18	U	0.19	U	**0.072**	J	1.1	U	**0.074**	J	0.2	U	0.18	U	1	U	0.18	U	0.18	U	0.2	U	0.99	U	0.19	U	**0.39**	J	**0.31**	J
Perfluorohexanesulfonic Acid (PFHxS)	355-46-4	10	ng/L	**0.69**		**0.6**		**0.62**		**0.7**	J	**0.65**		**0.16**	J	**0.13**	J	1	U	**0.13**	J	**0.28**	J	**0.3**	J	0.99	U	**0.27**	J	**3.8**		**3.1**	
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	—	ng/L	0.18	U	0.19	U	0.19	U	1.1	U	0.18	U	0.2	U	0.18	U	1	U	0.18	U	0.18	U	0.2	U	0.99	U	0.19	U	**0.13**	J	**0.13**	J
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	4	ng/L	**0.95**		**0.71**		**0.56**		**0.65**	J	**0.49**		**0.22**	J	**0.18**	J	1	U	0.18	U	**0.29**	J	**0.34**	J+	0.99	U	**0.25**	J+	**7.3**		**7.2**	
Perfluoro-1-nonanesulfonic acid (PFNS)	68259-12-1	—	ng/L	0.18	U	0.19	U	0.19	U	1.1	U	0.18	U	0.2	U	0.18	U	1	U	0.18	U	0.18	U	0.2	U	0.99	U	0.19	U	0.2	U	0.18	U
Perfluorodecanesulfonic Acid (PFDS)	335-77-3	—	ng/L	0.27	U	0.28	U	0.29	U	1.1	U	0.27	U	0.3	U	0.27	U	1	U	0.27	U	0.27	U	0.29	U	0.99	U	0.28	U	0.3	U	0.27	U
Perfluorododecanesulfonic Acid (PFDoS)	79780-39-5	—	ng/L	0.18	U	0.19	U	0.19	U	1.1	U	0.18	U	0.2	U	0.18	U	1	U	0.18	U	0.18	U	0.2	U	0.99	U	0.19	U	0.2	U	0.18	U
1H,1H,2H,2H-Perfluorohexane Sulfonic Acid (4:2 FTS)	757124-72-4	—	ng/L	0.73	U	0.76	U	0.77	U	2.1	U	0.73	U	0.8	U	0.72	U	2	U	0.72	U	0.71	U	0.78	U	2	U	0.75	U	0.79	U	0.72	U
1H,1H, 2H, 2H-Perfluorooctane Sulfonic Acid (6:2 FTS)	27619-97-2	—	ng/L	0.73	U	0.76	U	0.77	U	2.1	U	3.1	U	**1.6**	J	0.72	U	2	U	3.1	U	**1.2**	J	**0.5**	J	2	U	0.75	U	0.79	U	0.72	U
1H,1H, 2H, 2H-Perfluorodecane Sulfonic Acid (8:2 FTS)	39108-34-4	—	ng/L	0.73	U	0.76	U	0.77	U	2.1	U	0.73	U	0.8	U	0.72	U	2	U	0.72	U	0.71	U	0.78	U	2	U	0.75	U	0.79	U	0.72	U
1H,1H,2H,2H-perfluorododecane Sulfonic Acid (10:2 FTS)	120226-60-0	—	ng/L	—		—		—		—		0.73	U	—		—		—		0.72	U	—		—		—		0.75	U	—		—	
N-Methyl Perfluorooctane Sulfonamide (NMeFOSA)	31506-32-8	—	ng/L	0.73	U	0.76	U	0.77	U	1.1	U	0.73	U	0.8	U	0.72	U	1	U	0.72	U	0.71	U	0.78	U	0.99	U	0.75	U	0.79	U	0.72	U
N-Ethyl Perfluorooctane Sulfonamide (NEtFOSA)	4151-50-2	—	ng/L	0.73	U	0.76	U	0.77	U	1.1	U	0.73	U	0.8	U	0.72	U	1	U	0.72	U	0.71	U	0.78	U	0.99	U	0.75	U	0.79	U	0.72	U
Perfluorobutane Sulfonamide (PFBSA)	30334-69-1	—	ng/L	—		—		—		—		0.18	U	—		—		—		0.18	U	—		—		—		0.19	U	—		—	
Perfluorohexane Sulfonamide (PFHxSA)	41997-13-1	—	ng/L	—		—		—		—		0.18	U	—		—		—		0.18	U	—		—		—		0.19	U	—		—	
Perfluorooctane Sulfonamide (PFOSA)	754-91-6	—	ng/L	0.18	U	0.19	U	0.19	U	1.1	U	0.18	U	0.2	U	0.18	U	1	U	0.18	U	0.18	U	0.2	U	0.99	U	0.19	U	0.2	U	0.18	U
N-Methyl Perfluorooctane Sulfonamidoacetic Acid	2355-31-9	—	ng/L	0.18	U	0.19	U	0.19	U	1.1	U	0.18	U	0.2	U	0.18	U	1	U	0.18	U	0.18	U	0.2	U	0.99	U	0.19	U	0.2	U	0.18	U
N-Ethyl Perfluorooctane Sulfonamidoacetic Acid (NEtFOSAA)	2991-50-6	—	ng/L	0.18	U	0.19	U	0.19	U	1.1	U	0.18	U	0.2	U	0.18	U	1	U	0.18	U	0.18	U	0.2	U	0.99	U	0.19	U	0.2	U	0.18	U
N-Methyl Perfluorooctane Sulfonamidoethanol (NMeFOSE)	24448-09-7	—	ng/L	1.1	U	1.1	U	1.2	U	5.3	U	1.1	U	1.2	U	1.1	U	5	U	1.1	U	1.1	U	1.2	U	4.9	U	1.1	U	1.2	U	1.1	U
N-Ethyl Perfluorooctane Sulfonamidoethanol (NEtFOSE)	1691-99-2	—	ng/L	1.1	U	1.1	U	1.2	U	5.3	U	1.1	U	1.2	U	1.1	U	5	U	1.1	U	1.1	U	1.2	U	4.9	U	1.1	U	1.2	U	1.1	U
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	1.5	ng/L	0.37	U	0.38	U	0.39	U	0.75	U	0.36	U	0.4	U	0.36	U	0.7	U	0.36	U	0.35	U	0.39	U	0.69	U	0.38	U	0.4	U	0.36	U
4,8-dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	—	ng/L	0.37	U	0.38	U	0.39	U	1.1	U	0.36	U	0.4	U	0.36	U	1	U	0.36	U	0.35	U	0.39	U	0.99	U	0.38	U	0.4	U	0.36	U
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	—	ng/L	0.37	U	0.38	U	0.39	U	1.1	U	0.36	U	0.4	U	0.36	U	1	U	0.36	U	0.35	U	0.39	U	0.99	U	0.38	U	0.4	U	0.36	U
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	—	ng/L	0.37	U	0.38	U	0.39	U	1.1	U	0.36	U	0.4	U	0.36	U	1	U	0.36	U	0.35	U	0.39	U	0.99	U	0.38	U	0.4	U	0.36	U
3:3 Fluorotelomer carboxylic acid	356-02-5	—	ng/L	0.73	U	0.76	U	0.77	U	2.1	U	0.73	U	0.8	U	0.72	U	2	U	0.72	U	0.71	U	0.78	U	2	U	0.75	U	0.79	U	0.72	U
5:3 Fluorotelomer carboxylic acid	914637-49-3	—	ng/L	0.73	U	0.76	U	0.77	U	5.3	U	0.73	U	0.8	U	0.72	U	5	U	0.72	U	0.71	U	0.78	U	4.9	U	0.75	U	0.79	U	0.72	U
7:3 Fluorotelomer carboxylic acid	812-70-4	—	ng/L	0.73	U	0.76	U	0.77	U	5.3	U	0.73	U	0.8	U	0.72	U	5	U	0.72	U	0.71	U	0.78	U	4.9	U	0.75	U	0.79	U	0.72	U
2H-Perfluoro-2-octenoic acid (6:2 FTUCA)	70887-88-6	—	ng/L	—		—		—		—		0.18	U	—		—		—		0.18	U	—		—		—		0.19	U	—		—	
2H-Perfluoro-2-decenoic acid (8:2 FTUCA)	70887-84-2	—	ng/L	—		—		—		—		0.18	U	—		—		—		0.18	U	—		—		—		0.19	U	—		—	
Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	—	ng/L	0.37	U	0.38	U	0.39	U	1.1	UJ	0.36	U	0.4	U	0.36	U	1	U	0.36	U	0.35	U	0.39	U	0.99	UJ	0.38	U	0.4	U	0.36	U
Perfluoro(4-ethylcyclohexane)sulfonic acid (PFEtCHxS)	646-83-3	—	ng/L	—		—		—		—		0.35	U	—		—		—		0.34	U	—		—		—		0.36	U	—		—	
Perfluoro(4-Methyoxybutanoic) Acid (PFMBA)	863090-89-5	—	ng/L	0.37	U	0.38	U	0.39	U	1.1	U	0.36	U	0.4	U	0.36	U	1	U	0.36	U	0.35	U	0.39	U	0.99	U	0.38	U	0.4	U	0.36	U
Perfluoro-3-methoxypropanoic acid	377-73-1	—	ng/L	0.37	U	0.38	U	0.39	U	1.1	U	0.36	U	0.4	U	0.36	U	1	U	0.36	U	0.35	U	0.39	U	0.99	U	0.38	U	0.4	U	0.36	U
Nonafluoro-3,6-Dioxaheptanoic Acid (NFDHA)	151772-58-6	—	ng/L	0.37	U	0.38	U	0.39	U	1.1	UJ	0.36	U	0.4	U	0.36	U	1	UJ	0.36	U	0.35	U	0.39	U	0.99	UJ	0.38	U	0.4	U	0.36	U
bis(trifluoromethylsulfonyl)amine (TFSI)	82113-65-3	590	ng/L	—		—		—		1.1	U	0.27	U					1	U	0.27	U					0.99	U	0.28	U				

Table B-7: Summary of Area B Basal Groundwater Quarterly Expedited Sampling Analytical Data (cont'd)
RI WP PFAS Release RHBFSF JBPHH Oahu HI

			Location	OWDFMW04A		OWDFMW04A		OWDFMW05A		OWDFMW05A		OWDFMW05A		OWDFMW05A		OWDFMW05A		OWDFMW05A		OWDFMW06A		OWDFMW06A		OWDFMW06A		OWDFMW06A		OWDFMW07A		OWDFMW07A		OWDFMW07A	
			COC ID	JV177		JV240		JV028		JV122		JV178		JV179		JV241		JV242		JV126		JV127		JV181		JV246		JV129		JV183		JV248	
			Matrix	WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG	
			Sample Type	N		N		N		N		N		FD		N		FD		N		FD		N		N		N		N		N	
			Sample Date	4/4/2025		7/29/2025		10/15/2024		1/29/2025		4/4/2025		4/4/2025		7/30/2025		7/30/2025		2/28/2025		2/28/2025		4/1/2025		7/30/2025		2/26/2025		4/2/2025		7/30/2025	
Chemical	Cas No.	PSL[a,b]	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Perfluoropropanoic acid (PFPrA)	422-64-0	980	ng/L	**11**		**9.3**		—		—		**29**		**45**		**51**		**52**		—		—		**9.4**	J	**2.8**		—		5.1	U	**0.67**	J
Perfluorobutanoic Acid (PFBA)	375-22-4	1800	ng/L	**9.2**		**9.7**		**44**		**73**		**50**		**68**		**93**		**92**		**3.1**		**3**		**3.5**	J	**2.3**		**0.22**	J	2	U	0.71	U
Perfluoropentanoic Acid (PFPeA)	2706-90-3	—	ng/L	**18**		**16**		**120**		**210**		**210**		**190**		**240**		**240**		**5.8**		**5.8**		**7.9**		**3.9**		**0.3**	J	1	U	**1.1**	J+
Perfluorohexanoic Acid (PFHxA)	307-24-4	990	ng/L	**13**	J	**11**		**81**		**140**		**120**		**140**		**190**		**200**		**5.4**		**5.1**		**4.7**		**2.3**		**0.33**	J	1	U	0.77	U
Perfluoroheptanoic Acid (PFHpA)	375-85-9	—	ng/L	**13**		**14**		**24**		**39**		**40**		**52**		**53**		**55**		**1.4**		**1.4**		**1.5**	J	**1.1**	J	**0.082**	J	1	U	0.77	U
Perfluorooctanoic Acid (PFOA)	335-67-1	4	ng/L	**10**		**7.7**		**1.2**		**2.1**		**2.4**		**2.8**		**2**		**1.9**		**0.36**	J	**0.33**	J	1	U	**0.27**	J	0.29	U	1	U	0.26	U
Perfluorononanoic Acid (PFNA)	375-95-1	5.9	ng/L	**2.8**		**2.6**		**0.44**		**0.62**		**1.1**	J	**0.97**	J	**0.83**		**0.91**		0.19	U	**0.096**	J	1	U	0.19	U	0.2	U	1	U	0.18	U
Perfluorodecanoic Acid (PFDA)	335-76-2	0.52	ng/L	1	U	**0.17**	J	0.18	U	**0.13**	J	1	U	1	U	**0.13**	J	**0.11**	J	0.19	U	0.19	U	1	U	0.19	U	0.2	U	1	U	0.18	U
Perfluoroundecanoic Acid (PFUnA)	2058-94-8	—	ng/L	1	U	0.29	U	0.27	U	0.27	U	1	U	1	U	0.28	U	0.27	U	0.28	U	0.28	U	1	U	0.28	U	0.29	U	1	U	0.26	U
Perfluorododecanoic Acid (PFDoA)	307-55-1	—	ng/L	1	U	0.2	U	0.18	U	0.18	U	1	U	1	U	0.19	U	0.18	U	0.19	U	0.19	U	1	U	0.19	U	0.2	U	1	U	0.18	U
Perfluorotridecanoic Acid (PFTrDA)	72629-94-8	—	ng/L	1	U	0.29	U	0.27	U	0.27	U	1	U	1	U	0.28	U	0.27	U	0.28	U	0.28	U	1	U	0.28	U	0.29	U	1	U	0.26	U
Perfluorotetradecanoic Acid (PFTA)	376-06-7	—	ng/L	1	U	0.29	U	0.27	U	0.27	U	1	U	1	U	0.28	U	0.27	U	0.28	U	0.28	U	1	U	0.28	U	0.29	U	1	U	0.26	U
Perfluorohexadecanoic Acid (PFHxDA)	67905-19-5	—	ng/L	1	U	0.29	U					1	U	1	U	0.28	U	0.27	U					1	U	0.28	U			1	U	0.26	U
Perfluorooctadecanoic Acid (PFODA)	16517-11-6	—	ng/L	1.4	U	0.29	UJ					1.4	U	1.4	U	0.28	UJ	0.27	UJ					1.4	U	0.28	UJ			1.4	U	0.26	UJ
Perfluorobutanesulfonic Acid (PFBS)	375-73-5	600	ng/L	**2.4**		**2.8**		**0.67**		**1.1**		**1.5**	J	**1.1**	J	**1.4**		**1.4**		**0.37**	J	**0.37**		**0.5**	J	**0.42**		0.2	U	1	U	0.18	U
Perfluoropentanesulfonic Acid (PFPeS)	2706-91-4	—	ng/L	1	U	**0.29**	J	**0.25**	J	**0.4**		1	U	1	U	**0.62**		**0.51**		**0.26**	J	**0.27**	J	1	U	**0.28**	J	0.2	U	1	U	0.18	U
Perfluorohexanesulfonic Acid (PFHxS)	355-46-4	10	ng/L	**3.1**		**3.3**		**2**		**3.2**		**3.3**		**3.8**		**4.2**		**4.3**		**1.8**		**1.8**		**2**		**2**		0.2	U	1	U	0.18	U
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	—	ng/L	1	U	**0.11**	J	**0.047**	J	**0.087**	J	1	U	1	U	**0.12**	J	**0.13**	J	0.19	U	0.19	U	1	U	0.19	U	0.2	U	1	U	0.18	U
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	4	ng/L	**7.2**		**6.5**		**1.7**		**2.9**		**3.8**		**4**		**4**		**4.1**		**1.6**		**1.7**		**2.1**		**1.6**		**0.068**	J	1	U	0.18	U
Perfluoro-1-nonanesulfonic acid (PFNS)	68259-12-1	—	ng/L	1	U	0.2	U	0.18	U	0.18	U	1	U	1	U	0.19	U	0.18	U	0.19	U	0.19	U	1	U	0.19	U	0.2	U	1	U	0.18	U
Perfluorodecanesulfonic Acid (PFDS)	335-77-3	—	ng/L	1	U	0.29	U	0.27	U	0.27	U	1	U	1	U	0.28	U	0.27	U	0.28	U	0.28	U	1	U	0.28	U	0.29	U	1	U	0.26	U
Perfluorododecanesulfonic Acid (PFDoS)	79780-39-5	—	ng/L	1	U	0.2	U	0.18	U	0.18	U	1	U	1	U	0.19	U	0.18	U	0.19	U	0.19	U	1	U	0.19	U	0.2	U	1	U	0.18	U
1H,1H,2H,2H-Perfluorohexane Sulfonic Acid (4:2 FTS)	757124-72-4	—	ng/L	2	U	0.78	U	0.72	U	0.73	U	2	U	2	U	0.75	U	**0.28**	J	0.75	U	0.74	U	2	U	0.75	U	0.78	U	2	U	0.71	U
1H,1H, 2H, 2H-Perfluorooctane Sulfonic Acid (6:2 FTS)	27619-97-2	—	ng/L	2	U	3.1	U	**110**		**200**		**230**		**280**		**350**		**360**		**22**		**20**		**20**		**3.1**	J	**0.48**	J	2	U	3.1	U
1H,1H, 2H, 2H-Perfluorodecane Sulfonic Acid (8:2 FTS)	39108-34-4	—	ng/L	2	U	0.78	U	0.72	U	0.73	U	2	U	2	U	0.75	U	0.71	U	0.75	U	0.74	U	2	U	0.75	U	0.78	U	2	U	0.71	U
1H,1H,2H,2H-perfluorododecane Sulfonic Acid (10:2 FTS)	120226-60-0	—	ng/L	—		0.78	U	—		—		—		—		0.75	U	0.71	U	—		—		—		0.75	U	—		—		0.71	U
N-Methyl Perfluorooctane Sulfonamide (NMeFOSA)	31506-32-8	—	ng/L	1	U	0.78	U	0.72	U	0.73	U	1	U	1	U	0.75	U	0.71	U	0.75	U	0.74	U	1	U	0.75	U	0.78	U	1	U	0.71	U
N-Ethyl Perfluorooctane Sulfonamide (NEtFOSA)	4151-50-2	—	ng/L	1	U	0.78	U	0.72	U	0.73	U	1	U	1	U	0.75	U	0.71	U	0.75	U	0.74	U	1	U	0.75	U	0.78	U	1	U	0.71	U
Perfluorobutane Sulfonamide (PFBSA)	30334-69-1	—	ng/L	—		0.2	U	—		—		—		—		0.19	U	0.18	U	—		—		—		0.19	U	—		—		0.18	U
Perfluorohexane Sulfonamide (PFHxSA)	41997-13-1	—	ng/L	—		0.2	U	—		—		—		—		0.19	U	0.18	U	—		—		—		0.19	U	—		—		0.18	U
Perfluorooctane Sulfonamide (PFOSA)	754-91-6	—	ng/L	1	U	0.2	U	0.18	U	0.18	U	1	U	1	U	0.19	U	0.18	U	0.19	U	0.19	U	1	U	0.19	U	0.2	U	1	U	0.18	U
N-Methyl Perfluorooctane Sulfonamidoacetic Acid	2355-31-9	—	ng/L	1	U	0.2	U	0.18	U	0.18	U	1	U	1	U	0.19	U	0.18	U	0.19	U	0.19	U	1	U	0.19	U	0.2	U	1	U	0.18	U
N-Ethyl Perfluorooctane Sulfonamidoacetic Acid (NEtFOSAA)	2991-50-6	—	ng/L	1	U	0.2	U	0.18	U	0.18	U	1	U	1	U	0.19	U	0.18	U	0.19	U	0.19	U	1	U	0.19	U	0.2	U	1	U	0.18	U
N-Methyl Perfluorooctane Sulfonamidoethanol (NMeFOSE)	24448-09-7	—	ng/L	5	U	1.2	U	1.1	U	1.1	U	5.1	U	5	U	1.1	U	1.1	U	1.1	U	1.1	U	5	U	1.1	U	1.2	U	5.1	U	1.1	U
N-Ethyl Perfluorooctane Sulfonamidoethanol (NEtFOSE)	1691-99-2	—	ng/L	5	U	1.2	U	1.1	U	1.1	U	5.1	U	5	U	1.1	U	1.1	U	1.1	U	1.1	U	5	U	1.1	U	1.2	U	5.1	U	1.1	U
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	1.5	ng/L	0.7	U	0.39	U	0.36	U	0.37	U	0.71	U	0.7	U	0.38	U	0.36	U	0.38	U	0.37	U	0.7	U	0.38	U	0.39	U	0.71	U	0.35	U
4,8-dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	—	ng/L	1	U	0.39	U	0.36	U	0.37	U	1	U	1	U	0.38	U	0.36	U	0.38	U	0.37	U	1	U	0.38	U	0.39	U	1	U	0.35	U
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	—	ng/L	1	U	0.39	U	0.36	U	0.37	U	1	U	1	U	0.38	U	0.36	U	0.38	U	0.37	U	1	U	0.38	U	0.39	U	1	U	0.35	U
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	—	ng/L	1	U	0.39	U	0.36	U	0.37	U	1	U	1	U	0.38	U	0.36	U	0.38	U	0.37	U	1	U	0.38	U	0.39	U	1	U	0.35	U
3:3 Fluorotelomer carboxylic acid	356-02-5	—	ng/L	2	U	0.78	U	0.72	U	**0.73**	J	2	U	2	U	**1.3**	J	**1.4**	J	**0.57**	J	0.74	U	2	U	0.75	U	0.78	U	2	U	0.71	U
5:3 Fluorotelomer carboxylic acid	914637-49-3	—	ng/L	5	U	0.78	U	**0.91**	J	**2**		5.1	U	**2.6**	J	**3.1**		**3.5**		**0.54**	J	**0.43**	J	5	U	0.75	U	0.78	U	5.1	U	0.71	U
7:3 Fluorotelomer carboxylic acid	812-70-4	—	ng/L	5	U	0.78	U	0.72	U	0.73	U	5.1	U	5	U	0.75	U	0.71	U	0.75	U	0.74	U	5	U	0.75	U	0.78	U	5.1	U	0.71	U
2H-Perfluoro-2-octenoic acid (6:2 FTUCA)	70887-88-6	—	ng/L	—		0.2	U	—		—		—		—		**0.17**	J	**0.21**	J	—		—		—		0.19	U	—		—		0.18	U
2H-Perfluoro-2-decenoic acid (8:2 FTUCA)	70887-84-2	—	ng/L	—		0.2	U	—		—		—		—		0.19	U	0.18	U	—		—		—		0.19	U	—		—		0.18	U
Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	—	ng/L	1	U	0.39	U	0.36	U	0.37	U	1	UJ	1	U	0.38	U	0.36	U	0.38	U	0.37	U	1	UJ	0.38	U	0.39	U	1	U	0.35	U
Perfluoro(4-ethylcyclohexane)sulfonic acid (PFEtCHxS)	646-83-3	—	ng/L	—		0.37	U	—		—		—		—		0.36	U	0.34	U	—		—		—		0.36	U	—		—		0.34	U
Perfluoro(4-Methyoxybutanoic) Acid (PFMBA)	863090-89-5	—	ng/L	1	U	0.39	U	0.36	U	0.37	U	1	U	1	U	0.38	U	0.36	U	0.38	U	0.37	U	1	U	0.38	U	0.39	U	1	U	0.35	U
Perfluoro-3-methoxypropanoic acid	377-73-1	—	ng/L	1	U	0.39	U	0.36	U	0.37	U	1	U	1	U	0.38	U	0.36	U	0.38	U	0.37	U	1	U	0.38	U	0.39	U	1	U	0.35	U
Nonafluoro-3,6-Dioxaheptanoic Acid (NFDHA)	151772-58-6	—	ng/L	1	UJ	0.39	U	0.36	U	0.37	U	1	UJ	1	U	0.38	U	0.36	U	0.38	U	0.37	U	1	UJ	0.38	U	0.39	U	1	U	0.35	U
bis(trifluoromethylsulfonyl)amine (TFSI)	82113-65-3	590	ng/L	1	U	0.29	U					1	U	1	U	0.28	U	0.27	U					1	U	0.28	U			1	U	0.26	U

Table B-7: Summary of Area B Basal Groundwater Quarterly Expedited Sampling Analytical Data (cont'd)
RI WP PFAS Release RHBFSF JBPHH Oahu HI

			Location	OWDFMW08A		OWDFMW08A		OWDFMW08A		OWDFMW08A		RHM[redacted]		RHM[redacted]		RHM[redacted]		RHM[redacted]		RHM[redacted]		RHP01		RHP01		RHP01		RHP01		RHP02		RHP02	
			COC ID	JV034		JV125		JV186		JV245		JV012		JV094		JV160		JV212		JV213		JV007		JV096		JV161		JV215		JV008		JV097	
			Matrix	WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG	
			Sample Type	N		N		N		N		N		N		N		N		FD		N		N		N		N		N		N	
			Sample Date	10/16/2024		1/29/2025		4/29/2025		7/22/2025		10/8/2024		1/21/2025		4/21/2025		7/15/2025		7/15/2025		10/3/2024		1/22/2025		4/22/2025		7/17/2025		10/3/2024		1/22/2025	
Chemical	Cas No.	PSL[a,b]	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Perfluoropropanoic acid (PFPrA)	422-64-0	980	ng/L	—		—		4.8	U	**2**		—		—		**3.4**	J	**1.2**	J	**0.88**	J	—		—		**29**		**22**		—		—	
Perfluorobutanoic Acid (PFBA)	375-22-4	1800	ng/L	**3.9**		0.75	U	1.9	U	**1.7**		0.73	U	**0.35**	J	2	U	0.75	U	0.73	U	**14**		**15**		**15**		**15**		**14**		**14**	
Perfluoropentanoic Acid (PFPeA)	2706-90-3	—	ng/L	**3.1**		**0.37**	J	0.97	U	**0.61**	J+	**0.73**	J	**0.97**		0.98	U	**0.8**		**0.77**		**9.2**		**9.4**		**10**		**8.3**		**11**		**9.9**	
Perfluorohexanoic Acid (PFHxA)	307-24-4	990	ng/L	**0.81**		**0.21**	J	0.97	U	**0.24**	J	**0.67**		**0.74**		**0.78**	J	**0.62**		**0.74**		**4.4**		**4.6**		**4.3**		**4.1**		**5.5**		**4.9**	
Perfluoroheptanoic Acid (PFHpA)	375-85-9	—	ng/L	**0.59**		**0.26**	J	0.97	U	**0.29**	J	**0.42**		**0.42**		0.98	U	**0.4**		**0.43**		**4**		**3.8**		**3.8**		**3.2**		**4.4**		**4.2**	
Perfluorooctanoic Acid (PFOA)	335-67-1	4	ng/L	**0.34**	J	**0.21**	J	0.97	UJ	**0.31**	J	**0.68**		**0.77**		**1.1**	J	**0.83**		**0.68**		**6.2**		**5.9**		**7.1**		**5.8**		**6.8**		**6.9**	
Perfluorononanoic Acid (PFNA)	375-95-1	5.9	ng/L	**0.099**	J	**0.093**	J	0.97	U	**0.12**	J	0.18	U	**0.093**	J	0.98	U	0.19	U	**0.17**	J	**1.1**		**1.3**		**1.7**	J	**1.7**		**1.7**		**2**	
Perfluorodecanoic Acid (PFDA)	335-76-2	0.52	ng/L	0.18	U	0.19	U	0.97	U	0.18	U	0.18	U	0.19	U	0.98	U	0.19	U	0.18	U	**0.34**	J	**0.36**	J	**0.56**	J	**0.4**		**0.42**		**0.44**	
Perfluoroundecanoic Acid (PFUnA)	2058-94-8	—	ng/L	0.27	U	0.28	U	0.97	U	0.27	U	0.28	U	0.28	U	0.98	U	0.28	U	0.27	U	0.28	U	0.3	U	1	U	0.29	U	0.28	U	0.29	U
Perfluorododecanoic Acid (PFDoA)	307-55-1	—	ng/L	0.18	U	0.19	U	0.97	U	0.18	U	0.18	U	0.19	U	0.98	U	0.19	U	0.18	U	0.18	U	0.2	U	1	U	0.19	U	0.18	U	0.19	U
Perfluorotridecanoic Acid (PFTrDA)	72629-94-8	—	ng/L	0.27	U	0.28	U	0.97	U	0.27	U	0.28	U	0.28	U	0.98	U	0.28	U	0.27	U	0.28	U	0.3	U	1	U	0.29	U	0.28	U	0.29	U
Perfluorotetradecanoic Acid (PFTA)	376-06-7	—	ng/L	0.27	U	0.28	U	0.97	U	0.27	U	0.28	U	0.28	U	0.98	U	0.28	U	0.27	U	0.28	U	0.3	U	1	U	0.29	U	0.28	U	0.29	U
Perfluorohexadecanoic Acid (PFHxDA)	67905-19-5	—	ng/L					0.97	U	0.27	U					0.98	U	0.28	U	0.27	U					1	U	0.29	U				
Perfluorooctadecanoic Acid (PFODA)	16517-11-6	—	ng/L					1.4	U	0.27	U					1.4	U	0.28	UJ	0.27	UJ					1.4	U	0.29	U				
Perfluorobutanesulfonic Acid (PFBS)	375-73-5	600	ng/L	**0.21**	J	**0.17**	J	0.97	U	**0.14**	J	**0.6**		**0.7**		**0.75**	J	**0.66**		**0.66**		**1.9**		**1.9**		**2.1**		**2**		**3.7**		**4.1**	
Perfluoropentanesulfonic Acid (PFPeS)	2706-91-4	—	ng/L	**0.083**	J	**0.089**	J	0.97	U	**0.11**	J	**0.071**	J	**0.064**	J	0.98	U	**0.076**	J	**0.068**	J	**0.45**		**0.47**		**0.53**	J	**0.43**		**0.46**		**0.44**	
Perfluorohexanesulfonic Acid (PFHxS)	355-46-4	10	ng/L	**0.8**		**0.73**		**0.91**	J	**0.84**		**0.63**		**0.6**		**0.91**	J	**0.7**		**0.6**		**5.5**		**5.5**		**5.7**		**5.4**		**5.4**		**5**	J-
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	—	ng/L	0.18	U	0.19	U	0.97	U	0.18	U	0.18	U	0.19	U	0.98	U	0.19	U	0.18	U	**0.23**	J	**0.26**	J	1	U	**0.23**	J	**0.22**	J	**0.2**	J
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	4	ng/L	**0.47**		**0.5**		**0.6**	J	**0.44**		**0.73**	J+	**0.77**		**0.85**	J	**0.73**		**0.79**		**14**		**15**		**14**		**14**		**15**		**14**	
Perfluoro-1-nonanesulfonic acid (PFNS)	68259-12-1	—	ng/L	0.18	U	0.19	U	0.97	U	0.18	U	0.18	U	0.19	U	0.98	U	0.19	U	0.18	U	0.18	U	0.2	U	1	U	0.19	U	0.18	U	0.19	U
Perfluorodecanesulfonic Acid (PFDS)	335-77-3	—	ng/L	0.27	U	0.28	U	0.97	U	0.27	U	0.28	U	0.28	U	0.98	U	0.28	U	0.27	U	0.28	U	0.3	U	1	U	0.29	U	0.28	U	0.29	U
Perfluorododecanesulfonic Acid (PFDoS)	79780-39-5	—	ng/L	0.18	U	0.19	U	0.97	U	0.18	U	0.18	U	0.19	U	0.98	U	0.19	U	0.18	U	0.18	U	0.2	U	1	U	0.19	U	0.18	U	0.19	U
1H,1H,2H,2H-Perfluorohexane Sulfonic Acid (4:2 FTS)	757124-72-4	—	ng/L	0.71	U	0.75	U	1.9	U	0.72	U	0.73	U	0.75	U	2	U	0.75	U	0.73	U	0.74	U	0.79	U	2	U	0.78	U	0.74	U	0.77	U
1H,1H, 2H, 2H-Perfluorooctane Sulfonic Acid (6:2 FTS)	27619-97-2	—	ng/L	**0.82**	J	0.75	U	1.9	U	0.72	U	0.73	U	0.75	U	2	U	0.75	U	0.73	U	**0.32**	J	**2.2**		**1.5**	J	**0.37**	J	0.74	U	0.77	U
1H,1H, 2H, 2H-Perfluorodecane Sulfonic Acid (8:2 FTS)	39108-34-4	—	ng/L	0.71	U	0.75	U	1.9	U	0.72	U	0.73	U	0.75	U	2	U	0.75	U	0.73	U	0.74	U	0.79	U	2	U	0.78	U	**0.26**	J	0.77	U
1H,1H,2H,2H-perfluorododecane Sulfonic Acid (10:2 FTS)	120226-60-0	—	ng/L	—		—		—		0.72	U	—		—		—		0.75	U	0.73	U	—		—		—		0.78	U	—		—	
N-Methyl Perfluorooctane Sulfonamide (NMeFOSA)	31506-32-8	—	ng/L	0.71	U	0.75	U	0.97	U	0.72	U	0.73	U	0.75	U	0.98	U	0.75	U	0.73	U	0.74	U	0.79	U	1	U	0.78	U	0.74	U	0.77	U
N-Ethyl Perfluorooctane Sulfonamide (NEtFOSA)	4151-50-2	—	ng/L	0.71	U	0.75	U	0.97	U	0.72	U	0.73	U	0.75	U	0.98	U	0.75	U	0.73	U	0.74	U	0.79	U	1	U	0.78	U	0.74	U	0.77	U
Perfluorobutane Sulfonamide (PFBSA)	30334-69-1	—	ng/L	—		—		—		0.18	U	—		—		—		0.19	U	0.18	U	—		—		—		0.19	U	—		—	
Perfluorohexane Sulfonamide (PFHxSA)	41997-13-1	—	ng/L	—		—		—		0.18	U	—		—		—		0.19	U	0.18	U	—		—		—		0.19	U	—		—	
Perfluorooctane Sulfonamide (PFOSA)	754-91-6	—	ng/L	0.18	U	0.19	U	0.97	U	0.18	U	0.18	U	0.19	U	0.98	U	0.19	U	0.18	U	0.18	U	0.2	U	1	U	0.19	U	0.18	U	0.19	U
N-Methyl Perfluorooctane Sulfonamidoacetic Acid	2355-31-9	—	ng/L	0.18	U	0.19	U	0.97	U	0.18	U	0.18	U	0.19	U	0.98	U	0.19	U	0.18	U	0.18	U	0.2	U	1	U	0.19	U	0.18	U	0.19	U
N-Ethyl Perfluorooctane Sulfonamidoacetic Acid (NEtFOSAA)	2991-50-6	—	ng/L	0.18	U	0.19	U	0.97	U	0.18	U	0.18	U	0.19	U	0.98	U	0.19	U	0.18	U	0.18	U	0.2	U	1	U	0.19	U	0.18	U	0.19	U
N-Methyl Perfluorooctane Sulfonamidoethanol (NMeFOSE)	24448-09-7	—	ng/L	1.1	U	1.1	U	4.8	U	1.1	U	1.1	U	1.1	U	4.9	U	1.1	U	1.1	U	1.1	U	1.2	U	5	U	1.2	U	1.1	U	1.2	U
N-Ethyl Perfluorooctane Sulfonamidoethanol (NEtFOSE)	1691-99-2	—	ng/L	1.1	U	1.1	U	4.8	U	1.1	U	1.1	U	1.1	U	4.9	U	1.1	U	1.1	U	1.1	U	1.2	U	5	U	1.2	U	1.1	U	1.2	U
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	1.5	ng/L	0.36	U	0.38	U	0.68	U	0.36	U	0.37	U	0.38	U	0.68	U	0.37	U	0.36	U	0.37	U	0.4	U	0.7	U	0.39	U	0.37	U	0.39	U
4,8-dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	—	ng/L	0.36	U	0.38	U	0.97	U	0.36	U	0.37	U	0.38	U	0.98	U	0.37	U	0.36	U	0.37	U	0.4	U	1	U	0.39	U	0.37	U	0.39	U
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	—	ng/L	0.36	U	0.38	U	0.97	U	0.36	U	0.37	U	0.38	U	0.98	U	0.37	U	0.36	U	0.37	U	0.4	U	1	U	0.39	U	0.37	U	0.39	U
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	—	ng/L	0.36	U	0.38	U	0.97	U	0.36	U	0.37	U	0.38	U	0.98	U	0.37	U	0.36	U	0.37	U	0.4	U	1	U	0.39	U	0.37	U	0.39	U
3:3 Fluorotelomer carboxylic acid	356-02-5	—	ng/L	0.71	U	0.75	U	1.9	U	0.72	U	0.73	U	0.75	U	2	U	0.75	U	0.73	U	0.74	U	0.79	U	2	U	0.78	U	0.74	U	0.77	U
5:3 Fluorotelomer carboxylic acid	914637-49-3	—	ng/L	0.71	U	0.75	U	4.8	U	0.72	U	0.73	U	0.75	U	4.9	U	0.75	U	0.73	U	0.74	U	0.79	U	5	U	0.78	U	0.74	U	0.77	U
7:3 Fluorotelomer carboxylic acid	812-70-4	—	ng/L	0.71	U	0.75	U	4.8	U	0.72	U	0.73	U	0.75	U	4.9	U	0.75	U	0.73	U	0.74	U	0.79	U	5	U	0.78	U	0.74	U	0.77	U
2H-Perfluoro-2-octenoic acid (6:2 FTUCA)	70887-88-6	—	ng/L	—		—		—		0.18	U	—		—		—		0.19	U	0.18	U	—		—		—		0.19	U	—		—	
2H-Perfluoro-2-decenoic acid (8:2 FTUCA)	70887-84-2	—	ng/L	—		—		—		0.18	U	—		—		—		0.19	U	0.18	U	—		—		—		0.19	U	—		—	
Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	—	ng/L	0.36	U	0.38	U	0.97	U	0.36	U	0.37	U	0.38	U	0.98	U	0.37	U	0.36	U	0.37	U	0.4	U	1	U	0.39	U	0.37	U	0.39	U
Perfluoro(4-ethylcyclohexane)sulfonic acid (PFEtCHxS)	646-83-3	—	ng/L	—		—		—		0.34	U	—		—		—		0.36	U	0.34	U	—		—		—		0.37	U	—		—	
Perfluoro(4-Methyoxybutanoic) Acid (PFMBA)	863090-89-5	—	ng/L	0.36	U	0.38	U	0.97	U	0.36	U	0.37	U	0.38	U	0.98	U	0.37	U	0.36	U	0.37	U	0.4	U	1	U	0.39	U	0.37	U	0.39	U
Perfluoro-3-methoxypropanoic acid	377-73-1	—	ng/L	0.36	U	0.38	U	0.97	U	0.36	U	0.37	U	0.38	U	0.98	U	0.37	U	0.36	U	0.37	U	0.4	U	1	U	0.39	U	0.37	U	0.39	U
Nonafluoro-3,6-Dioxaheptanoic Acid (NFDHA)	151772-58-6	—	ng/L	0.36	U	0.38	U	0.97	U	0.36	U	0.37	U	0.38	U	0.98	U	0.37	U	0.36	U	0.37	U	0.4	U	1	U	0.39	U	0.37	U	0.39	U
bis(trifluoromethylsulfonyl)amine (TFSI)	82113-65-3	590	ng/L					0.97	U	0.27	U					0.98	U	0.28	U	0.27	U					1	U	0.29	U				

Table B-7: Summary of Area B Basal Groundwater Quarterly Expedited Sampling Analytical Data (cont'd)
RI WP PFAS Release RHBFSF JBPHH Oahu HI

			Location	RHP02		RHP02		RHP03		RHP03		RHP03		RHP03		RHP03		RHP04A		RHP04A		RHP04A		RHP04A		RHP04B		RHP04B		RHP04B		RHP04B	
			COC ID	JV162		JV216		JV013		JV098		JV163		JV217		JV218		JV014		JV099		JV164		JV219		JV026		JV118		JV165		JV237	
			Matrix	WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG	
			Sample Type	N		N		N		N		N		N		FD		N		N		N		N		N		N		N		N	
			Sample Date	4/22/2025		7/17/2025		10/9/2024		1/22/2025		4/22/2025		7/17/2025		7/17/2025		10/9/2024		1/23/2025		4/21/2025		7/15/2025		10/15/2024		1/28/2025		4/28/2025		7/22/2025	
Chemical	Cas No.	PSL[a,b]	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Perfluoropropanoic acid (PFPrA)	422-64-0	980	ng/L	**33**		**24**		—		—		**13**		**12**		**11**		—		—		**6.6**	J	**4.1**		—		—		5.1	U	0.72	U
Perfluorobutanoic Acid (PFBA)	375-22-4	1800	ng/L	**15**		**15**		**7.3**		**7.8**		**7.7**		**8.8**		**9.7**		**1.7**		**1.8**		**1.9**	J	**1.9**		0.78	U	**0.61**	J+	2	U	**1.3**	J
Perfluoropentanoic Acid (PFPeA)	2706-90-3	—	ng/L	**12**		**9.7**		**7**		**6.1**		**6.8**		**6.8**		**7.1**		**1.5**		**1**		**1.1**	J	**0.93**		**0.37**	J	**0.48**	J	**0.63**	J	**0.49**	J+
Perfluorohexanoic Acid (PFHxA)	307-24-4	990	ng/L	**6.3**		**4.5**		**3.7**		**3.3**		**3.1**		**3.7**		**4.1**		**1.2**		**0.59**		**0.63**	J	**0.57**		**0.29**	J	**0.34**	J	1	U	**0.24**	J
Perfluoroheptanoic Acid (PFHpA)	375-85-9	—	ng/L	**4.9**		**3.9**		**3.1**		**2.9**		**3.2**		**3.3**		**3.6**		**0.79**		**0.57**		**0.66**	J	**0.6**		**0.12**	J	**0.076**	J	1	U	**0.059**	J
Perfluorooctanoic Acid (PFOA)	335-67-1	4	ng/L	**8.5**		**6**		**3.7**		**3.6**		**4.3**		**4**		**4.2**		**1.3**		**1.4**		**1.6**	J	**1.3**		0.29	U	0.28	U	1	U	0.27	U
Perfluorononanoic Acid (PFNA)	375-95-1	5.9	ng/L	**2**		**1.6**		**0.54**		**0.56**		**0.76**	J	**0.97**		**0.97**		**0.56**		**0.94**		**0.95**	J	**0.78**		0.2	U	0.19	U	1	U	0.18	U
Perfluorodecanoic Acid (PFDA)	335-76-2	0.52	ng/L	0.97	U	**0.4**		0.18	U	0.2	U	0.97	U	**0.13**	J	**0.13**	J	0.2	U	0.18	U	0.96	U	0.19	U	0.2	U	0.19	U	1	U	0.18	U
Perfluoroundecanoic Acid (PFUnA)	2058-94-8	—	ng/L	0.97	U	0.3	U	0.27	U	0.29	U	0.97	U	0.29	U	0.29	U	0.3	U	0.27	U	0.96	U	0.28	U	0.29	U	0.28	U	1	U	0.27	U
Perfluorododecanoic Acid (PFDoA)	307-55-1	—	ng/L	0.97	U	0.2	U	0.18	U	0.2	U	0.97	U	0.19	U	0.19	U	0.2	U	0.18	U	0.96	U	0.19	U	0.2	U	0.19	U	1	U	0.18	U
Perfluorotridecanoic Acid (PFTrDA)	72629-94-8	—	ng/L	0.97	U	0.3	U	0.27	U	0.29	U	0.97	U	0.29	U	0.29	U	0.3	U	0.27	U	0.96	U	0.28	U	0.29	U	0.28	U	1	U	0.27	U
Perfluorotetradecanoic Acid (PFTA)	376-06-7	—	ng/L	0.97	U	0.3	U	0.27	U	0.29	U	0.97	U	0.29	U	0.29	U	0.3	U	0.27	U	0.96	U	0.28	U	0.29	U	0.28	U	1	U	0.27	U
Perfluorohexadecanoic Acid (PFHxDA)	67905-19-5	—	ng/L	0.97	U	0.3	U					0.97	U	0.29	U	0.29	U					0.96	U	0.28	U					1	U	0.27	U
Perfluorooctadecanoic Acid (PFODA)	16517-11-6	—	ng/L	1.4	U	0.3	U					1.4	U	0.29	U	0.29	U					1.3	U	0.28	UJ					1.4	U	0.27	U
Perfluorobutanesulfonic Acid (PFBS)	375-73-5	600	ng/L	**4.5**		**3.6**		**2.5**		**2.6**		**2.7**		**3.1**		**3.4**		**0.76**		**0.91**		**0.88**	J	**0.93**		0.2	U	0.19	U	1	U	0.18	U
Perfluoropentanesulfonic Acid (PFPeS)	2706-91-4	—	ng/L	**0.52**	J	**0.46**		**0.47**		**0.44**		0.97	U	**0.5**		**0.42**		**0.49**		**0.46**		**0.6**	J	**0.47**		0.2	U	0.19	U	1	U	0.18	U
Perfluorohexanesulfonic Acid (PFHxS)	355-46-4	10	ng/L	**5.8**		**5.4**		**5**		**5.1**		**5.4**		**5.4**		**5.4**		**4.6**		**4.6**		**5.4**		**4.3**		0.2	U	**0.042**	J	1	U	**0.05**	J
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	—	ng/L	0.97	U	**0.24**	J	**0.16**	J	**0.16**	J	0.97	U	**0.14**	J	**0.16**	J	**0.07**	J	**0.076**	J	0.96	U	**0.081**	J	0.2	U	0.19	U	1	U	0.18	U
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	4	ng/L	**16**		**14**		**5.6**		**6.1**		**7.6**		**6.3**		**6.6**		**1.7**		**2.2**		**2.2**		**2**		**0.14**	J	**0.17**	J+	1	U	0.18	U
Perfluoro-1-nonanesulfonic acid (PFNS)	68259-12-1	—	ng/L	0.97	U	0.2	U	0.18	U	0.2	U	0.97	U	0.19	U	0.19	U	0.2	U	0.18	U	0.96	U	0.19	U	0.2	U	0.19	U	1	U	0.18	U
Perfluorodecanesulfonic Acid (PFDS)	335-77-3	—	ng/L	0.97	U	0.3	U	0.27	U	0.29	U	0.97	U	0.29	U	0.29	U	0.3	U	0.27	U	0.96	U	0.28	U	0.29	U	0.28	U	1	U	0.27	U
Perfluorododecanesulfonic Acid (PFDoS)	79780-39-5	—	ng/L	0.97	U	0.2	U	0.18	U	0.2	U	0.97	U	0.19	U	0.19	U	0.2	U	0.18	U	0.96	U	0.19	U	0.2	U	0.19	U	1	U	0.18	U
1H,1H,2H,2H-Perfluorohexane Sulfonic Acid (4:2 FTS)	757124-72-4	—	ng/L	1.9	U	0.8	U	0.71	U	0.78	U	1.9	U	0.78	U	0.77	U	0.79	U	0.72	U	1.9	U	0.75	U	0.78	U	0.75	U	2	U	0.72	U
1H,1H, 2H, 2H-Perfluorooctane Sulfonic Acid (6:2 FTS)	27619-97-2	—	ng/L	1.9	U	0.8	U	0.71	U	0.78	U	1.9	U	**2.9**	J	**2**		0.79	U	0.72	U	1.9	U	0.75	U	**5**		**3.4**		**3.9**	J	**1.9**	
1H,1H, 2H, 2H-Perfluorodecane Sulfonic Acid (8:2 FTS)	39108-34-4	—	ng/L	1.9	U	0.8	U	0.71	U	0.78	U	1.9	U	0.78	U	0.77	U	0.79	U	0.72	U	1.9	U	0.75	U	**0.1**	J	0.75	U	2	U	0.72	U
1H,1H,2H,2H-perfluorododecane Sulfonic Acid (10:2 FTS)	120226-60-0	—	ng/L	—		0.8	U	—		—		—		0.78	U	0.77	U	—		—		—		0.75	U	—		—		—		0.72	U
N-Methyl Perfluorooctane Sulfonamide (NMeFOSA)	31506-32-8	—	ng/L	0.97	U	0.8	U	0.71	U	0.78	U	0.97	U	0.78	U	0.77	U	0.79	U	0.72	U	0.96	U	0.75	U	0.78	U	0.75	U	1	U	0.72	U
N-Ethyl Perfluorooctane Sulfonamide (NEtFOSA)	4151-50-2	—	ng/L	0.97	U	0.8	U	0.71	U	0.78	U	0.97	U	0.78	U	0.77	U	0.79	U	0.72	U	0.96	U	0.75	U	0.78	U	0.75	U	1	U	0.72	U
Perfluorobutane Sulfonamide (PFBSA)	30334-69-1	—	ng/L	—		0.2	U	—		—		—		0.19	U	0.19	U	—		—		—		0.19	U	—		—		—		0.18	U
Perfluorohexane Sulfonamide (PFHxSA)	41997-13-1	—	ng/L	—		0.2	U	—		—		—		0.19	U	0.19	U	—		—		—		0.19	U	—		—		—		0.18	U
Perfluorooctane Sulfonamide (PFOSA)	754-91-6	—	ng/L	0.97	U	0.2	U	0.18	U	0.2	U	0.97	U	0.19	U	0.19	U	0.2	U	0.18	U	0.96	U	0.19	U	0.2	U	0.19	U	1	U	0.18	U
N-Methyl Perfluorooctane Sulfonamidoacetic Acid	2355-31-9	—	ng/L	0.97	U	0.2	U	0.18	U	0.2	U	0.97	U	0.19	U	0.19	U	0.2	U	0.18	U	0.96	U	0.19	U	0.2	U	0.19	U	1	U	0.18	U
N-Ethyl Perfluorooctane Sulfonamidoacetic Acid (NEtFOSAA)	2991-50-6	—	ng/L	0.97	U	0.2	U	0.18	U	0.2	U	0.97	U	0.19	U	0.19	U	0.2	U	0.18	U	0.96	U	0.19	U	0.2	U	0.19	U	1	U	0.18	U
N-Methyl Perfluorooctane Sulfonamidoethanol (NMeFOSE)	24448-09-7	—	ng/L	4.9	U	1.2	U	1.1	U	1.2	U	4.9	U	1.2	U	1.2	U	1.2	U	1.1	U	4.8	U	1.1	U	1.2	U	1.1	U	5.1	U	1.1	U
N-Ethyl Perfluorooctane Sulfonamidoethanol (NEtFOSE)	1691-99-2	—	ng/L	4.9	U	1.2	U	1.1	U	1.2	U	4.9	U	1.2	U	1.2	U	1.2	U	1.1	U	4.8	U	1.1	U	1.2	U	1.1	U	5.1	U	1.1	U
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	1.5	ng/L	0.68	U	0.4	U	0.36	U	0.39	U	0.68	U	0.39	U	0.39	U	0.39	U	0.36	U	0.67	U	0.38	U	0.39	U	0.37	U	0.72	U	0.36	U
4,8-dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	—	ng/L	0.97	U	0.4	U	0.36	U	0.39	U	0.97	U	0.39	U	0.39	U	0.39	U	0.36	U	0.96	U	0.38	U	0.39	U	0.37	U	1	U	0.36	U
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	—	ng/L	0.97	U	0.4	U	0.36	U	0.39	U	0.97	U	0.39	U	0.39	U	0.39	U	0.36	U	0.96	U	0.38	U	0.39	U	0.37	U	1	U	0.36	U
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	—	ng/L	0.97	U	0.4	U	0.36	U	0.39	U	0.97	U	0.39	U	0.39	U	0.39	U	0.36	U	0.96	U	0.38	U	0.39	U	0.37	U	1	U	0.36	U
3:3 Fluorotelomer carboxylic acid	356-02-5	—	ng/L	1.9	U	0.8	U	0.71	U	0.78	U	1.9	U	0.78	U	0.77	U	0.79	U	0.72	U	1.9	U	0.75	U	0.78	U	0.75	U	2	U	0.72	U
5:3 Fluorotelomer carboxylic acid	914637-49-3	—	ng/L	4.9	U	0.8	U	0.71	U	0.78	U	4.9	U	0.78	U	0.77	U	0.79	U	0.72	U	4.8	U	0.75	U	0.78	U	0.75	U	5.1	U	0.72	U
7:3 Fluorotelomer carboxylic acid	812-70-4	—	ng/L	4.9	U	0.8	U	0.71	U	0.78	U	4.9	U	0.78	U	0.77	U	0.79	U	0.72	U	4.8	U	0.75	U	0.78	U	0.75	U	5.1	U	0.72	U
2H-Perfluoro-2-octenoic acid (6:2 FTUCA)	70887-88-6	—	ng/L	—		0.2	U	—		—		—		0.19	U	0.19	U	—		—		—		0.19	U	—		—		—		0.18	U
2H-Perfluoro-2-decenoic acid (8:2 FTUCA)	70887-84-2	—	ng/L	—		0.2	U	—		—		—		0.19	U	0.19	U	—		—		—		0.19	U	—		—		—		0.18	U
Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	—	ng/L	0.97	U	0.4	U	0.36	U	0.39	U	0.97	U	0.39	U	0.39	U	0.39	U	0.36	U	0.96	U	0.38	U	0.39	U	0.37	U	1	U	0.36	U
Perfluoro(4-ethylcyclohexane)sulfonic acid (PFEtCHxS)	646-83-3	—	ng/L	—		0.38	U	—		—		—		0.37	U	0.37	U	—		—		—		0.36	U	—		—		—		0.34	U
Perfluoro(4-Methyoxybutanoic) Acid (PFMBA)	863090-89-5	—	ng/L	0.97	U	0.4	U	0.36	U	0.39	U	0.97	U	0.39	U	0.39	U	0.39	U	0.36	U	0.96	U	0.38	U	0.39	U	0.37	U	1	U	0.36	U
Perfluoro-3-methoxypropanoic acid	377-73-1	—	ng/L	0.97	U	0.4	U	0.36	U	0.39	U	0.97	U	0.39	U	0.39	U	0.39	U	0.36	U	0.96	U	0.38	U	0.39	U	0.37	U	1	U	0.36	U
Nonafluoro-3,6-Dioxaheptanoic Acid (NFDHA)	151772-58-6	—	ng/L	0.97	U	0.4	U	0.36	U	0.39	U	0.97	U	0.39	U	0.39	U	0.39	U	0.36	U	0.96	U	0.38	U	0.39	U	0.37	U	1	U	0.36	U
bis(trifluoromethylsulfonyl)amine (TFSI)	82113-65-3	590	ng/L	0.97	U	0.3	U					0.97	U	0.29	U	0.29	U					0.96	U	0.28	U					1	U	0.27	U

Table B-7: Summary of Area B Basal Groundwater Quarterly Expedited Sampling Analytical Data (cont'd)
RI WP PFAS Release RHBFSF JBPHH Oahu HI

			Location	RHP04C		RHP04C		RHP04C		RHP04C		RHP05		RHP05		RHP05		RHP05		RHP06		RHP06		RHP06		RHP06		RHP06		RHP07		RHP07	
			COC ID	JV027		JV119		JV166		JV238		JV063		JV103		JV167		JV223		JV015		JV016		JV100		JV168		JV220		JV045		JV107	
			Matrix	WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG	
			Sample Type	N		N		N		N		N		N		N		N		N		FD		N		N		N		N		N	
			Sample Date	10/15/2024		1/28/2025		4/28/2025		7/22/2025		10/25/2024		1/23/2025		4/22/2025		7/18/2025		10/10/2024		10/10/2024		1/23/2025		4/22/2025		7/15/2025		10/23/2024		1/24/2025	
Chemical	Cas No.	PSL[a,b]	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Perfluoropropanoic acid (PFPrA)	422-64-0	980	ng/L	—		—		5	U	0.74	U	—		—		5.1	J	3.4		—		—		—		15		12		—		—	
Perfluorobutanoic Acid (PFBA)	375-22-4	1800	ng/L	0.8	U	0.64	J+	2	U	1.8		2		3		1.2	J	3.3		4.8		3.6		5.5		5.5		6.3		9.2		11	
Perfluoropentanoic Acid (PFPeA)	2706-90-3	—	ng/L	1.6		0.77		1.3	J	0.95	J+	3.6		3.3		1.5	J	3.8		5.1		5		6.9		7.8		7.3		5.8		5.5	
Perfluorohexanoic Acid (PFHxA)	307-24-4	990	ng/L	0.54		0.26	J	1	U	0.17	J	3.1		2.8		1.3	J	3		3.7		3.7		4.6		5.3		4.8		2.6		2.9	
Perfluoroheptanoic Acid (PFHpA)	375-85-9	—	ng/L	0.093	J	0.076	J	1	U	0.041	J	2		2.1		1	J	1.9	J-	2.6		2.6		3.8		3.6		4.1		2.5		2.3	
Perfluorooctanoic Acid (PFOA)	335-67-1	4	ng/L	0.15		0.28	U	1	U	0.28	U	4.5		3.9		3.9		3.8		3.5		3.2		4.4		4.2		4.1		4.9		3.3	
Perfluorononanoic Acid (PFNA)	375-95-1	5.9	ng/L	0.2	U	0.19	U	1	U	0.18	U	1.1		1.1		1.3	J	0.93		0.55		0.47		0.64		0.83	J	0.89		1.1		0.8	
Perfluorodecanoic Acid (PFDA)	335-76-2	0.52	ng/L	0.2	U	0.19	U	1	U	0.18	U	0.2	U	0.18	J	0.98	U	0.18	U	0.2	U	0.2	U	0.2	U	0.97	U	0.19	U	0.21	J	0.13	J
Perfluoroundecanoic Acid (PFUnA)	2058-94-8	—	ng/L	0.3	U	0.28	U	1	U	0.28	U	0.3	U	0.27	U	0.98	U	0.27	U	0.3	U	0.3	U	0.3	U	0.97	U	0.28	U	0.28	U	0.3	U
Perfluorododecanoic Acid (PFDoA)	307-55-1	—	ng/L	0.2	U	0.19	U	1	U	0.18	U	0.2	U	0.18	U	0.98	U	0.18	U	0.2	U	0.2	U	0.2	U	0.97	U	0.19	U	0.19	U	0.2	U
Perfluorotridecanoic Acid (PFTrDA)	72629-94-8	—	ng/L	0.3	U	0.28	U	1	U	0.28	U	0.3	U	0.27	U	0.98	U	0.27	U	0.3	U	0.3	U	0.3	U	0.97	U	0.28	U	0.28	U	0.3	U
Perfluorotetradecanoic Acid (PFTA)	376-06-7	—	ng/L	0.3	U	0.28	U	1	U	0.28	U	0.3	U	0.27	U	0.98	U	0.27	U	0.3	U	0.3	U	0.3	U	0.97	U	0.28	U	0.28	U	0.3	U
Perfluorohexadecanoic Acid (PFHxDA)	67905-19-5	—	ng/L					1	U	0.28	U					0.98	U	0.27	U							0.97	U	0.28	U				
Perfluorooctadecanoic Acid (PFODA)	16517-11-6	—	ng/L					1.4	U	0.28	U					1.4	U	0.27	U							1.4	U	0.28	UJ				
Perfluorobutanesulfonic Acid (PFBS)	375-73-5	600	ng/L	0.2	U	0.19	U	1	U	0.18	U	1.1		1.2		1.1	J	1.2		1.7		1.6		2		2.3		1.9		1.4		1.5	
Perfluoropentanesulfonic Acid (PFPeS)	2706-91-4	—	ng/L	0.2	U	0.16	J	1	U	0.18	U	0.4	J	0.46		0.98	U	0.45		0.38	J	0.4		0.37	J	0.97	U	0.43		0.44		0.49	
Perfluorohexanesulfonic Acid (PFHxS)	355-46-4	10	ng/L	0.19	J	0.18	J	1	U	0.17	J	4.8		5.3		5.1		5.6		3.5		3.3		3.6		3.5		3.5		5.1		5.4	
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	—	ng/L	0.2	U	0.19	U	1	U	0.18	U	0.11	J	0.13	J	0.98	U	0.13	J	0.11	J	0.11	J	0.11	J	0.97	U	0.11	J	0.28	J	0.25	J
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	4	ng/L	0.28	J	0.23	J+	1	U	0.2	J+	4.6		4.5		4.5		4.2		5		4.3		5.3		5.7		6.1		19		14	
Perfluoro-1-nonanesulfonic acid (PFNS)	68259-12-1	—	ng/L	0.2	U	0.19	U	1	U	0.18	U	0.2	U	0.18	U	0.98	U	0.18	U	0.2	U	0.2	U	0.2	U	0.97	U	0.19	U	0.19	U	0.2	U
Perfluorodecanesulfonic Acid (PFDS)	335-77-3	—	ng/L	0.3	U	0.28	U	1	U	0.28	U	0.3	U	0.27	U	0.98	U	0.27	U	0.3	U	0.3	U	0.3	U	0.97	U	0.28	U	0.28	U	0.3	U
Perfluorododecanesulfonic Acid (PFDoS)	79780-39-5	—	ng/L	0.2	U	0.19	U	1	U	0.18	U	0.2	U	0.18	U	0.98	U	0.18	U	0.2	U	0.2	U	0.2	U	0.97	U	0.19	U	0.19	U	0.2	U
1H,1H,2H,2H-Perfluorohexane Sulfonic Acid (4:2 FTS)	757124-72-4	—	ng/L	0.8	U	0.74	U	2	U	0.74	U	0.8	U	0.71	U	2	U	0.71	U	0.81	U	0.81	U	0.79	U	1.9	U	0.75	U	0.74	U	0.79	U
1H,1H, 2H, 2H-Perfluorooctane Sulfonic Acid (6:2 FTS)	27619-97-2	—	ng/L	0.82	J	0.74	U	2	U	0.74	U	45		11	J-	2	U	7.1		30		32		0.36	J	33		4.3		4.2		0.79	U
1H,1H, 2H, 2H-Perfluorodecane Sulfonic Acid (8:2 FTS)	39108-34-4	—	ng/L	0.8	U	0.74	U	2	U	0.74	U	0.8	U	0.71	U	2	U	0.71	U	0.81	U	0.81	U	0.79	U	1.9	U	0.75	U	0.74	U	0.79	U
1H,1H,2H,2H-perfluorododecane Sulfonic Acid (10:2 FTS)	120226-60-0	—	ng/L	—		—		—		0.74	U	—		—		—		0.71	U	—		—		—		—		0.75	U	—		—	
N-Methyl Perfluorooctane Sulfonamide (NMeFOSA)	31506-32-8	—	ng/L	0.8	U	0.74	U	1	U	0.74	U	0.8	U	0.71	U	0.98	U	0.71	U	0.81	U	0.81	U	0.79	U	0.97	U	0.75	U	0.74	U	0.79	U
N-Ethyl Perfluorooctane Sulfonamide (NEtFOSA)	4151-50-2	—	ng/L	0.8	U	0.74	U	1	U	0.74	U	0.8	U	0.71	U	0.98	U	0.71	U	0.81	U	0.81	U	0.79	U	0.97	U	0.75	U	0.74	U	0.79	U
Perfluorobutane Sulfonamide (PFBSA)	30334-69-1	—	ng/L	—		—		—		0.18	U	—		—		—		0.18	U	—		—		—		—		0.19	U	—		—	
Perfluorohexane Sulfonamide (PFHxSA)	41997-13-1	—	ng/L	—		—		—		0.18	U	—		—		—		0.18	U	—		—		—		—		0.19	U	—		—	
Perfluorooctane Sulfonamide (PFOSA)	754-91-6	—	ng/L	0.2	U	0.19	U	1	U	0.18	U	0.2	U	0.18	U	0.98	U	0.18	U	0.2	U	0.2	U	0.2	U	0.97	U	0.19	U	0.19	U	0.2	U
N-Methyl Perfluorooctane Sulfonamidoacetic Acid	2355-31-9	—	ng/L	0.2	U	0.19	U	1	U	0.18	U	0.2	U	0.18	U	0.98	U	0.18	U	0.2	U	0.2	U	0.2	U	0.97	U	0.19	U	0.19	U	0.2	U
N-Ethyl Perfluorooctane Sulfonamidoacetic Acid (NEtFOSAA)	2991-50-6	—	ng/L	0.2	U	0.19	U	1	U	0.18	U	0.2	U	0.18	U	0.98	U	0.18	U	0.2	U	0.2	U	0.2	U	0.97	U	0.19	U	0.19	U	0.2	U
N-Methyl Perfluorooctane Sulfonamidoethanol (NMeFOSE)	24448-09-7	—	ng/L	1.2	U	1.1	U	5	U	1.1	U	1.2	U	1.1	U	4.9	U	1.1	U	1.2	U	1.2	U	1.2	U	4.8	U	1.1	U	1.1	U	1.2	U
N-Ethyl Perfluorooctane Sulfonamidoethanol (NEtFOSE)	1691-99-2	—	ng/L	1.2	U	1.1	U	5	U	1.1	U	1.2	U	1.1	U	4.9	U	1.1	U	1.2	U	1.2	U	1.2	U	4.8	U	1.1	U	1.1	U	1.2	U
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	1.5	ng/L	0.4	U	0.37	U	0.7	U	0.37	U	0.4	U	0.36	U	0.68	U	0.36	U	0.4	U	0.4	U	0.39	U	0.68	U	0.37	U	0.37	U	0.4	U
4,8-dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	—	ng/L	0.4	U	0.37	U	1	U	0.37	U	0.4	U	0.36	U	0.98	U	0.36	U	0.4	U	0.4	U	0.39	U	0.97	U	0.37	U	0.37	U	0.4	U
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	—	ng/L	0.4	U	0.37	U	1	U	0.37	U	0.4	U	0.36	U	0.98	U	0.36	U	0.4	U	0.4	U	0.39	U	0.97	U	0.37	U	0.37	U	0.4	U
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	—	ng/L	0.4	U	0.37	U	1	U	0.37	U	0.4	U	0.36	U	0.98	U	0.36	U	0.4	U	0.4	U	0.39	U	0.97	U	0.37	U	0.37	U	0.4	U
3:3 Fluorotelomer carboxylic acid	356-02-5	—	ng/L	0.8	U	0.74	U	2	U	0.74	U	0.8	U	0.71	U	2	U	0.71	U	0.81	U	0.81	U	0.79	U	1.9	U	0.75	U	0.74	U	0.79	U
5:3 Fluorotelomer carboxylic acid	914637-49-3	—	ng/L	0.8	U	0.74	U	5	U	0.74	U	0.8	U	0.71	U	4.9	U	0.71	U	0.81	U	0.81	U	0.79	U	4.8	U	0.75	U	0.74	U	0.79	U
7:3 Fluorotelomer carboxylic acid	812-70-4	—	ng/L	0.8	U	0.74	U	5	U	0.74	U	0.8	U	0.71	U	4.9	U	0.71	U	0.81	U	0.81	U	0.79	U	4.8	U	0.75	U	0.74	U	0.79	U
2H-Perfluoro-2-octenoic acid (6:2 FTUCA)	70887-88-6	—	ng/L	—		—		—		0.18	U	—		—		—		0.18	U	—		—		—		—		0.19	U	—		—	
2H-Perfluoro-2-decenoic acid (8:2 FTUCA)	70887-84-2	—	ng/L	—		—		—		0.18	U	—		—		—		0.18	U	—		—		—		—		0.19	U	—		—	
Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	—	ng/L	0.4	U	0.37	U	1	U	0.37	U	0.4	U	0.36	U	0.98	U	0.36	U	0.4	U	0.4	U	0.39	U	0.97	U	0.37	U	0.37	U	0.4	U
Perfluoro(4-ethylcyclohexane)sulfonic acid (PFEtCHxS)	646-83-3	—	ng/L	—		—		—		0.35	U	—		—		—		0.34	U	—		—		—		—		0.35	U	—		—	
Perfluoro(4-Methyoxybutanoic) Acid (PFMBA)	863090-89-5	—	ng/L	0.4	U	0.37	U	1	U	0.37	U	0.4	U	0.36	U	0.98	U	0.36	U	0.4	U	0.4	U	0.39	U	0.97	U	0.37	U	0.37	U	0.4	U
Perfluoro-3-methoxypropanoic acid	377-73-1	—	ng/L	0.4	U	0.37	U	1	U	0.37	U	0.4	U	0.36	U	0.98	U	0.36	U	0.4	U	0.4	U	0.39	U	0.97	U	0.37	U	0.37	U	0.4	U
Nonafluoro-3,6-Dioxaheptanoic Acid (NFDHA)	151772-58-6	—	ng/L	0.4	U	0.37	U	1	U	0.37	U	0.4	U	0.36	U	0.98	U	0.36	U	0.4	U	0.4	U	0.39	U	0.97	U	0.37	U	0.37	U	0.4	U
bis(trifluoromethylsulfonyl)amine (TFSI)	82113-65-3	590	ng/L					1	U	0.28	U					0.98	U	0.27	U							0.97	U	0.28	U				

Table B-7: Summary of Area B Basal Groundwater Quarterly Expedited Sampling Analytical Data (cont'd)
RI WP PFAS Release RHBFSF JBPHH Oahu HI

			Location	RHP07		RHP07		RHP07		RHP08		RHP08		RHP08		RHP08		RHP08		RHP08B		RHP08B		RHP08B		RHP08B	
			COC ID	JV108		JV169		JV227		JV009		JV101		JV170		JV171		JV221		JV031		JV123		JV172		JV243	
			Matrix	WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG		WG	
			Sample Type	FD		N		N		N		N		N		FD		N		N		N		N		N	
			Sample Date	1/24/2025		4/23/2025		7/16/2025		10/29/2024		1/23/2025		4/22/2025		4/22/2025		7/15/2025		10/16/2024		1/29/2025		4/25/2025		7/24/2025	
Chemical	Cas No.	PSL[a,b]	Units	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Perfluoropropanoic acid (PFPrA)	422-64-0	980	ng/L	—		**21**		**17**		—		—		4.9	U	4.9	U	**2.6**		—		—		4.9	U	**0.81**	J
Perfluorobutanoic Acid (PFBA)	375-22-4	1800	ng/L	**11**		**9.5**		**10**		**1.1**	J	**1.2**	J	**1.6**	J	**1.5**	J	**1.5**		**0.95**	J	0.73	U	2	U	**1.2**	J
Perfluoropentanoic Acid (PFPeA)	2706-90-3	—	ng/L	**5.4**		**5.4**		**5.6**		**0.87**		**1.3**		**2.4**		**2.1**		**2**		**0.99**		**0.39**	J	0.98	U	0.38	U
Perfluorohexanoic Acid (PFHxA)	307-24-4	990	ng/L	**2.7**		**2.8**		**2.9**		**0.78**	J	**1.1**		**1.7**	J	**1.7**	J	**1.7**		**0.11**	J	0.18	U	0.98	U	0.19	U
Perfluoroheptanoic Acid (PFHpA)	375-85-9	—	ng/L	**2.3**		**2.7**		**2.6**		**0.65**		**0.74**		**1.3**	J	**1.1**	J	**1.1**		**0.044**	J	0.18	U	0.98	U	0.19	U
Perfluorooctanoic Acid (PFOA)	335-67-1	4	ng/L	**3.6**		**4.5**		**4.4**		**1.2**		**1.6**		**2.8**		**2.8**		**2.4**		0.28	U	0.28	U	0.98	U	0.29	U
Perfluorononanoic Acid (PFNA)	375-95-1	5.9	ng/L	**0.79**		**1.1**	J	**0.85**		0.2	U	0.2	U	0.98	U	0.97	U	**0.092**	J	0.19	U	0.18	U	0.98	U	0.19	U
Perfluorodecanoic Acid (PFDA)	335-76-2	0.52	ng/L	**0.14**	J	0.87	U	**0.21**	J	0.2	U	0.2	U	0.98	U	0.97	U	0.17	U	**0.14**	J	0.18	U	0.98	U	0.19	U
Perfluoroundecanoic Acid (PFUnA)	2058-94-8	—	ng/L	0.29	U	0.87	U	0.28	U	0.29	U	0.3	U	0.98	U	0.97	U	0.26	U	0.28	U	0.28	U	0.98	U	0.29	U
Perfluorododecanoic Acid (PFDoA)	307-55-1	—	ng/L	0.19	U	0.87	U	0.18	U	0.2	U	0.2	U	0.98	U	0.97	U	0.17	U	0.19	U	0.18	U	0.98	U	0.19	U
Perfluorotridecanoic Acid (PFTrDA)	72629-94-8	—	ng/L	0.29	U	0.87	U	0.28	U	0.29	U	0.3	U	0.98	U	0.97	U	0.26	U	0.28	U	0.28	U	0.98	U	0.29	U
Perfluorotetradecanoic Acid (PFTA)	376-06-7	—	ng/L	0.29	U	0.87	U	0.28	U	0.29	U	0.3	U	0.98	U	0.97	U	0.26	U	0.28	U	0.28	U	0.98	U	0.29	U
Perfluorohexadecanoic Acid (PFHxDA)	67905-19-5	—	ng/L			0.87	U	0.28	U					0.98	U	0.97	U	0.26	U					0.98	U	0.29	U
Perfluorooctadecanoic Acid (PFODA)	16517-11-6	—	ng/L			1.2	U	0.28	U					1.4	U	1.4	U	0.26	UJ					1.4	U	0.29	U
Perfluorobutanesulfonic Acid (PFBS)	375-73-5	600	ng/L	**1.6**		**1.6**	J	**1.5**		**1.1**		**1.3**		**1.5**	J	**1.6**	J	**1.3**		0.19	U	0.18	U	0.98	U	0.19	U
Perfluoropentanesulfonic Acid (PFPeS)	2706-91-4	—	ng/L	**0.43**		**0.51**	J	**0.47**		**0.16**	J	**0.19**	J	0.98	U	0.97	U	**0.21**	J	0.19	U	0.18	U	0.98	U	0.19	U
Perfluorohexanesulfonic Acid (PFHxS)	355-46-4	10	ng/L	**4.9**		**5.6**		**5.3**		**1.7**		**2.2**		**3.1**		**3**		**2.5**		0.19	U	0.18	U	0.98	U	0.19	U
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	—	ng/L	**0.22**	J	0.87	U	**0.21**	J	**0.067**	J	**0.068**	J	0.98	U	0.97	U	**0.074**	J	0.19	U	0.18	U	0.98	U	0.19	U
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	4	ng/L	**12**		**13**		**9.9**		**1.8**		**1.9**		**2.7**		**2.5**		**2.1**		**0.12**	J	**0.1**	J	0.98	U	0.19	U
Perfluoro-1-nonanesulfonic acid (PFNS)	68259-12-1	—	ng/L	0.19	U	0.87	U	0.18	U	0.2	U	0.2	U	0.98	U	0.97	U	0.17	U	0.19	U	0.18	U	0.98	U	0.19	U
Perfluorodecanesulfonic Acid (PFDS)	335-77-3	—	ng/L	0.29	U	0.87	U	0.28	U	0.29	U	0.3	U	0.98	U	0.97	U	0.26	U	0.28	U	0.28	U	0.98	U	0.29	U
Perfluorododecanesulfonic Acid (PFDoS)	79780-39-5	—	ng/L	0.19	U	0.87	U	0.18	U	0.2	U	0.2	U	0.98	U	0.97	U	0.17	U	0.19	U	0.18	U	0.98	U	0.19	U
1H,1H,2H,2H-Perfluorohexane Sulfonic Acid (4:2 FTS)	757124-72-4	—	ng/L	0.78	U	1.7	U	0.74	U	0.78	U	0.79	U	2	U	1.9	U	0.7	U	0.76	U	0.73	U	2	U	0.76	U
1H,1H, 2H, 2H-Perfluorooctane Sulfonic Acid (6:2 FTS)	27619-97-2	—	ng/L	0.78	U	1.7	U	**0.81**	J	0.78	U	0.79	U	2	U	1.9	U	**0.83**	J	0.76	U	0.73	U	2	U	0.76	U
1H,1H, 2H, 2H-Perfluorodecane Sulfonic Acid (8:2 FTS)	39108-34-4	—	ng/L	0.78	U	**1.2**	J	0.74	U	0.78	U	0.79	U	2	U	1.9	U	0.7	U	0.76	U	0.73	U	2	U	0.76	U
1H,1H,2H,2H-perfluorododecane Sulfonic Acid (10:2 FTS)	120226-60-0	—	ng/L	—		—		0.74	U	—		—		—		—		0.7	U	—		—		—		0.76	U
N-Methyl Perfluorooctane Sulfonamide (NMeFOSA)	31506-32-8	—	ng/L	0.78	U	0.87	U	0.74	U	0.78	U	0.79	U	0.98	U	0.97	U	0.7	U	0.76	U	0.73	U	0.98	U	0.76	U
N-Ethyl Perfluorooctane Sulfonamide (NEtFOSA)	4151-50-2	—	ng/L	0.78	U	0.87	U	0.74	U	0.78	U	0.79	U	0.98	U	0.97	U	0.7	U	0.76	U	0.73	U	0.98	U	0.76	U
Perfluorobutane Sulfonamide (PFBSA)	30334-69-1	—	ng/L	—		—		0.18	U	—		—		—		—		0.17	U	—		—		—		0.19	U
Perfluorohexane Sulfonamide (PFHxSA)	41997-13-1	—	ng/L	—		—		0.18	U	—		—		—		—		0.17	U	—		—		—		0.19	U
Perfluorooctane Sulfonamide (PFOSA)	754-91-6	—	ng/L	0.19	U	0.87	U	0.18	U	0.2	U	0.2	U	0.98	U	0.97	U	0.17	U	**0.1**	J	0.18	U	0.98	U	0.19	U
N-Methyl Perfluorooctane Sulfonamidoacetic Acid	2355-31-9	—	ng/L	0.19	U	0.87	U	0.18	U	0.2	U	0.2	U	0.98	U	0.97	U	0.17	U	0.19	U	0.18	U	0.98	U	0.19	U
N-Ethyl Perfluorooctane Sulfonamidoacetic Acid (NEtFOSAA)	2991-50-6	—	ng/L	0.19	U	0.87	U	0.18	U	0.2	U	0.2	U	0.98	U	0.97	U	0.17	U	0.19	U	0.18	U	0.98	U	0.19	U
N-Methyl Perfluorooctane Sulfonamidoethanol (NMeFOSE)	24448-09-7	—	ng/L	1.2	U	4.4	U	1.1	U	1.2	U	1.2	U	4.9	U	4.9	U	1	U	1.1	U	1.1	U	4.9	U	1.1	U
N-Ethyl Perfluorooctane Sulfonamidoethanol (NEtFOSE)	1691-99-2	—	ng/L	1.2	U	4.4	U	1.1	U	1.2	U	1.2	U	4.9	U	4.9	U	1	U	1.1	U	1.1	U	4.9	U	1.1	U
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	1.5	ng/L	0.39	U	0.61	U	0.37	U	0.39	U	0.39	U	0.69	U	0.68	U	0.35	U	0.38	U	0.37	U	0.69	U	0.38	U
4,8-dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	—	ng/L	0.39	U	0.87	U	0.37	U	0.39	U	0.39	U	0.98	U	0.97	U	0.35	U	0.38	U	0.37	U	0.98	U	0.38	U
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	—	ng/L	0.39	U	0.87	U	0.37	U	0.39	U	0.39	U	0.98	U	0.97	U	0.35	U	0.38	U	0.37	U	0.98	U	0.38	U
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	—	ng/L	0.39	U	0.87	U	0.37	U	0.39	U	0.39	U	0.98	U	0.97	U	0.35	U	0.38	U	0.37	U	0.98	U	0.38	U
3:3 Fluorotelomer carboxylic acid	356-02-5	—	ng/L	0.78	U	1.7	U	0.74	U	0.78	U	0.79	U	2	U	1.9	U	0.7	U	0.76	U	0.73	U	2	U	0.76	U
5:3 Fluorotelomer carboxylic acid	914637-49-3	—	ng/L	0.78	U	4.4	U	0.74	U	0.78	U	0.79	U	4.9	U	4.9	U	0.7	U	0.76	U	0.73	U	4.9	U	0.76	U
7:3 Fluorotelomer carboxylic acid	812-70-4	—	ng/L	0.78	U	4.4	U	0.74	U	0.78	U	0.79	U	4.9	U	4.9	U	0.7	U	0.76	U	0.73	U	4.9	U	0.76	U
2H-Perfluoro-2-octenoic acid (6:2 FTUCA)	70887-88-6	—	ng/L	—		—		0.18	U	—		—		—		—		0.17	U	—		—		—		0.19	U
2H-Perfluoro-2-decenoic acid (8:2 FTUCA)	70887-84-2	—	ng/L	—		—		0.18	U	—		—		—		—		0.17	U	—		—		—		0.19	U
Perfluoro(2-ethoxyethane)sulfonic acid	113507-82-7	—	ng/L	0.39	U	0.87	U	0.37	U	0.39	U	0.39	U	0.98	U	0.97	U	0.35	U	0.38	U	0.37	U	0.98	U	0.38	U
Perfluoro(4-ethylcyclohexane)sulfonic acid (PFEtCHxS)	646-83-3	—	ng/L	—		—		0.35	U	—		—		—		—		0.33	U	—		—		—		0.36	U
Perfluoro(4-Methyoxybutanoic) Acid (PFMBA)	863090-89-5	—	ng/L	0.39	U	0.87	U	0.37	U	0.39	U	0.39	U	0.98	U	0.97	U	0.35	U	0.38	U	0.37	U	0.98	U	0.38	U
Perfluoro-3-methoxypropanoic acid	377-73-1	—	ng/L	0.39	U	0.87	U	0.37	U	0.39	U	0.39	U	0.98	U	0.97	U	0.35	U	0.38	U	0.37	U	0.98	U	0.38	U
Nonafluoro-3,6-Dioxaheptanoic Acid (NFDHA)	151772-58-6	—	ng/L	0.39	U	0.87	U	0.37	U	0.39	U	0.39	U	0.98	U	0.97	U	0.35	U	0.38	U	0.37	U	0.98	U	0.38	U
bis(trifluoromethylsulfonyl)amine (TFSI)	82113-65-3	590	ng/L			0.87	U	0.28	U					0.98	U	0.97	U	0.26	U					0.98	U	0.29	U

Notes:
Units are in ng/L
Analysis conducted using EPA Method 1633 (EPA 2024)
— = not applicable
Bold and shaded text indicates analyte was detected above the PSL
Bold text indicates analyte was detected
abbr. = abbreviated chemical name
Cas No. = chemical abstracts service registry number
COC = chain of custody
EPA = Environmental Protection Agency, United States
FD = field duplicate sample
ID = identification
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 low
J+ = the result was an estimated quantity, but the result may be biased high

LOD = limit of detection
N = primary sample
ng/L = nanogram per liter
OWDF = former oily waste disposal facility
PSL = project screening level
Q = data qualifier
RSL = regional screening level
U = the analyte was not detected and was reported as less than the LOD
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.
WG = groundwater
[a] = EPA tap water RSL using a THQ of 0.1 and a target cancer risk of 1E-06 – November 2024 (EPA 2024).
[b] = PSLs consistent with DoD memorandum (ASD 2025). PSLs are identified in Worksheet #15.

References:
ASD 2025. Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program. Memorandum : Office of the Assistant Secretary of Defense January 21, 2025.
EPA 2024. EPA Method 1633: Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS. Environmental Protection Agency, United States, January 2024.

Appendix C:
Standard Operating Procedures
(on CD-ROM)

I. Field Procedures

Procedure I-A Planning

- Procedure I-A-1 Development of Project Quality Objectives
- Procedure I-A-5 Utility Clearance
- Procedure I-A-6 Investigation-Derived Waste Management
- Procedure I-A-7 Analytical Data Validation Planning and Coordination
- Procedure I-A-8 Sample Naming

Procedure I-B Sampling

- Procedure I-B-1 Soil Sampling

Procedure I-C Well Construction and Well Development

- Procedure I-C-1 Monitoring Well Installation and Abandonment
- Procedure I-C-2 Monitoring Well Development
- Procedure I-C-3 Monitoring Well Sampling

Procedure I-E Soil and Rock Classification

Procedure I-F Equipment Decontamination

Procedure I-H Direct Push Sampling Techniques

Procedure I-I Land Surveying

II. Data Validation Procedures

Procedure II-S Data Quality Assessment Report

III. QC Procedures

Procedure III-A Laboratory QC Samples (Water, Soil)

Procedure III-B Field QC Samples (Water, Soil)

Procedure III-D Logbooks

Procedure III-E Record Keeping, Sample Labeling, and Chain-of-Custody

Procedure III-F Sample Handling, Storage, and Shipping

PFAS Sampling

PFAS Sampling Quick Reference Field Guide

General PFAS Sampling Guidance

Groundwater PFAS Sampling Guidance

Soil PFAS Sampling Guidance

PFMW01B Sampling SOP

Development of Project Quality Objectives

1. Purpose

This standard operating procedure establishes standard guidelines for the United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel for the development of project quality objectives (PQOs) for a contract task order (CTO). These procedures will help ensure that CTOs meet the purpose and objectives of the task order, as well as the necessary documentation of the environmental decisions that need to be made and the level of data quality needed to ensure that those decisions are based on sound scientific data. The PQOs will be used to develop the work plan (WP), which provides the detailed project-specific objectives, specifications, and procedures needed to conduct a successful data collection activity. Data will be collected according to specifications set forth in the WP, and a data quality assessment will be performed to determine whether PQOs have been satisfied.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program. As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 Applicable or Relevant and Appropriate Requirements (ARARS)

ARARs include cleanup or control standards, regulatory requirements, or limitations promulgated under federal or state environmental laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance that applies to a particular CTO.

3.2 Analytes

Analytes are contaminants that might be present at a site as well as other chemical and physical properties for which the laboratory will analyze samples.

3.3 Analytical Methods

Analytical methods are standardized procedures used to identify and quantify analytes in environmental samples.

3.4 PQOs

PQOs are qualitative and quantitative statements derived from a systematic planning process (e.g., U.S. Environmental Protection Agency [EPA] *Guidance on Systematic Planning Using the Data*

Quality Objectives Process (EPA 2006) that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors. PQOs will be used as the basis for establishing the quality and quantity of data needed to support decisions.

3.5 PQO PROCESS

The PQO process is a systematic planning tool based on the scientific method for establishing criteria for data quality and for developing a data collection design.

3.6 ACTION LEVEL

Action levels (ALs) are analyte concentrations that if exceeded in site media, indicate that some action is needed to address hazards associated with onsite contamination.

4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that development of PQOs is performed in compliance with this procedure and for identifying instances of noncompliance. The CTO Manager is responsible for ensuring that all personnel involved in sampling and/or testing shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

5. Procedures

PQOs shall be developed following performance of the site reconnaissance and prior to development of the WP for all CTOs. When critical environmental decisions need to be made,(e.g., final decision-making or compliance with a standard), the project team should follow a formal systematic planning process such as the data quality objectives (DQO) process described in the *Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4* (EPA 2006). The formal DQO process as described in EPA QA/G-4 requires statistical expertise to define the amount of error acceptable when making an environmental decision and includes the following seven steps:

1. State the problem.
2. Identify the goals of the study.
3. Identify information inputs.
4. Define the study boundaries.
5. Develop the analytic approach.
6. Specify performance or acceptance criteria.
7. Develop the plan for obtaining data.

Graded Approach

For data collection activities that are either exploratory or small in nature, or where specific decisions cannot be identified, the formal process is not necessary. For these projects, the project

team should use an abbreviated systematic planning process (e.g., Steps 1-4) to help identify the PQOs and action limits, and to select appropriate sampling, analytical and assessment activities.

Incremental Sampling Approach

Incremental sampling methodology (ISM) is such an integral part of environmental investigations in Hawaii, and therefore, a discussion of ISM PQOs is necessary. The State Department of Health strongly encourages the use of incremental sampling (IS) to enhance the sample representativeness during environmental investigations when appropriate (DOH 2009). IS is a structured sampling protocol that enhances sample representativeness and reduces data variability in the investigation of contaminated soil. The objective of IS is to obtain a single sample for analysis that has an analyte concentration representative of a decision unit within the error limitations required for the project. IS improves the reliability and defensibility of sampling data by reducing variability when compared to conventional discrete sampling strategies. An IS approach requires site-specific information to be considered during the planning process. Therefore, the steps necessary to complete the DQO process as they apply to investigations where IS is used is detailed in Attachment I-A-1-1.

5.1 STEP 1: STATE THE PROBLEM

The first step of the PQO process is to state the problem. Clearly define the problem once it has been identified. Assemble a planning team to completely assess the problem. Designate one member of the planning team as the primary decision maker. The planning team shall compile and evaluate available information to develop a concise description of the problem and a conceptual site model (CSM). The CSM describes exposure pathways and exposure scenarios, facilitates identification of decisions that must be made, and identifies deficiencies in the existing information. Prepare a brief summary of the problem once these have been identified.

5.1.1 Identify Members of the Planning Team

The members of the planning team shall be appropriate for the size and complexity of the problem. PQO development requires that the data users be involved in the planning of CTO activities. Because of the interdisciplinary nature of activities, it is important to obtain the appropriate technical expertise in developing PQOs. Data users normally consist of the primary decision maker, and primary and secondary data users.

Primary data users generally consist of those individuals involved in the ongoing CTO activities. The CTO Manager must identify those technical staff needed for the project and involve them in the planning process. For example, if groundwater contamination is a concern, hydrogeologists must be involved. Persons with expertise in analytical chemistry must be involved to specify the type of analyses that may be used and the limitations of these analyses. Toxicologists or others familiar with risk assessment must also be involved to ensure that migration and exposure pathways, potential receptors, and contaminants and levels of concern are considered.

Secondary data users are those that use data to support their activities. These include Navy personnel, and state and federal regulatory enforcement agencies. The roles and responsibilities shall be determined for each member of the planning team. The objectives of the team are to develop a concise description of the problem, specify resources that are available, and determine deadlines for the study.

5.1.2 Identify the Primary Decision Makers

Identify the primary decision makers for the planning team. These individuals have the ultimate authority for making final decisions based on recommendations from the planning team. Examples of primary decision makers are the Navy personnel who must determine what the site will ultimately be used for and the project manager who determines how the investigation should be conducted to meet the investigation objectives.

5.1.3 Develop a Concise Description of the Problem

The planning team shall prepare a brief summary that concisely describes the problem and the conditions or circumstances that are causing the problem. This summary should be based on a site reconnaissance, and a review of site history and potential sources of contamination. Procedure Number I-A-4, *Site Reconnaissance* provides the procedures for conducting a site reconnaissance. Review literature and studies to ensure that the problem is correctly defined and has not been previously solved. Information regarding site history and potential sources of contamination can be obtained from previous studies and investigations.

The CSM may be helpful in developing a description of the problem. The Department of the Navy Environmental Restoration Program manual (DON 2006) and Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (EPA 1988) provide a general discussion about the development and use of the CSM. Additional CSM tools are available through the navy's Environmental Restoration Technology Transfer Tool (DON 2010). If a CSM already exists, it may need to be refined. A CSM describes the site and its surroundings, potentially complete and complete exposure pathways for the particular media for both human and ecological receptors, and exposure pathways. It also presents hypotheses regarding the contaminants present, their routes of migration, and their potential site impact. The hypotheses are tested, refined, and modified through the WP activities, which shall be referenced by the CSM.

The areas to be assessed during development of the CSM include the following:

- Population, environmental, and welfare concerns
- Potential exposure routes and contaminant transport pathways
- Nature and extent of contamination at the site
- Extent to which the contamination has been defined and can be defined in the future
- Potential for migration from the site (if known)
- Extent to which site contamination levels have exceeded ARARs or other related environmental or public health standards or criteria (if known)

A complex problem may require division into separate studies.

5.1.4 Specify Available Resources and Relevant Study Deadlines

Specify the budget, personnel, and projected deadline in the summary. Discuss time constraints, such as base closures, if appropriate.

5.2 STEP 2: IDENTIFY THE GOALS OF THE STUDY

The second step of the PQO process is to identify the goals of the study. Identify relationships between this decision and any other current or subsequent decisions.

5.2.1 Identify the Principal Study Question

Identify a principal study question based on the problem. The principal study question focuses on pertinent information that is necessary to resolve the problem. State the principal study question as specifically as possible. In general, the question is whether the site poses a threat to human health and/or the environment. Specific examples are as follows:

- Does the contaminant concentration in groundwater exceed acceptable levels?
- Does the pollutant concentration exceed the National Ambient Air Quality Standard?
- Does a contaminant pose a human health or ecological risk?
- Is the contaminant concentration significantly above background levels (suggesting a release)?

5.2.2 Define Alternative Actions that Could Result from Resolution of the Principal Study Question

Possible answers to the study question could result in one or more alternative actions including no action. The following example illustrates how alternative actions are defined based on possible answers to the principal study question: “Does a contaminant pose a human health or ecological risk?” If the answer is yes, alternative actions could be site remediation through removal of contaminated soil, contaminant removal through a soil vapor extraction system, or bioremediation. A quarterly groundwater program may also be implemented to monitor the effect of the site contamination on groundwater. If the answer is no, then the site investigation will go to No Further Response Action Planned.

5.2.3 Combine the Principal Study Question and Alternative Actions into a Decision Statement

Create a decision statement by combining the principal study question with alternative actions. The format may be as follows: “Determine whether or not [unknown environmental conditions/issues/criteria from the principal study question] require (or support) [taking alternative actions].” Using the example above, the decision statement could be “Determine whether or not volatile organic constituent contamination from the site poses a risk to groundwater and requires quarterly groundwater sampling. If the answer is no, then no further action is required.”

5.2.4 Organize Multiple Decisions

If multiple decision statements are necessary to resolve the problem, they should be organized and prioritized. Describe the decision-making process, taking into account how the data from a previous phase will affect the following phase. Implement a phased approach to sampling if relationships exist between this decision and other current or subsequent decisions. A flowchart or diagram may be helpful.

5.3 STEP 3: IDENTIFY INFORMATION INPUTS

The third step of the PQO process is to identify the information needed and sources for each information input. Determine contaminant-specific ALs, sampling techniques, and analytical methods during this step.

5.3.1 Identify the Information Required To Resolve the Decision Statement

Collect various types of information in order to resolve the decision statement. Information types include data uses and types of data. Data uses can be described in terms of general categories, which include the following:

- Identification of the presence or absence of contamination at a site
- Site characterization (delineation of the nature and extent of contamination)
- Assessment of immediate public health or worker health and safety concerns for site investigation activities
- Completion of a risk assessment
- Evaluation and design of remedial action alternatives

Acquire information using either a monitoring or modeling approach, or a combination of both. Use this information with existing site information and the CSM to determine what type of data is required to meet the CTO objective. Data types generally consist of types of samples that need to be collected (soil, groundwater, aquifer hydraulic conductivity, and geotechnical), as well as sample analytes. Refer to Procedure Number I-A-2, *Selection of Analytes*, for procedures on selection of sample analytes.

5.3.2 Determine Sources for Each Informational Input

Identify and qualitatively evaluate for appropriateness the sources for each informational input. Information input sources include previous investigative results, historical records, regulatory guidance, professional judgment, or scientific literature. List those inputs that are obtained through environmental measurements.

5.3.3 Determine the Necessary Information for Establishing Action Levels

Determine the basis for establishing contaminant-specific ALs. The AL is the threshold value that provides the criterion for selecting an alternative action. Derive contaminant-specific action levels from regulatory thresholds or standards, technology based limits, or exposure assessment analysis.

ALs directly affect data quality requirements, in that the analytical methods chosen must have reporting limits that are well below the AL. Reporting limits depend upon the parameter and analytical method being considered.

5.3.4 Identify Potential Sampling Techniques and Appropriate Analytical Methods

Identify potential sampling techniques and appropriate analytical methods for environmental measurements that were previously listed. Use the Project Procedures Manual as the protocol for sampling, and identify significant deviations. Determine the detection limit, limit of detection, and limit of quantitation for each analytical method.

5.4 STEP 4: DEFINE THE STUDY BOUNDARIES

The fourth step of the PQO process is to define the spatial boundaries of the study and the temporal boundaries of the decision. The boundaries ensure that the data collection design incorporates the time periods during which the study shall be implemented, populations and geographic areas that shall be sampled, and the applicable time period. The study area may be stratified into subpopulations in order to reduce the complexity of the problem. The spatial boundaries or geographical region of the general study area may expand or contract with each phase of sampling and may include focused areas of sampling or hot spots. Define practical constraints on data collection during this step.

5.4.1 Specify the Characteristics that Define the Population of Interest

Specify the characteristics that define the population of interest. For example, Aroclor-1260 is more specific than polychlorinated biphenyls (PCBs), and adult construction worker receptor is more specific than human receptor.

5.4.2 Define the Geographic Area Applicable to the Decision(s)

Define the geographic area that is applicable to the decision. The property boundary, depth below ground surface, or natural habitat range for a particular animal species may define a specific geographic area.

5.4.3 Divide the Population into Strata with Relatively Homogeneous Characteristics

The population of the study area may be stratified into subpopulations with relatively homogeneous characteristics in order to reduce the complexity of the problem. Examples of characteristics include specific contaminants, age, and species type.

5.4.4 Determine the Decision Timeframe

Determine the timeframe to which the decision applies. Define time frames for the overall population and for any subpopulation of interest; then address discrepancies that may arise from the short time frame of data collection relative to the long time periods for implementing decisions.

5.4.5 Determine When to Collect Data

Determine the data collection time based upon the most favorable conditions. These conditions include weather, temperature, humidity, wind, or amount of sunlight. For example, a quarterly groundwater monitoring program could be implemented because seasonal changes could affect groundwater concentrations.

5.4.6 Determine the Scale of Decision Making

Determine the most appropriate scale of decision-making based on the spatial or temporal boundaries. For example, in a study where the decision statement is, “Determine whether volatile organic constituent contamination from the site is a risk to groundwater and requires quarterly groundwater monitoring,” the geographic area is the site boundary, and the population is benzene, toluene, ethyl benzene, and xylene (BTEX). The scale of decision-making could be set to a particular chemical that is associated with BTEX, such as benzene, which is a known carcinogen. A scale of decision-making based on temporal boundaries could specify the time between groundwater sampling events.

5.4.7 Identify Practical Constraints on Data Collection

Identify practical constraints that could potentially interfere with data collection, such as seasonal or meteorological conditions, access to property or buildings, time, or unavailable personnel.

5.5 STEP 5: DEVELOP THE ANALYTIC APPROACH

The fifth step of the PQO process is to develop the analytic approach. This procedure involves identifying the statistical parameter that characterizes the population of interest, specifying the ALs for the decision, and combining the outputs from the previous PQO steps in order to develop decision rules.

5.5.1 Specify the Statistical Parameter of the Population of Interest

Specify statistical parameters that characterize the population or parameter of interest. The parameter may be the mean, median, or percentile that will be used by the decision maker. Statistical parameters may be specified by the regulatory agency or the risk assessment analysis.

Using the mean as the statistical parameter is useful when the AL is based on long-term, average health effects, when the population is uniform, and generally requires fewer samples than the other statistical parameters. However, this may not be a representative measure for highly skewed populations or populations that contain a large number of nondetect measurements.

Using the median as the statistical parameter is useful when the AL is based on long-term, average health effects, is more representative than the mean when the population is skewed or contains a large number of nondetect measurements, and relies on few statistical assumptions. However, this approach may be impacted by extreme values and is still not a representative measure for highly skewed populations.

Using the upper proportion or percentile statistical parameter is useful for protection against extreme health effects, provides the best control of extreme values for highly variable populations, is useful for skewed distributions, may be appropriate for populations that contain a large number of nondetect measurements (provided the detection limit is less than the AL), and relies on few statistical assumptions. However, this approach requires larger sample sizes than the mean statistical parameter.

5.5.2 Specify the Action Level for the Study

The decision maker shall specify the AL for the study. For example, if the trichloroethene (TCE) concentration in groundwater samples exceeds the drinking water criteria of 5 micrograms per liter (µg/L), a particular action may be specified. If TCE is detectable at levels below 5 µg/L, another action may be specified. Specify the procedure for establishing background levels in this step.

5.5.3 Combine Outputs from the Previous PQO Steps into a Decision Rule

Incorporate the parameter of interest and action levels into a decision rule or an “if…then…” statement. If a parameter of interest exceeds a specified AL, then an alternative action will result. For example, if the concentration of TCE in groundwater samples exceeds 5 µg/L, then the production well that distributes this groundwater to the population for consumption will be shut off. If the production well is shut off due to elevated TCE concentrations, then remediation of groundwater may be necessary using a water treatment system.

5.6 STEP 6: SPECIFY PERFORMANCE OR ACCEPTANCE CRITERIA

When required by the project objectives, the sixth step is to specify performance or acceptance criteria. This step involves determining the possible range of the parameter of interest, defining the potential consequences of both types of decision errors, specifying a range of minor consequences for decision errors, assigning probability values to reflect the acceptable probability for decision errors to occur, and ensuring that decision errors accurately reflect consequences.

5.6.1 Determine the Possible Range of the Parameter of Interest

Determine the possible range of the parameter of interest by establishing upper and lower boundaries or control limits. Historical data may be used to establish the range of the parameter of interest. For example, the mean concentration of TCE may be between 0.5 and 10 µg/L based on quarterly groundwater sampling results. Only the range of parameters that are expected to drive risk is defined. In some instances, this will not be known and should be so stated.

5.6.2 Define the Potential Consequences of Decision Errors

Environmental sample data has inherent uncertainty associated with it. The uncertainty can be described in terms of sampling design error and measurement error. Sample design error is associated with both random and systematic errors at different stages of the sample acquisition.

Sampling design error arises when sampling plans don't allow for complete variability of the site, thus not allowing an appropriate decision to be made for the site. This type of error can result in data variability or imprecision (random error) and bias data (systematic error).

Measurement error is variability resulting from imperfections in the measurement and analysis system. This type of error is introduced during sample collection, handling, preparation, and analysis. Other contributors to measurement error include data reduction, transmission, and storage.

Sampling design error together with measurement error is defined as "total study error" or "total variability." It is necessary to manage the total study error by rigorous evaluation of the sample design and measurement systems to control decision errors to acceptable levels.

Perform the management of decision error through the use of hypothesis testing. Hypothesis testing requires that a baseline condition (i.e., contaminants are below the AL) and an alternative condition (i.e., contaminants exceed the AL) be defined. This test can be used to show that there is insufficient evidence to indicate that the baseline condition is false (acceptance that the baseline condition is true), or that the baseline condition is probably false (acceptance that the alternative condition is true). This process places the burden of proof on rejecting the baseline condition unless there is substantial evidence that the baseline condition is not true.

The two types of decision errors are false rejection errors and false acceptance errors. A false rejection error occurs when the limited amount of sample data leads to the belief that the baseline condition is probably false when it is really true. A false acceptance error occurs when the data leads to the belief that the baseline condition is true when it is really false. Define the false rejection and false acceptance errors for each decision rule and describe the potential consequences of each. For example, the baseline condition could be that a particular site has PCB contamination below AL; a false rejection error (of the baseline condition) could occur when PCB concentrations are determined to be above the AL, when the true PCB concentrations are below the AL. A false acceptance error

(of the baseline condition) could occur when the PCB concentrations are determined to be below the AL when the true PCB concentrations are above the AL. Define and evaluate the potential consequences of each of these in terms such as human health and ecological risks, economic and social costs, and political and legal ramifications.

Decision errors can never be completely eliminated from environmental investigations but they can be managed. Careful evaluation of the sampling design and measurement methods will help ensure an adequate number of samples are collected utilizing the appropriate protocol and analyzing with the appropriate technique.

A comprehensive discussion of decision errors can be found in Section 6 Specify Tolerable Limits on Decision Errors in *Guidance on Systematic Planning Using the Data Quality Objectives Process. EPA QA/G-4.* (EPA 2006).

5.6.3 Specify a Range of Minor Consequences for Decision Errors

Specify a broad range of minor consequences or a gray region for decision errors when statistical sampling is used. The gray region is a range of possible parameter values where the consequences of false rejection or acceptance decision errors are relatively minor.

5.6.4 Assign Limits to Reflect the Acceptable Probability for Decision Errors to Occur

For statistical sampling, assign probability values to points above and below the gray region that reflect the decision maker's tolerable limits for making an incorrect decision. At a minimum, the decision maker shall specify a false rejection decision error limit at the AL and a false acceptance decision error limit at the lower end of the gray range. Aggressive identification of reasonably high levels of error is recommended because the risk assessment procedures are relatively conservative.

5.6.5 Ensure that Decision Errors Accurately Reflect Consequences

For statistical sampling programs, check the limits on decision errors to ensure that they accurately reflect the relative consequences for each type of decision error.

5.7 STEP 7: DEVELOP THE PLAN FOR OBTAINING DATA

When required by the project objectives, the seventh step of the PQO process is to develop the plan for obtaining data. This procedure involves reviewing the PQO outputs and existing environmental data, developing general sampling and analysis design alternatives, verifying that PQOs are achieved for each design, selecting the most resource-effective design that satisfies all of the PQOs, and documenting the details and assumptions in the sampling and analysis plan.

5.7.1 Review PQO Outputs and Existing Environmental Data

Review the PQO outputs from the previous steps for internal consistency. Also review existing data and identify data significant to the design.

5.7.2 Develop General Sampling and Analysis Design Alternatives

Develop general sampling and analysis design alternatives based on the PQO outputs and other relevant information. These alternatives shall be cost effective and balance the sample size and measurement performance with the sample collection techniques and analytical methods available. Factors to be considered in this step include the phase, media, sample type, number of samples,

sampling locations, analytical methods, and QA/quality control requirements. Also develop a schedule for all sampling activities. The output of this process is a well-defined WP.

For nonstatistical sampling programs, present a justification for using purposive sampling, as well as identification and rationale for using a phased approach and other sampling strategies that are somewhat unusual. Discuss alternative analytical and field sampling strategies and provide rationales for using them. Develop and describe several different sampling scenarios for statistically based plans.

5.7.3 Verify that PQOs Are Achieved for Each Design

Briefly show that the sampling design will achieve the PQOs. For statistically based plans, define a method for testing the hypothesis and a corresponding sample size formula (e.g., T-test), develop a statistical model that describes the relationship between the measured value and the true value, and develop a cost function that relates the number of samples to the total cost of sampling and analysis.

5.7.4 Select the Most Resource-Effective Design that Satisfies all of the PQOs

Evaluate each design option in order to select the most resource-effective and/or cost-effective design that satisfies all of the PQOs.

5.7.5 Document Details and Assumptions in the Work Plan

Document the operational details and theoretical assumptions of the selected design in the WP.

6. Records

None.

7. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

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Environmental Protection Agency, United States (EPA). 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA.* Interim Final. EPA/540/G-89/004. Office of Emergency and Remedial Response. October.

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Naval Facilities Engineering Command (NAVFAC). 2010. *NAVFAC Technology Transfer (T2) Program.*

Procedure I-A-2, *Selection of Analytes.*

Procedure I-A-4, *Site Reconnaissance.*

8. Attachments

Attachment I-A-1-1: DQO Process Using IS Approach

Attachment I-A-1-1
DQO Process Using IS Approach

The State of Hawaii, Department of Health, Hazard Evaluation and Emergency Response Office strongly encourages the use of incremental sampling (IS) to enhance sample representativeness in the investigation of contaminated soil (DOH 2009). IS is a structured composite sampling and processing protocol that reduces data variability and provides a reasonably unbiased estimate of mean contaminant concentrations in a volume of soil targeted for sampling. IS provides representative samples of specific soil volumes defined as decision units (DUs) by collecting numerous increments of soil (typically 30–100 increments) that are combined, processed, and subsampled according to specific protocols (DOH 2009 and ITRC 2012).

Similar to other sampling designs, systematic planning must be conducted and used to develop the scope of the investigation. The following subsections detail the steps needed to complete the data quality objective (DQO) process (EPA 2006) as they apply to IS investigations.

1. Define the problem that is prompting the investigation. This step should include:
   - A description of the problem
   - Development of a conceptual site model for the issue being investigated
   - Identification of the types of data needed along with alternative approaches
   - Identification of planning team members
   - A schedule, including constraints and deadlines, for the project
2. Identify the goals of the investigation. This step should include identification of the principle study questions (PSQs) and alternative outcomes for each PSQ. Decision statements can then be written based on the PSQs and various outcomes.
3. Identify what information is needed to address the problem statement and associated PSQs. This should include the environmental parameters or characteristics (i.e., data) that will be needed to answer the questions being asked at a site. The data could be historical or it could be that new, better, or additional data is needed. This should be identified in the sampling plan. Details of the specific data may include, but are not limited to the following:
   - Chemical parameters
   - Physical parameters
   - How many DUs
   - What size DUs are needed
   - How many replicate samples are needed
   - How many increments per sample are necessary (Anything less than 30 increments should have a full justification)

   Also included in this section is the type of data needed to meet the performance criteria for the site. The number and location of DUs proposed for field replicate sampling and the number of replicates for those DUs must be included. In addition to the field replicates, it must be determined whether laboratory replicates should be collected on the project. Laboratory replicates are used to determine the source of sampling error (i.e., field or laboratory) once your data is received from the laboratory.

4. Define the boundaries of the investigation. There is typically a spatial and temporal boundary for the investigation. This is where the target population of interest is identified which informs the size and thickness of the DUs, which is identified here. Also included in this section is the smallest unit on which decisions will be made. This is normally equal to the size of your DUs. Lastly, factors or site features that restrict the ability to collect all the data specified in step three above, should be identified here. These are usually access limitations, either physical or legal.
5. This section should introduce the decision rules for the investigation. These are comprised of a series of "if…then" statements. These if/then statements will be generated using the action level or screening criteria selected for the project and identified in your Uniform Federal Policy for Quality Assurance Project Plans Sampling and Analysis Plan (SAP).
6. This step should specify the acceptance criteria for the study. Acceptance criteria will typically be based on an evaluation of the total study error, which includes the field sampling error and the total laboratory error. The total study error is measured using the relative standard deviation (RSD) of the field replicates. The acceptance criterion should be an RSD less than or equal to 35 percent RSD. If the data do not meet this criterion, they will have to be evaluated further by the project stakeholders to decide whether the DQOs have been met. One factor for evaluating the data is whether the result is within an order of magnitude of the screening level. Data more than an order of magnitude from the screening level are unlikely to be affected sufficiently to prevent a good decision from being made. Another method to assist stakeholders with data that don't meet the acceptance criterion is to calculate a 95 percent upper confidence limit (UCL). Use of the 95 percent UCL rather than the laboratory reported value will give an additional level of confidence to decision makers that the reported values are protective of the receptors. In addition to the acceptance criterion, the detection limit, limit of detection, and limit of quantitation for the various analytes needed to achieve the performance objectives for the project should be provided in Worksheet #15 of the SAP.
7. The last step must include a compilation of all the information generated in the first six steps. This information should then be used to identify alternative sampling and analysis designs that meet the project objectives. This section should lay out how the samples will be collected, the size, shape, and depth of the DUs, reference to the sampling procedures that will be followed, the sampling instruments that will be used as well as the laboratory containers that will be used to send samples to the laboratory for analysis. Also, reference to the laboratory processing and sub-sampling procedures should be documented in this section. If the soil type at the site is unknown, it is recommended that at least one backup type of sampling tool be kept available in case the primary tool proves unusable for some reason. For instance, if the SAP called for a hand tool (e.g., slide hammer driven soil corer) and the soil turns out to be very hard, the project team should have a backup method to collect the increments such as some kind of power tool or direct push rig.

DU size, depth, and location will determine whether the data is able to satisfy your project objectives. It is imperative that your DUs are suitable for achieving these project objectives.

Things to consider when deciding DU size:

- If you need to make a decision about whether unrestricted use is appropriate for a site, then the DUs should be no larger than 5,000 square feet (default residential lot in Hawaii) unless regulators and Navy agree it can be larger.
- If commercial/industrial use is intended, then DUs can be larger than 5,000 square feet. The size of DUs should be agreed upon by project stakeholders upfront in the planning phase (e.g., SAP or work plan). Also, any land use other than unrestricted use will require LUCs on the property.
- Depending on the needs or goals of the investigation, DUs can be reduced in size to whatever is needed (e.g. DUs for remediation or confirmation sampling).
- Involve a risk assessor if risk assessment is planned with the data. You will need to determine what receptors and pathways will be evaluated in the risk assessment and the data must be able to satisfy those objectives. Risk assessment needs will often impact the size, location, and depth of your DUs.

Things to consider when deciding where to place DUs (Many of these same criteria should also be used to determine which DUs should have replicate samples collected, when less than 100 percent of the DUs will have replicate samples collected):

- Evaluate historical land use.
- Evaluate site features such as geology to identify different soil types or possible transport mechanisms.
- Identify potential source areas (current and past).
- Evaluate fate and transport properties of the chemicals of potential concern.
- Evaluate existing sampling data from the site.
- Consult a risk assessor if the data will be used in a risk assessment. Again, receptors and pathways must be evaluated to ensure the DUs will provide data to meet the risk assessment and project objectives. Risk assessors can also provide input on which DUs and how many should have replicate samples collected.
- Evaluate site access restrictions due to current site use that could affect where DUs are placed.

References

Department of Health, State of Hawaii (DOH). 2009. *Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan*. Interim Final. Honolulu: Office of Hazard Evaluation and Emergency Response. 21 June. http://www.hawaiidoh.org/tgm.aspx.

Environmental Protection Agency, United States (EPA). 2006. *Guidance on Systematic Planning Using the Data Quality Objectives Process. EPA QA/G-4.* EPA/240/B-06/001. Office of Environmental Information. February.

Interstate Technology and Regulatory Council (ITRC). 2012. *Incremental Sampling Methodology*. February.

Utility Clearance

1. Purpose

This standard operating procedure describes the process for determining the presence of subsurface utilities and other cultural features at locations where planned site activities involve the physical disturbance of subsurface materials. The procedure applies to the following activities: soil gas surveying, excavating, trenching, drilling of borings and installation of monitoring and extraction wells, use of soil recovery or slide-hammer hand augers, and all other intrusive sampling activities. The primary purpose of the procedure is to minimize the potential for damage to underground utilities and other subsurface features, which could result in physical injury, disruption of utility service, or disturbance of other subsurface cultural features.

2. Scope

This procedure applies to all United States Navy Environmental Restoration (ER) Program projects performed in the Naval Facilities Engineering Command, Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 Utility

For this procedure, a utility is defined as a manmade underground line or conduit, cable, pipe, vault or tank that is, or was, used for the transmission of material or energy (e.g., gas, electrical, telephone, steam, water or sewage, product transfer lines, or underground storage tanks).

3.2 As-Built Plans

As-built plans are plans or blueprints depicting the locations of structures and associated utilities on a property.

3.3 One-Call

The Utility Notification Center is the one-call agency for Oregon, Washington, Montana, and Hawaii. The Utility Notification Center is open 24 hours a day, and accepts calls from anyone planning to dig in. The phone number for the Hawaii One Call Center is 1-866-423-7287 (or 811). Additional information can be found at http://www.callbeforeyoudig.org/hawaii/index.asp.

Calling before you dig ensures that any publicly owned underground lines will be marked, so that you can dig around them safely. Having the utility lines marked not only prevents accidental damage to the lines, but prevents property damage and personal injuries that could result in breaking a line.

The following information will need to be provided when a request is placed to One-Call:

- Your name, phone number, company name (if applicable), and mailing address.
- What type or work is being done. This should be a description of the specific reason for the work, not the method used.
- Who the work is being done for.
- The county and city the work is taking place in.
- The address or the street where the work is taking place.
- Marking instructions, (specific instructions as to where the work is taking place).

Under normal circumstances it takes between 2 days to 5 days from the time you call (not counting weekends or holidays) to have the underground lines marked. Because these laws vary from state to state, exactly how long it will take depends on where your worksite is located. You will be given an exact start time and date when your locate request is completed, which will comply with the laws in your area.

In the event of an emergency (any situation causing damage to life or property, or a service outage), lines can be marked sooner than the original given time if requested, but must be handled via voice contact with One-Call.

3.4 TONING

Toning is the process of surveying an area utilizing one or more surface geophysical methods to determine the presence or absence of underground utilities. Typically, toning is conducted after identifying the general location of utilities and carefully examining all available site utility plans. Each location is marked according to the type of utility being identified. In addition, areas cleared by toning are flagged or staked to indicate that all identified utilities in a given area have been toned.

4. Responsibilities

The prime contractor CTO Manager is responsible for verifying that these utility locating procedures are performed prior to the initiation of active subsurface exploration. The CTO Manager is responsible for ensuring that all personnel involved in sampling and/or testing shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The onsite Field Manager (FM) and Site Safety and Health Officer (SSHO) are responsible for planning utility clearance and for locating and marking underground utilities according to this procedure.

Field personnel are responsible for the implementation of this procedure.

5. Procedures

Follow the following steps at all sites where subsurface exploration will include excavations, drilling, or any other subsurface investigative method that could damage utilities at a site. In addition to the steps outlined below, always exercise caution while conducting subsurface exploratory work.

5.1 Prepare Preliminary Site Plan

Prepare a preliminary, scaled site plan depicting the proposed exploratory locations as part of the work plan. Include as many of the cultural and natural features as practical in this plan.

5.2 Review Background Information

Search existing plan files to review the as-built plans and available geographic information system databases to identify the known location of utilities at the site. In addition, the contractor should contact the Navy RPM to obtain the most updated GIS layers. Plot the locations of utilities identified onto a preliminary, scaled site plan. Inform the CTO Manager if utilities lie within close proximity to a proposed exploration or excavation location. The CTO Manager will determine if it is necessary to relocate proposed sampling or excavation locations.

Include the utility location information gathered during investigation (e.g., remedial investigation or remedial site evaluation) work in the project design documents for removal or remedial actions. In this manner, information regarding utility locations collected during implementation of a CTO can be shared with the other contractors during implementation of a particular task order. In many instances, this will help to reduce the amount of additional geophysical surveying work the other contractor may have to perform.

Conduct interviews with onsite and facility personnel familiar with the site to obtain additional information regarding the known and suspected locations of underground utilities. In addition, if appropriate, contact shall be made with local utility companies to request their help in locating underground lines. Pencil in the dimensions, orientation, and depth of utilities, other than those identified on the as-built plans, at their approximate locations on the preliminary plans. Enter the type of utility, the personnel who provided the information, and the date the information was provided into the field log.

During the pre-fieldwork interviewing process, the interviewer will determine which site personnel should be notified in the event of an incident involving damage to existing utilities. Record this information in the field logbook with the corresponding telephone numbers and addresses.

5.3 Dig Permit

Prior to all activities requiring excavation work that may disrupt utility services, vehicular or aircraft traffic flow, protection provided by fire and intrusion alarm systems, or routine activities at Navy bases (including Joint Base Pearl Harbor-Hickam and Naval Base Guam), as well as intrusive work at Marine Corps Base Hawaii, current procedures shall be followed. The dig permit process tries to identify, as much as practical, any known, potentially hazardous work condition related to excavation activities and is intended to prevent accidents. It also informs key Navy personnel of the digging work and coordinates the required work with these activities to minimize inconveniences (JBPHH 2013).

5.4 SITE VISIT – LOCATE UTILITIES – TONING

Prior to the initiation of field activities, the field task manager or similarly qualified staff personnel shall visit the site and note existing structures and evidence of associated utilities, such as fire hydrants, irrigation systems, manhole and vault box covers, standpipes, telephone switch boxes, free-standing light poles, gas or electric meters, pavement cuts, and linear depression. Compare notes of the actual site configuration to the preliminary site plan. Note deviations in the field logbook and on the preliminary site plan. Accurately locate or survey and clearly mark with stakes, pins, flags, paint, or other suitable devices all areas where subsurface exploration is proposed. These areas shall correspond with the locations drawn on the preliminary site plan.

Following the initial site visit by the FM, a trained utility locator will locate, identify, and tone all utilities depicted on the preliminary site plan. The locator should use appropriate sensing equipment to attempt to locate utilities that might not have appeared on the as-built plans. This may involve the use of surface geophysical methods (Procedure I-B-2, *Geophysical Testing*). At a minimum, use a utility locator, metal detector, and/or magnetometer; however, it is important to consider the possibility that non-metallic utilities or tanks might be present at the site. Use other appropriate surface geophysical methods, such as Ground Penetrating Radar, if non-metallic cultural features are likely to be present at the site. Clear proposed exploration areas of all utilities in the immediate area where subsurface exploration is proposed. Clearly tone all anomalous areas. Clearly identify all toned areas on the preliminary site plan. After toning the site and plotting all known or suspected buried utilities on the preliminary site plan, the utility locator shall provide the FM with a copy of the completed preliminary site plan. Alternatively, the FM or designee shall document the results of the survey on the preliminary site plan.

Report to the FM anomalous areas detected and toned that are in close proximity to the exploration or excavation areas. The FM shall determine the safe distance to maintain from the known or suspected utility. It may be necessary to relocate proposed exploration or excavation areas. If this is required, the FM or a similarly qualified individual shall relocate them and clearly mark them using the methods described above. Completely remove the markings at the prior location. Plot the new locations on the site plan and delete the prior locations from the plan. In some instances, such as in areas extremely congested with subsurface utilities, it may be necessary to dig by hand to determine the location of the utilities.

5.5 PREPARE SITE PLAN

Prior to the initiation of field activities, draft a final site plan that indicates the location of subsurface exploration areas and all known or suspected utilities present at the site. Provide copies of this site plan to the Contracting Officer's Representative (COR), the CTO Manager, and the subcontractor who is to conduct the subsurface exploration/excavation work. Review the site plan with the COR to verify its accuracy prior to initiating subsurface sampling activities.

6. Records

Keep a bound field logbook detailing all activities conducted during the utility locating procedure. The logbook will describe any changes and modifications made to the original exploration plan. The trained utility locator shall prepare a report and keep it in the project file. Also keep a copy of the final site plan on file.

7. Health and Safety

Field personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Joint Base Pearl Harbor-Hickam (JBPHH). 2013. *Dig Permit Requests*. JBPHH Instruction 11013.1. 15 March 2013.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual.* EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-B-2, *Geophysical Testing.*

9. Attachments

None.

Investigation-Derived Waste Management

1. Purpose

This standard operating procedure describes the activities and responsibilities of the United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific with regard to management of investigation-derived waste (IDW). The purpose of this procedure is to provide guidance for the minimization, handling, labeling, temporary storage, inventory, classification, and disposal of IDW generated under the ER Program. This procedure will also apply to personal protective equipment (PPE), sampling equipment, decontamination fluids, non-IDW trash, non-indigenous IDW, and hazardous waste generated during implementation of removal or remedial actions. The information presented will be used to prepare and implement work plans (WPs) for IDW-related field activities. The results from implementation of WPs will then be used to develop and implement final IDW disposal plans.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

This procedure focuses on the requirements for minimizing, segregating, handling, labeling, storing, and inventorying IDW in the field. Certain drum inventory requirements related to the screening, sampling, classification, and disposal of IDW are also noted in this procedure.

3. Definitions

3.1 IDW

IDW consists of all materials generated during site investigations that might be contaminated with chemicals of concern. IDW might consist of many types of potentially contaminated materials, including but not limited to, PPE, disposable sampling and decontamination equipment, investigation-derived soil, sludge, and sediment, well development and purge water, and decontamination fluids.

3.2 PPE

PPE, as defined in this procedure, refers to all disposable materials used to protect personnel from contact with potentially contaminated site media, such as inner and outer gloves, Tyvek suits and overboots, and disposable respirator cartridges. Non-consumable items, such as steel-toe boots, respirators, and hard hats are not included in this procedure.

3.3 DISPOSABLE SAMPLING EQUIPMENT

Disposable sampling equipment consists of all single-use equipment that might have come in contact with potentially contaminated site media, including sample bailers, Draeger air monitoring tubes, used soil sampling trowels and spatulas, plastic drop cloths, plastic bags and bucket liners, and sample containers from field analytical test kits.

3.4 INVESTIGATION-DERIVED SOIL, SLUDGE, AND SEDIMENT

Investigation-derived soil consists of all potentially contaminated soil that is disturbed as part of site investigation activities. The most commonly encountered form of IDW soil is drill cuttings brought to the ground surface by drilling. Other forms of disturbed soil, including trenching spoils and excess soil remaining from surface sampling, should not be stored as IDW. Excavated soil should be returned to its source if site conditions permit.

Investigation-derived sludge consists of all potentially contaminated sludge materials generated or disturbed during site investigation activities. Generated sludge might consist of drilling mud used or created during intrusive activities. Other sludge might include solvents or petroleum-based materials encountered at the bottom of storage tanks and grease traps.

Investigation-derived sediment consists of all potentially contaminated sediments that are generated or disturbed during site investigation activities. Generated sediments might include solids that settle out of suspension from well development, purge, or decontamination water (see Definitions 3.5 and 3.6) while stored in 55-gallon drums or during sample filtration. Disturbed sediments might also consist of catch basin sediments or excess sediment from surface water activities.

3.5 WELL DEVELOPMENT AND PURGE WATER

Development water consists of groundwater withdrawn from newly installed monitoring wells in preparation for well purging or pump testing. Monitoring well development methods are discussed in Procedure I-C-2, *Monitoring Well Development*.

Purge water consists of groundwater that is removed from monitoring wells immediately prior to sampling. Well purging methods are discussed in Procedure I-C-3, *Monitoring Well Sampling*. Groundwater derived during aquifer testing shall be addressed on a site-specific basis. Procedures for handling groundwater generated during aquifer testing shall be included in the WP or equivalent document for the CTO.

3.6 DECONTAMINATION FLUIDS

Decontamination fluids consist of all fluids used in decontamination procedures conducted during site investigation activities. These fluids consist of wash water, rinse water, and solvents used for the decontamination of non-consumable PPE, sampling equipment, and drilling equipment. Decontamination procedures are discussed in Procedure I-F, *Equipment Decontamination*.

3.7 NON-IDW TRASH

Non-IDW trash is all waste materials, such as waste paper, drink containers, food, and packaging, generated in the support zone that have not come in contact with potentially contaminated site media.

3.8 NON-INDIGENOUS IDW

Non-indigenous IDW consists of all waste materials from offsite sources that are generated in the transition or contamination reduction zones and have not come in contact with potentially contaminated site media. Non-indigenous IDW includes materials, such as PPE from "clean" field activities (e.g., field blank generation, water sampling events) and refuse from monitoring well installation (e.g., unused sections of well casing, used bentonite buckets, sand bags, and cement bags).

Non-indigenous waste does not include material/waste that is abandoned at the ER site (including the IDW waste storage area) by other parties not associated with the ER work. Disposal of abandoned material/waste in the vicinity of IDW is the responsibility of the property owner (e.g., Navy Region Hawaii) or party responsible for abandoning the material/waste. The ER contractor shall notify the Contracting Officer's Representative (COR) of the situation as soon as possible so that recovery actions can be coordinated by the Government.

3.9 RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) HAZARDOUS WASTE

Under the RCRA, a solid waste that is not excluded from regulation is defined as hazardous if it:

- Is "listed" as a hazardous waste in Chapter 40, Code of Federal Regulations (CFR), Parts 261.31 through 261.33
- Exhibits any of four hazardous "characteristics"—ignitability, corrosivity, reactivity, or toxicity (as determined using the Toxicity Characteristic Leachate Procedure [TCLP]) (40 CFR 261.20-24)
- Is subject to certain "mixture" or "derived-from" rules (40 CFR 261.3).

Under certain circumstances, petroleum- or polychlorinated biphenyl (PCB)-contaminated wastes are not considered RCRA hazardous when they only exhibit toxicity characteristic (40 CFR 261.4(b)(10) and 261.8). If IDW is determined to be RCRA hazardous waste, then RCRA storage, transport, and disposal requirements shall apply unless exempt.

3.10 RCRA LAND DISPOSAL RESTRICTIONS (LDR)

Land disposal, as defined in RCRA, is any placement of RCRA hazardous waste on the land in a waste pile, landfill, impoundment, well, land treatment area, etc. LDRs are regulatory restrictions placed on land disposal, including pre-treatment standards, engineered containment, capacity constraints, and reporting and permitting requirements.

3.11 AREA OF CONTAMINATION (AOC)

The U.S. Environmental Protection Agency (EPA) considers the RCRA AOC to be a single land-based disposal unit, usually a "landfill," and includes non-discrete land areas in which there is generally dispersed contamination. Storing IDW in a container (i.e., portable storage devices, such as drums and tanks) within the AOC and returning it to its source, whether RCRA hazardous or not, does not trigger RCRA LDRs. In addition, sampling and direct replacement of wastes within an AOC do *not* constitute land disposal.

3.12 CERCLA HAZARDOUS SUBSTANCES

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) hazardous substances are listed in 40 CFR Table 302.4 and include substances regulated by the RCRA Subtitle C, Clean Water Act (CWA), Clean Air Act (CAA), and Toxic Substances Control Act (TSCA). The CFR is updated annually; therefore, the most recent CFR should be referenced for the CERCLA hazardous waste list.

CERCLA hazardous substances are defined independent of their concentration level (i.e., any detection of a listed CERCLA constituent is considered a "CERCLA hazardous substance"). "Reportable quantities" identified for chemicals in 40 CFR Table 302.4 concern only CERCLA and RCRA requirements for notification to EPA when a release has occurred; they do not dictate whether a chemical is a hazardous substance.

The definition of CERCLA hazardous substances excludes "petroleum, including crude oil or any fraction thereof;" natural gas; natural gas liquids; liquefied natural gas; and synthetic gas usable for fuel, unless specifically listed or designated under the act. Excluded fractions of crude oil contain hazardous substances, such as benzene, that are indigenous in those petroleum substances or that are normally mixed with or added to petroleum during the refining process. However, hazardous substances that are (1) added to petroleum after the refining process, (2) increase in concentration as a result of contamination of the petroleum during use, or (3) commingled with petroleum after a release to the environment, are not considered part of the petroleum exclusion provision, and therefore, are regulated under CERCLA. In addition, some waste oils are regulated under CERCLA because they are specifically listed.

The scope of CERCLA hazardous substances includes the smaller subsets of RCRA hazardous wastes, PCB Aroclors, and other constituents. Therefore, a RCRA hazardous waste is always considered a CERCLA hazardous substance for a CERCLA-driven response action; however, a CERCLA hazardous substance is not always a RCRA hazardous waste.

CERCLA only regulates releases or threats of releases of hazardous substances into the environment. If there is no evidence that (1) a release has occurred (based on site history, visual observations, background metals evaluation), (2) there is a threat of release (as from abandoned, discarded, or non-maintained chemical receptacles), or (3) the release has entered the environment (as defined below), then CERCLA does not regulate the constituent even though it is identified on the CERCLA hazardous substance list.

3.12.1 CERCLA Hazardous Substances: TSCA/PCBs

PCBs are a CERCLA hazardous substance. PCBs belong to a broad family of man-made organic chemicals known as chlorinated hydrocarbons. PCBs were domestically manufactured from 1929 until their manufacture was banned in 1979. They have a range of toxicity and vary in consistency from thin, light-colored liquids to yellow or black waxy solids. Due to their non-flammability, chemical stability, high boiling point, and electrical insulating properties, PCBs were used in hundreds of industrial and commercial applications including electrical, heat transfer, and hydraulic equipment; as plasticizers in paints, plastics, and rubber products; in pigments, dyes, and carbonless copy paper; and many other industrial applications. Although no longer commercially produced in the United States, PCBs may be present in products and materials produced before the 1979 PCB ban.

If PCBs are detected at concentrations equal to or greater than 50 parts per million (ppm), the sample is considered TSCA-regulated. Current PCB regulations can be found in the CFR at 40 761. The EPA Q and A Manual (EPA 2009), referring to CFR 761.61 explains PCB remediation waste must be managed and disposed of based on the concentration at which the PCBs are found. It is unacceptable to dilute the as-found concentration of the contaminated soil by mixing it with clean soil during excavation or other IDW management activities.

3.13 ENVIRONMENT

Environment means navigable waters, ocean waters, surface water, groundwater, drinking water supply, land surface or subsurface strata, and ambient air, within the U.S. or under federal jurisdiction (see Section 101(8) of CERCLA or 40 CFR 300.5 for complete definition).

3.14 ONSITE AREA

The CERCLA onsite area is defined in 40 CFR 300.400(e)(1) as an area that includes:

- AOC
- All suitable areas in very close proximity to the contamination that are necessary for the implementation of the response action

The delineation of the onsite area is further discussed in Volume 55 Federal Register (FR) Page 8688 and EPA guidance.

Neither CERCLA, the National Oil and Hazardous Substances Pollution Contingency Plan, nor RCRA define the terms “area of contamination” or “contamination.” However, the area of contamination is interpreted as containing “varying types and concentrations of contaminants” (55 FR 8760) that may or may not pose a risk to human health or the environment.

The onsite area may also include several noncontiguous aerial extents of contaminations if they share a common nexus (55 FR 8690).

3.15 OFFSITE AREA

The offsite area consists of all areas outside the onsite area.

3.16 CERCLA OFFSITE RULE

The CERCLA offsite rule (400 CFR 300.440) states that IDW containing CERCLA hazardous substances (at any concentration) must be stored, treated, or disposed of offsite only at facilities having current EPA approval to accept such CERCLA wastes. RCRA-permitted facilities (Subtitle C and D) must also have specific EPA approval to accept waste generated at a CERCLA site (even if the waste is RCRA hazardous).

With some restrictions, the offsite rule does not apply to the following:

- Wastes generated during non-CERCLA actions
- Treatability study samples

- Wastes generated during emergency response actions
- Laboratory samples

CERCLA allows IDW to be managed, stored, and disposed of onsite within or near the AOC without the need for EPA approval (i.e., CERCLA facility approval) or RCRA permits. If IDW is to be stored or disposed of on site, the onsite area (and the AOC) should be delineated on a figure in the project field book and revised, based on best professional judgment, as site data become available.

4. Responsibilities

The prime contractor CTO Manager is responsible for preparing WPs and IDW disposal plans and reports in compliance with this procedure, and is responsible for documenting instances of noncompliance. The CTO Manager is responsible for ensuring that all personnel involved in sampling and/or testing shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for implementing this IDW procedure and ensuring that all project field staff follow these procedures.

Field personnel are responsible for the implementation of this procedure.

5. IDW Management Procedures

The procedures for IDW management in the field are described below.

5.1 Planning for IDW Management

The project team should begin planning for IDW issues early in the site investigation planning stage. The proper management of IDW involves all of the following tasks:

- Obtain Navy approval for a designated IDW storage area prior to commencement of field work
  - Complete Navy form, including IDW Tracking Sheet and provide to remedial project manager (RPM) for processing
- Waste generation and minimization
- Chemical screening and characterization of the waste
- Waste handling, storage, and associated maintenance in compliance with all regulations (prepare an IDW drum inventory, ensure storage areas are compliant with type of waste [double containment, TSCA requirements, etc.] maintain condition of drum and labeling, maintain safety and assess controls, comply with permit requirements [for offsite storage])
- Waste transport and disposal within required holding times
- Waste tracking, documentation, record keeping, and reporting

As part of IDW planning, the CTO Manager should consult with the COR and environmental regulatory agencies to clearly identify the primary federal or state regulatory authority that is driving the site investigation. This authority may be CERCLA, RCRA (Subtitle C), RCRA (subtitle I), TSCA, CWA, or an equivalent state program. The primary investigation authority and regulations promulgated under this authority set forth requirements for IDW management. These requirements may differ under the various response authorities. For CERCLA-driven actions, IDW storage and disposal should comply with all applicable or relevant and appropriate requirements (ARARs) and to-be-considered (TBC) criteria to the extent practicable.

Lastly, the CTO Manager should consider the disposal criteria of the anticipated disposal facility when developing the sampling and analysis plan (SAP). Some offsite facilities do not accept waste that is characterized by association with samples collected from the investigation site or they may require analytical data for chemicals that are not of potential concern at the site. Facility disposal criteria may dictate laboratory reporting limits.

If unknown waste is observed onsite, notify the project RPM and COR for further instructions.

5.2 IDW MINIMIZATION

Field managers (FMs) and their designates shall minimize the generation of onsite IDW to reduce the need for special storage or disposal requirements that might result in substantial additional costs and provide little or no reduction in site risks (EPA 1992b). Reduce the volume of IDW by applying minimization practices throughout the course of site investigation activities. These minimization strategies include substitution of biodegradable raw materials; using low-volume IDW-generating drilling techniques; where possible, returning excess material to the source location; using disposable sampling equipment versus generating more decontamination fluids from reusable sampling equipment; using bucket and drum liners; and separating trash from IDW.

Material substitution consists of selecting materials that degrade readily or have reduced potential for chemical impacts to the site and the environment. An example of this practice is the use of biodegradable detergents (e.g., Alconox or non-phosphate detergents) for decontamination of non-consumable PPE and sampling equipment. In addition, field equipment decontamination can be conducted using isopropyl alcohol rather than hexane or other solvents (for most analytes of concern) to reduce the potential onsite chemical impacts of the decontamination solvent. Select decontamination solvents carefully so that the solvents, and their known decomposition products, are *not* potentially RCRA hazardous waste, unless absolutely necessary.

Give priority to drilling methods that minimize potential IDW generation. Select hollow-stem auger and air rotary methods, where feasible, over mud rotary methods. Mud rotary drilling produces waste drilling mud, while hollow stem and air rotary drilling methods produce relatively low volumes of soil waste. Use small-diameter borings and cores when soil is the only matrix to be sampled at the boring location; however, the installation of monitoring wells requires the use of larger-diameter borings.

If possible, return soil, sludge, or sediment removed from borings, containment areas, and shallow test trenches to the source immediately after sampling and/or geological logging of the soils (EPA 1991, 1992b). Immediate replacement of solid waste in the source location during investigation activities avoids RCRA LDRs, which permit movement of IDW within the same AOC without considering land disposal to have occurred, even if the IDW is later determined to contain RCRA

hazardous material (EPA 1991). Place soil IDW from borings and trenches on polyethylene sheeting (e.g., Visqueen) during excavation and segregate it by approximate depth and any apparent contamination (i.e., visible staining). Following excavation, replace the soil IDW from above the saturated layer into the boring or trench and compact it, if possible. Efforts should be made to return the waste to the approximate depth from which it was generated. Soil and sludge IDW generated at or below the saturated layer of a boring or trench should be placed in drums and not returned to the source area. Suspected contaminated soil and sludge IDW generated above the saturated layer of a boring or trench should not be returned below the saturated layer."

Often monitoring wells are constructed outside the area of concern for soil contamination to sample for potential groundwater contamination or collect characteristic background data. At these locations, soil cuttings generated from above the saturation zone may be immediately disposed of near the wellhead in a shallow pit covered with natural topsoil from the site, and compacted. Contain soil and sludge IDW generated at or below the saturated layer in drums.

Reduce the quantity of decontamination rinse water generated by using dedicated and disposable sampling equipment, such as plastic bailers, trowels, and drum thieves that do not require decontamination. In general, decontamination fluids, and well development and purge water should not be minimized because the integrity of the associated analytical data might be affected.

Minimize the storage of visibly soiled PPE and disposable sampling equipment IDW by implementing decontamination procedures. If, based upon the best professional judgment of the FM, the PPE and disposable sampling equipment can be rendered non-contaminated after decontamination, then double-bag the PPE and disposable sampling equipment and dispose of it off site at a (RCRA Subtitle D) municipal solid waste disposal facility at the end of each work day (EPA 1991, 1992b). Since the decontaminated waste does not contain CERCLA hazardous substances, it need not be disposed of at a CERCLA-approved disposal facility in accordance with the CERCLA offsite rule.

Bucket liners can be used in the decontamination program to reduce the volume of solid IDW generated, and reduce costs on larger projects. The plastic bucket liners can be crushed into a smaller volume than the buckets, and only a small number of plastic decontamination buckets are required for the entire project. The larger, heavy-duty, 55-gallon drum liners can be used for heavily contaminated IDW to provide secondary containment, and reduce the costs of disposal and drum recycling. Drum liners may extend the containment life of the drums in severe climates and will reduce the costs of cleaning out the drums prior to recycling.

All waste materials generated in the support zone are considered non-IDW trash. To minimize the total volume of IDW, separate all trash from IDW, seal it in garbage bags, and properly dispose of it off site as municipal waste at the end of each work day.

Keep excess cement, sand, and bentonite grout prepared for monitoring well construction to a minimum. FMs shall observe well construction to ensure that a sufficient, but not excessive, volume of grout is prepared. Some excess grout may be produced. Unused grout (that should not come in contact with potentially contaminated soil or groundwater) shall be considered non-hazardous trash, and the drilling subcontractor shall dispose of it off site. Surplus materials from monitoring well installation, such as scrap plastic sections, used bentonite buckets, and cement/sand bags that do not

come in contact with potentially contaminated soil, shall be considered non-IDW trash, the drilling subcontractor shall dispose of it off site.

Following proper segregation procedures, as discussed in the next section, can minimize the quantity of contaminated IDW generated.

5.3 SEGREGATION OF IDW BY MATRIX AND LOCATION

It is necessary to properly segregate IDW in order to:

- Avoid commingling contaminated waste with clean waste, thereby creating a larger volume of waste that must be treated as contaminated
- Facilitate the sampling, screening, classification, and disposal of waste that may require different management methods

Take efforts to segregate IDW even when these activities will increase storage container and storage space requirements. These efforts will drastically reduce the sampling and documentation required for characterizing the waste and their associated costs.

In general, segregate IDW by matrix and source location and depth at the time it is generated. IDW from only one matrix shall be stored in a single drum (e.g., soil, sediment, water or PPE shall *not* be mixed in one drum). Groundwater and decontamination water should not be commingled; however, development and purge water from the same well may be stored together.

In general, IDW from separate sources should not be combined in a single drum or stockpile. Take efforts to segregate waste by increments of depth below ground surface. Most importantly, segregate soil IDW generated at or from below the saturated zone from soil generated above this zone (soil below this zone might be impacted by contaminated groundwater, whereas soil above the zone may be “clean”). Similarly, segregate soil above and below an underground storage tank (UST). Label each drum of soil to indicate the approximate depth range from which it was generated; this task may require cuttings to be segregated on plastic sheeting as they are generated or drums to be filled during the trenching or boring operation if this can be done in a safe manner.

It is possible that monitoring well development and purge water will contain suspended solids, which will settle to the bottom of the storage drum as sediment. Include significant observations on the turbidity or sediment load of the development or purge water in the logbook see Procedure III-D, *Logbooks* and Section 5.5). To avoid mixed matrices in a single drum (i.e., sediment and water), it may be necessary to decant the liquids into a separate drum after the sediments have settled out. This segregation may be accomplished during subsequent IDW sampling activities or during consolidation in a holding tank prior to disposal.

Place potentially contaminated well construction materials in a separate drum. No soil, sediment, sludge, or liquid IDW shall be placed in drums with potentially contaminated waste well construction materials. In addition, potentially contaminated well construction materials from separate monitoring wells shall not be commingled.

Store potentially contaminated PPE and disposable sampling equipment in drums separate from other IDW. Segregate PPE from generally clean field activities, such as water sampling, from visibly

soiled PPE, double-bag it, and dispose of it off site as municipal waste. Disposable sampling equipment from activities, such as soil, sediment, and sludge sampling, includes plastic sheeting used as liner material in containment areas around drilling rigs and waste storage areas, disposable sampling equipment, and soiled decontamination equipment. If, according to the Field Manager's best professional judgment, the visibly soiled PPE can be decontaminated and rendered non-hazardous, then double-bag the decontaminated PPE and disposed of it off site as municipal waste (EPA 1991, 1992b). PPE and disposable sampling equipment generated on separate days in the field may be combined in a single drum, provided clean and visibly soiled IDW are segregated as discussed above.

IDW generated from the use of field analytical test kits consists of those parts of the kit that have come into contact with potentially contaminated site media, and used or excess extracting solvents and other reagents. Contain potentially contaminated solid test kit IDW in plastic bags and store it with contaminated PPE or disposable sampling equipment IDW from the same source area as soil material used for the analyses. Segregate the small volumes of waste solvents, reagents, and water samples used in field test kits, and dispose of it accordingly (based upon the characteristics of the solvents as described in this procedure). Most other test kit materials should be considered non-IDW trash, and be disposed of as municipal waste.

Store decontamination fluids in drums separate from groundwater and other IDW. If practical, decontamination fluids generated from different sources should not be stored in the same drum. If decontamination fluids generated over several days or from different sources are stored in a single drum, record information about the dates and IDW sources represented in the drum. Note this information in the field notebook, on the drum label (Section 5.4.3), and in the drum inventory (Section 5.5).

The FM and designated personnel should separate the liquid and sediment portions of the equipment decontamination fluid present in the containment unit used by the drilling or excavation field crew. The contents of this unit normally consist of turbid decontamination fluid above a layer of predominantly coarse-grained sediment. When the contents of the containment unit are to be removed for storage in IDW drums, the FM shall instruct the field crew to place as much of the liquid into drums as possible and transfer the remaining solids into separate drums. Note observations of the turbidity and sediment load of the liquid IDW in the field notebook, on the drum label (Section 5.4.3), and in attachments to the drum inventory (Section 5.5). It is likely that decontamination fluids will contain minor amounts of suspended solids that will settle out of suspension to become sediment at the bottom of IDW storage drums. As noted above, it may be necessary to segregate the drummed water from sediment during subsequent IDW sampling or disposal activities.

Documentation for waste storage containers should include IDW source and segregation information and be maintained as follows:

1. Field logbook should be updated, at least weekly, with all IDW drum additions – update storage area location map to include new drum position and drum number.

2. External drum log (hard copy and electronic copy) should be updated with each IDW drum addition (drum numbers, source, and generation date) and closure of drum (fill date).

5.4 DRUM FILLING, HANDLING, AND LABELING, AND INVENTORYING

Drum handling consists of those actions necessary to prepare an IDW drum for labeling. Drum labeling consists of those actions required to legibly and permanently identify the contents of an IDW drum.

5.4.1 Drum Filling

Each drum of solid IDW shall be completely filled, when possible. For liquid IDW, drums should be left with headspace of approximately 5 percent by volume to allow for expansion of the liquid and potential volatile contaminants.

5.4.2 Drum Handling

IDW shall be containerized using U.S. Department of Transportation-(DOT) approved drums. The drums shall be made of steel or plastic, have a 55-gallon capacity, be completely painted or opaque, and have removable lids (i.e., United Nations Code 1A2 or 1H2). Drums having removable lids with bung holes are preferred to facilitate verification of drum contents. Typically 55-gallon drums are used, however small drums may be used depending on the amount of waste generated. New steel drums are preferred over recycled drums. Recycled drums should not be used for hazardous waste, PCBs or other regulated shipments. For short-term storage of liquid IDW prior to discharge, double-walled bulk steel or plastic storage tanks may be used. For this scenario, consider the scheduling and cost-effectiveness of this type of bulk storage, treatment, and discharge system versus longer-term drum storage.

The Guam Environmental Protection Agency may require double-walled drums or other secondary containment for the storage of liquid IDW. For long-term IDW storage at other project locations, the DOT-approved drums with removable lids are recommended. Verify the integrity of the foam or rubber sealing ring located on the underside of some drum lids prior to sealing drums containing IDW liquids. If the ring is only partially attached to the drum lid, or if a portion of the ring is missing, select another drum lid with a sealing ring that is in sound condition.

To prepare IDW drums for labeling, wipe clean the outer wall surfaces and drum lids of all material that might prevent legible and permanent labeling. If potentially contaminated material adheres to the outer surface of a drum, wipe that material from the drum, and segregate the paper towel or rag used to remove the material with visibly soiled PPE and disposable sampling equipment. Label all IDW drums and place them on appropriate pallets prior to storage.

5.4.3 Drum Labeling

Proper labeling of IDW drums is essential to the success and cost-effectiveness of subsequent waste screening and disposal activities (see Attachment I-A-6-1 and Attachment I-A-6-2). Labels shall be permanent and descriptive to facilitate correlation of field analytical data with the contents of individual IDW drums. Label all IDW drums using the **three distinct labeling methods** described below to ensure durability of the information. These three methods are completing and affixing preprinted NAVFAC Pacific ER Program labels; marking information on drum surfaces with paint; and, affixing aluminum tags to the drum. **Use of the preprinted labels, painted labeling, and aluminum tags is *mandatory***. These methods are described below.

5.4.3.1 PREPRINTED LABELS

Complete **two** preprinted NAVFAC Pacific ER Program drum labels as described below and presented in Attachment I-A-6-1. Seal both labels in separate heavy-duty, clear plastic bags, or use permanent markers on weatherproof stickers, to prevent moisture damage.

1. Place one label on the outside of the drum with the label data facing outward. Affix the bag/sticker to the drum at the midpoint of the drum height using a sufficient quantity of adhesive tape (e.g., duct tape, packing/strapping tape) so the bag will remain on the drum as long as possible during storage.

2. Affix the second label (sealed as mentioned above) to the underside of the drum lid, sealing it inside the drum when the lid is replaced.

The use of two or more preprinted labels for outer IDW drum identification purposes should be considered as a short-term backup to the information on the aluminum tags discussed below.

Print the requested information legibly on the drum labels in black, indelible ink. Instructions for entering the required drum-specific information for each label field are presented below:

CTO: Enter the four-digit number of the CTO for the project during which the IDW was generated. Include any initial zeroes in the CTO number (e.g., CTO 0047).

Activity-Site: Enter the name of the Navy activity responsible for the project site (e.g., Naval Supply Center, Naval Facilities Engineering Command Hawaii) and the name of the site where the project is taking place (e.g., Orote, Landfill, Building [Bldg.] 18).

Drum#: Enter the drum identification number according to the convention described below.

(xxxx-AA-DMzzz);

Where:

xxxx	represents the four-digit CTO number
AA	represents the unique site identifier assigned by the CTO Manager for multiple site CTOs (e.g., for CTO 0047, OW denotes Old Westpac, OR denotes Orote)
DM	represents a *drum* identification number
zzz	the sequential drum number for the site, beginning with 001

Date Collected: Enter the date the IDW was generated and placed in the drum. If IDW was generated over a number of days, enter the start and end dates for the period.

Contents: Record the source identification number on the label. Enter a "√" in the box corresponding to the type of IDW placed in the drum. For "Soil" and "Water," use the line provided to record observations on the condition of the drum contents (e.g., diesel odor, high turbidity, specific liquid IDW type). Check "Solid Waste" for PPE and indicate that PPE is present in the drum. Check

"Other" for disposable sampling equipment and potentially contaminated monitoring well construction materials, and indicate the type of waste on the line provided.

Project Type: Enter a "√" in the box corresponding to the type of investigation. Choices are Remedial Investigation, RCRA Facility Inspection, UST, and Other. If "Other" is specified, indicate the type of project in the "Comments" area, as described below.

Comments: Enter any additional information regarding the drum contents that will assist individuals who will characterize and dispose of the contents of the drum. "Other" project types include Site Inspection, Feasibility Study, Removal/Remedial Action, and Emergency Response activity. In addition, use this space on the label to complete any descriptions that were too large to fit in preceding label fields, such as the turbidity of decontamination water or the site activities from which the PPE was generated.

For Information Contact: Enter the project COR activity / code, address, and phone number.

It is essential that all relevant information recorded on individual drum labels be repeated in the field notebook for later development of the drum inventory database (see Section 5.5 and Procedure III-D, *Logbooks*).

5.4.3.2 PAINTED LABELS

The second method for labeling drums is to paint label information directly on the outer surface of the drum. At a minimum, the information placed on the drum shall include the CTO number, the drum number (following the numbering convention given above), the source identification number and type, the generation date(s), and the telephone number provided at the bottom of the preprinted label appropriate for the project location. The drum surface shall be dry and free of material that could prevent legible labeling. Confine label information to the upper two-thirds of the total drum height. The top surface of the drum lid may be used as an additional labeling area, but this area should only be used *in addition* to the upper two-thirds of the sides of the drum. The printing on the drum shall be large enough to be easily legible. Yellow, white, black, or red paint markers (oil-based enamel paint) that are non-photodegradable are recommended to provide maximum durability and contrast with the drum surface.

5.4.3.3 ALUMINUM TAGS

The third method for labeling drums is to affix an aluminum tag to the drum with neatly printed information that shall consist of the **CTO number**, the **drum identification number**, the **type of contents**, the **generation date(s)**, the **source** identification number and type, and the **telephone number** provided at the bottom of the appropriate preprinted label. Attachment I-A-6-2 to this procedure presents an example of the aluminum tag, which shall measure approximately 1 inch by 3 inches, or larger. When a ballpoint pen is used to fill out the aluminum tag, the information is permanently recorded as indentations on the tag. A fine ballpoint pen shall be used, and block-printed lettering is required for legibility. Indentations on the tag shall be sufficiently deep to be legible after the label has been exposed to weathering for an extended period.

Complete aluminum tags after the drum has been sealed. Affix the tags to the drum using a wire, which passes through predrilled holes in the label and shall be wrapped around the bolt used to seal the drum lid. The wire is the most likely part of the aluminum tag to decay during exposure. Use of

plastic insulated, copper-core electrical wire of appropriate diameter is recommended if long-term exposure to severe weathering is anticipated.

5.4.3.4 WASTE LABELS

Standard green and white non-hazardous and/or other hazardous waste stickers may be used in conjunction with, but not in lieu of, the above labeling procedures.

5.5 DRUM INVENTORY

Accurate preparation of an IDW drum inventory is essential to all subsequent activities associated with IDW drum tracking and disposal. Prepare an inventory for each project in which IDW is generated, stored, and disposed of. This information provided in the inventory report constitutes the results of preparing and implementing an IDW sampling, screening, characterization, and disposal program for each site.

The drum inventory information shall include 10 elements that identify drum contents and indicate their outcome. These elements are discussed in Sections 5.5.1 through 5.5.10.

5.5.1 Navy Activity (Generator)/Site Name

Inventory data shall include the Navy activity and the site name where the IDW was generated (e.g., Fleet Industrial Supply Center Pearl/Red Hill, Naval Magazine Headquarters/USTs).

5.5.2 CTO Number

Inventory data shall include the four-digit CTO number associated with each drum (e.g., 0089) and contract number as necessary.

5.5.3 Drum Number

Include the drum number assigned to each drum in the inventory database. Drum numbers shall adhere to the numbering convention presented in Section 5.4.3.1 (e.g., 0091-LF-DM006).

5.5.4 Storage Location Prior to Disposal

Include the storage location of each drum prior to disposal in the inventory database (e.g., Bldg. 394 Battery Disassembly Area, or Adjacent to West end of Bldg. 54). As part of the weekly inventory, a site visit to the IDW storage location shall be performed to observe the condition of the drums and covers. Drums and covers are considered acceptable when the integrity of the drums and covers are structurally intact, drum identification is legible, and the location of the drum storage is secure. An unacceptable classification will require recommendations to remedy the unacceptable classification.

5.5.5 Origin of Contents

Specify the source identification of the contents of each IDW drum in the inventory database (e.g., soil boring number, monitoring well number, sediment sampling location, or the multiple sources for PPE- or rinse water-generating activities).

5.5.6 IDW Type

Inventory data shall include the type of IDW in each drum (e.g., soil, PPE, disposable sampling equipment, sludge, sediment, development water, steam cleaning water, decontamination rinse water).

5.5.7 Waste Volume

Specify the amount of waste in each drum in the inventory database as a percentage of the total drum volume or an estimated percentage-filled level (e.g., 95 percent maximum for liquid IDW).

5.5.8 Generation Date

Inventory data shall include the date IDW was placed in each drum. If a drum contains IDW generated over more than one day, the start date for the period shall be specified in dd-mmm-yy format. This date is *not* to be confused with a RCRA hazardous waste accumulation date (40 CFR 262).

5.5.9 Expected Disposal Date

Specify the date each drum is expected to be disposed of as part of the inventory in mmm-yy format. This date is for the Navy's information only and shall not be considered contractually binding.

5.5.10 Actual Disposal Date

The actual drum disposal date occurs at the time of onsite disposal, or acceptance by the offsite treatment or disposal facility. Enter this date in the drum inventory data base only when such a date is available in dd-mmm-yy format.

Information required to complete all 10 of the inventory elements for the monthly inventory report described above and summarized in Attachment I-A-6-3, will be located on the IDW labels or provided by the CTO Manager.

Actual disposition of the IDW drum contents will be provided to the Navy.

5.6 IDW CLASSIFICATION

In general, the CTO Manager should follow IDW classification guidance contained in the *Generic IDW Disposal Plans* for Hawaii and Guam (Ogden 1994, 1995) and EPA guidance (EPA 1991, 1992a). The IDW classification process consists of chemical screening and characterization of the waste.

Various federal and state laws and guidance contain requirements for IDW management (handling, storage, transport, disposal, and recordkeeping) based on the type(s) and concentrations of chemicals present in the waste. To ensure that IDW is managed in compliance with these requirements and to evaluate disposal options, the CTO Manager should

- Directly sample and analyze the IDW or associate it with historical data, observed site conditions, and/or samples collected on site at the source of the waste
- Screen the waste to identify the maximum concentrations of individual chemicals in, or associated with, the waste

- Screen waste constituents against chemical background data, if available
- Characterize the waste based on regulated groups of chemical constituents present in the waste
- Screen waste constituents against risk-based health criteria, ARARs, and TBC criteria for onsite disposal, or disposal facility criteria for offsite disposal

Each of the above steps is distinct and should be performed separately to avoid potential mistakes in the IDW classification process. The following subsections discuss these steps in greater detail.

5.6.1 IDW Sampling and Chemical Screening

IDW should be screened to identify chemicals present in the waste and their maximum concentrations. Screening may be facilitated by (1) directly sampling the waste, (2) associating the waste with analytical results from samples collected at the source of the IDW (e.g., a well boring), (3) visual observation of the waste, (4) historical activity data from the site, or (5) a combination of these methods (e.g., association with limited sampling). Composite sampling may be required if the unit volume of IDW is non-homogeneous. Data from samples collected directly from the IDW should take precedence over associated site sample data when making waste management decisions. Procedure I-D-1, *Drum Sampling* discusses methods for drum sampling.

Typically, IDW is screened for chemicals of potential concern at the site and against background data if available. If IDW is generated from outside the suspected AOC (e.g., soil cuttings from the installation of a background monitoring well), assume it is clean, and dispose of it accordingly.

The CTO Manager should consider the disposal criteria of any offsite disposal facility anticipated to be used when developing the SAP. Some offsite facilities do not accept waste that is characterized by association with samples collected from the investigation site or they may require analytical data for chemicals that are not of potential concern at the site. Direct sampling and analysis of the waste may be required for these other constituents. Some disposal facilities prefer to collect and analyze the samples themselves. In addition, disposal facility criteria may dictate laboratory reporting limits. When possible, the CTO Manager should coordinate sampling and data requirements with the disposal subcontractor and anticipated disposal facility. Such efforts may allow IDW sampling to be conducted while the field team is mobilized for the site investigation, rather than conducting a separate IDW sampling event later.

5.6.2 IDW Characterization

Various federal and state laws and guidance contain requirements for IDW management (handling, storage, transport, disposal, and recordkeeping) based on the particular constituent or *group(s) of chemical constituents* present in the waste. Therefore, to ensure that IDW is managed in compliance with these requirements, characterize IDW based on the chemical screening results to determine whether any of the following regulated constituents are present in the waste:

- Petroleum hydrocarbons (regulated by RCRA Subtitle I when released from a UST; see 40 CFR Part 280)
- Hazardous wastes (regulated by RCRA Subtitle C; see 40 CFR 261-299)
- Non-hazardous, solid wastes (regulated by RCRA Subtitle D; see 40 CFR 257-258)

- Hazardous substances and commingled petroleum (regulated by CERCLA; see 40 CFR 300.400 and 302.4)
- PCBs (regulated by TSCA; see 40 CFR 700)
- Asbestos (regulated by CAA for disposal; see 40 CFR 61, Subpart M)
- Radioactive wastes (regulated by the Nuclear Regulatory Commission; see 10 CFR [various parts], 40 CFR, Subchapter F, and other applicable laws)

EPA regulations and guidance do not require IDW to be tested to properly characterize it. Instead waste may be characterized based on historical site data, site observations, analytical data from the source of the IDW, and professional judgment (EPA 1991). Specifically, the EPA has indicated that IDW may be assumed not to be "listed" wastes under RCRA unless available information about the site suggests otherwise (53 FR 51444). Similarly, RCRA procedures for determining whether waste exhibits RCRA hazardous characteristics do not require testing if the decision can be made by "applying knowledge of the hazard characteristic in light of the materials or process used" (40 CFR 262.11(c); EPA 1991). If applicable, the disposal plans and reports should state, "there is no evidence based on site data and observations that the IDW contains listed RCRA wastes or exhibits RCRA characteristics."

For soil IDW, the potential for exhibiting toxicity may be determined by comparing constituent concentrations in the waste against screening values that are 20 times the TCLP criteria as specified in Section 1.2 of EPA Method Solid Waste-846 1311 *Toxicity Characteristic Leaching Procedure* (EPA 2007). Otherwise, samples associated with the soil can be tested using the TCLP.

5.7 IDW STORAGE

In general, the CTO Manager should follow IDW storage guidance contained in the *Generic IDW Disposal Plans* for Hawaii and Guam (Ogden 1994, 1995) and EPA guidance (EPA 1990, 1991, 1992a).

Always store IDW in a manner that is secure, protected from weather, and protective of human health and the environment. It is preferable to store IDW within the AOC(s) or on site; however, the Navy may assign a specific IDW storage area away from the project site.

If the IDW is determined to be RCRA hazardous, then RCRA storage, transport, and disposal requirements may apply, including a limited **90-day** storage permit exemption period prior to required disposal. If onsite disposal is an option, store RCRA waste within the AOC so that RCRA LDRs will not apply in the future. LDRs may be triggered if the waste is stored within the onsite area, but outside of the AOC or if the waste is removed from and later returned to the AOC for disposal. The AOC concept does not affect the approach for managing IDW that did not come from the AOC, such as PPE, decontamination equipment and fluids, and groundwater. If RCRA hazardous, these wastes must be managed under RCRA and drummed and disposed of off site (EPA 1991).

RCRA waste should not be stored within the AOC prior to disposal when professional judgment suggests the IDW might pose an immediate or permanent public endangerment (EPA 1991b).

Offsite storage of CERCLA waste must comply with the CERCLA offsite rule (40 CFR 300.440).

If the IDW is determined to be TSCA-regulated, then TSCA storage requirements as described in CFR 764.65, transport, and disposal requirements apply, including a limited **30-day** storage period prior to required disposal. Storage requirements are as follows:

1. Storage facilities must provide an adequate roof and walls to prevent rain water from reaching the stored PCBs.

2. Storage facilities must provide an adequate floor that has continuous curbing with a minimum 6-inch-high curb.

3. Storage facilities must contain no drain valves, floor drains, expansion joints, sewer lines, or other openings that would permit liquids to flow from the curbed area.

4. Storage facilities must provide floors and curbing constructed of continuous smooth and impervious materials to minimize penetration of PCBs.

5. Storage facilities must not be located at a site that is below the 100-year flood water elevation.

6. PCBs in concentrations of 50 ppm or greater must be disposed of within 1 year after being placed in storage.

PCB waste can also be stored in a RCRA-approved waste storage area for 30 days from date of generation.

NAVFAC Pacific requires that all CERCLA, RCRA, and other types of waste be removed from JBPHH areas within 90 days of its generation, particularly within the shipyard area, and 30 days of generation for TSCA waste. Efforts should also be made to dispose of IDW within the 30- and 90-day periods at other Navy installations, unless the IDW will be managed with remediation waste to be generated during a cleanup action in the near future. The Navy may approve extensions of the storage time limit for wastes that are non-hazardous on a project-specific basis.

5.7.1 Drum Storage

Implement drum storage procedures to minimize potential human contact with the stored IDW and prevent extreme weathering of the stored drums. Place all IDW drums upright on pallets before the drums are stored. RCRA storage requirements include the following: containers shall be in good condition and closed during storage; wastes shall be compatible with containers; storage areas shall have a containment system; and spills or leaks shall be removed as necessary.

Place all IDW drums generated during field activities at a single AOC or designated IDW storage area together in a secure, fenced onsite area to prevent access to the drums by unauthorized personnel. When a secure area is not available, place drums in an area of the site with the least volume of human traffic. At a minimum, place plastic sheeting (or individual drum covers) around the stored drums. Post signage at the IDW storage area stating that drums should not be removed from the area without first contacting the Navy COR.

Liquid IDW drums must be stored under secondary containment (either secondary containment pallets or handmade plastic sheeting/polyvinyl chloride frame containment) and all IDW drums (soil

and water) must utilize secondary containment when stored within 15 feet of a surface water body or storm drain inlet.

Drums from projects involving multiple AOCs shall remain at the respective source areas where the IDW was generated. IDW should not be transferred off site for storage elsewhere, except under rare circumstances, such as the lack of a secure onsite storage area.

Implement proper drum storage practices to minimize damage to the drums from weathering and possible human exposure to the environment. When possible, store drums in dry, shaded areas and cover them with impervious plastic sheeting or tarpaulin material. Make every effort to protect the preprinted drum labels from direct exposure to sunlight, which causes ink on the labels to fade. In addition, store drums in areas that are not prone to flooding. Secure the impervious drum covers appropriately to prevent dislodging by the wind. It may be possible to obtain impervious plastic covers designed to fit over individual drums; nonetheless, repeat the labeling information on the outside of these opaque covers.

Drums in storage shall be placed with sufficient space between rows of drum pallets and shall not be stacked, such that authorized personnel may access all drums for inspection. Proper placement will also render subsequent IDW screening, sampling, and disposal more efficient when individual drum removal is necessary. It is recommended that IDW drums be segregated in separate rows/areas by matrix (i.e., soil, liquid or PPE/other).

If repeated visits are made to the project site, inspect the IDW drums to clear encroaching vegetation, check the condition and integrity of each drum, secondary containment if applicable, check and replace aluminum tags as necessary, and replace or restore the tarpaulin covers.

5.7.2 IDW Stockpiles

Consider IDW stockpiling only when a very large quantity of IDW will be generated. Segregate stockpiled IDW, and inventory it by source location and depth to the extent practicable. Stockpiling and media mixing should not be used as methods to dilute chemical concentrations in the waste. Line stockpiles on the bottom, cover it with sturdy plastic, and locate it in areas where weather elements (e.g., wind, rainfall runoff) will not cause migration of the waste. Never dispose of liquid IDW on a stockpile; drum or store liquid waste in other appropriate containers. Follow applicable regulation and guidance when sampling stockpiled waste for characterization purposes.

5.8 IDW DISPOSAL

Various methods and requirements for onsite and offsite disposal of IDW are discussed in the *Generic IDW Disposal Plans* for Hawaii and Guam (Ogden 1994, 1995) and EPA guidance (EPA 1990, 1991, 1992b). This section explains the disposal evaluation process and highlights some of the more important requirements for onsite and offsite IDW disposal options.

IDW sampling, characterization, and disposal analysis, particularly for onsite disposal, can be unexpectedly complex and require compliance with many different laws (that act as ARARs for IDW management and disposal). Before preparing the IDW disposal plan, compare estimated costs for onsite vs. offsite disposal. Offsite disposal may be more cost effective than devising and documenting the justification for onsite disposal when the quantity of IDW is small (less than 10 drums) and/or the waste fails the initial conservative screening against conservative risk-based

criteria. Also weigh cost savings against the policy preference of the EPA and State of Hawaii Department of Health to manage and dispose of IDW on site, when possible.

5.8.1 Onsite Disposal

In general, the EPA preference is to dispose of IDW on site when the disposal action:

- Does not pose an unacceptable long-term risk to human health and the environment
- Is in accordance with chemical-, location- and action-specific ARARs "to the extent practicable" (40 CFR 300.415(i); 55 FR 8756)
- Does not introduce contaminants into clean soil or other site media
- Does not mobilize or significantly increase concentrations of any hazardous constituents already present in the environment
- Is consistent with the final remedy planned for the site
- Takes into account any community concerns regarding waste storage and the disposal method

Base onsite disposal options on best professional judgment and available site-specific data. For some projects, it may be prudent to store the waste temporarily until additional site data become available (e.g., sample analytical data, preliminary risk-assessment results, AOC delineation, and establishment of background values). Factors to consider include, but are not limited to the following:

- The detected or suspected contaminants, their concentrations, and total volume of IDW
- Media potentially affected (e.g., groundwater drinking source)
- Background metals data for site media
- Site access, conditions, and potential receptors
- Current and future land use
- Public perceptions (especially if drum storage and/or disposal takes place in open view)
- Time limits for IDW storage
- Potential requirements to treat waste before disposing of it on site
- Lack of unpaved areas to disposed of waste on site
- Potential wind, erosion, runoff, or flood conditions that might cause offsite migration of disposed waste
- Proximity to the ocean, surface water, or environmentally sensitive habitats
- Natural attenuation processes
- Need for additional utility survey before excavating to backfill waste
- Need for land use controls required to limit exposure pathways (e.g., backfill waste, provide permanent security around site, replant site to prevent erosion)

Protection of human health can be evaluated by comparing chemical concentrations in the waste to the more conservative of EPA residential regional screening levels), environmental action levels, and chemical-specific ARARs and TBC criteria. Ecological receptors can be protected by screening the IDW against EPA ecological soil screening levels. Onsite disposal of surface and groundwater IDW can be evaluated by initially screening against EPA tap-water PRGs, State Safe Drinking Water Standards (maximum contaminant levels and non-zero maximum contaminant level goals), and/or State Surface Water Quality Standards. These criteria are not always ARARs for the disposal method or site conditions; however, they may be useful to affirmatively show that the disposal is protective. Alternatively, the IDW may be associated with human-health and eco-risk assessment results for the site if the onsite placement of IDW is consistent with exposure pathway assumptions made during the risk assessment (e.g., contaminated soil might not present an unacceptable health risk at depth, but could pose such a risk if disposed of at the ground surface).

In general, return IDW consisting of environmental media to or near its source, and return waste generated from depth to its original depth, if possible and approved by NAVFAC in advance. Bury all contaminated soil and water IDW to be disposed of on site below grade at a depth of at least 3 feet and cover it with clean soil to reduce the potential for future exposure to human and ecological receptors.

Dispose of non-indigenous IDW and contaminated decontamination fluids off site. The cleaning detergent Alconox, often used in the decontamination process, is itself non-hazardous and biodegradable. Small quantities of clean decontamination water containing Alconox may be disposed of to clean areas on site. If onsite disposal is appropriate for RCRA IDW, this waste should be disposed of within the AOC to avoid the need to comply with LDRs.

IDW from several non-contiguous onsite areas may be consolidated and disposed of at one of the areas, provided a nexus exists between the wastes generated and response projects (55 FR 8690-8691).

IDW may also be temporarily disposed of back to the AOC without detailed analysis or documentation if the waste will be addressed with other site contamination during a future response action and will not present a significant short-term threat to human health and the environment.

5.8.2 Offsite Disposal

If onsite disposal is not a viable option, dispose of the IDW at an appropriate offsite treatment and/or disposal facility. Offsite transport and disposal of IDW must comply with all applicable laws and criteria specific to the chosen disposal facility. These requirements may include, but are not limited to the following:

- RCRA LDRs
- RCRA waste storage permits and time limits
- National Pollutant Discharge Elimination System and sewer disposal criteria
- CERCLA offsite rule
- TSCA treatment requirements
- DOT hazardous material transport packaging, manifesting, and security provisions

- International Maritime Organization ocean transport rules
- Certifications and training for waste transport contractors
- State notification requirements when importing certain types of waste

The CERCLA offsite rule (40 CFR 300.440) requires that CERCLA waste be disposed of only at facilities specifically approved by the EPA to receive such waste for treatment, storage, or disposal. The acceptability status of a disposal facility can change quickly (e.g., if there is a release at the facility); therefore, the CTO Manager should contact the EPA Region 9 CERCLA Offsite Rule Coordinator no more than 60 days prior to disposal of the IDW to verify the facility's approval status. The offsite rule applies to any CERCLA-driven remedial or removal action involving the offsite transfer of waste containing hazardous substances regardless of the concentrations present.

RCRA hazardous waste manifests must always be signed by authorized Navy personnel. In some cases, the Navy may authorize contractors to sign non-hazardous manifests. Navy authorization to allow contractor signature of non-hazardous manifests shall be based upon a Navy review of the contractor's RCRA and DOT training records. In addition, the Navy shall always be allowed the opportunity to review/approve non-hazardous manifests and waste profiles prior to waste disposal efforts.

Disposal of liquid IDW into the Navy sanitary sewer shall occur only if first approved by the Navy. Requests for disposal to Navy facilities should be coordinated through the COR. Discharge to the public sewer system is discouraged and should occur only if approved by state and local government agencies.

5.9 RECORDS

The CTO Manager is responsible for completing and updating the site-specific IDW drum inventory spreadsheet and submitting it as needed, and reviewing the IDW disposal plan (IDW disposal paperwork).

FMs and designates are responsible for documenting all IDW-related field activities in the field notebook including most elements of the IDW drum inventory spreadsheet. The correct methods for developing and maintaining a field notebook are presented in Procedure III-D, *Logbooks*.

Guidance related to preparing an IDW disposal plan (if required) is presented in the *Generic IDW Disposal Plans* for Hawaii and Guam (Ogden 1994, 1995).

5.9.1 IDW Disposal Documentation

Upon receipt of analytical data from the investigation or from IDW-specific analytical data, the generator information request form will be completed and provided to the IDW subcontractor to begin IDW characterization. Completed IDW disposal paperwork received from the IDW subcontractor should be reviewed for accuracy prior to submitting for Navy review.

The CTO Manager is responsible for submitting backup documentation (actual site or drum sampling results) along with the IDW disposal paperwork to the Navy.

Navy-approved contractor personnel may sign non-hazardous waste IDW documentation. Hazardous waste IDW documentation must be signed by an authorized Navy Environmental Coordinator.

All manifests (non-hazardous and hazardous) must be tracked, and if completed manifests (signed by disposal facility) are not received within 30 days of initial transportation, then contractor must notify the RPM weekly of the shipping status (e-mail is acceptable). Hazardous waste must be disposed of within 45 days of initial transportation. If not, specific IDW transportation details must be supplied to the Navy in order to prepare and file an exception report.

TSCA-regulated waste must be physically destroyed and or buried within 1 year of generation (date placed in IDW drum). Disposal certificates should be provided by the waste facility to the IDW subcontractor and Navy contractor.

Following disposal of IDW, the CTO Manager should prepare a short IDW disposal report summarizing the disposal operation and appending any associated records (e.g., final drum log, waste profiles, transport manifests, bills of lading, disposal facility certifications). Minimal topics to include in the report:

- IDW inventory and storage
- IDW chemical screening and characterization
- IDW transport and disposal
- Manifests
- Drum storage photographs
- Site figure

6. Health and Safety

Field Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

7. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

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Procedure I-C-2, *Monitoring Well Development*.

Procedure I-C-3, *Monitoring Well Sampling*.

Procedure I-D-1, *Drum Sampling.*

Procedure I-F, *Equipment Decontamination.*

Procedure III-D, *Logbooks.*

8. Attachments

Attachment I-A-6-1: IDW Drum Label

Attachment I-A-6-2: Drum Label – Aluminum Tag

Attachment I-A-6-3: Monthly IDW Drum Inventory Updates

Attachment I-A-6-1
IDW Drum Label

IDW Drum Label

Contract #:

CTO #:

ACTIVITY SITE: _____

_____

DRUM # (_ _ _ _ - _ _ - D M _ _ _)

DATE COLLECTED

CONTENTS: (please ✓ and explain)

☐ Soil _____

☐ Water _____

☐ Solid Waste _____

☐ Other _____

PROJECT TYPE

☐ RI ☐ RFI ☐ UST ☐ Other

COMMENTS: _____

_____

_____

_____

_____

FOR INFORMATION CONTACT:

COR Activity/ Code:

Address:

Telephone:

Attachment I-A-6-2
Drum Label - Aluminum Tag

Drum Label - Aluminum Tag

Attachment I-A-6-3
Monthly IDW Drum Inventory Updates

Table I-A-6-1: Monthly IDW Drum Inventory Updates

Navy Activity / Site Name (Generator Site)	CTO Number (0bbb)	Drum Number (xxxx-AA-DMzzz)	Drum Storage Location	Origin of Contents (Source ID #)	IDW Type	Waste Volume (Fill level %)	Waste Generation Date (dd-Mon-yy)	Expected Disposal Date (Mon-yy)	Actual Disposal Date (dd-Mon-yy)
Inspector:									
Date of Inspection:									
NSC Pearl Harbor/ Landfill	0068	0068-LF-DM001	NSC, Bldg 7	SB-1	Soil Cuttings	100	16-Dec-92	Dec-93	N/A
		0068-LF-DM002	N/A	MW-1 MW-2 MW-3	Purge Water	75	20-Dec-92	Jul 93	26-Jul-93
		0068-LF-DM003	N/A	MW-1 MW-2 MW-3	Decon. Water	95	20-Dec-92	Jul-93	26-Jul-93
		0068-LF-DM004	NSC, Bldg.16	SB-1 SB-2 SB-3 SB-4 MW-1 MW-2 MW-3	PPE	50	16-Dec-92	Oct-93	N/A
NAVSTA Guam/ Drum Storage	0047	0047-DS-DM001	Hazmat Storage Area	SB-1 SB-2	Soil Cuttings	100	18-Feb-93	Sep-93	N/A

N/A Not Applicable

Analytical Data Validation Planning and Coordination

1. Purpose

This standard operating procedure describes data validation planning and coordination for all United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific sampling projects involving data validation.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the 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 Critical Samples

Critical samples are samples that are especially important for assessing exposure and/or risk at a particular site, or are key in identifying remedial options.

3.2 Data Quality Assessment Report

The data quality assessment report summarizes the QA/quality control (QC) evaluation of the data according to precision, accuracy, representativeness, completeness, and comparability relative to the Project Quality Objectives (PQOs). The report provides a quantitative and qualitative assessment of the data and identifies potential sources of error, uncertainty, and bias that may affect the overall usability.

3.3 Data Validation

Data validation is a process that determines the technical usability of analytical data by comparison with a set of performance criteria. The performance criteria are designed in a manner that will enable the data user to know if the set of data will meet the intended purpose.

3.4 Data Validation Strategy

The data validation strategy includes the percentage of data to be validated (e.g., 100 percent or a smaller percentage), all samples from an entire sample delivery group (SDG) versus selected samples from various SDGs, and whether samples for Level D validation will be identified in advance or only after critical or risk-driving results for the risk assessment have been identified.

3.5 DATA VALIDATION LEVELS

The level of data validation possible for a given set of samples is based on the level of data package provided by the laboratory. The three levels of data validation considered are Level B (requires a Level 2 data package), Level C (requires a Level 3 data package), and Level D (requires a Level 4 data package). These levels have been identified in previous standard operating procedures as Cursory (Level B), Standard (Level C), and Full (Level D). Description for the extent of each level of data validation is presented below and further in Procedure II-A, *Data Validation*.

3.6 RAW DATA

Raw data is information that has not been processed, formatted, or reduced for end use. Examples of raw data include gas chromatographs, instrument printouts, copies of log books, chemist worksheets, etc.

3.7 SAMPLE DELIVERY GROUP (SDG)

A SDG, or analytical batch, typically includes up to 20 field samples plus associated batch QC samples.

4. Responsibilities

The prime contractor CTO Manager shall ensure coordination between data validators and appropriate project personnel. The CTO Manager is responsible for critical sample selection. The project chemist, laboratory coordinator, or other designated person, shall coordinate with the data validation task leader.

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

5. Procedures

An independent party who is not responsible for the generation of the data shall perform data validation. Section 5.1 discusses guidelines for selecting a data validation strategy, while Section 5.2 presents planning and coordination guidelines.

5.1 DATA VALIDATION STRATEGY SELECTION

Consult the Contracting Officer's Representative, any appropriate regulatory agencies, and any Federal Facilities Agreements when choosing a data validation strategy. Clearly define the proposed level of effort for data validation in the project work plan. Based on the data validation requirements identified in the project planning documents, the analytical data may undergo "Level B," "Level C," or "Level D" data validation or some combination of these validation levels.

Guidelines for the required level of effort for data validation is described below and further in Procedure II-A, *Data Validation*.

5.1.1 Amount of Raw Data Acquired

It is recommended to request and obtain from the laboratory all raw data generated for the project sample analyses. While not all of the raw data will likely be reviewed, it is more time-efficient and cost-effective to obtain the data at the time of analysis than to request the laboratory to provide them

at a later date. In addition, project chemists and risk assessors may use portions of the raw data to more fully evaluate analytical data. Attachment I-A-7-1 presents the laboratory analytical data reporting requirements that shall be followed for the NAVFAC Pacific Area of Responsibility.

For projects with quick turnaround time (TAT) requirements, one option is to receive results only for the quick TAT, while receiving the remaining data at the normal TAT. This will allow the laboratory more time to compile the entire data package. Consult project-specific PQOs to determine if this approach is feasible.

5.1.2 Level B Validation

Level B validation is the least intensive of the three levels of data validation and is appropriate for non-critical data. Level B validation consists of evaluating factors such as holding times, spike analyses, blank analyses, and field QC samples. Examples of analytical results evaluated under data review include data generated during compliance monitoring, field analytical testing, or investigation derived waste sampling.

5.1.3 Level C Validation

Level C validation is the intermediary of the three levels of data validation and is appropriate for critical samples used in decision making. Level C validation consists of evaluating factors such as holding times, instrument calibration, spike and blank analyses, and field QC samples. Level C validation may be performed on a percentage or all of the project data. The exact percentage of data to undergo Level C validation will depend on the project objectives. Examples of analytical results evaluated under Level C validation include data generated for risk assessments, removal action verification, remedial designs, etc.

5.1.4 Level D Validation

Level D validation is the most rigorous of the three levels of data validation and is appropriate for critical samples used in decision making. Level D validation consists of evaluating factors such as holding times, instrument calibration, spike and blank analyses, field QC samples, and raw data. Level D validation may be performed on a percentage or all of the project data. The exact percentage of data to undergo Level D validation will depend on the project objectives. Examples of analytical results evaluated under Level D validation include data generated for risk assessments, removal action verification, remedial designs, etc.

Depending on the objectives of the project, a representative portion of data shall be chosen for Level D validation by selecting random samples and analyses, or more practically, be selected by identifying certain representative SDGs. This may include selecting all samples and analyses from one of the first SDGs of field samples for Level D data validation, and also for SDGs with different matrices, subsequent phases of work/mobilizations, and for each laboratory if more than one is used.

Larger projects typically require lower frequencies of Level D validation than smaller projects. For example, a project with one SDG may require 100 percent Level D validation. For a CTO with five SDGs, the first SDG may require Level D validation with the remaining four SDGs validated at Level C.

If significant issues, as defined in the data validation procedures presented in Section II of this procedures manual, are noted during Level D validation, additional Level D validation above the

originally planned percentage may be warranted and should be proposed. Additionally, the first several SDGs validated should be evaluated and corrective actions taken immediately if issues are identified.

5.2 PLANNING AND COORDINATION

During the planning and cost estimating stage of a project, contact the data validation task leader. Discuss the level of quality control, data validation strategy, number of samples per method, number of SDGs, schedule, and due dates. Copy all planning documents to the data validation task leader when they are completed (draft and final).

Hardcopy data validation reports are typically required and electronic entry of data qualifiers and qualification codes may be required if an analytical database is used for data interpretation.

Continuing coordination is critical. Notify the data validation task leader of any changes to the sampling schedule, analytical plan, or number of samples. Inform the data validators as well as the laboratory of every change from the chain of custody/analytical request form in sample numbers and/or requested analyses. Communicate changes to analytical methods agreed upon with the laboratory to the data validation task leader.

A schedule, which is updated as needed, is necessary to track the status of data validation activities. The prime contractor QA Manager or Technical Director shall coordinate and set priorities between CTOs. Attachment I-A-7-2 is an example of a form that may be used by CTO personnel to track the data validation status of hardcopy data.

A cross-reference list of field QC samples associated with site samples is required to validate data. This list must be provided by field personnel or from the chain-of-custody logbook (Procedure III–E, *Record Keeping, Sample Labeling, and Chain-of-Custody*).

6. Records

Data validation reports generated by data validators shall include content discussed in Procedure II-A, *Data Validation* and be included as an appendix in the report and summarized in the report. Changes in the schedule, number of samples, or analytical plan shall be sent to the data validators verbally and in writing.

The data validation effort shall be summarized for inclusion as a section of the report. It may also be helpful to summarize the data validation results in the form of a data quality assessment report (DQAR). The DQAR should summarize the net results of data validation for each QC parameter evaluated. It is recommended that precision, accuracy, and percent completeness objectives also be presented in the report. This task could be conducted by the data validators, or by project staff more familiar with the PQOs. The content and format of the DQAR is discussed in Procedure II-S, *Data Quality Assessment Report*.

As part of the summary, the project personnel shall ensure that all data requested for analysis and validation were actually analyzed and validated. Identification of rejected data (and the reasons) may be the most critical results. Data that have been qualified from detections to nondetections, or data for which numerical values have changed significantly, are also important. The summary may focus

on the analytes and samples that are considered most critical for each project and include a summary of field QC results by field QC type.

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 II-A, *Data Validation*.

Procedure II-S, *Data Quality Assessment Report*.

Procedure III–E, *Record Keeping, Sample Labeling, and Chain-of-Custody*.

9. Attachments

Attachment I-A-7-1: DoD QSM Appendix DoD A Reporting Requirements

Attachment I-A-7-2: Example Hardcopy Data Validation Status Tracking Form

Attachment I-A-7-1
DoD Quality Systems Manual Appendix DoD A Reporting Requirements

APPENDIX DOD-A – REPORTING REQUIREMENTS

In the absence of client specified reporting criteria, the reporting requirements outlined below shall be used for hard-copy data reports or electronic versions of hard-copy data (such as pdf). They include mandatory requirements for all printed data reports, and requirements for data reports requiring third party data review or validation. Optional reporting requirements are those that may be required by a specific project, depending upon their needs. The following elements are required: cover sheet, table of contents, case narrative, analytical results, sample management records, and Quality Assessment/Quality Control (QA/QC) information. Information for third-party review may be required depending on project-specific requirements or the method being used.

1.0 Cover Sheet

The cover sheet shall specify the following information:

- Title of report (i.e., test report, test certificate);
- Name and location of laboratory (to include a point of contact, phone and facsimile numbers, and e-mail address);
- Name and location of any subcontractor laboratories, and appropriate test method performed (information can also be located in the case narrative as an alternative);
- Unique identification of the report (such as serial number);
- Client name and address;
- Project name and site location;
- Statement of data authenticity and official signature and title of person authorizing report release;
- Amendments to previously released reports that clearly identify the serial number for the previous report and state the reason(s) for reissuance of the report; and
- Total number of pages.

2.0 Table of Contents

Laboratory data packages shall be organized in a format that allows for easy identification and retrieval of information. An index or table of contents shall be included for this purpose.

3.0 Case Narrative

A case narrative shall be included in each report. The purpose of the case narrative is to:

- Describe any abnormalities and deviations that may affect the analytical results;
- Summarize any issues in the data package that need to be highlighted for the data user to help them assess the usability of the data; and
- Provide a summary of samples included in the report with the methods employed in order to assist the user in interpretation.

The case narrative shall provide (Information need not be repeated if noted elsewhere in the data package):

- A table(s) summarizing samples received, providing a correlation between field sample numbers and laboratory sample numbers, and identifying which analytical, preparation, and clean-up methods were performed. If multiple laboratories performed analyses, the name and location of each laboratory **shall** be associated with each sample;
- A list of samples that were received but not analyzed;
- Date of samples received;
- Sample preservation or condition at receipt;
- A description of extractions or analyses that are performed out of holding times;
- A definition of all data qualifiers or flags used;
- Identification of deviations of any calibration standards or QC sample results from appropriate acceptance limits and a discussion of the associated corrective actions taken by the laboratory;
- Identification of multiple sample runs with reason(s) identified (e.g., dilutions or multiple cleanups);
- Identification of samples and analytes for which manual integration was necessary; and
- Appropriate notation of any other factors that could affect the sample results (e.g., air bubbles in volatile organic compounds (VOC) sample vials, excess headspace in soil VOC containers, the presence of multiple phases, sample temperature or pH excursions, and container type or volume).

4.0 Analytical Results

The results for each sample shall contain the following information at a minimum: (Information need not be repeated if noted elsewhere in the data package):

- Project name and site location;
- Field sample ID number as written on custody form;
- Laboratory sample ID number;
- Preparation batch number(s);
- Matrix (soil, water, oil, air, etc.);
- Date and time sample collected;
- Date and time sample prepared;
- Date and time sample analyzed;
- Method numbers for all preparation, cleanup, and analysis procedures employed;
- Analyte or parameter with the Chemical Abstracts Service (CAS) Registry Number if available;

- Sample aliquot analyzed;
- Final extract volume;
- Identification of analytes in which manual integration occurred, including the cause and justification;
- Analytical results with correct number of significant figures;
- Detection Limit, Limit of Detection, and Limit of Quantitation associated with sample results and adjusted for sample-specific factors (e.g., aliquot size, dilution/concentration factors, and moisture content);
- Any data qualifiers assigned;
- Concentration units;
- Dilution factors;
- All multiple sample run results shall be reported;
- Percent moisture or percent solids (all soils are to be reported on a dry weight basis); and
- Statements of the estimated uncertainty of test results (optional).

5.0 Sample Management Records

Sample Management records shall include the documentation accompanying the samples, such as:

- Chain-of-custody records;
- Shipping documents;
- Records generated by the laboratory which detail the condition of the samples upon receipt at the laboratory (e.g., sample cooler receipt forms, cooler temperature, and sample pH);
- Telephone conversation or e-mail records associated with actions taken or quality issues; and
- Records of sample compositing done by the laboratory.

6.0 QA/QC Information

The minimum laboratory internal QC data package shall include:

- Method blank results;
- Percent recoveries for Laboratory Control Sample (LCS), Laboratory Control Sample Duplicates (LCSD), Matrix spike (MS), and Matrix Spike Duplicates (MSD);
- MSD or matrix duplicate Relative percent differences (RPD);
- Surrogate percent recoveries;
- Tracer recoveries;
- Spike concentrations for LCS, MS, surrogates;
- QC acceptance criteria for LCS, MS, surrogates;
- Post-Digestion Spike (PDS) recoveries;

- In-house or project specified LCS control limits, as applicable;
- Serial dilutions (SD) percent difference; and
- Batch numbers (preparation, analysis, and cleanup).

7.0 Data Reports for Third Party Review or Validation

When third party review or data validation is to be performed, the extent (stage) of data validation that can be performed is dependent upon the type (level) of data report delivered by the laboratory. The data report level and data validation stage required to meet project data quality objectives should be specifically defined in the QAPP.

The minimum reporting requirements for each level of data report are outlined below.

- A cover sheet, table of contents, and case narrative including all of the information specified in the above sections are required for all levels of data reports.
- **Level 1**: Analytical results, Sample Management Records.
- **Level 2**: **Level 1** reporting requirements plus QA/QC Information, Instrument QA/QC Information, Instrument and Preparation logs.
- **Level 3**: **Level 2** reporting requirements plus Instrument Quantitation Reports.
- **Level 4**: **Level 3** reporting requirements plus Instrument Chromatograms and Spectra.
- In addition, Standards traceability should be included in Levels 3 and 4 if a legal chain of custody is required.

The data validation guidelines established in other Department of Defense guidance or project-specific guidelines may have distinct reporting formats. The appropriate QAPP should be consulted to determine what type of data package is required.

Attachment I-A-7-2
Example Data Validation Status Tracking Form

Table I-A-7-2-1: CTO xxxx Data Validation Report Status Tracking Form

SDG	Due Date	VOCs Rec'd	PCBs Rec'd	TPH Rec'd	Metals Rec'd	Cr+6 Rec'd	Otin Rec'd	TOC Rec'd
DB360	7/30	7/21	8/21	8/21	8/7	X	8/23	5/25
DB383	7/30	7/21	8/21	8/21		X	8/23	5/25
DB401	6/15	6/9	6/9	6/9	6/9	X	7/7	6/9
DC160	8/15	7/21	8/21	8/21			X	8/7
DC180	8/15	7/21	8/21	7/23		7/21	8/23	8/21
CK0693	7/30	X	X	X	X	7/20	X	X
CK0694	7/30	X	X	X	X	7/20	X	X
CK0732	7/30	X	X	X	X	7/20	X	X
DC205	9/15		X			X	X	
DC209	9/15		X			X	X	
DB429	9/15		X			X	X	
DB439	9/15		X			X	X	X
DB458	9/15		X			X	X	X

PCB polychlorinated biphenyl
TOC total organic carbon
TPH total petroleum hydrocarbons
VOC volatile organic compound
7/21 date data validation report was received
X no analysis for that method for that SDG
blank data validation report not yet received

Sample Naming

1. Purpose

This standard operating procedure describes the naming convention for samples collected and analyzed, and whose resulting data will be stored in the database for the United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific projects. Unique sample names are used to facilitate tracking by laboratory personnel and project personnel, and for purposes of storing, sorting, and querying data in the database.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 Chain of Custody Sample Number

The chain of custody (COC) sample number is a five-character identification number that is used by the laboratory and project personnel for tracking purposes. A unique COC sample number must be used for each sample collected from a particular location at a particular time. It is useful for the first two characters to be letters unique to a particular site or project, while the remaining three characters may be digits from 001 to 999 (e.g., AA001). The COC sample number is the only identifier that should be presented to the laboratory.

3.2 Sample Identification Number

The sample identification number is a unique multi-alpha, multi-numeric identifier that is used by the field team to associate sampling results to the particular sampling location, sample type, number of times the location has been sampled, and depth. To avoid potential bias in sample analysis, the sample identifier is not provided to the laboratory. The sample identification number shall be recorded in the field logbook concurrently with the COC sample number.

4. Responsibilities

The prime contractor CTO Manager shall ensure that a proper sample naming convention is identified in the field sampling plan. The Field Quality Control (QC) Supervisor or other field-sampling leader shall ensure that the sample naming convention is implemented. The laboratory coordinator, CTO Manager, and/or other designated personnel shall ensure on a daily basis that unique, appropriate COC sample numbers and sample identifiers have been assigned. The prime

contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The prime contractor Technical Director will designate one person in each office (e.g., the laboratory coordinator) to track site designations used in the COC sample number.

5. Procedures

A COC sample number and sample identifier shall be assigned as described below. It is critical that each sample name have a unique COC sample number and sample identifier; otherwise, data cannot be properly stored and tracked in the database.

5.1 COC SAMPLE NUMBER

Use the following format for the COC sample number:

abccc

Where:

a = A letter indicating the office managing the CTO

b = A letter indicating the project or site, for example

- A = first site
- B = second site
- C = third site, etc.

ccc = Chronological number, for example

- 001 = first sample from the site
- 002 = second sample from the site
- 105 = 105th sample from the site
- Field QC samples should be included in this chronological sequence

For example, the 23rd sample from the Carpentry Shop Dip Tank site (assigned project “A” for b above; the office will be assigned “D”) being investigated would be referred to as “DA023.” This might be a soil sample, water sample, trip blank, equipment blank, field duplicate, or other sample type. Using this COC sample number, the samples will be submitted to the laboratory “blind,” that is, the laboratory should not know whether each sample received is a site or field QC sample.

If a sample is lost during shipping, the replacement sample must be assigned a new COC sample number. If different containers for the same sample are shipped on different days, a new COC sample number must be assigned.

When numbering reaches the letter Z, the 26th site, it may begin with a new first letter “a,” which must be coordinated with the prime contractor QA Manager or Technical Director and Coordinator or designee to ensure that it has not been used by another CTO.

Alternatively, the "ab" designators can serve to identify a unique project field, such as "RH" for the Red Hill site.

5.2 SAMPLE IDENTIFICATION NUMBER

The following format is provided as a suggested guidance. Individual site objectives may necessitate variations to the suggested guidance. Coordinate with the prime contractor QA Manager or Technical Director when considering deviating from this guidance.

AA-bbcc-dee-Dff.f

Where:

AA = Designates the site identification

bb = Sample type and matrix (see Table I-A-8-1)

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

d = Field QC sample type (see Table I-A-8-2)

ee = Chronological sample number from a particular sampling location (e.g., 01, 02, 03)

D = The letter "D" denoting depth

ff.f = Depth of sample in feet bgs (to the measured decimal place). For field blanks, trip blanks and equipment blanks, the depth field will contain the month and date of collection.

For example, the first subsurface soil sample collected from the Foundry Building (FB) borehole location four at a depth of 10 feet would be designated "FB-BS04-S01-D10.0." These characters will establish a unique sample identifier that can be used when evaluating data.

Table I-A-8-1 presents the character identifiers to be used in the sample and matrix portion of the sample identification number. In all cases, the second letter indicates the sample matrix. Note grab, composite, and undisturbed sample designations in the field logbook.

Table I-A-8-1: Sample Type and Matrix Identifiers

Identifier	Sample Type	Matrix
SS	Surface Soil	Soil
IS	Surface Soil (ISM)	Soil
IB	Subsurface Soil (ISM)	Soil
BS	Subsurface Soil	Soil
BG	Subsurface Soil (Geotechnical)	Soil
SD	Sediment	Sediment
GW	Groundwater	Water
SW	Surface Water	Water
FP	Free Product	Oil
WQ	Water Blanks	Water
SG	Soil Gas	Soil gas
CC	Concrete Chips	Concrete

Identifier	Sample Type	Matrix
WS	Waste (IDW)	Soil
WW	Waste (IDW)	Water

IDW investigation-derived waste
ISM incremental sampling methodology

Table I-A-8-2 describes the field QC designator types. These field QC designators clarify the type of sample collected.

Table I-A-8-2: Field QC Sample Type Identifiers

Identifier	QC Sample Type	Description
S	Normal (Primary) Sample	All non-field QC samples
D	Duplicate	Collocate (adjacent liners)
R	Triplicate	Replicate
E	Equipment Rinsate	Water
B	Field Blank	Water
T	Trip Blank	Analytical-laboratory-prepared sample -Water
M	Trip Blank	Analytical-laboratory-prepared sample – Methanol
L	Batch Test Sample	Batch Test Leaching Model Sample
P	Blind Spike	Performance testing sample

6. Records

Sample identifiers (and COC sample numbers, if appropriate) shall be identified in advance if the exact numbers of samples to be collected are known; these numbers may be listed on a spreadsheet along with requested analyses to be used as a reference by field sampling personnel.

The COC/analytical request form must be used to track all sample names. Copies of each COC form shall be sent daily to the CTO Laboratory Coordinator and with the samples to the analytical laboratory. An example of a COC form is included as Attachment III-E-2 of Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*.

In the field, personnel shall record in the field logbook the COC sample number of each sample collected, as well as additional information, such as the sampling, date, time, and pertinent comments.

7. Health and Safety

Not applicable.

8. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*.

9. Attachments

None.

Soil Sampling

1. Purpose

This section sets forth the standard operating procedure for soil sampling (surface samples, trench samples, and boring samples) to be used by United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

None.

4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that these standard soil sampling procedures are followed during projects conducted under the NAVFAC Pacific ER Program, and that they are conducted or supervised by a qualified individual. A qualified individual for subsurface sampling is defined as a person with a degree in geology, hydrogeology, or geotechnical/civil engineering with at least 1 year of experience in the supervision of soil boring construction. A qualified individual for trenching, excavation (e.g., pit), or surface sampling supervision is one who has sufficient training and experience to accomplish the objectives of the sampling program. The CTO Manager shall also ensure that a qualified person, as defined in Procedure I-E, *Soil and Rock Classification*, conducts soil classification during all types of soil sampling. The CTO Manager is responsible for ensuring that all personnel involved in sampling and/or testing shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for ensuring that all project field staff follow these procedures.

Field sampling personnel are responsible for the implementation of this procedure.

5. Procedures

5.1 Considerations For Munitions and Explosives of Concern

Potential Munitions and Explosives of Concern (MEC) hazards may be encountered in any area formerly or currently occupied or used by the Department of Defense (DoD). MEC hazards may occur on the ground surface, in the subsurface, and within bodies of water, and may not always be readily observable, or identifiable. As a result, whether or not munitions-related activities ever occurred on the specific work area or within waters in which Navy operations/activities will take place, special care should always be taken when conducting field operations, especially intrusive activities, in the event that MEC may be encountered.

If the site is currently recognized as belonging in the Military Munitions Response Program and has a current, Naval Ordnance Safety and Security-accepted, site-specific Explosives Safety Submission (ESS) (per DON 2010), then field activities, especially intrusive activities, shall adhere to the safety procedures outlined within the ESS.

If suspected MEC is encountered on an active DoD installation, immediately notify your supervisor, DoD Point of Contact, and installation Point of Contact, who will contact and facilitate military Explosive Ordnance Disposal response.

5.2 Subsurface Soil Sampling

The purpose of subsurface soil sampling is to acquire accurate, representative information about subsurface materials penetrated during drilling or trenching. This is accomplished by logging lithologic information, classifying lithologic materials, and collecting lithologic samples for analysis using geotechnical or chemical methods.

5.2.1 Inspection of Equipment

The collection of reliable samples of subsurface materials depends partly on the types of samples that can be collected when using various subsurface exploration techniques. These procedures are described in Section 5.2. In all cases, the equipment shall be inspected prior to commencement of drilling for signs of fluid leakage, which could introduce contaminants into the soil. If, at any time during subsurface exploration, fluid is observed leaking from the rig, operations shall cease and the leak shall be immediately repaired or contained. All soil and other materials affected by the leak will be collected, containerized, and labeled for proper disposal (Procedure I-A-6, *Investigation-Derived Waste Management*).

5.2.2 Preparation of Site

Proper preparation of the site prior to the commencement of subsurface exploration is essential for smooth drilling operations. It is required to protect the health and safety of site personnel. First, the

site shall be inspected to ensure that there are no overhead hazards that could affect subsurface exploration. Then, all subsurface sampling locations shall be assessed using geophysical methods to identify subsurface utilities or hazards. If possible, the area shall be excavated by hand to a depth of 2 to 3 feet before beginning drilling. If surface or shallow samples are required, it is suggested that the hand excavation be done as close to the actual subsurface exploration as possible. The drill rig must have a means to guard against employee contact with the auger (e.g., guard around the auger; barricade around the perimeter of the auger; electronic brake activated by a presence-sensing device). All members of the field crew shall know the location of the kill switch, which must be readily accessible, for the equipment.

The equipment shall be situated upwind or side-wind of the borehole. The area surrounding, and in the vicinity of, the borehole shall be covered with plastic, including the area where cuttings are placed into 55-gallon drums and the equipment decontamination area. The required exclusion zones shall be established by using plastic tape or cones to designate the various areas.

5.2.3 Equipment Decontamination

To avoid cross-contamination, all sampling equipment utilized for borehole drilling and soil sampling that may potentially come into contact with environmental samples shall be thoroughly decontaminated as described in Procedure I-F, *Equipment Decontamination*. All sampling tools shall be decontaminated between each sampling event and between each borehole or trench. At a minimum, all equipment shall be steam-cleaned or undergo the wash-and-rinse process. All wash-and-rinse water shall be collected, containerized, and labeled for proper disposal. Clean equipment (e.g., augers and samplers) shall be protected from contact with contaminated soils or other contaminated materials prior to sample collection. Equipment shall be kept on plastic or protected in another suitable fashion. After a borehole is completed, all augers and contaminated downhole equipment shall be stored on plastic sheeting.

5.2.4 Handling of Drill Cuttings

All soil cuttings from borehole drilling shall be placed into 55-gallon U.S. Department of Transportation (DOT)-approved drums or other appropriate containers, such as a roll-off bin. The containerized cuttings shall be stored in a centralized area pending sample analysis to determine their final disposition. The procedure on investigation-derived waste (IDW) (see Procedure I-A-6, *Investigation-Derived Waste Management*) details drum handling and labeling procedures.

5.3 SUBSURFACE SOIL SAMPLE COLLECTION METHODS

Table I-B-1-1 describes the characteristics of the sampling methods for the drilling techniques frequently used for soil borings and monitoring well installation, as described in Procedure I-C-1, *Monitoring Well Installation and Abandonment*. The split-spoon sampling method is the most commonly used soil sampling technique. However, in certain circumstances, other methods may have to be used to obtain optimal soil sampling results.

Sampling and handling procedures for samples submitted for volatile organic compound (VOC) analyses are provided in Attachment I-B-1-1. Considerations when using incremental sampling (IS) methods are provided in Attachment I-B-1-1.

Table I-B-1-1: Characteristics of Common Subsurface Formation-Sampling Methods

Type of Formation	Sample Collection Method	Sample Quality	Potential for Continuous Sample Collection?	Samples Suitable for Analytical Testing?	Discrete Zones Identifiable?
Unconsolidated	Bulk Sampling (Cuttings)	Poor	No	No	No
	Thin Wall	Good	Yes	Yes	Yes
	Split Spoon	Good	Yes	Yes	Yes
	Trench	Good	No	Yes	Yes
	Core Barrels	Good	Yes	Yes	Yes
Consolidated	Cuttings (direct rotary)	Poor	No	No	No
	Core Barrels	Good	Yes	Yes	Yes

The following text describes the primary soil sampling methods used for the NAVFAC Pacific ER Program.

5.3.1 Split-Spoon Samples

Split-spoon sampling is usually used in conjunction with the hollow-stem or solid-stem auger drilling method and can be used for sampling most unconsolidated and semi-consolidated sediments. It is used less frequently for air and mud rotary, and casing drive methods. It cannot normally be used to sample bedrock, such as basalt, limestone, or granite. The method can be used for highly unconsolidated sands and gravels if a stainless-steel sand catcher is placed in the lower end of the sampler.

The split-spoon sampler consists of a hardened metal barrel, 2 to 3 inches in diameter (2 to 2.5 inches inner diameter) with a threaded, removable fitting on the top end for connection to the drill rods and a threaded, removable “shoe” on the lower end that is used to penetrate the formation. The barrel can be split along its length to allow removal of the sample.

The following steps are required to obtain a representative soil sample using a split-spoon sampler:

- Advance the borehole by augering until the top of the desired sampling interval is reached. Then withdraw the drill bit from the hollow-stem augers.
- Equip the sampler with interior liners that are composed of materials compatible with the suspected contaminants if samples are to be retained for laboratory analytical analysis. Generally, these liners consist of brass or stainless steel and are slightly smaller than the inner diameter of the sampler. It is recommended to use stainless-steel liners rather than

brass if samples are to be analyzed for metals. Always evaluate the composition of the liners with respect to the types of contaminants that are suspected.

- Attach the properly decontaminated split-spoon sampler (equipped with liners) either to the drill rods or to a cable system and lower it to the bottom of the borehole through the augers.
- Drive the sampler into the formation by either a manual or automatic hammer (usually a 140-pound weight dropped through a 30-inch interval). Record the number of blows required to drive the sampler at 6-inch intervals in the boring log since blow counts provide an indication of the density/compaction of the soils being sampled. The field geologist, hydrogeologist, or geotechnical engineer shall carefully observe the internal measuring technique of the driller and keep track of sampling materials to ensure the accurate location of samples. Continuous samples can be collected with the split-spoon method by augering or drilling to the bottom of the previously sampled interval and repeating the operation. Whether continuous or intermittent, this collection method disturbs samples and cannot be used for certain geotechnical tests that require undisturbed samples.
- Bring the split-spoon sampler to ground surface and remove it from the drill rods or cable system following sample acquisition. Loosen the upper and lower fittings and take the sampler to the sample handling area. At the sample handling area, remove the fittings, split the barrel of the sampler, and remove one side of the sampler. At this time, it is important to observe and record the percentage of sample recovery.

Liners—Sampler liners can be used to collect and store samples for shipment to laboratories, for field index testing of samples, and for removing samples from solid barrel type samplers. Liners are available in plastic, Teflon, brass, and stainless steel. Other materials can be used as testing needs dictate. Liners are available in lengths from 6 inches (152.4 millimeters) to 5.0 feet (1.53 meters). Liner material selection often is based on the chemical composition of liner/soil to minimize sample reaction with liner. Most liner use is short-term as samples are subsampled and preserved immediately on site. Teflon may be required for mixed wastes and for long-term storage. Liners generally are split in the field for subsampling. Individually split liners are available in some sizes for field use. The liner should have a slightly larger inside diameter than the soil specimen to reduce soil friction and enhance recovery. When a slightly oversized liner is used, the potential for air space exists around the sample. Certain chemical samples may be affected by the enclosed air. Liners with less tolerance may be required and a shortened sample interval used to reduce friction in the liner. Metal liners can be reused after proper cleaning and decontamination. Plastic liners should be disposed of properly after use (ASTM 2005).

Immediately remove the liners containing the soil samples from the sampler. Generally, the lowermost liner is considered the least disturbed and shall be retained as the analytical laboratory sample. However, in certain circumstances (such as with the use of a sand catcher), other liners may be more appropriate for retention as the laboratory sample. If liners containing the sample material are to be submitted to the laboratory, then cover the ends of the sample liner to be retained as the analytical laboratory sample with Teflon film and sealed with plastic caps. While currently not

preferred by the State of Hawaii, if liners are submitted, the laboratories should be instructed to prepare the soil from the liner as an incremental sample to prevent biasing the results that can occur when discretely collecting the analytical volume. The site geologist, hydrogeologist, or geotechnical engineer shall observe the ends of the liner destined for analytical sampling and describe the physical nature of the sample (e.g., soil or rock type, grain size, color, moisture, as indicated in Procedure I-E, *Soil and Rock Classification*.) Then label the sample according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*, and immediately place it on ice in a cooler as described in Procedure III-F, *Sample Handling, Storage, and Shipping*.

- Collect split-spoon soil samples submitted for VOC analysis using the procedure found in Attachment I-B-1-1.
- Collect split-spoon soil samples submitted for non-VOC analysis using the IS procedure found in Attachment I-B-1-1
- Any remaining liners collected from the sample can then be used for other purposes, such as providing a duplicate sample for field quality control or material for lithologic logging. These samples can also be used for headspace analysis as described in Section 5.4.
- Conduct lithologic logging of each sample in accordance with Procedure I-E, *Soil and Rock Classification*, and enter each sample into the boring log presented in Figure I-B-1-1. In most instances, an additional liner full of material is available for this purpose. Check to ensure that all liners contain similar material. If an extra liner full of material is not available, then log by collecting the extra material present in the end of the sampler shoe. Make a comparison to the material visible at the end of the sample liner destined for laboratory analysis to ensure that the entire sample consists of similar material. If not, then describe the different material to the extent possible by relating it to similar material that was encountered previously.
- If VOCs are suspected to be present, screen the sample with an organic vapor monitor (OVM) or equivalent, and collect headspace samples according to Section 5.4.
- Decontaminate all sampling equipment prior to each use according to Procedure I-F, *Equipment Decontamination*.

5.3.2 Thin-Wall Samples

The thin-wall or Shelby tube sampler is usually used in conjunction with the hollow-stem and solid-stem auger drilling methods and is most useful when sampling clay- and silt-rich sediments. It can also be used with air and mud rotary and casing drive drilling techniques. It is amenable only to lithologies that are relatively soft and, in some cases, is not capable of penetrating hard clays or compacted sands. In addition, samples of unconsolidated sands cannot normally be acquired because they cannot be retained within the sampler, although a sand catcher can be utilized, in some cases, with moderate success.

The thin-wall sampler often consists of a single thin tube that is 3 to 4 inches in outer diameter and 1 to 3 feet in length. The upper end of the sampler has a solid metal section with a fitting for drill rods. There is no fitting for the lower end of the sampler, and it is usually open to allow sample acquisition; however, when sampling in poorly consolidated materials, a sand catcher may be placed in the lower end to ensure retention of the sample.

The following steps are required to obtain a representative soil sample using a thin-wall sampler:

- Advance the borehole by augering or drilling until the top of the desired sampling interval is reached. Then withdraw the drill bit from the hollow-stem augers.
- Place the sampler on the end of the drill rods and lower it to the bottom of the borehole.
- Instead of driving the sampler, use the hydraulic apparatus associated with the kelly bar on the drilling rig to press the sampler into the undisturbed formation. The thin-wall sampler may lack sufficient structural strength to penetrate the materials, in which case another sampling technique may be required. The samples obtained using this method cannot be used for certain geotechnical tests where undisturbed samples are required.
- Thin-wall samples submitted for VOC analysis must be collected using the procedure found in Attachment I-B-1-1.
- Following sample acquisition, bring the thin-wall sampler to the ground surface, remove it from the drill rods, and take it to the sample handling area.
- Immediately cover the ends of the sample with Teflon film and sealed with plastic caps if the sample is to be retained as a laboratory sample. Then label the sample according to Procedure III-E, *Record Keeping Sample Labeling, and Chain of Custody* and immediately place it on ice in a cooler. Extrude the sample from the sampler and inspect it if the sample is to be used only for lithologic logging.
- Conduct lithologic logging of each sample in accordance with Procedure I-E, *Soil and Rock Classification* and enter each sample into the boring log presented in Figure I-B-1-1. If the sample is contained in a sleeve, observe the ends of the sample in the sleeve to assess lithologic and stratigraphic characteristics.
- If VOCs are suspected to be present, screen the sample with an OVM or equivalent, and collect headspace samples according to Section 5.4.
- Decontaminate all sampling equipment prior to each use according to Procedure I-F, *Equipment Decontamination.*

5.3.3 Cores

A core barrel is often used to obtain core samples from harder lithologic materials, such as basalt, granite, and limestone, in instances where undisturbed samples are required for geotechnical testing, and in cases where completely continuous sampling is required. Complete recovery of samples during coring is often difficult when sampling unconsolidated and semi-consolidated lithologies, such as clays, silts, and sands.

Field Log of Boring

BORING NUMBER

SHEET ____ OF _____

PROJECT NAME	PROJECT NUMBER	ELEVATION AND DATUM	LOCATION
DRILLING COMPANY	DRILLER	DATE AND TIME STARTED	DATE AND TIME COMPLETED
DRILLING EQUIPMENT	DRILLING METHOD	COMPLETION DEPTH	TOTAL NO. OF SAMPLES
SIZE AND TYPE OF BIT	HOLE DIAMETER	NO. OF SAMPLES: BULK / SS	DRIVE / PITCHER
DRILLING FLUID	DRILLING ANGLE	WATER LEVEL: FIRST	AFTER _____ HOURS
SAMPLE HAMMER TYPE DRIVING WT. DROP		HYDROGEOLOGIST/DATE	CHECKED BY/DATE

LITHOLOGY	DEPTH (FEET)	SAMPLES	RECOVERY	BLOW COUNT	DESCRIPTION	USCS SYMBOL	ESTIMATED PERCENT OF GR	SA	FI	COMMENTS

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 G	S	F	COMMENTS
							Description taken _____ feet
							from _____ end of trench.

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

SURFACE AND SHALLOW SOIL SAMPLE LOG

Project Number	Project Name	Date	Time
Sample Identification Number and Time		Checked by	
Sampled by		Recorded by	
Method of Collection			
Surface Description			
Notes			

Soil Sample Data

Location	
Coordinates	Elevation

LITHOLOGY	DEPTH (FEET)	DESCRIPTION	USCS SYMBOL	Est. % of			COMMENTS
				G	S	F	

Figure I-B-1-3: Surface and Shallow Soil Sample Log

5.4.4 Hand Sampling Using Sample Liners

Surface soil samples can sometimes be collected by hand using just the sample liners. This method can be used in cases where the surface soils are soft or where it is advantageous to minimize the disturbance of the sample (such as when sampling for volatiles). Obtaining surface soil samples with this method consists merely of pushing or driving the sample tube into the ground by hand.

The sample liner (with the collected sample inside) is then removed from the ground and capped with Teflon film and plastic end caps. The sample is labeled according to Procedure III-E, *Record Keeping, Sampling Labeling, and Chain-Of-Custody* and immediately placed on ice in a cooler. All liners shall be decontaminated prior to use in accordance with Procedure I-F, *Equipment Decontamination.* Since the only pieces of equipment used are the sample liners, this method helps to minimize the required amount of equipment decontamination.

5.5 VOLATILE ORGANICS SCREENING AND HEADSPACE ANALYSIS

Volatile organics screening and headspace analysis is performed to preliminarily assess if the sample contains VOCs. Volatile organics screening and headspace analysis of samples shall be performed using a portable organic vapor analyzer (OVA), a portable photoionization detector (PID), or other similar instrument.

Volatile organics screening and headspace analysis is intended as a field screen for the presence of VOCs. The method measures the presence or absence of VOCs in the headspace (air) above a soil sample. Various factors affect the level of VOCs volatilizing from soils, such as concentration in the soil, temperature of the soil and air, organic carbon content of the soil, equilibration time, moisture content of the soil, and the chemical and physical characteristics of the VOCs. Therefore, headspace readings can only be regarded as qualitative assessments of volatiles, and caution should be exercised if using this technique to select samples for analytical testing. OVA and PID readings can vary because the two instruments have different sensitivities to the various VOCs and are usually calibrated relative to different gas standards (i.e., methane for the OVA and isobutylene for the PID).

In order to screen samples for VOCs, the instrument probe shall be inserted into the top of the sample liner immediately after the sampler is opened. The instrument response (normally in parts per million) is then recorded in the field notebook and/or the field log.

For headspace analysis, a portion of the sample is transferred into a zipper storage bag or pre-cleaned glass jar, which is then sealed and agitated. The VOCs are allowed to volatilize into the headspace and equilibrate for 15 to 30 minutes. Next, the instrument probe is then inserted into the container to sample the headspace, and the instrument response is recorded in the field notebook and/or the field log.

6. Records

Soil classification information collected during soil sampling should be documented in borehole, trench, and surface soil log forms. All log entries shall be made in indelible ink. Information

concerning sampling activities shall be recorded on sample log forms or in the field logbook. The CTO Manager or designee shall review all field logs on at least a monthly basis. Procedures for these activities are contained in this manual. Copies of this information should be sent to the CTO Manager and to the project files.

7. Health and Safety

Field Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

ASTM International (ASTM). 2005. *Standard Guide for Direct Push Soil Sampling for Environmental Site Characterizations*. ASTM D6282-98. West Conshohocken, PA.

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Procedure I-A-6, *Investigation-Derived Waste Management.*

Procedure I-C-1, *Monitoring Well Installation and Abandonment.*

Procedure I-E, *Soil and Rock Classification*.

Procedure I-F, *Equipment Decontamination.*

Procedure I-I, *Land Surveying.*

Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody.*

Procedure III-F, *Sample Handling, Storage, and Shipping.*

9. Attachment

Attachment I-B-1-1: Sampling and Handling Procedure: Analysis of Soil for Volatile Organic Compounds

Attachment I-B-1-1
Sampling and Handling Procedure:
Analysis of Soil for Volatile Organic Compounds

1. Laboratory Requirements

The laboratory must be capable of performing (1) United States (U.S.) Environmental Protection Agency (EPA) Solid Waste (SW)-846 Method 5035 and (2) Method 8260, 8021, or 8015 (purgeable hydrocarbons), depending on the project objectives (EPA 2007). The laboratory must have method performance data to verify this capability.

Sampling and handling procedures for the analysis of soil for volatile organic compounds (VOCs) will depend on the project objectives and the sampling approach. The laboratory is responsible for providing the necessary sample containers with preservatives (if applicable) that meet consumable certification requirements. The following section describes the consumable options for VOC soil sampling. In addition, sample containers must have a sample label and be weighed prior to shipment to the field for use. The laboratory is responsible for recording the weight of each container before and after sampling. Alternately, EnCore-type samplers may be employed.

The laboratory must provide a minimum of three prepared containers, or EnCore-type samplers, for each soil sample analyzed for VOCs.

2. Supplies

- Disposable coring devices (hereafter referred to as coring devices): either vendor-calibrated sample coring devices, or EnCore-type samplers. One coring device sampler per sampling location, plus additional coring devices (5 percent) in case of breakage.
- The number and type of laboratory prepared sample containers will depend upon the sampling scheme employed.
- For discrete soil VOCs, two 40 milliliter (mL) volatile organic analyte (VOA) vials with 5 mL of ASTM International (ASTM) Type II water, single-use magnetic stir bar with Teflon lined septa cap, one VOA vial with 5 mLs of methanol with a Teflon lined septa cap, and sample label, or three EnCore-type samplers.
- For incremental soil VOC samples, the total number of sample containers will depend upon the number of increments collected. The laboratory shall provide containers which contain a maximum of 30 mL of methanol (or as dictated by Federal Laws for transporting Exempted Limited Quantities of Dangerous Goods (49 CFR 100-185) with a Teflon lined septa cap, and sample label.
- Reagent/trip blanks: laboratory-prepared in identical fashion to sample vials.
- Temperature blanks: laboratory-prepared.
- 2-ounce glass jars with Teflon-lined lid: for dilution purposes and percent moisture determination.
- Nitrile or equivalent gloves.

3. Field Sampling

The following directions apply to all sampling techniques for soil coring devices: For reasons stated in section 3.4of this attachment and explained in detail in Sections 8.2.1.8 and A7.2 of EPA Method 5035, core-type (i.e., Terra Core, EnCore, etc.) samplers are recommended for sample collection, not sample collection and transport (EPA 2007).

- Always wear clean gloves while handling sample containers to help prevent soil and other debris from adding to the weight of the vial. Always don a new pair of gloves and use a new core sampler for each sampling location.
- Whenever possible, collect the soil samples for VOC analysis in place. If this is not possible, practical, or safe, collect the sample from a sample liner, or if absolutely necessary, from a backhoe bucket. Avoid having particles of soil adhering to the grooves of the screw cap or the container threads.
- Collect VOA samples as quickly as possible to avoid unnecessary VOC losses. EPA Region 9 recommends total exposure of the soil sample to ambient conditions should not exceed 10 seconds.
- Once the soil has been transferred to the sample container, screw the cap back on and mark the sample ID on the label with a ballpoint pen. Do not use a pen that has high solvent concentrations in the ink such as a Sharpie.
- Place the VOA vial inside a cooler containing either wet ice in sealed bags or gel ice.
- Collect the number of sample containers as describe in Section 2 of this standard operating procedure at each sampling location. The same core sampler may be used to prepare all containers. Duplicate samples require collecting additional sample containers. For percent moisture purposes, soil must also be collected in 2-ounce or greater glass jars with Teflon-lined lids at each sampling location. If other analyses are being conducted for the sampling location, then the percent moisture may be obtained from other sample containers. The 2-ounce jar will be completely filled with zero headspace. If other analyses are not being conducted at the sampling location, then an additional sample must be collected in another 2-ounce glass jar for percent moisture.
- When incrementally collecting samples from a liner for non-VOC analysis, a core sampler may be used to obtain equal incremental sample volumes. The liner will have been sliced open prior to incremental sample collection for access to the entire length of the sample.
- Depending on the 1) pre-selected volume to be collected per sample, 2) the sample/liner length available for incremental sampling, and 3) the size of the core tool, collect as many cores from the entire soil sample/liner section that will total to the required sample volume. For example, if 30 grams is the volume to be collected per sample location, the sample/liner length is 6 inches, and a 5 gram core tool is used, then 6 incremental samples, located throughout the sample length to provide adequate, representative coverage of the entire

6 inches of sample, would be collected (i.e., 6 incremental samples could be taken at equally spaced locations across the sample length, totaling 30 grams of sample).

- Collect one equipment blank per laboratory or vendor shipment of Terra Core, as described in Procedure III-B, *Field QC Samples (Water, Soil)*, unless the syringes are certified clean (e.g., certificate of analysis or equivalent documentation) by the vendor.
- Place samples in bubble wrap or other protective covering. Place custody seals on the covering. Custody seals or tape must not be placed directly on the sample vials, as this will interfere with the analytical instrumentation, final weight of the sample, and ultimate sample VOC concentration.

The following additional directions for VOC soil sample collection are taken from EPA SW-846 Method 5035A Appendix A7.0 (EPA 2002).

Collection of Samples for Analysis

After a fresh surface of the solid material is exposed to the atmosphere, the subsample collection process should be completed in the least amount of time to minimize the loss of VOCs due to volatilization. Removing a subsample from a material should be done with the least amount of disruption (disaggregation) as possible. Additionally, rough trimming of the sampling location's surface layers should be considered if the material may have already lost VOCs (been exposed for more than a couple of minutes) or if it might be contaminated by other waste, different soil strata, or vegetation. Removal of surface layers can be accomplished by scraping the surface using a clean spatula, scoop, knife, or shovel (ASTM 2005, Hewitt et al. 1999).

Subsampling of Cohesive Granular but Uncemented Materials Using Devices Designed to Obtain a Sample Appropriate Analysis

Collect subsamples of the appropriate size for analysis using a metal or rigid plastic coring tool. For example, coring tools for the purpose of transferring a subsample can be made from disposable plastic syringes by cutting off the tapered front end and removing the rubber cap from the plunger or can be purchased as either plastic or stainless-steel coring devices. These smaller coring devices help to maintain the sample structure during collection and transfer to the VOA vials, as do their larger counterparts used to retrieve subsurface materials. When inserting a clean coring tool into a fresh surface for sample collection, air should not be trapped behind the sample. If air is trapped, it could either pass through the sampled material causing VOCs to be lost or push the sample prematurely from the coring tool.

The commercially available EasyDraw Syringe, Powerstop Handle, and Terra Core sampler coring devices are designed to prevent headspace air above the sample contents. For greater ease in pushing into the solid matrix, sharpen the front edge of these tools. The optimum diameter of the coring tool depends on the following:

- Size of the opening on the collection vial or bottle (tool should fit inside mouth)
- Dimensions of the original sample, particle size of the solid materials (e.g., gravel-size particles would require larger samplers)
- Volume of sample required for analysis

For example, when a 5-gram (g) subsample of soil is specified, only a single 3-cubic-centimeter (cm^3) volume of soil has to be collected (assuming the soil has density of 1.7 g/cm^3). Larger subsample masses or more subsample increments are preferred as the heterogeneity of the material increases. After an undisturbed sample has been obtained by pushing the barrel of the coring tool into a freshly exposed surface and then removing the filled corer, quickly wipe the exterior of the barrel with a clean disposable towel.

The next step varies depending on whether the coring device is used for sample storage and transfer or solely for transfer. If the coring tool is used as a storage container, cap the open end after ensuring that the sealing surfaces are cleaned. If the device is to be solely used for collection and not for storage, immediately extrude the sample into a VOA vial or bottle by gently pushing the plunger while tilting the VOA vial at an angle (to avoid splashing any deionized water or methanol). The volume of material collected should not cause excessive stress on the coring tool during intrusion into the material, or be so large that the sample easily falls apart during extrusion. Obtain and transfer samples rapidly (<10 seconds) to reduce volatilization losses. If the vial or bottle contains ASTM reagent Type II water, hold it at an angle when extruding the sample into the container to minimize splashing. Just before capping, visually inspect the lip and threads of the sample vessel, and remove any foreign debris with a clean towel, allowing an airtight seal to form.

Devices that Can Be Used for Subsampling a Cemented Material

The material requiring sampling may be so hard that even metal coring tools cannot penetrate it. Subsamples of such materials can be collected by fragmenting a larger portion of the material using a clean chisel to generate aggregate(s) of a size that can be placed into a VOA vial or bottle. When transferring the aggregate(s), precautions must be taken to prevent compromising the sealing surfaces and threads of the container. Losses of VOCs by using this procedure are dependent on the location of the contaminant relative to the surface of the material being sampled. Therefore, take caution in the interpretation of the data obtained from materials that fit this description. As a last resort, when this task cannot be performed on site, a large sample can be collected in a vapor-tight container and transported to the laboratory for subsampling. Collect, fragment, and add the sample to a container as quickly as possible.

Devices that Can Be Used for Subsampling a Non-cohesive Granular Material

As a last resort, gravel, or a mixture of gravel and fines that cannot be easily obtained or transferred using coring tools, can be quickly sampled using a stainless-steel spatula or

scoop. If the collection vial or bottle contains ASTM reagent Type II water, transfer samples with minimal splashing and without the spatula or scoop contacting the liquid contents. For some solids, a wide-bottom funnel or similar channeling device may be necessary to facilitate transfer to the container and prevent compromising the sealing surfaces of the container. Take caution when interpreting the data obtained from materials that fit this description. Loss of VOCs is likely due to the nature of the sampling method and the non-cohesive nature of the material, which exposes more surface area to the atmosphere than other types of samples. During the sampling process, non-cohesive materials also allow coarser materials to separate from fines, which can skew the concentration data if the different particle sizes, which have different surface areas, are not properly represented in the sample.

Use of the EnCore Sampler (or Equivalent) for Sample Transport and Storage

The EnCore sampler is a sampling device that can be used as both a simultaneous coring tool for cohesive soils and a transport device to a support laboratory (field or off site). The EnCore sampler is intended to be a combined sampler-storage device for soils until a receiving laboratory can initiate either immediate VOC analysis, or preserve extruded soil aliquots for later VOC analysis. It is meant to be disposed of after use. The commercially available device is constructed of an inert composite polymer. It uses a coring/storage chamber to collect either a 5-gram or 25-gram sample of cohesive soils. It has a press-on cap with hermetically a vapor-tight seal and locking arm mechanism. It also has a vapor-tight plunger for the non-disruptive extrusion of the sample into an appropriate container for VOC analysis of soil.

An individual disposable EnCore sampler (or equivalent) is needed for each soil aliquot collected for vapor partitioning or ASTM reagent Type II water sample preparation. Upon soil sample collection, store the EnCore sampler is at 4 ±2 degrees centigrade (°C) until laboratory receipt within 48 hours. Upon laboratory receipt, soil aliquots are extruded to appropriate tared and prepared VOA vials.

Validation data have been provided to support use of the EnCore sampler for VOC concentrations in soil between 5 and 10 parts per million, for two sandy soils, with a 2-day holding time at 4 ±2°C. Preliminary data (Soroni et al. 2001) demonstrate an effective 2-day (48-hour) holding time at 4 ±2°C for three sandy soil types with VOC concentrations at 100 parts per billion (ppb) (benzene and toluene at 300 ppb), as well as an effective 1- or 2-week holding time at <-7°C (freezing temperature). Recent published work (EPA 2001) neither definitively supports nor shows the EnCore device to be ineffective for sample storage at these preservation temperatures. Soils stored in the EnCore device for 2 calendar days at 4 ± 2°C are subject to loss of benzene, toluene, ethylbenzene, and xylene (BTEX) compounds by biodegradation if the soil is an aerated, biologically active soil (e.g., garden soil) (Soroni et al. 1999), but this BTEX loss is eliminated for up to 48 hours under freezing conditions (Hewitt 1999).

Further details on the EnCore sampler can be found in ASTM D4547-09 (ASTM 2009) or other publications.

Since Naval Facilities Engineering Command, Pacific action levels for VOCs in soil are typically associated with EPA Region 9 preliminary remediation goals for residential exposure scenarios, it is recommended that if EnCore samplers are used, they be frozen on site prior to shipment to the laboratory or extruded into a 40-mL VOA vial before shipment.

4. Sample Shipping and Holding Times

Samples preserved with water may be shipped either at 4 ±2°C or frozen at –7°C. The primary difference between the two shipping temperatures is the allowable holding time of the sample between sample collection and sample analysis. Samples shipped at 4 ±2°C must either be received and analyzed by the laboratory within 48 hours of sample collection or be received by the laboratory within 48 hours, frozen upon receipt, and analyzed within 14 days of sample collection. Samples shipped at –7°C and received/maintained by the laboratory in a frozen state must be analyzed within 14 days of sample collection.

If soil samples are to be field frozen, place the frozen samples in a cooler containing fresh, frozen gel packs or an ice and rock salt mixture, and ship the cooler using an overnight carrier. Dry ice may be used as a refrigerant for sample shipment, but must be coordinated with the overnight carrier in advance. The sample vials and caps must never be placed in direct contact with the dry ice since cracking may occur.

Soil or sediment samples contained in methanol and 2-ounce glass jars may be shipped in standard coolers using conventional shipping protocols described in Procedure III-F, *Sample Handling, Storage, and Shipping*, if the sample appears to have a moisture content that might cause the sample to expand and the glass jar to break due to freezing. If soil samples contained in 2-ounce glass jars are shipped in this manner, then trip blanks must accompany them during shipment.

Reagent/trip blanks that contain the same volume of ASTM Type II water and sample label used in the sample VOA vials must be included in each shipment. The reagent/trip blanks will be packaged, shipped, and analyzed in the same manner as field samples. Reagent/trip blanks will be analyzed to evaluate cross-contamination during shipment and to identify potential reagent contamination issues.

5. Laboratory Receipt

Upon receipt by the analytical laboratory, the sample temperature must be measured and recorded. The laboratory should note whether the samples are frozen. The samples must be logged in and assigned an analysis date to ensure that samples are analyzed within the 14-day holding time.

Once the samples have been logged in, they are placed in a freezer at 0°C or colder until they are analyzed. Samples arriving in a non-frozen state (greater than 0°C) are to be frozen upon receipt or

analyzed within 48 hours of sample collection. If the duration of sample shipment exceeds 48 hours, the non-frozen samples should be analyzed on the day of laboratory receipt.

The laboratory will prepare the samples for analysis as dictated by laboratory standard operating procedures and SW-846 Method 5035, and analyzed by Method 8260, 8021, or 8015 (purgeable hydrocarbons), depending on the project objectives.

6. References

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Procedure III-B, *Field QC Samples (Water, Soil).*

Procedure III-F, *Sample Handling, Storage, and Shipping.*

Monitoring Well Installation and Abandonment

1. Purpose

This standard operating procedure describes the methods to be used by the United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel during the installation of groundwater monitoring wells. It describes the components of monitoring well design and installation and sets forth the rationale for use of various well installation techniques in specific situations.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 FILTER PACK

Filter pack is sand or gravel that is smooth, uniform, clean, well-rounded, and siliceous. It is placed in the annulus of the well between the borehole wall and the well screen to prevent formation materials from entering the well and to stabilize the adjacent formation.

3.2 ANNULUS

The annulus is the downhole space between the borehole wall and the well casing and screen.

3.3 BRIDGE

An obstruction in the drill hole or annulus. A bridge is usually formed by caving of the wall of the well bore, by the intrusion of a large boulder, or by filter pack materials during well completion. Bridging can also occur in the formation during well development.

3.4 GROUT

Grout is a fluid mixture of cement and water that can be forced through a pipe and emplaced in the annular space between the borehole and casing to form an impermeable seal. Various additives, such as sand, bentonite, and polymers, may be included in the mixture to meet certain requirements.

3.5 SIEVE ANALYSIS

Sieve analysis is the evaluation of the particle-size distribution of a soil, sediment, or rock by measuring the percentage of the particles that will pass through standard sieves of various sizes.

4. Responsibilities

CTO Managers are responsible for issuing WPs that reflect the procedures and specifications presented in this procedure. Individual municipalities, county agencies, and, possibly, state regulatory agencies enforce regulations that may include well construction and installation requirements. The CTO Manager shall be familiar with current local and state regulations, and ensure that these regulations are followed. Regulations are subject to constant revision. Every effort should be made to stay informed of these changes through contact with the agencies that oversee work in specific project areas, prior to initiation of field activities. The CTO Manager or designee shall review all well construction logs on a minimum monthly basis. The CTO Manager is responsible for ensuring that all personnel involved in monitoring well installation and abandonment have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager (FM) is responsible for direct supervision of the installation of monitoring wells and ensuring that procedures and specifications are implemented in the field. The qualifications for the FM include a degree in geology, hydrogeology, civil/geotechnical/environmental engineering, or equivalent with at least 2 years of field experience in the installation of monitoring wells.

Field sampling personnel are responsible for the implementation of this procedure.

The onsite geologist/hydrogeologist/engineer is expected to obtain a description of the lithologic samples obtained during the excavation and construction of a monitoring well. These data are often required to provide guidance regarding the installation of specific components of the monitoring well. Guidance for lithologic sample collection and sample description is contained within Procedure I-B-1, *Soil Sampling.*

5. Procedures

5.1 CONSIDERATIONS FOR MUNITIONS AND EXPLOSIVES OF CONCERN

Potential Munitions and Explosives of Concern (MEC) hazards may be encountered in any area formerly or currently occupied or used by the Department of Defense (DoD). MEC hazards may occur on the ground surface, in the subsurface, and within bodies of water, and may not always be readily observable, or identifiable. As a result, whether or not munitions-related activities ever occurred on the specific work area or within waters in which Navy operations/activities will take place, special care should always be taken when conducting field operations, especially intrusive activities, in the event that MEC may be encountered.

If the site is currently recognized as belonging in the Military Munitions Response Program and has a current, Naval Ordnance Safety and Security-accepted, site-specific Explosives Safety Submission

(ESS) (per DON 2010), then field activities, especially intrusive activities, shall adhere to the safety procedures outlined within the ESS.

If suspected MEC is encountered on an active DoD installation, immediately notify your supervisor, DoD Point of Contact, and installation Point of Contact, who will contact and facilitate military Explosive Ordnance Disposal response.

5.2 BACKGROUND INFORMATION

The primary objectives of installing a monitoring well at a site are: to observe groundwater levels and flow conditions; to obtain samples for determining groundwater quality; and to evaluate the hydraulic properties of water-bearing strata. To achieve these objectives, it is necessary to satisfy the following criteria:

- Construct the well with minimum disturbance to the formation.
- Construct the well with materials that are compatible with the anticipated geochemical environment.
- Properly complete the well in the desired zone.
- Adequately seal the well with materials that will not interfere with the collection of representative water samples.
- Sufficiently develop the well to remove drilling fluids or other additives or conditions associated with drilling, and provide unobstructed flow to the well.

The proper design and construction of monitoring wells requires an understanding of site geology and hydrogeology, and knowledge of contaminant transport in subsurface materials.

A significant difference between monitoring wells and production or “water” wells is that the intake section of monitoring wells is often purposely completed in a zone of poor water quality and/or poor yield. The quality of water entering a monitoring well can vary from drinking water to a hazardous waste or leachate. In contrast, production wells are normally designed to efficiently obtain water from highly productive zones containing good quality water. The screen of a monitoring well often extends only a short length (typically 10 feet or less) to monitor hydraulic conditions within, and obtain water samples from, selected water-bearing intervals. In contrast, water wells are often designed to obtain economic quantities of water from multiple zones of water-bearing strata.

5.3 MONITORING WELL DESIGN CONSIDERATIONS

The following information was compiled from a number of technical references. For additional information related to monitoring well installation, consult the references listed in Section 8.

5.3.1 Well Placement

Select the location of a monitoring well according to the purpose of the monitoring program, which will vary among different sites and may include detection of contaminants in groundwater, verification of contaminant migration predictions, the monitoring of leachate at a landfill site, or remediation of a contaminated site. Each of these purposes will require a specialized array of monitoring locations and completion intervals, and a specific sampling program. Therefore, design the monitoring well network to satisfy the needs of the particular situation.

Determine the position of a monitoring well in a contaminant flow path for a monitoring effort based on the interpretation of preliminary data. These data shall be sufficient to facilitate identification of potential contaminant sources. Also consider site history, topography, climate, surface hydrology, and the location of nearby pumping wells.

Design the layout of the groundwater monitoring network following preliminary evaluation of the approximate direction of groundwater flow. A minimum of three wells is necessary to estimate local hydraulic gradients. Ideally, at least one well will be located hydraulically upgradient, and two or more wells strategically located hydraulically downgradient of each potential contaminant source. Determination of the horizontal and vertical extent of a contaminant plume is often an iterative process requiring the installation and sampling of wells in several phases.

Install monitoring wells hydraulically downgradient and as close as physically possible to the areas of suspected contamination in order to immediately detect releases from a hazardous waste site. Locate additional monitoring wells based on the interception of potential groundwater flow paths and direction of contaminant migration.

The placement of groundwater monitoring wells shall also consider the three-dimensional nature of groundwater flow. Significant vertical gradients and heterogeneous and/or anisotropic hydraulic conditions may exist at a site. Thus, the direction of groundwater flow may not necessarily coincide with the apparent horizontal gradient observed by the triangulation provided by three monitoring wells. Determine the completion intervals of existing wells prior to the calculation of groundwater gradient directions. Consider temporal/seasonal groundwater flow conditions if the monitoring well network is located near existing active well fields, near tidal zones, or near ephemeral surface water (e.g., canals, dry river beds).

5.3.2 Well Depth and Screened Interval

A detailed understanding of the site stratigraphy, including both horizontal and vertical extent of geologic formations, is necessary to identify zones of different permeabilities, and discontinuities, such as bedding planes, fractures, or solution channels. Groundwater flow and/or contaminant transport beneath the site preferentially occur in the more permeable zones. Equally important is the identification of relatively low permeability zones that may impede migration of contaminants. The occurrence and movement of groundwater in the subsurface is closely related to lithology. Thus, geologic conditions will influence the location, design, and methods used to locate and install monitoring wells.

The depth of a monitoring well is determined by the depth of one or more water-bearing zones that are to be monitored. For example, if preliminary soil borings indicate that multiple water-bearing zones are present at a site, and it is believed that zones other than the uppermost zone may be impacted by surface contamination, a well should be completed in each individual water-bearing zone encountered. Where two or more saturated zones occur beneath a site, and the intent of the monitoring program is to monitor water quality in the lower zone, the monitoring well will generally require surface casing to isolate the upper water-bearing zone from the deeper zone prior to drilling into the deeper zone.

In multiple aquifer systems, highly variable conditions may occur. For example, an overlying unconfined aquifer may be contaminated, whereas the underlying confined aquifer may not contain contaminants. Exercise extreme care to ensure that the installation/completion of monitoring wells

does not cause cross-contamination of the aquifers. In these cases, it may be preferable to install surface casing through the contaminated aquifer to minimize the possibility of cross-contamination to the lower aquifer system.

Characteristics of lithologic materials encountered at the site, such as the degree of consolidation and grain size, also influence the type of well completion. In unconsolidated alluvial deposits, screened well intakes are typically used. An emplaced filter pack, consisting of well-sorted, clean, inert silica sand with a grain size and well screen slot size appropriate for the formation, typically is used to filter out fine-grained materials present within formations encountered in the borehole. Where permeable, consolidated formations are present, casing may be extended through overlying unconsolidated deposits and the well may be completed with a section of open borehole in the consolidated water-bearing zone. Even in these cases, however, fine-grained materials may enter the well through fractures, and if severe enough, an artificial filter pack and screened intake may be required. Also, many regulatory agencies require a screened interval installed with filter pack for all well completions.

Placement of the screened interval depends primarily on two factors: the interval to be monitored and the type of contaminants. The desired interval to be monitored shall dictate the interval to be screened. Determine which stratigraphic horizons represent potential pathways for contaminant migration by the site characterization. Short screened sections provide more specific data on the vertical distribution of contaminants and hydraulic head, while long screen intervals can result in a cumulative dilution of contamination in one zone with uncontaminated groundwater in another zone, as well as less specific information on hydraulic head. In addition, a long screened interval could potentially create vertical conduits that might result in cross-contamination.

Consider the type of contaminants involved prior to well installation. Contaminants that have a density less than water migrate differently than contaminants with a density equal to or greater than water. For example, if the contaminant in an unconfined aquifer has a density lower than water, such as diesel or gasoline, it is important to ensure that the screened interval of the well extends above the maximum seasonal elevation of the water table. Doing so facilitates an accurate determination of apparent thickness of free product in a monitoring well. In general, the screen shall extend 3 to 5 feet above the highest anticipated level of the water table when monitoring the upper portions of an unconfined aquifer.

Conversely, if the contaminant of concern has a density higher than water, such as trichloroethene (TCE), the screened interval of one or more monitoring wells should be installed just above the lower confining bed of a potentially impacted aquifer. TCE may be transported at high concentrations as a dense, nonaqueous phase liquid (DNAPL) near the source area, and migrate along the top of a confining bed at the base of an impacted aquifer.

Give special attention to interpretation of site stratigraphy when assessing DNAPL, particularly with respect to dipping beds, as it is possible for DNAPLs to effectively move hydraulically upgradient if low permeability perching horizons dip in a direction opposite the hydraulic gradient. This type of situation is important to consider when selecting monitoring well locations.

If time and budget allow, correlate conventional borehole geophysical methods and continuous cores of soil samples to yield a more complete stratigraphic characterization. A continuous profile of borehole conditions is compared to field observations and is used to select screened intervals.

5.3.3 Well Permitting

All wells shall be permitted in accordance with the regulations of the jurisdiction where well installation is occurring, if this is Navy policy for the region of activity. Contact local authorities prior to establishing well construction requirements for the project.

The permit procedure may require permit fees, site inspections, and an application signed by a registered professional geologist or engineer. Permit requirements may impact field schedules and budgets. The driller may also be required by law to be licensed and bonded. Provide documentation that all legal requirements have been met to the appropriate agencies prior to the installation of a monitoring well.

5.4 SELECTION OF DRILLING METHOD

Monitoring well installation at hazardous waste sites may involve drilling through or near hazardous materials, in areas where the extent of contamination is unknown, or through more than one geologic material or aquifer. Use of any drilling method at a hazardous waste site involves an element of risk related to the potential spread of contamination or creation of a pathway through which contaminants can migrate. Selection of a method most appropriate for site-specific conditions is essential to minimize these risks. Table I-C-1-1 provides an interpretation of how geologic conditions may influence the selection of a particular drilling method.

Most drill rigs use gasoline or diesel fuel, as well as hydraulic fluid during operation. Because these fluids are all potential contaminants, it is important to protect the drill hole and immediate area from these substances. Whenever leaking fluid from the drill rig is detected, drilling operations shall cease as soon as practical following stabilization of the drill stem, and the rig shall be moved to a safe area to be repaired.

Table I-C-1-1: Relative Performance of Different Drilling Methods in Various Types of Geologic Formations; Commonly Utilized Drilling Methods

Type of Formation	Auger-Hollow Stem	Rotary Bucket Auger*	Rotary with Fluids (foam, mud)*	Air Rotary	Air Rotary with Casing Hammer	Down the Hole Air Hammer	Dual Tube/ Casing Hammer	Coring	Reverse Rotary with Fluids*	Reverse Rotary with Dual Tube	Direct Push **
Loose sand and gravel	G	P	P-G	NR	E	NR	E	NR	P-E	E	E
Loose boulders in alluvium	P	P-G	G	NR	E	NR	P	NR	P	G	NR
Clay, silt	E	G	E	NR	E	NR	E	P-G	E	E	G
Shale	P	NR	E	P	E	NR	NR	E	E	E	NR
Sandstone	P	NR	G	E	NR	NR	NR	E	G	E	P
Limestone with chert	NR	NR	G	E	NR	E	NR	E	G	G	NR
Limestone with and without fractures	NR	NR	G-E	E	NR	E	NR	E	P-E	E	P
Limestone, cavernous	NR	NR	P-G	P-G	NR	E	NR	E	NR	E	NR

Type of Formation	Auger-Hollow Stem	Rotary Bucket Auger*	Rotary with Fluids (foam, mud)*	Air Rotary	Air Rotary with Casing Hammer	Down the Hole Air Hammer	Dual Tube/ Casing Hammer	Coring	Reverse Rotary with Fluids*	Reverse Rotary with Dual Tube	Direct Push **
Dolomite	NR	NR	E	E	NR	E	NR	E	E	E	NR
Basalts-thin layers in sedimentary rocks	P	NR	G	E	NR	NR	NR	E	G	E	P
Tuff	P	NR	G	E	NR	E	NR	E	G	G	NR
Basalts-thick layers	NR	NR	P	G	NR	E	NR	E	G	G	NR
Basalts-highly fractured	NR	NR	NR	P	NR	G	NR	E	NR	G	NR
Metamorphic rocks	NR	NR	NR-P	G	NR	E	NR	E	G	G	NR
Granite	NR	NR	NR-P	E	NR	E	NR	E	G	G	NR

E Excellent
G Good
NR Not Recommended
P Poor
* Cannot be used for analytical soil sampling
** Procedure I-H, *Direct-Push Sampling Techniques* discusses protocol associated with direct push applications.

The following sections discuss commonly used drilling methods and their applicability to installation of monitoring wells. Regardless of the drilling method selected, decontaminate all drilling equipment using Procedure I-F, *Equipment Decontamination*. Follow these procedures before use and between borehole locations to prevent cross-contamination. In addition to selecting the proper drilling technique, take other precautions to prevent distribution of any existing contaminants throughout the borehole.

5.4.1 Hollow-stem Continuous-flight Auger

Hollow-stem continuous-flight auger (HSA) is the most frequently employed method used in the environmental industry for the drilling and installation of shallow monitoring wells in unconsolidated materials. Drilling with HSA is possible in loose sand and gravel, loose boulders in alluvium, clay, silt, shale, and sandstone. HSA drilling is usually limited to unconsolidated materials and depths of approximately 150 to 200 feet. HSA drill rigs are mobile, relatively inexpensive to operate, generally cause minimal disturbance to the subsurface materials, and have the additional advantage of not introducing drilling fluids (e.g., air, mud, or foam) to the formation.

Another advantage of the HSA method is that undisturbed samples are obtained by driving a split-spoon sampler below the lead auger. Soil samples can usually be easily collected in this manner with a minimum of tripping sampling tools into and out of the hole.

Moreover, in the HSA drilling method, the well is constructed inside the HSAs as the augers are gradually removed from the ground. This method decreases the possibility of the borehole collapsing before the well is installed. HSAs shall have a nominal outside auger-flight diameter of 10 to 12 inches and a minimum inside diameter of 8 inches. Larger inside diameter auger flights are sometimes available. Well casing diameter is usually limited to 4 inches or less when using the HSA

method. The difference between the inner diameter (I.D.) of the auger and the outer diameter (O.D.) of the well casing shall be at least 4 inches (i.e., a minimum 2-inch annular space) to permit effective placement of filter pack, bentonite seal, and grout without bridging.

5.4.2 Rotary Bucket Auger

Rotary bucket auger drilling, or bucket auger drilling (BAD), utilizes a large-diameter bucket auger to excavate earth materials. Excavated material is collected in a cylindrical bucket that has auger-type cutting blades on the bottom of the bucket. The bucket is attached to the lower end of a kelly bar that passes through, and is rotated by, a large ring gear that serves as a rotary table.

The kelly bar is square in cross-section and consists of two or more lengths of square steel tubing, with each successive length of tubing telescoped inside the previous length. This design permits boring to a depth several times the collapsed length of the kelly bar before having to add a length of drill rod between the kelly and the bucket. In drilling with the telescoping kelly, the bucket is typically lifted and dumped without disconnecting, thereby speeding up the process when drilling deep holes. Depths of 75 to 100 feet are achievable with most telescoping kellys. It is possible to construct wells more than 250 feet deep by this method, although depths of 50 to 150 feet are more typical.

The BAD technique is most effective in semi-consolidated or clayey formations that stand open without caving. Drilling through unconsolidated materials within the saturated zone is difficult, but not impossible if the hole is kept full of water or mud (see direct rotary methods with foam or mud). Drilling mud may be necessary, particularly in loose formations consisting of unconsolidated fine- to medium-grained sands and silts. In the right conditions, a bucket auger bit will remove a cylinder of material 12 to 24 inches deep with each run. Therefore, samples obtained by the BAD method are representative of the formation being drilled, unless sloughing or caving of the borehole walls occurs.

Boreholes drilled with the BAD technique generally range from 18 to 48 inches in diameter. Because of the large diameter of the borehole drilled with this technique, and the common need to add either water or mud to maintain the borehole in unconsolidated, near-surface deposits, it is recommended to use this method only for the installation of surface casing through the first water-bearing unit at a hazardous waste site.

5.4.3 Direct Rotary with Foam or Mud

Direct rotary drilling (DRD) techniques involve the use of various types of drilling fluids, which typically include air, foam, and mud. In each of the DRD methods, drilling fluids are circulated down through the inside of the drilling pipe into the borehole, and then up through the annulus between the drilling pipe and the borehole wall to carry drill cuttings up to the surface. The drilling fluids may also be used for stabilizing the borehole wall, which may be especially useful in unconsolidated, caving formations. In this section, the DRD method and its use with either foam or mud are discussed.

A variety of bit types may be used with each of these drilling fluids, depending on the type of formational material encountered; however, typically, the tri-cone or roller bit is used. The drilling bit is attached directly to a heavy section of drill pipe called a drill collar, which is attached to help keep the borehole straight. The drill collar is in turn attached to the drill pipe and the kelly.

General types of drilling fluids available for use with the DRD method include water with clay additives, water with polymeric additives, water with clay and polymeric additives, and foams (comprised of air or water, surfactants, and occasionally clays or polymers). The drilling fluid density may be adjusted during drilling to improve or resume circulation within the borehole, or to attempt to stabilize the borehole wall. A major problem with the addition of these fluids is that it is almost impossible to estimate the amount introduced into the formation through the saturated and unsaturated zones. Additionally, it is also very difficult to estimate the magnitude and duration of the impact to groundwater quality by the use of these fluids.

The drilling fluids and associated cuttings shall not be allowed to flow over the site unrestricted. A downhole circulation system, or fluid diversion system shall be used to keep the fluids and cuttings contained in a reasonable manner, yet still allow the collection of grab samples for lithologic identification.

While in some geologic situations DRD may be the most efficient method of drilling a borehole, potential problems associated with the drilling fluids usually make DRD a last-resort drilling technique for environmental purposes; one that should be avoided whenever possible.

Potential Problems of DRD with Foam or Mud

- The chemistry of the drilling fluid could adversely affect the chemistry of groundwater samples, soil samples, or the efficiency of the well (when using mud).
- Bentonite mud reduces the effective porosity of the formation around the well, thereby compromising the estimates of well recovery. Bentonite may also affect groundwater pH. Additives to adjust viscosity and density may introduce contaminants to the system or force irrecoverable quantities of mud into the formation.
- Some organic polymers and compounds provide an environment for bacterial growth, which in turn, reduces the reliability of sampling results.
- Uncontained drilling foam and/or mud may create unsafe working conditions at the surface around the rig.

Solutions

- DRD should only be utilized as a last resort.
- The hydrogeologist should ensure that the fluids used will not affect the chemistry of the soil samples and groundwater samples. One possibility is to collect samples of the drilling fluid for laboratory analysis.
- The hydrogeologist shall keep track of the amount of water and fluids introduced to the borehole in order to purge this quantity during well development.
- Provisions to contain drilling mud and foam shall be discussed in the drilling contractor scope of work.

5.4.4 Air Rotary and Air Rotary with Casing Hammer

Air rotary drilling (ARD) and air rotary with casing hammer (ARCH) force air down the drill pipe and back up the borehole and remove drill cuttings in the same manner as DRD with foam or mud. Without a casing hammer, the use of ARD techniques is best suited to hard-rock formations where

the borehole will stand open on its own and circulation loss is not a major concern. ARCH is most useful in unconsolidated sediments of all types due to the use of a hardened steel casing that is driven behind the bit with a pneumatic casing hammer to keep the hole open. A combination of these two drilling techniques is very useful where unconsolidated overburden overlies consolidated rock. In this case, the casing hammer attachment would be used to set the surface casing at the top of the consolidated formation while continuing with ARD. As a well is being installed or the hole is being abandoned, the casing can be retrieved for use on another hole, or left in place to serve as surface casing.

Air from the compressor shall be filtered to ensure that oil or hydraulic fluid is not introduced into the soils and/or groundwater system to be monitored. In addition, foam or hydrocarbon-based lubricating joint compounds for the drill rods shall not be used with any rotary drilling method due to the potential for introduction of contaminants into the native materials and/or groundwater. Teflon-based joint lubricating compounds that are typically mixed with vegetable oil are available for this purpose.

Potential Problems of ARD and ARCH

- In the case of sampling with a split-spoon sampler to collect soil samples for laboratory analysis, the high-pressure air from inside the drill pipe can cause volatilization of contaminants from the soils beneath the bit in unconsolidated sediments. If installing deep wells or boreholes, this problem may not be avoidable.
- Fine-grained saturated materials that may cause surging and heaving problems are common in many coastal areas. Heaving sediments may cause problems during sampling and well installation when drilling with ARD.
- Rocks and other drill cuttings may be ejected from the borehole at high velocities, creating a secondary hazard around the rig.

Solutions

- ARD and ARCH should not be used for soil sampling in shallow, unconsolidated situations where a HSA rig could be used as effectively.
- One method to compensate for heaving and surging aquifer materials is to over drill the borehole by 5 or 10 feet to provide space for heaving sediments to fill in while well completion is being performed.
- Another method to control heaving sands is to add clean water to a level above the water table to create a downward pressure on the heaving materials. This additional volume of water should also be extracted during well development.
- Drill rigs shall be equipped with cyclones or equivalent devices designed to contain formation projectiles.

5.4.5 Dual Tube Casing Hammer with Reverse Air Circulation

Dual tube casing hammer with reverse air circulation (DTCH) is useful in unconsolidated sediments, but is most effective as a method for drilling through thick sequences of materials, such as coarse-grained sands and gravels. The DTCH system operates by simultaneously driving a pair of heavy gauge steel pipes into the ground while using high pressure reverse air circulation to blow air down

the annulus of the two pipes and bring air and unconsolidated lithologic materials out through the inside of the inner pipe. The method does not employ a typical bit in that the formational materials are not ground up, sliced, nor cut into pieces. Instead, the bit consists of a special shoe that is used to funnel materials either into, or away from, the inner pipe, depending on whether the formational material is fine- or coarse-grained, respectively.

Typically, the method can drill through 200 feet of gravel in a day with relative ease. The inside diameter of the inner pipe is about 6 inches, with the borehole diameter being about 10 inches. Cobbles with long axes of up to 6 inches come up through the inner pipe easily. Larger conglomerate clasts must be either pushed aside or broken up using the pneumatic hammer to drive the heavy shoe down onto the clast.

Conversely, the method works poorly in clay-rich materials. The shoe acts as a large cookie cutter, forcing a plug of clay into the inner pipe, which then must be forced to the surface and physically removed from the diverter/shoe assembly with the hammer. This method should probably be avoided where large thicknesses of clay are expected to be encountered in the subsurface.

Typically, the DTCH method can drill to approximately 200 feet with standard equipment. Deeper holes will likely require a larger air volume for circulation via an additional compressor hooked up to the drilling rig. Additionally, a variation of the DTCH called “triple tube” can be used to install larger-diameter wells to depths of about 200 feet depending upon the site. This method can also be used to supply a temporary surface casing to avoid cross-contamination of deeper zones while extending the boring to greater depths.

Potential Problems of DTCH

- In the case of soil sampling with a split-spoon sampler to collect samples for laboratory analysis, the high-pressure air from inside the drill pipe can cause volatilization of contaminants from the soils beneath the bit in unconsolidated sediments. If installing deep wells or boreholes, this problem may not be avoidable.

Solutions

- DTCH should not be used for sampling soil in shallow, unconsolidated situations where a HSA rig could be used as effectively.

5.5 MONITORING WELL DESIGN PROCEDURES

The designs of typical groundwater monitoring wells are depicted in Figure I-C-1-1 and Figure I-C-1-2. A discussion of the design of the individual components of a typical monitoring well is given in the following subsections.

5.5.1 Pre-installation Design Drawing

Develop a pre-installation design drawing after the borehole for the well has been completed and well-specific lithologic and hydrologic information are available. The pre-design drawing shall identify the anticipated depth of the well, the locations of the top and bottom of the screened interval, the anticipated top of the filter pack, the anticipated top of the bentonite seal, and the locations of centralizers (if applicable). In addition, calculate the volumes of sand, bentonite, and grout

anticipated to be placed in the annular space of the well. Maintain the drawing as documentation of the well design.

5.5.2 Casing Selection

The cased section of a monitoring well is a pipe without slots or openings, which is installed to prevent the well from directly accessing formations above the screened interval. The casing isolates the screened interval.

The selection of appropriate casing materials must take into account several site-specific factors, such as: (1) geology, (2) geochemistry, (3) well depth, (4) size and type of equipment to be used in the well, and (5) the types and concentrations of suspected contaminants. In addition, consider several other logistical factors, including drilling method, cost, and availability.

Typical casing materials comprise polyvinyl chloride (PVC), chlorinated PVC, fiberglass reinforced plastic, Teflon, galvanized steel, carbon steel, Type 304 stainless steel, and Type 316 stainless steel. Casing materials must be compatible with the environment into which they will be placed. Metallic casings are most subject to corrosion, while thermoplastic casings are most subject to chemical degradation. Some thermoplastic materials are susceptible to sorption and desorption of chemicals. The extent to which these processes occur is related to water quality, the concentration of contaminants, and the type of casing materials. Choose casing material with knowledge of the existing or anticipated groundwater chemistry. If non-aqueous phase liquids (light non-aqueous-phase liquid or DNAPL) are potentially present at a site, careful consideration of the concentrations and types of chemicals that may come into contact with the casing must be made to insure the casing will not degrade over time. Table I-C-1-2 presents the relative compatibilities of some typical casing materials.Table I-C-1-2: Relative Chemical Compatibility of Rigid Well-Casing Material

	PVC [a] 1	Galvanized Steel	Carbon Steel	Low-Carbon Steel	Stainless [b] Steel 304	Stainless [b] Steel 316	Teflon [c]
Buffered weak acid	100	56	51	59	97	100	100
Weak acid	98	59	43	47	96	100	100
Mineral acid/high solids	100	48	57	60	80	82	100
Aqueous/organic mixtures	64	69	73	73	98	100	100
Percent overall rating [d]	91	58	56	59	93	96	100

[a] PVC casing shall not be installed in a groundwater environment containing chlorinated solvent or other destructive contaminants where the concentration of organics is greater than 1 part per million, and where the desired detection limit is less than 25 part per billion.
[b] Type 316 stainless steel screen and/or casing shall be used rather than type 304 when conditions are unknown and the lifespan of the monitoring well is to be greater than 5 years, or where the pH (indicates the hydrogen ion concentration – acidity or basicity) is less than 4.5, or where chloride concentration is greater than 1,000 part per million.
[c] Trademark of E.I. DuPont de Nemours
[d] Overall rating based on scale of 0 to 100 with 0 being the least compatible and 100 being the most compatible.

Besides chemical compatibility, a second consideration for specification of casing materials is the depth of the monitoring well. Well installations greater than 150 feet deep require casing materials of greater structural strength. In the case of PVC casing, Schedule 80 PVC rather than Schedule 40 may be required to prevent over-stressing of the casing couplings. The build-up of heat during grout setup might adversely affect some thermo-plastic materials.

Regardless of the type of casing materials, use only flush-threaded couplings. Flush-threaded couplings ensure that no screws, mechanical adapters, glues, or solvents are necessary to join individual sections. Steel conductor casing shall be welded at the joints, and the joint shall be at least as thick as the thickness of the casing wall. The weld shall be fully penetrating and shall meet the standards of the American Welding Society. Outside steel collars may be used to increase the strength of the welded joint. Do not use Teflon tape on PVC or stainless steel casing joints because it reduces the tensile strength of the joints.

The selection of an appropriate casing diameter is also important. The I.D. shall be 4 inches or greater to allow better access to the well and more rigorous well development than is commonly possible with smaller-diameter wells. Wells with casing smaller than 4-inch I.D. shall only be installed with the approval of the QA Manager or Technical Director. Wells greater than 150 feet in depth may require diameters larger than 4 inches to ensure that development and sampling equipment can be moved easily through the well. In addition, wells designed for groundwater extraction shall have a casing diameter large enough to accommodate a pump capable of achieving the appropriate pumping rate. The borehole in which the well is to be installed shall be a minimum of 4 inches larger in diameter than the O.D. of the well casing.

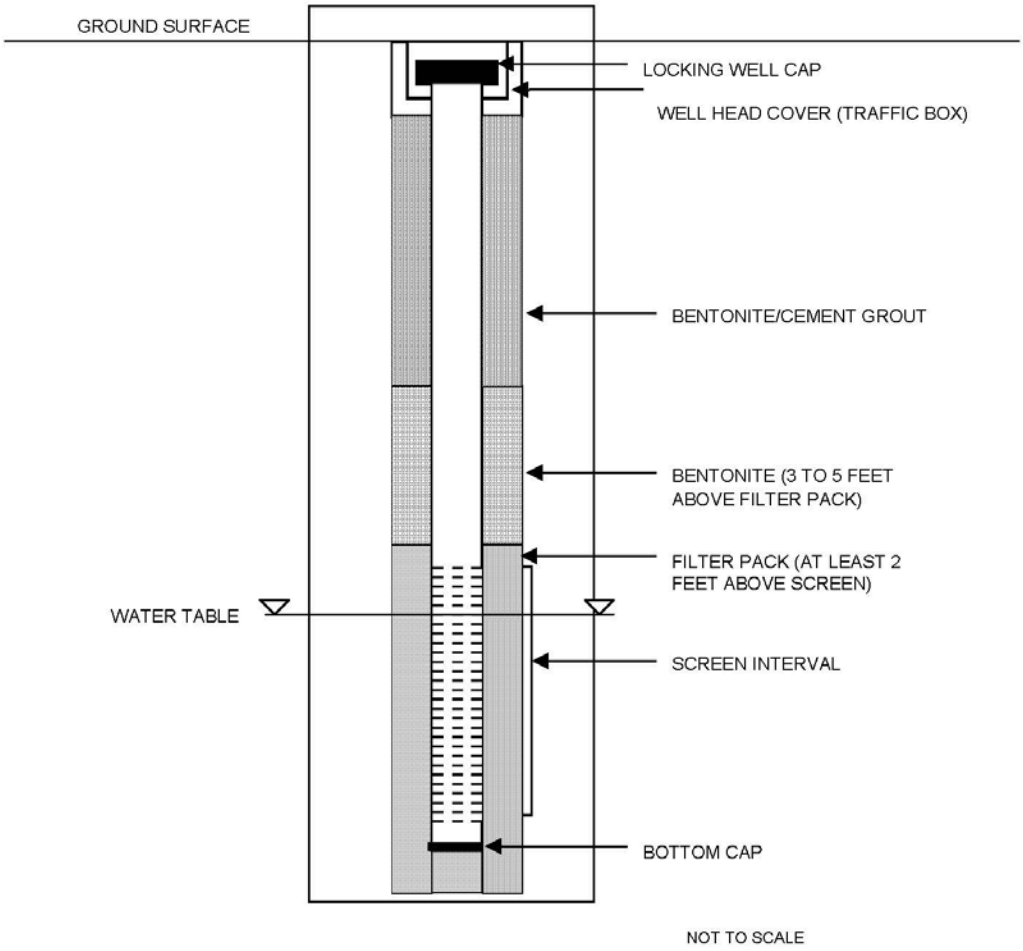


Figure I-C-1-1: General Cross Section of Monitoring Well, Unconfined Water Bearing Zone

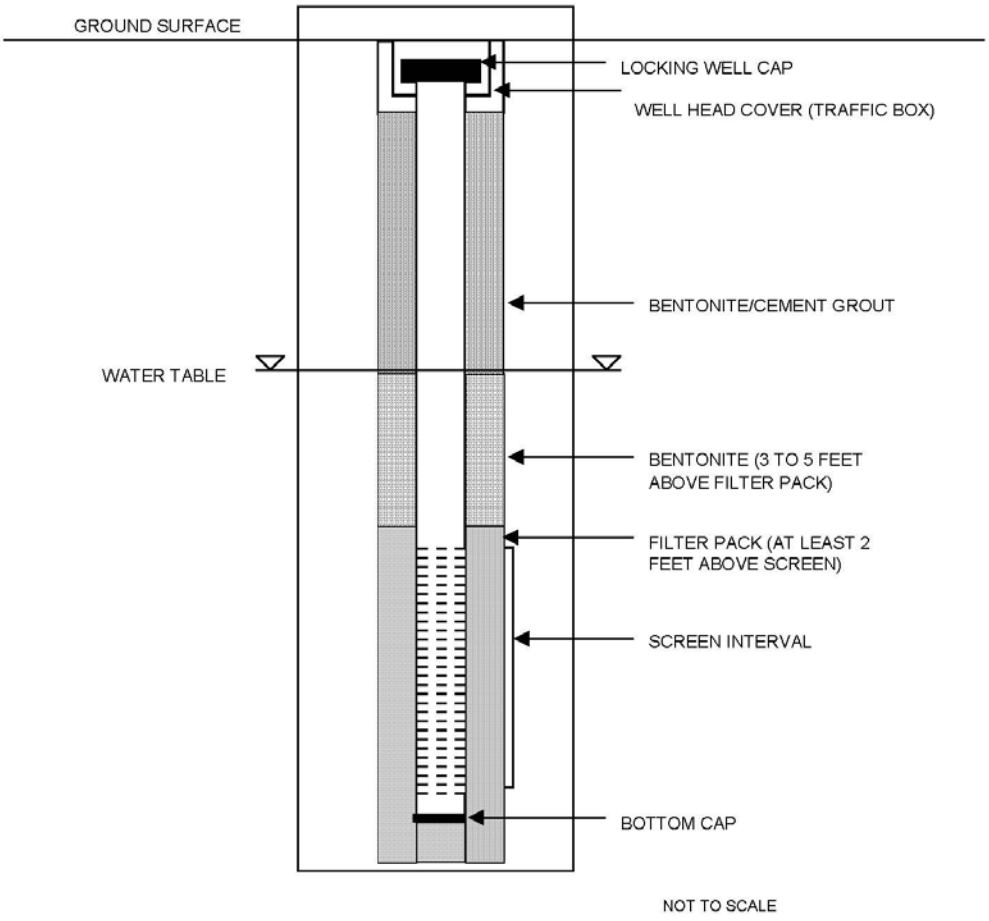


Figure I-C-1-2: General Cross Section of Monitoring Well, Confined Water Bearing Zone

5.5.3 Well Screen Selection

The screened section of the monitoring well allows groundwater to flow freely into the well, while retarding movement of fine-grained lithologic materials into the well. When designing a well screen, consider important factors, such as type of well screen material, length of the screened section, location of the screened section, the intake opening (slot) size, the type of intake opening, and size of filter pack to be utilized.

Five factors directly affect the performance of the monitoring well and are evaluated in the selection of an appropriate screen: (1) chemical resistance/interference, (2) screen length, (3) screen placement, (4) intended use of well (e.g., long-term groundwater extracted); and (5) intake opening size.

Selection of a screen material that provides chemical resistance and minimizes interference follows the same basic procedures as the selection of an appropriate casing material (see Table I-C-1-2). Some typical screen materials consist of PVC, Teflon, Type 304 stainless steel, and Type 316 stainless steel. Again, use only flush-threaded couplings. Screen sections constructed of different metals in the same well may cause electrochemical reactions that could rapidly degrade the casing or screen; therefore, do not use this type of composite well construction. In addition, construct wells intended for long-term groundwater extraction with well screen rather than slotted casing for facilitating redevelopment.

Selection of the screen length depends on its primary use(s). Most monitoring wells function as both groundwater sampling points and piezometers. Shorter-screened sections provide more specific data on vertically distributed contaminants, hydraulic head, and flow, and are generally preferred to longer-screened lengths. Saturated sections in groundwater monitoring wells shall be limited to between 5 and 10 feet in length; however, longer intervals may be justified in certain circumstances with approval of the QA Manager or Technical Director.

Placement of the screened interval within a groundwater monitoring well depends primarily upon two factors: the discrete interval and the type of contaminants to be monitored. The location of the discrete interval to be monitored will dictate the location of the screened interval within a monitoring well; however, also consider the characteristics of the contaminants to be monitored (i.e., light, non-aqueous phase liquid; dense, non-aqueous phase liquid) when choosing placement of the screened interval.

An additional consideration in the design of the screened section of the well is the hydraulic characteristics of the water-bearing zone that is to be monitored (i.e., confined or unconfined). If an unconfined zone is being monitored for contaminants that are less dense than water (e.g., gasoline, diesel, waste oil), place 3 to 5 feet of screened interval above the highest level of the water table to allow for evaluation of fluctuations in water level and to ensure that contaminant phases less dense than water can be observed. Conversely, if an unconfined zone is being monitored for contaminants that are denser than water (e.g., chlorinated solvents), place approximately 5 feet of screened interval (maximum) just above the confining unit at the base of the water-bearing zone to facilitate detection of the dense-phase contaminants. In the case of a confined water-bearing zone, use a maximum-screened interval of approximately 5 feet.

Selection of an appropriate intake opening size is critical to the performance of the monitoring well and to the integrity of groundwater samples obtained from the well. The size of the intake openings

can only be determined following the selection of an appropriate filter pack, which itself is selected based upon the grain-size of the formation. An intake size is generally designed to hold back between 85 to 100 percent of the filter pack material. Figure I-C-1-3 can be used to select appropriate intake opening sizes. The screen slots shall be factory-made (or formed).

5.5.4 Filter Pack Design

Filter pack material shall be clean and chemically stable within the monitoring well environment to minimize addition to, or sorption from, the groundwater. Filter pack shall meet the following minimum specifications:

- Filter pack material shall be at least 95 percent silica, consisting of hard, durable grains that have been washed until free of dust and contamination, and graded.
- Filter pack material shall not be angular and non-uniform such that it will bridge in the annular space, leaving a void or poorly packed materials that can consolidate or settle after construction.
- Select filter pack to meet the grading specification determined from sieve analysis of the geologic formation to be screened, if available.
- Filter pack material shall be commercially packaged in bags that prevent the entrance of contaminants, and allow proper handling, delivery, and storage at the monitoring well site. Do not use material delivered in broken bags for monitoring well construction.

In investigations where there are limited data on site conditions prior to monitoring well installation, select the filter pack size prior to field activities based on available lithologic data. Use finer filter pack sizes if fine-grained formations are anticipated to be present, and use coarser-grained filter packs in coarser lithologies and consolidated formations.

In investigations where sieve analysis data exist for a site prior to field activities, base selection of a proper filter pack upon the grain size of the formation materials to be monitored. Use the sieve data for the finest lithology identified in the interval to be monitored for establishing filter pack size. The U.S. Environmental Protection Agency recommends that filter pack grain size be selected by multiplying the 70 percent retained grain size of the formation materials by a factor between 4 and 6. Use a factor of 4 if the formation materials are fine-grained and uniform, and use a factor of 6 if the formation materials are coarse-grained and non-uniform. In any case, the actual filter pack used should fall within the area defined by these two curves. An example of this technique is presented in Figure I-C-1-4.

5.5.5 Annular Seal

The annular seal is placed directly above the filter pack in the annulus between the borehole and the well casing. The annular space must be sealed to prevent the migration of water and contaminants through the annulus. The annular seal is also intended to hydraulically and chemically isolate discrete water-bearing zones.

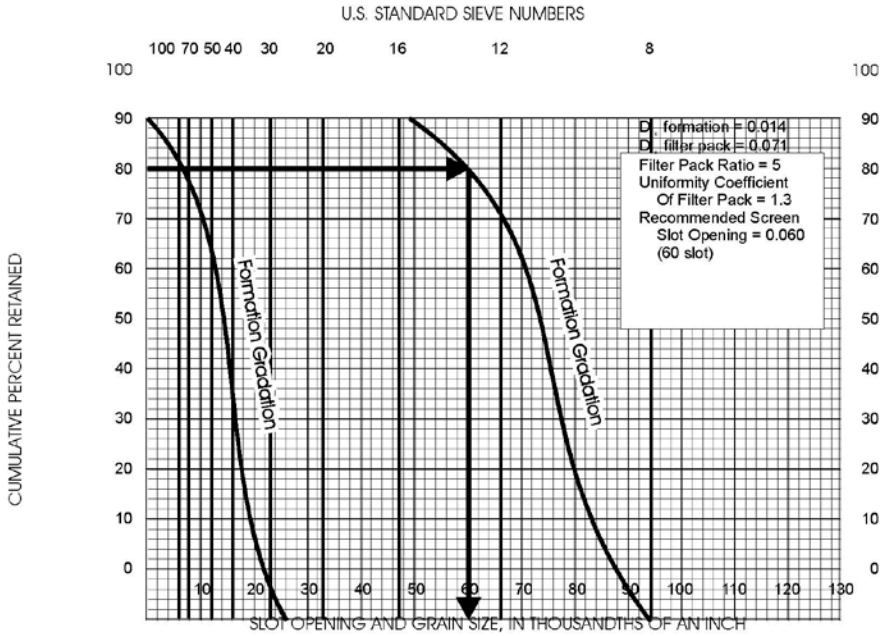


Figure I-C-1-3: Selecting Well Intake Slot Size Based on Filter Pack Grain Size

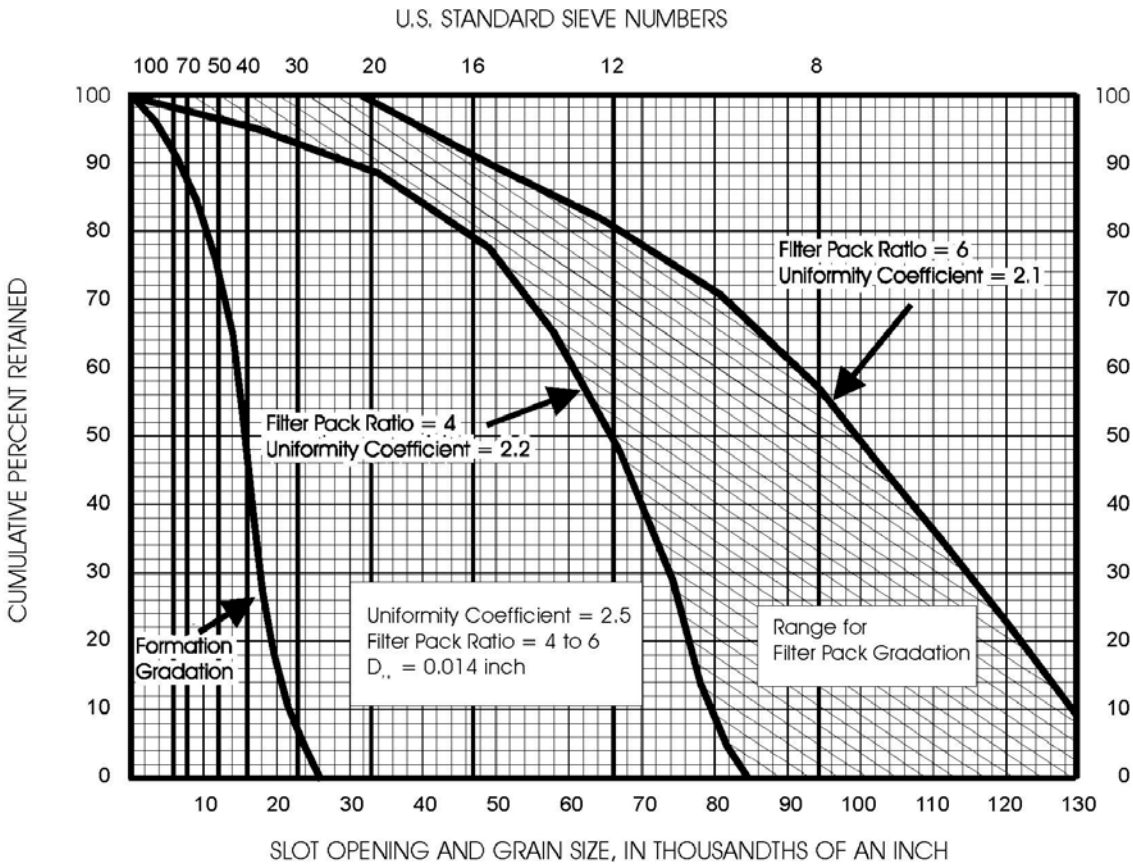


Figure I-C-1-4: Filter Pack Design Criteria

Typically, annular seals consist of two discrete sections. The first section, known as the bentonite seal, consists of a pure sodium bentonite seal. To be effective, the bentonite seal should be emplaced directly over the top of the filter pack and extend approximately 3 to 5 feet (no less than 3 feet thick). Typical materials for the seal consist of granular sodium bentonite, or sodium bentonite pellets or chips.

The second section of the annular seal typically contains grout slurry, which completely fills the remaining annular space from the bentonite seal to just below the ground surface. Grout consists of either sodium bentonite and Portland cement slurry or neat cement slurry. Give special consideration to the selection of annular seal material for wells installed in coastal areas where groundwater may contain elevated concentrations of sulfates. In this situation, use a sulfate resistant grout to prolong the usefulness of the well.

5.5.6 Surface Completion

The surface of the well shall be completed using either an above-grade (monument) style, or a flush-to-grade (traffic box) style. In either case, the protection of the wellhead at land surface is accomplished by means of a surface seal of concrete and a metal completion box surrounding the well casing. The surface seal serves to prevent infiltration of surface water and unauthorized entry, and where necessary, to provide protection from vehicular traffic.

5.6 MONITORING WELL INSTALLATION TECHNIQUES

The following general procedures describe the installation of groundwater monitoring wells.

5.6.1 General Casing and Screen Installation Techniques

Following completion of the borehole, the FM or designate will first measure the total depth of the hole to ensure that the desired depth has been attained. The lengths of casing and screen shall also be measured. These measurements shall be made with an accuracy of 0.01 feet using either a fiberglass or steel tape measure.

Installation of the casing and screen is normally accomplished by emplacing them into the well as an integral unit. Prior to installation, decontaminate individual lengths of the well casing and screen according to Procedure I-F, *Equipment Decontamination*, unless the casing and screen were certified by the manufacturer to have been properly pre-cleaned at the factory and sealed in plastic. Following decontamination, inspect each length to ensure that damaged or otherwise unsuitable sections are not used.

To ensure even distribution of filter pack, bentonite seal, and grout materials around the well within the borehole, suspend the casing and screen with a threaded hoisting plug and do not allow them to rest on the bottom of the boring unless the installation is less than 30 feet deep.

5.6.2 Centralizers

Install centralizers at the top and bottom of screened sections when using the air or mud rotary techniques for well installation. Also place centralizers at 20- to 40-foot intervals on blank casing; the FM will determine the spacing according to the depth of the well. Align the centralizers from top to bottom of the casing so that they do not interfere with the insertion and removal of the tremie pipe. All devices used to affix centralizers to the casing shall not puncture the casing or contaminate the groundwater with which they come in contact. Centralizers shall be constructed of stainless steel.

5.6.3 Filter Pack Installation

Prior to the addition of any filter pack material, cover the top of the well casing to prevent filter pack material from entering it.

The filter pack is usually installed through HSAs, conductor casing, or a tremie pipe depending on the drilling technique used; however, if the depth to the bottom of the screened interval is less than 10 feet, and lithologic materials are sufficiently consolidated to preclude the possibility of hole collapse, the filter pack may be poured into the annular space of the well from the ground surface. This procedure applies to any drilling method.

During installation, measure the level of the top of the filter pack periodically to ensure that no bridging has occurred, and to determine the depth to the top of the filter pack. Be sure that the filter pack encloses the entire length of the screened section. For wells less than 100 feet in total depth, the filter pack shall generally extend to 2 feet above the top of the screened section of the well. For wells greater than 100 feet in total depth, an additional 1 foot of filter pack may be emplaced above the screen for each 100 feet of well depth.

An alternative to conventional monitoring well construction and installation is through the use of small diameter pre-fabricated monitoring wells, commonly referred to as “pre-pack” wells. Pre-pack wells typically consist of a well screen (slotted PVC) surrounded by sand (filter-pack) held in place by a stainless steel or polyethylene mesh. The pre-pack well assembly is commonly used in conjunction with direct-push drilling methodologies, which allows a relatively quick installation of these small diameter wells. Having the filter pack around the slotted PVC before the well screen is installed ensures that the filter pack is located directly around the well screen and minimizes the effort required for the filter pack installation.

The filter pack is normally an inert (e.g., siliceous) granular material that has a grain-size distribution chosen to retain formation materials. A sleeved screen consists of a slotted pipe base over which a sleeve of stainless steel mesh filled with selected filter media is installed. Pre-packed or sleeved screens may be used for any formation conditions, but they are most often used where heaving, running or blowing sands make placement of conventional well screens and filter packs difficult, or where predominantly fine-grained formation materials are encountered (ASTM 2010). During installation, the boring is advanced using hollow drive rods with an expendable drive point. Upon reaching the desired monitoring well installation depth, the entire well assembly (i.e., pre-pack well) is lowered to the desired depth within the hollow drive rods. At the desired depth, the hollow drive rods are retracted to a point above the screen. At this step a barrier is placed directly above the screen to prevent grout or material from entering the screened interval as the hollow drive rods are extracted from the boring. This barrier can be created either by natural formation collapse (occurring during the initial rod retraction), by gravity installation of fine-grade sand through the rod annulus, or as part of the pre-pack monitoring well components (e.g. expanding foam bridge). With the barrier in place, granular bentonite or bentonite slurry is then installed in the annulus to form a well seal. When installing pre-pack screens additional sand must be used to fill in the annular space between the pre-pack and the edge of the borehole. Furthermore, filter sand should be installed to at least 2 feet above the top of the pre-packed well screen.

Vendors offer pre-pack monitoring well components with varying outer diameters, which is typically based on the inner diameter of the hollow drill rods. These types of wells may be sampled by several

methods including peristaltic pump, mini-bailer, or bladder pump to yield data of similar quality to that of conventional monitoring wells.

Following the installation of the filter pack, a surge block or large bailer shall be placed into and removed from the casing for approximately 10 minutes to set and compact the filter pack and to begin well development. Then, check the level of the filter pack again. Add more filter pack material according to the procedures described above if any settling of the filter pack has occurred. After emplacement, note the volume of filter pack material placed in the well, record it in the well completion record (Figure I-C-1-5), and compare it to the calculated volume of filter pack that was expected to have been used.

5.6.4 Annular Seal Installation

The sodium bentonite seal shall have a minimum thickness of 3 feet. Generally, to be effective the bentonite seal should extend above the filter pack approximately 3 to 5 feet. It may be constructed of powdered, granular, or pelletized bentonite, and may be emplaced as a dry solid, powder, or slurry. Use only sodium bentonite manufactured specifically for use in the drilling and construction of water wells. Typically, granular or pelletized bentonite is emplaced dry. Powdered bentonite is usually mixed with potable water to produce a slurry. Depending on the type of installation method, the bentonite may be emplaced through the HSAs, conductor casing, or tremie pipe.

In dry form, place the bentonite directly on the top of the filter pack. After emplacing each 1-foot-thick layer of dry bentonite in the well, add approximately 5 gallons of water of known chemical quality to hydrate the bentonite. Allow a minimum of 15 minutes for hydration of the bentonite seal once it is completely installed.

When emplacing the bentonite in slurry form, take care to ensure that the bentonite is thoroughly mixed, with no visible lumps to ensure the proper consistency. Then place a 1-foot layer of fine-grained silica sand over the top of the filter pack. This fine-grained sand layer will prevent infiltration of the filter pack by the bentonite slurry.

Emplace the remaining annular seal following the installation of the bentonite seal. The annular seal shall be a slurry consisting of 7 to 9 gallons of water per 94-pound bag of Portland cement Type I or II and a minimum of 3 to 5 percent bentonite (1/4 to 1/2 bags of bentonite powder per five bags of Portland cement). The slurry may be emplaced through a HSA, conductor casing, or tremie pipe, depending on the method of installation. Thoroughly mix the grout to ensure the proper consistency with no visible lumps of dehydrated powder. The rates at which the augers or pipe are withdrawn and the slurry added will be such that the level of the grout within the well annulus is just below the lowermost auger or pipe.

If a tremie pipe is used, emplace the annular grout seal by pumping through a pipe with a minimum 1-inch I.D., in one continuous pour, from the top of the transition seal to the ground surface. Place the bottom of the tremie pipe about 5 to 10 feet above the transition seal, depending on the stability of the hole and impact velocity of the grout.

A tremie pipe is not required for annular seals less than 10 feet from the ground surface to the top of the transition seal or for grouting within dual wall drill strings or HSAs. Measure the volume of grout seal material placed in the well, record it in the well construction log, and compare it with the

calculated volume. The slurry shall extend from the top of the bentonite seal to a depth of approximately 2 feet below ground surface (bgs).

5.6.5 Annular Seal "Set Time" and Setting

Let the annular grout seal set at least 12 hours before disturbing the casing or well so that separations or breaks do not occur between the seal and the casing, or between the seal and the borehole. Development of the well is prohibited until the grout seal has set. Likewise, the concrete slab, traffic box, and/or casing riser of the surface completion shall not be poured and constructed until the grout seal has set. Top off any settlement of the grout seal as soon as possible after it sets. Record all pertinent data on the well construction log.

5.6.6 Surface Completion

The surface of a groundwater monitoring well shall be either an above-ground completion or as a flush-to-ground completion. Regardless of the method, each monitoring well shall have, at a minimum, a casing cap, concrete slab and annular seal, and a locking protective casing or locking vault. Although wellheads vary in size, effort should be made to use a consistent size wellhead or similar completion per site.

In an above-ground completion, the protective casing or monument is installed around the top of the well casing within a cement surface seal. A 2-foot-long by 2-foot-wide cement pad with a minimum thickness of 3 inches is constructed around the protective casing. Type 1 Portland cement, which meets the requirements of CLASS A standards, is used for the surface seal. Inspect the monument prior to installation to ensure that no oils, coatings, or chemicals are present. Once installed, maintain the monument in a plumb position with 2 to 3 inches of clearance between the top of the well casing and the lid of the monument. The monument shall extend at least 18 inches above grade and at least 12 inches below grade. Construct a minimum of three concrete-filled posts around the well to protect it from vehicular damage.

Inside the monument, cut or scribe two permanent survey marks, approximately 0.25 inches apart, into the top of the well casing, and also permanently mark the well with its identification number. Permanent marks may include painting, marking, or engraving on the protective casing or surface completion. An alternate option may be to attach a non-corroding, imprinted metal tag to part of the well. Cover the top of the well casing with a slip cap or locking cap to prevent debris from entering the well. Fit the monument with a casehardened lock to prevent unauthorized entry.

In a flush-to-ground completion, the protective casing or traffic box is installed around the top of the well casing, which has been cut off slightly below grade. The traffic box has a lid that is held firmly in place by bolts and has a flexible O-ring or rubber gasket to prevent water from entering the box. Whenever possible, wells with flush completions should not be placed in low spots where surface water can accumulate. If this is unavoidable, consider an aboveground completion. The traffic box is set within a cement surface seal slightly above grade to deflect surface water flow away from the well. The surface seal must form an apron at ground surface that is at least 2 feet wide and 4 inches thick. The concrete apron must slope away from the well (a minimum of 1 percent) to prevent surface water leakage into the well head (DOH 2009). An effort should be made to standardize the appearance of the well completions at a particular site. Type 1 Portland cement, which meets the requirements of CLASS A standard, is used for the surface seal. Where monitoring well protection must be installed flush with the ground, an internal cap should be fitted on top of the riser within the

manhole or vault. This cap should be leak-proof so that if the vault or manhole fills with water, the water will not enter the well casing. The cap should also be able to lock to prevent unwanted access or tampering with the well. Ideally, the manhole cover cap should also be leak-proof (ASTM 2010). Inspect the traffic box prior to installation to ensure that no oils, coatings, or chemicals are present. Once installed, maintain the traffic box in a level position that leaves 2 to 3 inches of clearance between the top of the well casing and the lid of the traffic box. Regular maintenance may be necessary to maintain the integrity of the seals and pads protecting the wells.

Cut two permanent survey marks into the top of the well casing, approximately 0.25 inches apart, and also permanently mark the well with its identification number. Cover the top of the well casing with a lockable cap to prevent debris from entering the well. Also fit the lockable cap with a casehardened lock to prevent unauthorized entry.

In areas where there is a high probability of damaging the well (high traffic, heavy equipment, poor visibility), it may be necessary to enhance the normal protection of the monitoring well through the use of posts, markers, signs, or other means. The level of protection should meet the damage threat posed by the location of the well (ASTM 2010).

5.6.7 Installation of Surface Casing

The use of surface casing may be required to minimize the potential for cross-contamination of different hydrogeologic zones within the subsurface of a site. The depth of placement of the surface casing shall be based on site-specific geologic knowledge obtained from lithologic samples collected in situ during the drilling of the well boring.

If a surface casing is to be installed permanently along with the well, grout it in place. The borehole shall be of sufficient diameter that a tremie or grout pipe can be easily placed between the borehole wall and the outside of the surface casing. After the desired placement depth is reached and the drilling tools are removed from the borehole, lower the casing into the borehole and center it. The bottom of the surface casing may be plugged or driven into the sediment at the base of the borehole to keep grout from entering the casing, if necessary.

Install grout through the tremie pipe and pump it from the bottom of the casing to ground surface. As the grout is being placed, raise the tremie pipe slowly to avoid excessive backpressure and potential clogging of the tremie pipe. After the grout has been allowed to set for at least 24 hours, drilling and subsequent well installation can continue. The required time for grout to set before drilling can continue depends on the volume of grout emplaced; the more grout used, the longer the delay time.

JOB NO.: _____ WELL NO. _____ HYDROGEOLOGIST: _____

CLIENT: _____ DRILLER: _____

WELL LOCATION: _____ DATE/TIME: _____

DETAILS OF CONSTRUCTION

Date Completed _____

Borehole Diameter (in.) _____

Type and Size of Casing (in.) _____

Type and Size of Screen (in.) _____

Screen Perforation Diameter (in.) _____

Screen Length (ft.) _____

Centralizer Depths (ft.) _____

Completion Technique

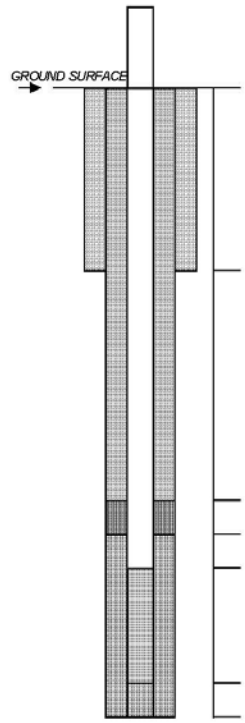
1. Type of Filter Pack and Placement Method _____
2. Type of Be ntonite and Placement Method _____
3. Type of Grout Mixture and Placement Method _____

Description of Potential Problems With Well:

_____

Development Technique

_____



Well Head Elevation _____

Ground Surface Elev. _____

Well Head Completion Method

_____

Drilling Method/Rig Type _____

Surface Casing: Type _____
Diameter _____
Length _____

MATERIALS

Cement (sks.) _____

Filter Pack Material (ft.^{3}) _____

Casing Material (ft.) _____

Bentonite (ft.^{3}) _____

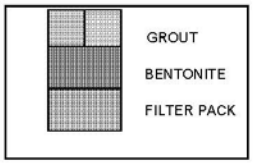
Top of Be ntonite Seal _____ ft.

Top of Filter Pack _____ ft.

Top of Screen _____ ft.

Bottom of Screen _____ ft.

Bottom of Hole _____ ft.



NOTE: ALL DEPTHS ARE REFERENCED TO GROUND SURFACE

Figure I-C-1-5: Well Completion Record

5.6.8 Shallow Well Completion

Due to the occurrence of shallow groundwater in some areas, there are instances when the top of the screened interval must be placed at a depth so shallow that it is impossible to install the well using the typical design for annular materials (i.e., 2 feet above the screen for filter pack followed by a 3-foot thickness of bentonite seal). In cases where the top of the screen must be placed between 4 and 6 feet bgs, use the following design alteration:

- Place the filter pack 1 foot above the top of the screened interval.
- Place a minimum of 3 feet of bentonite seal above the filter pack.
- Fill the remainder of annular space with a 3 percent to 5 percent bentonite-cement grout.

In no case shall the top of the screen be brought higher than 4 feet bgs because it is difficult to install a reliable annular seal at these shallow depths.

5.6.9 Method-specific Well Installation Techniques

The following sections describe well installation techniques for groundwater monitoring at hazardous waste sites. Sections on troubleshooting common problems encountered when using each technique and potential solutions to the problems are included.

5.6.9.1 HSA

General methods of well installation using the HSA technique are listed below:

- Complete a pre-installation design drawing in accordance with Section 5.4.1.
- Prior to well installation, properly decontaminate and measure the well screen, cap, and casing to ensure accurate placement of well casing and screen. Mark the well casing near the ground surface to signal to the drillers where the casing should be placed.
- Remember that wells are constructed within the augers as the augers are removed from the ground.
- The diameter of the well casing constructed within an HSA is limited to 4 inches. *Note:* The difference between the I.D. of the HSA and O.D. of the well casing must be at least 4 inches to permit effective placement of filter pack, bentonite seal, and grout.
- Remove the inner rod and hammer quickly, measure the depth of the borehole, and place the well screen and casing quickly into the auger to the desired depth. *Note:* the well screen and casing shall be suspended in hole by the use of a hoisting bail in order to ensure proper depth and plumb construction. This may not be necessary for wells less than 30 feet in depth.
- Prior to adding filter pack, cover the top of the well casing to prevent filter pack material from entering it.
- The HSA acts as tremie pipe for placement of filter pack, bentonite, and grout.
- Slowly pour filter pack between the inside of the auger and the outside of the well casing.
- While the filter pack material is being poured, incrementally withdraw the auger. The rate of auger withdrawal and filter pack placement shall allow for the top of the filter pack level to be just below the lead auger. In general, the augers should be withdrawn in increments of

2 to 3 feet. *Note:* The level of the top of the filter pack shall be constantly tagged with a measuring tape during emplacement of the filter pack.

- Surge the well to consolidate the filter pack; add more if settlement occurs.
- Emplace bentonite pellets or chips through the HSA. Tag the level of the bentonite periodically to ensure accurate placement. For each foot of bentonite seal installed in an unsaturated completion, pour 5 gallons of water of known chemical quality into the well to hydrate the bentonite. If the bentonite seal is less than 10 feet bgs and the borehole is stable, the bentonite may be emplaced directly from the top of the borehole rather than through the HSA.
- After allowing 15 minutes for the bentonite seal to hydrate, emplace a grout seal through the HSA from the top of the bentonite seal to within 2 feet of ground surface. The grout shall be emplaced from bottom to top in one continuous pour. If the top of the bentonite seal is less than 10 feet bgs and the borehole is not subject to collapse, the grout may be emplaced directly from the top of the borehole. If the top of the bentonite seal is greater than 10 feet bgs, a tremie tube shall be used to emplace the grout. The composition of the grout is detailed in Section 5.4.5.
- Construct an above- or below-ground wellhead.

Potential Problems and Solutions

Bridging Filter Pack or Bentonite Seal

Bridging filter pack or bentonite can create unwanted void spaces or lock the well casing within the HSA.

Avoidance of Locked Well Casing

- Carefully tag the filter pack level and keep it just below the lead auger while the auger is inched up and sand is slowly added.
- Use an auger with a larger I.D.
- Use filter pack materials with a larger grain size.
- Add water of known chemical quality while pouring the sand filter pack. Try this only in cases where the filter pack is very fine.

Solutions for Unlocking Well Casing from Augers

- Gently hold the casing in place while lifting and twisting the auger (do not force).
- Insert the surge block into the casing and gently surge the water column if bridge is below water table.
- Add water between the well and auger if the sand bridge is above the water table.
- Attach an air compressor to a tremie pipe, and then gently blow the bridge away.
- Completely remove the casing and screen, and reinstall the well.
- Never drive the casing out of the auger with a hammer because this will break the casing.

Heaving, Surging Materials

Fine-grained saturated materials that might cause surging problems are common in coastal areas. Heaving sediments might cause problems when drilling with HSA.

Solutions for Heaving Sediments

- Over-drill the borehole by 5 or 10 feet to provide space for heaving sediments to fill in while well installation begins. Begin placement of filter pack as soon possible. Add it quickly until over-drilled space is filled.
- Add clean water to a level above the water table to create a downward pressure on the heaving materials. The volume of water added shall be recorded on the well installation log and extracted during well development.
- Drill an initial pilot borehole and sample with a 6-inch-diameter auger. The 6-inch auger may be fitted with plastic or metal core catcher on the lead auger, which will allow for soil sampling and prevent sediments from entering augers. After the total sampling depth is reached, the 6-inch auger is removed and 10-inch-diameter augers are substituted to ream out the borehole. Fit the lead auger with a tapered stainless steel plug. At a depth below the desired total depth of the well, use the sampling hammer and center rod to knock out the stainless steel plug. Then complete well installation.

5.6.9.2 Direct Rotary with Foam or Mud

General well installation techniques using direct rotary with foam or mud are listed below:

- Complete a pre-installation design drawing in accordance with Section 5.4.1.
- Prior to well installation, measure the well screen, cap, and casing to ensure accurate placement of well casing and screen. Place mark on the portion of the well casing near ground surface to identify to the drillers where the casing should be placed. Place centralizers on the well casing and screen as discussed in Section 5.5.2.
- With DRD techniques, wells are constructed in the borehole after the bit and drill pipe are removed from the hole. For mud rotary drilling, first thin the mud sufficiently prior to removing the bit and drill pipe from the hole. Thinning the mud allows faster and more accurate placement of the annular materials within the borehole, which balances the density of the borehole fluids so they more closely match the density of the fluids used to install the filter pack and bentonite seal. It also reduces the potential for annular materials to be washed out of the borehole through the tremie.
- After the bit and drill pipe are retrieved from the hole as smoothly and quickly as possible, measure the total depth of the hole to verify its depth and to check its stability.
- Suspend the well screen and casing in the hole by the use of hoisting bail in order to ensure proper depth and a plumb construction. This may be unnecessary for wells less than 30 feet in depth. Place the casing and screen in the hole as fast as is safely possible to minimize the time that the borehole stays open.
- Prior to the addition of filter pack, cover the top of the well casing to prevent filter pack material from entering the well casing.

- Use a tremie pipe for placement of filter pack, bentonite, and grout. Also emplace the filter pack and bentonite seal as soon as possible to avoid potential collapse of the hole.
- Slowly pour the filter pack into the tremie pipe to avoid bridging within the tremie pipe at the water table. The level of the top of the filter pack shall be constantly tagged with measuring tape as the filter pack is being emplaced.
- Make the bentonite seal at least 3 feet thick. It should consist of bentonite pellets or chips emplaced through the tremie pipe. Tag the level of the bentonite periodically to ensure accurate placement. If the bentonite seal is less than 10 feet bgs and the borehole is stable, the bentonite may be placed directly from the top of the borehole rather than through the tremie pipe.
- After allowing 15 minutes for the bentonite seal to hydrate, emplace a grout seal through the tremie pipe from the top of the bentonite seal to within 2 feet of ground surface. The grout shall be placed from bottom to top in one continuous pour. If the top of the bentonite seal is less than 10 feet bgs, and the borehole is not subject to collapse and is not filled with drilling fluid, the grout may be placed directly from the top of the borehole. The composition of the grout is detailed in Section 5.4.5.
- Construct an above- or below-ground wellhead.

Potential Problems and Solutions

Bridging Filter Pack or Bentonite Seal

Bridging filter pack or bentonite can create unwanted void spaces that might collapse in the future.

Solution

Controlled pouring of the annular materials is the best solution for bridging. In the case of mud rotary, however, it may be necessary to perform emplacement of the filter pack and bentonite chips or pellets through the borehole without the aid of a tremie pipe. For wells greater than 10 feet deep, obtain the approval of the QA Manager or Technical Director.

5.6.9.3 AIR ROTARY AND AIR ROTARY WITH CASING HAMMER

General well installation techniques using ARD or ARCH are listed below:

- Prepare a pre-installation design drawing in accordance with Section 5.4.1.
- Prior to well installation, properly decontaminate and measure the well screen, cap, and casing to ensure the accurate placement of well casing and screen.
- Remember that with ARD techniques, wells are constructed in the borehole after the bit and drill pipe are removed from the hole. With ARCH, the driven casing remains in the ground and is slowly withdrawn as well installation proceeds.
- After the bit and drill pipe are retrieved from the hole as smoothly and quickly as possible, measure the total depth of the hole to verify its depth and to check its borehole stability.
- To ensure proper depth and a plumb construction, suspend the well screen and casing in the hole using a hoisting bail. Place the casing and screen in the borehole as fast as is safely possible to minimize the time that the hole stays open, particularly for ARD.

- Before adding filter pack, cover the top of the well casing to prevent filter pack material from entering it.
- For ARD, use a tremie pipe for placement of filter pack, bentonite, and grout. Emplace the filter pack and bentonite seal as soon as possible to avoid potential collapse of the hole. For ARCH, the annular materials can in most cases be placed directly between the driven casing and the well casing. A tremie pipe is advisable if exacting placement is required.
- For ARD, place the tremie pipe within 2 feet of the interval where the filter pack is to be placed. Slowly pour the filter pack into the tremie pipe to avoid bridging within the tremie pipe at the water table. The tremie pipe shall be slowly withdrawn during placement.
- Periodically tag the level of the top of the filter pack with measuring tape while the filter pack is being emplaced. Install bentonite in a similar manner.
- For ARCH, pour the filter pack slowly between the well casing and driven casing. The driven casing shall be withdrawn periodically while the filter pack is being emplaced. Withdraw the driven casing in increments no greater than 2 to 3 feet.
- For ARD, emplace bentonite pellets or chips through the tremie pipe to a minimum thickness of 3 feet. Tag the level of the bentonite periodically to ensure accurate placement. For each foot of bentonite seal installed in an unsaturated completion, add 5 gallons of water of known chemical quality into the well to hydrate the bentonite. If the bentonite seal is less than 10 feet bgs and the borehole is stable, the bentonite may be emplaced directly from the top of the borehole rather than through the tremie pipe. For ARCH, emplace the bentonite between the well casing and the driven casing while the driven casing is being withdrawn.
- Emplace a grout seal through the tremie pipe for the ARD method or through the driven casing for the ARCH method. Emplace the grout from the top of the bentonite seal to within 2 feet of ground surface. The driven casing or tremie pipe shall be withdrawn as the grout is placed. Emplace the grout from bottom to top in one continuous pour following placement of the bentonite seal. If the top of the bentonite seal is less than 10 feet bgs and the borehole is not subject to collapse, emplace the grout directly from the top of the borehole. The composition of the grout is detailed in Section 5.4.5.
- Construct an above- or below-ground wellhead.

Potential Drilling Problems

Bridging Filter Pack or Bentonite Seal

Bridging filter pack or bentonite can create unwanted void spaces that might collapse in the future.

Solutions

Controlled pouring of the annular materials is the best solution against bridging.

Heaving Sediment

Fine-grained saturated materials that might cause heaving problems are common in coastal areas. Difficulties caused by heaving sediments might create problems when drilling with ARCH. Heaving sediments cannot be drilled using ARD techniques.

Solutions for Heaving Sediments

- Over-drill the borehole by 5 or 10 feet to provide space for heaving sediments to fill in while well completion is begun.
- Add clean water to a level above the water table to create a downward pressure on the heaving materials. The volume of water added should be extracted during well development.
- Heaving sands may also be controlled by first removing the drill pipe from the hole, and then constructing an airlift line made from the tremie pipe. If there is sufficient water above the heaving sands, an air line connected approximately 10 feet from the bottom of the tremie pipe can be used to air lift out the fine-grained sediments at the base of the casing.
- Begin placement of filter pack as soon as possible and add it quickly until the over-drilled space is filled.

5.6.9.4 DTCH

General well installation techniques using DTCH are listed below:

- Prepare a pre-installation design drawing in accordance with Section 5.4.1.
- Prior to well installation, measure the well screen, cap, and casing to ensure accurate depth placement of well casing and screen. Place a mark near the top of the casing to identify to the drillers the proper position to place the casing and screen.
- Like HSA drilling techniques, wells are constructed within the dual tube pipe as the pipe is removed from the ground.
- Prior to setting the casing and screen in the hole, verify total depth of the hole by measuring it and check for surging materials. Suspend the well screen and casing in the hole using a hoisting bail in order to ensure proper depth and plumb construction.
- Prior to addition of filter pack, cover the top of the well casing to prevent filter pack material from entering the well casing.
- The inner pipe of the dual tube assembly shall act as tremie pipe for placement of filter pack, bentonite, and grout.
- Slowly pour the filter pack between the inside of the augers and the outside of the well casing to avoid potential bridging of the annular materials. While the filter pack material is being poured, the dual tube pipe shall be incrementally withdrawn. The rate of pipe withdrawal and filter pack emplacement shall allow for the top of the filter pack level to be just below the shoe of the dual tube assembly. The level of the top of the filter pack shall be constantly tagged with measuring tape.
- Use bentonite pellets or chips to construct the well seal, which shall be a minimum of 3-feet thick, and shall also be emplaced through the dual tube assembly. For each foot of bentonite seal installed in an unsaturated completion, 5 gallons of water of known chemical quality shall be poured into the well to hydrate the bentonite. Tag the level of the bentonite periodically to ensure accurate emplacement. If the bentonite seal is less than 10 feet bgs and the borehole is stable, the bentonite may be emplaced directly from the top of the borehole rather than through the tremie pipe.

- Emplace a grout seal through the dual tube assembly from the top of the bentonite seal to within 2 feet of ground surface. Emplace the grout from bottom to top in one continuous pour immediately following emplacement of the bentonite seal. If the top of the bentonite seal is less than 10 feet bgs, the grout may be emplaced directly from the top of the borehole. The composition of the grout is detailed in Section 5.4.5.
- Construct an above- or below-ground wellhead.

Potential Problems and Solutions

Bridging Filter Pack or Bentonite Seal

Bridging filter pack or bentonite can create unwanted void spaces or lock the well casing and dual tube pipe together.

Avoidance of Locked Well Casing

- Tag carefully and always keep the filter pack just below the shoe while inching the dual tube assembly up and slowly adding sand.
- Use a smaller-diameter well casing.
- Use a filter pack with a larger grain size.
- Add water while pouring the sand filter pack. Avoid this unless absolutely necessary.

Solutions for Unlocking Well Casing from Dual Tube Pipe

- Insert a surge block into casing and gently surge the water column if the bridge is below water table.
- Add water between the well and piping if the sand bridge is above the water table.
- Attach an air compressor to a tremie pipe, and gently blow the bridge away.

Heaving, Surging Materials

Fine-grained saturated materials that might cause surging problems are common in coastal areas. Heaving sediments might cause problems when drilling with DTCH.

Solutions for Heaving Sediments

- Over-drill the borehole by 5 or 10 feet to provide space for heaving sediments to fill in while well completion begins.
- Add clean water to a level above the water table to create a downward pressure on the heaving materials. The volume of water added should be extracted during well development.
- Remove the drill pipe from the hole, and then construct an airlift line made from the tremie pipe. If there is sufficient water above the heaving sands, an air line connected approximately 10 feet from the bottom of the tremie pipe can be used to air lift out the fine-grained sediments at the base of the casing.
- Begin emplacement of the filter pack as soon as possible, and add it quickly until the over-drilled space is filled.

5.6.10 Well Construction Record Keeping Procedures

A written well completion record (Figure I-C-1-5) detailing the timing, amount of materials, and methods of installation/construction for each step of monitoring well construction shall be prepared during construction of each monitoring well by the FM or designate. Construction records shall be kept in a hard-bound field notebook dedicated to the CTO. An "as-built" drawing illustrating the placement location and amounts of all materials used in construction of each monitoring well shall be prepared in the field at the time of construction. The well construction record shall be filled out with indelible ink. Construction records shall include the date/time and quantities of materials used at each of the following stages of monitoring well construction, including:

- Drilling
  - Drill rig type
  - Drilling method/coring method
  - Drill bit/core barrel diameter (hole diameter)
  - Drill company, driller, helper(s)
  - Field geologist, supervising geologist
  - Dates/times start and finish drilling hole, interval drilling rates
  - Total depth of hole
  - Drilling location, surveyed ground elevation
  - Inclination of hole from horizontal
- Borehole abandonment – type, volume, and surface seal
- Casing material – type
- Casing decontamination – document process and equipment used
- Casing diameter – nominal I.D. of casing
- Screen material
  - Type
  - Top and bottom of section as actually installed
  - Length
  - Slot type, size, shape
  - Type of bottom plug and/or cap used
- Filter pack material
  - Composition and size gradation
  - Manufacturer
  - Actual volume and depth of top and bottom of filter pack
  - Calculated volume versus actual volume used and explanation of discrepancies
- Transition seal

  - Composition and depth of top and bottom of seal
  - Size (or gradation) or material used (e.g., pellets, granulated, or powdered)
  - Time allowed for hydration prior to emplacement of annular grout slurry seal
- Annular slurry seal
  - Date and time of beginning and completion of annular seal
  - Type and actual volume of seal
  - Calculated volume versus actual volume and explanation of discrepancies
  - Set time allowed prior to commencement of additional work
- Surface completion
  - Type of construction
  - Nature of materials used for surface completion
  - Date/time of completion

5.6.11 Well Location

A registered land surveyor shall survey each monitoring well location for exact horizontal location to the nearest 0.5 foot, and exact vertical location to the nearest 0.01 foot, referenced to mean sea level or mean low low water. The vertical elevation shall be surveyed between the two notches cut in the top of the well casing, which is the point from which all water level measurements shall be made. The elevation of the ground or top of the concrete slab adjacent to the monitoring well shall also be surveyed, to the nearest 0.01 foot.

5.7 WELL ABANDONMENT/DESTRUCTION

Once a monitoring well is no longer needed as part of an investigation, or has been damaged to the extent that it cannot be repaired, it is essential that it be properly abandoned. The proper abandonment of a monitoring well ensures that the underlying groundwater supply is protected and preserved. In addition, proper well abandonment eliminates a potential physical hazard and liability. An additional permit and/or inspection may be required for abandonment, depending on state or local regulations.

The standard procedures for the abandonment of a groundwater monitoring well apply to the HSA drilling method. This type of installation was chosen because it is the primary method of abandoning groundwater monitoring wells. For wells abandoned on Guam, the current Guam Environmental Protection Agency Well Abandonment Procedures shall be followed (Attachment I-C-1-1).

The first step in abandoning a groundwater monitoring well is to remove the surface completion from around the top of the well casing. This is normally accomplished using a jackhammer to break the surface cement seal, and then removing the monument or traffic box. When the surface seal and the wellhead cover have been removed, over-drill the well to its total depth using HSAs. Once the total depth of the well has been reached, remove the casing and screen from the borehole. Then completely backfill the borehole with a grout seal. Typically, the grout seal is emplaced as slurry of Portland cement grout, which contains a minimum of 3 to 5 percent bentonite as described in

Section 5.4.5. When mixing the slurry, take care that the bentonite is mixed according to the manufacturer's specifications to ensure the proper consistency.

Emplace the slurry through the HSAs. The rates at which the augers are withdrawn and the slurry is added shall be such that the level of the slurry within the borehole is just below the lead auger. The borehole seal shall extend from the total depth of the borehole to a depth of approximately 1 foot bgs. Then repair the surface to prior conditions and grade.

If the monitoring well casing cannot be pulled or drilled out, perforate the well casing adjacent to the saturated zones so that the annular space and any nearby voids can be filled with sealing material. Fill the perforated well or borehole from the bottom up with an appropriate sealing material, such as neat cement. Inject the neat cement under pressure to force it into the annular space, nearby voids, and filter pack. Apply pressure for a sufficient time to allow the cementing mixture to set. After the cement has hardened, excavate a hole around the well (use a backhoe if necessary) to the depth specified in the Monitoring Well Abandonment Work Plan (WP) and ensure the excavation depth is in accordance with local regulatory agency guidelines (Attachment 1 for *Guam Monitoring Well Abandonment Procedure*) (GEPA 2006). Remove the uppermost portion of the casing, (if still in place), and pour a cement cap on top of the abandoned well, and backfill the remaining portion of the excavation with sealing material. Note, if personnel are required to enter the excavation to remove the upper portion of the casing, then proper sloping and shoring are required as per Section 25, *Excavations* of The Safety and Health Requirements Manual EM 385-1-1 (USACE 2008).

The State of Hawaii Department of Health Hazard Evaluation and Emergency Response must be notified at least 1 week prior to any well abandonment activities conducted in Hawaii (DOH 2009, Section 6.2.5.1). Additionally, an Abandonment of Monitoring Well Summary Report should be prepared using the form presented in Attachment 1-C-1-2. The record should include the following information:

- Well construction information:
  - Date of installation
  - Drilling company
  - Total depth
  - Casing material/length
  - Screen material/length
  - Annular material
- General abandonment information:
  - Drilling firm (contact, mailing address, and phone number).
  - Consulting firm (contact, mailing address, and phone number).
- Well abandonment information
  - Date of abandonment
  - Reason for abandonment

- Details of how the casing/screen was removed drilled out or perforated.
- Sealing material (weight/volume/bags/mix ratio)

5.8 VAPOR EXTRACTION/MONITORING WELLS

Vapor extraction/monitoring wells have most of the same design and installation considerations and procedures as groundwater-monitoring wells, with the exception that they are screened in the unsaturated zone. Vapor extraction/monitoring wells generally shall not be screened over an interval greater than 20 feet and shall not be screened over two or more lithologies that have air permeabilities that differ by more than one order of magnitude. Vapor extraction/monitoring wells shall be installed using drilling techniques that do not require drilling fluids other than filtered air. Vapor monitoring wells may have casing I.D.s of 2 inches or less while extraction wells shall generally have casing I.D.s of at least 4 inches. The design of vapor extraction/monitoring wells is dependent upon many site-specific factors, such as the depth of contamination, soil conditions, geology, and depth to groundwater. As a result, specifics related to the design of these wells shall be included in the CTO WP, field sampling plan, or plans and specifications.

5.9 DRIVE POINTS

An alternative to conventional monitoring well construction is, under limited conditions, the use of drive points. These consist of slotted steel pipe that is pushed, hammered, or hydraulically jetted into the ground. A filter pack is not constructed around the screen, so the width of the screen openings must be sufficiently small to prevent the passage of significant quantities of sediment into the well during the withdrawal of water for sampling. In some instances, the drive points are used only as piezometers.

Drive points are commonly used in hazardous waste investigations to sample ambient soil gases in the vadose zone. It is often possible to extend the drive point below the water table to collect water samples. In some instances, permits may be required because the drive points are considered in some jurisdictions to be equivalent to a temporary monitoring well.

5.10 DISCRETE DEPTH GROUNDWATER SAMPLING

Another alternative to conventional monitoring well construction is the use of a discrete groundwater sampling device such as a Hydropunch. The Hydropunch tool can be used in conjunction with a standard drill rig, a cone penetrometer rig, or possibly a vehicle capable of driving vapor probes to sample groundwater and non-aqueous phase liquid in unconsolidated formations. The Hydropunch tool is constructed of a stainless steel drive point, a perforated section of Teflon pipe for a sample intake, and a stainless steel sample chamber. The tool is 55.5 inches long, 2 inches in O.D., and weighs approximately 24 pounds.

Ideally, a standard HSA drilling rig is used to drill a pilot hole to a depth just above the desired sampling depth. The Hydropunch tool is then hydraulically pushed or driven 4 to 5 feet through the saturated zone at each sampling location. As the tool is advanced, the sample intake screen remains pristine within the watertight stainless steel chamber. When the desired sampling interval is reached, the steel sampling chamber is unscrewed and withdrawn 1 foot to several feet, depending on how long a sampling interval is needed. This exposes the intake screen to the groundwater. Under hydrostatic pressure, groundwater flows through the intake screen and fills the sample chamber,

without aeration or agitation occurring. The drive cone, which is attached to the base of the screen, will remain in place by soil friction.

The pointed shape of the sampler and its smooth exterior surface prevent downward transport of surrounding soil and groundwater as the tool is advanced. Once in place, the intake screen will be sealed from groundwater above and below the interval being sampled, because the exterior of the Hydropunch tool is flush against the surrounding soil wall. Additionally, as the tool is advanced, the sample intake screen is retained within the steel watertight sample chamber.

A stainless steel or Teflon bailer with a bottom check valve is lowered into the sample chamber to collect the groundwater sample. Groundwater is then decanted at ground surface from the bailer into the appropriate sample containers.

6. Records

Monitoring well location, design, and construction shall be recorded in the field notebook for the CTO and on a well completion record form (Figure I-C-1-5). The field operations manager should provide a copy of this form to the CTO Manager for the project files.

7. Health and Safety

Field personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

ASTM International (ASTM) 2010. *Standard Practice for Design and Installation of Ground Water Monitoring Wells*. D5092-04^{e1}(Reapproved 2010). West Conshohocken, PA.

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Department of Health, State of Hawaii (DOH). 2009. *Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan.* Interim Final. Honolulu: Office of Hazard Evaluation and Emergency Response. 21 June.

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———.2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Guam Environmental Protection Agency (GEPA). 2006. *Well Abandonment Procedure*. Water Resources Management Program.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual*. EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-A-5, Utility Clearance.

Procedure I-B-1, Soil Sampling.

Procedure I-B-5, Surface Water Sampling.

Procedure I-F, Equipment Decontamination.

9. Attachments

Attachment I-C-1-1, Guam Monitoring Well Abandonment Procedure

Attachment I-C-1-2, DOH Abandonment of Monitoring Well Summary Report Form

Attachment I-C-1-1

Guam Well Abandonment Procedure

Well Abandonment Procedure

Guam Environmental Protection Agency
Water Resources Management Program

I. Abandonment procedure for cased wells that *will not* have its casing removed

1. Remove the well pedestal and concrete pad if applicable.
2. Excavate down to six (6) feet and cut the casing.
3. If the well extends into the water table, measure the depth to the water table(DWT) and fill the well with 3/8 to 3/4 inch clean washed aggregate to three (3) feet above the water table. If the well is completely within the vadose zone, proceed to item "I.4."
4. Provide a two-foot (2) a bentonite plug by placing 3/4 inch bentonite chip in six (6) inch lifts and hydrating with potable water.
5. Fill the casing with clean cement up to six (6) below the ground surface which will form a mushroom cap.
6. Fill the final six (6) feet with native soil.

Note:
a. For wells with a depth to the water table greater than eleven (11) feet, the total depth of fill for item "I.5" will be equal to DWT less eleven feet.
b. For shallow wells with a depth to the water table greater than nine (9) feet, but less than eleven (11) feet above the water table, item "I.5" will not be included.
c. For shallow wells with a depth to the water table greater than three (3) feet, but less than nine (9) feet, items "I.4" and "I.5" will not be included.

II. Abandonment procedure for wells that *will* have its casing removed and open boreholes.

1. Remove the old pedestal and concrete pad if applicable.
2. Remove the casing if not an open borehole.
3. If the well extends into the water table, measure the depth to the water table(DWT) and fill the well with 3/8 to 3/4 inch clean washed aggregate to three (3) feet above the measured water table. If the well is completely within the vadose zone, proceed to item "II.4."
4. Provide a two-foot (2) bentonite plug by placing 3/4 inch bentonite chips in six (6) inch lifts and hydrating with potable water.
5. Fill the remaining portion with bentonite/cement slurry (30% of bentonite by volume) in 10-foot lifts up to twenty-six (26) feet below the ground surface.
   a. After each 10-foot lift, the hole shall be sounded to determine if ten (10) feet of the hole is actually filled with the bentonite/cement slurry by at least eight (8) feet. If the depth of the fill is greater than eight (8) feet, continue with the next ten-foot (10) lift of bentonite/cement slurry. If the depth of the fill is less than eight (8) feet (an indication that there is a cavity), go to "II.5.b." Otherwise, continue with item "II.5.a." When the bentonite/cement fill reaches a height of twenty-six (26) feet below the ground surface, go to item "II.6."
   b. Fill the next ten (10) feet with 3/8 to 3/4 inch clean washed aggregate. Sound the hole to ensure that at least nine (9) feet has been filled with clean aggregate. If less than nine (9) feet is filled, repeat another ten-foot (10) lift of 3/8 to 3/4 inch clean washed aggregate until the sounding of the well/borehole reveals a rise of nine (9) feet or greater. Go to item "II.5.c."

c. Provide a two-foot (2) bentonite plug above the clean aggregate by placing 3/4 inch bentonite chips in six (6) inch lifts and hydrating with potable water. Continue with item "II.5.a."

6. Fill the next twenty (20) feet above the bentonite/cement fill with neat cement.
7. The remaining six (6) feet shall be filled with native soil.

Note:
a. For wells with a depth to the water table greater than thirty-one (31) feet, the total depth of fill for item "II.5" will be equal to DWT less thirty-one (31) feet.
b. For shallow wells with a depth to the water table greater than eleven (11) feet, but less than thirty-one (31) feet above the water table, item "II.5" will not be included.
c. For shallow wells with a depth to the water table greater than nine (9) feet, but less than eleven (11) feet above the water table, items "II.5" and "II.6" will not be included.
d. For shallow wells with a depth to the water table greater than three (3) feet, but less than nine (9) feet, items "II.4", "II.5" and "II.6" will not be included.

General Notes:

a. The driller shall submit a well abandonment plan following the above procedure to Guam EPA for review/approval.
b. The driller shall notify Guam EPA administrator 48 hours prior to starting date of the the approved abandonment plan.
c. All above-ground materials shall be removed from the well site and disposed in a manner that conforms to the Guam EPA's solid waste regulations.
d. If a well is in an area that is covered with asphalt or concrete that is not to be removed (such as a parking lot or a driveway/street), the native soil fill may be excluded and the well may be filled to the top with neat cement and then covered with new asphalt or concrete.

Attachment I-C-1-2

DOH Abandonment of Monitoring Well Summary Report Form

Abandonment of Monitoring Well Summary Report

_____ (Monitoring Well ID)

Submit form within 30 days of well abandonment or within 90 days if included in a site closure, monitoring, or investigation report. In addition, submit copies of the original boring log and well construction diagram for the monitoring well, a site map showing the location of the abandoned monitoring well, and the disposal documentation for wastes generated during the abandonment process. Submit all documentation to: Hawaii Department of Health, Hazard Evaluation and Emergency Response Office, Attention: SDAR, 919 Ala Moana Blvd, Rm. 206, Honolulu Hawaii 96814.

Location Information	Owner Information
Facility Name:	Well Owner:
Facility Address:	Contact Person:
	Mailing Address:
Latitude:	
Longitude:	Phone Number: Fax Number:
TMK:	Land Owner:
Location Description:	Contact Person:
	Mailing Address:
Monitoring Well Location Map Attached: Y N	Phone Number: Fax Number:
Well Construction Information	
Date of Installation:	Casing Material: Casing Diameter:
Drilling Company:	Casing Length: Casing Depth:
Total Depth:	Screen Material: Slot Size:
Depth to Water:	Screen Length: Screen Depth:
Was the Well Set in an Aquifer that is a Current or Potential	Annular Material: Depth:
Drinking Water Source: Y N	Annular Material: Depth:
Boring Log/Well Construction Diagram Attached: Y N	Annular Material: Depth:
General Abandonment Information	
Drilling Firm:	Consulting Firm:
Contact Person:	Contact Person:
Mailing Address:	Mailing Address:
Phone Number: Fax Number:	Phone Number: Fax Number:
Well Abandonment Information	
Date of Abandonment:	Sealing Material: Depth:
Reason for Abandonment:	Volume/Weight/Bags Mixing Ratio:
Casing/Screen Removed: Y N	Sealing Material: Depth:
If Yes, was annular material removed?: Y N	Volume/Weight/Bags Mixing Ratio:
If No, was casing cut off below the surface?: Y N	Method of Sealing Material Placement:
Comments:	
Driller's Signature:	Date:
Consultant's Signature:	Date:

Version: September 2005

Monitoring Well Development

1. Purpose

This section describes the standard operating procedures for monitoring well development to be used by United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

None.

4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that these monitoring well development procedures are followed during projects conducted under the NAVFAC Pacific ER Program. The CTO Manager is responsible for ensuring that all personnel involved in monitoring well development 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 personnel are responsible for the implementation of this procedure.

5. Procedure

5.1 INTRODUCTION

Well development procedures are crucial in preparing a well for sampling. They enhance the flow of groundwater from the formation into the well and remove the clay, silt, and other fines from the formation so that produced water will not be turbid or contain suspended matter that can interfere with chemical analyses. A monitoring well should be a “transparent” window into the aquifer from

which samples can be collected that are truly representative of the quality of water that is moving through the formation.

The goal of well development is to restore the area adjacent to a well to its natural condition by correcting damage to the formation during the drilling process. Well development shall accomplish the following tasks:

- Remove a filter cake or any drilling fluid within the borehole that invades the formation.
- Remove fine-grained material from the filter pack.
- Increase the porosity and permeability of the native formation immediately adjacent to the filter pack.

Well development shall not occur until 24 hours after the completion of well installation to allow the annular seal to fully set up.

5.2 FACTORS AFFECTING MONITORING WELL DEVELOPMENT

5.2.1 Type of Geologic Materials

Different types of geologic materials are developed more effectively by using certain development methods. Where permeability is greater, water moves more easily into and out of the formation and development is accomplished more quickly. Highly stratified deposits are effectively developed by methods that concentrate on distinct portions of the formation. If development is performed unevenly, a groundwater sample will likely be more representative of the permeable zones. In uniform deposits, development methods that apply powerful surging forces over the entire screened interval will produce satisfactory results.

5.2.2 Design and Completion of the Well

Because the filter pack reduces the amount of energy reaching the borehole wall, it must be as thin as possible if the development procedures are to be effective in removing fine particulate material from the interface between the filter pack and natural formation. Conversely, the filter pack must be thick enough to ensure a good distribution of the filter pack material during emplacement. The general rule is that filter pack material must be at least 2 inches thick.

The screen slot size must be appropriate for the geologic material and filter pack material in order for development to be effective. If slot size is too large, the removal of too much sediment may cause settlement of overlying materials and sediment accumulation in the casing. When screen openings are too small, full development may not be possible and well yield will be below the potential of the formation. Additionally, incomplete development coupled with a narrow slot size can lead to blockage of the screen openings.

5.2.3 Drilling Method

The drilling method influences development procedure. Typical problems associated with specific drilling methods include the following:

- If a mud rotary method is used, mud cake builds up on the borehole wall and must be removed during the development process.

- If drilling fluid additives have been used, the development process must include an attempt to remove all fluids that have infiltrated into the native formation.
- If driven casing or hollow-stem auger methods have been used, the interface between the casing or auger flights and the natural formation may have been smeared with fine particulate matter that must be removed during the development process.
- If an air rotary method has been used in rock formations, fine particulate matter is likely to build up on the borehole walls and may plug pore spaces, bedding planes, and other permeable zones. These openings must be restored during the development process.

5.3 PREPARATION

In preparing for monitoring well development, development logs for any other monitoring wells in the vicinity should be reviewed to determine the general permeability of the water-bearing formation and the appropriate development method.

Depth to groundwater and information from the well construction log should be used in calculating the required quantity of water to be removed. The distance between the equilibrated water level and the bottom of the screen is the saturated section. The saturated section (feet) multiplied by the unit well volume per foot (gallons/linear foot) equals the gallons required to remove one total well volume of water. The unit well volume is the sum of the casing volume and the filter pack pore volume, both of which depend upon casing and borehole diameter and the porosity of the filter pack material. Well volume can be calculated using Table I-C-2-1, Table I-C-2-2, or Table 1-C-2-3.

Table I-C-2-1: Casing Volume*

Casing Diameter (inches)	Volume (gallon/linear foot)
2	0.16
4	0.65
6	1.47

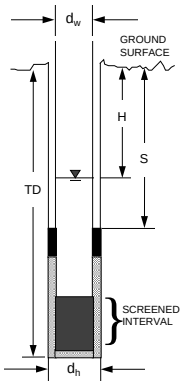
Table I-C-2-2: Filter Pack Pore Volume

Casing Diameter (inches)	Borehole Diameter (inches)	Volume [a] (gallon/linear foot)
2	6	0.52
2	8	0.98
4	10	1.37
4	12	2.09
6	12	1.76

* The above two volumes must be added together to obtain one unit well volume.
[a] Assumes a porosity of 40% for filter pack.

Table I-C-2-3: Well Volume Calculation

HOLE DIAMETER	d_h	=
WELL CASING INSIDE DIAMETER	$d_w ID$	=
OUTSIDE DIAMETER	$d_w OD$	= _____
DEPTH TO: WATER LEVEL	H	=
BASE OF SEAL	S	= _____
BASE OF WELL	TD	=
EST. FILTER PACK POROSITY	P	= _____



WELL VOLUME CALCULATION:

$$\text{CASING VOLUME} = V_c = \Pi\left(\frac{d_w ID}{2}\right)^2 (TD - H) = 3.14\left(\frac{\quad}{2}\right)^2 (____ - ____) = _____$$

$$\text{FILTER PACK PORE VOLUME} = V_f = \Pi\left[\left(\frac{d_h}{2}\right)^2 - \left(\frac{d_w OD}{2}\right)^2\right](TD - (S \text{ or } H^*)(P) = _____$$

(* if S > H, use S; if S < H, use H)

$$= 3.14\left[\left(\frac{\quad}{2}\right)^2 - \left(\frac{\quad}{2}\right)^2\right](____ - ____)(____) = _____$$

TOTAL WELL VOLUME = VT = Vc + Vf = ____ + ____ = _____ $ft.^3$ x 7.48 = _____ gal.

5.4 DECONTAMINATION

The purpose of decontamination of development equipment is to prevent cross-contamination between monitoring wells. Use disposable equipment where appropriate. Use a steam-cleaner, if available, to decontaminate development equipment. Clean the equipment away from the monitoring well in such a fashion that decontamination effluent can be intercepted and drummed.

A triple rinse decontamination procedure is acceptable for equipment, such as bailers, or if access to a steam cleaner is not possible (Procedure I-F, *Equipment Decontamination*).

During well development, place visqueen around the well to prevent contamination at ground surface. Properly dispose of this sheeting after each use.

5.5 WELL DEVELOPMENT MONITORING

Throughout the well development process, maintain a development record using the form presented in Attachment I-C-2-1. The record should include the following information:

- General:
  - Project name and number
  - Well name/number and location
  - Date, time, and weather conditions
  - Names of personnel involved
- Development volume:
  - Initial and final water level
  - Casing total depth and diameter
  - Borehole diameter
  - Casing volume, filter pack pore volume, total well volume
  - Volume of water to be evacuated
  - Method and rate of removal
  - Appearance of water before and after development
- Monitoring data for each sample point:
  - Date, time, elapsed time
  - Cumulative gallons removed, removal method, removal rate
  - Temperature, pH (indicates the hydrogen ion concentration – acidity or basicity), specific conductivity, turbidity, dissolved oxygen, redox potential, and salinity

Part of the well development procedure shall consist of acquisition and analysis of water samples at appropriate intervals considering the total quantity of water to be removed. Measure conductivity, pH, temperature, dissolved oxygen, redox potential, turbidity, and salinity in each sample using a multi-parameter meter and flow-through cell. Collect readings on a periodic basis (approximately every 3 to 5 minutes) during development and obtain at least one reading after removal of each well

volume. At the time each sample is analyzed, record the cumulative water removed, the time, the time elapsed during development, and calculated flow rate. Continue development until at least 3 borehole volumes have been removed, turbidity stabilizes at or below 5 nephelometric turbidity units, and three successive readings of the parameters have stabilized (values within 10 percent of each other). If stabilization has not been attained, if turbidity remains high, or if the well does not readily yield water, allow the water level in the well to recover, conduct an additional 15 minutes of mechanical surging and/or bailing, then continue development until stabilization can be achieved or for a reasonable time.

Section 5.7 describes well development in special situations, such as low yield formations and 2-inch wells.

5.6 METHODS OF MONITORING WELL DEVELOPMENT

The methods available for the development of monitoring wells have been inherited from production well practices. Methods include: (1) mechanical surging with a surge block or swab, and (2) surge pumping. Development methods using air or jetting of water into the well are generally inappropriate for development of monitoring wells due to the potential for affecting water quality.

Containerize and appropriately label all development water (unless it is permissible to discharge it on site). All development efforts must utilize mechanical surging or surge pumping, followed by bailing or groundwater removal with a pump. More detailed descriptions of appropriate development methods are presented below.

5.6.1 Mechanical Surging and Bailing

For mechanical surging and bailing, a surge block or swab is operated either manually or by a drill rig. The surge block or swab should be vented and be of sufficient weight to free-fall through the water in the well and create a vigorous outward surge. The equipment lifting the tool must be strong enough to extract it rapidly. A bailer is then used to remove fine-grained sediment and groundwater from the well.

Procedures:

1. Properly decontaminate all equipment entering the well.
2. Record the static water level and the total well depth.
3. Lower the surge block or swab to the top of the screened interval.
4. Operate in a pumping action with a typical stroke of approximately 3 feet.
5. Gradually work the surging downward through the screened interval during each cycle.
6. Surge for approximately 10 to 15 minutes per cycle.
7. Remove the surge block and attach the bailer in its place.
8. Bail to remove fines loosened by surging until the water appears clear.

9. Repeat the cycle of surging and bailing at least three times or until turbidity is reduced and stabilization of water quality parameters occurs.
10. The surging shall initially be gentle and the energy of the action should gradually increase during the development process.

The advantages (+) and disadvantages (–) of this method are listed below:

+ Reversing the direction of flow reduces bridging between large particles, and the inflow then moves the fine material into the well for withdrawal.
+ It affects the entire screened interval.
+ It effectively removes fines from the formation and the filter pack.
– It might cause upward movement of water in the filter pack that could disrupt the seal.
– Potential exists for damaging a screen with a tight-fitting surge block or with long surge strokes.

5.6.2 Surge Pumping

Procedures:

1. Properly decontaminate all equipment entering the well.
2. Record the static water level and the total well depth.
3. Lower a submersible pump or airlift pump without a check valve to a depth within 1 to 2 feet of the bottom of the screened section.
4. Start pumping and increase discharge rate to maximum capacity (overpumping), causing rapid drawdown of water in the well.
5. Periodically stop and start the pump, allowing the water in the drop pipe to fall back into the well and surge the formation (backwashing), thus loosening particulates.
6. The pump intake shall be moved up the screened interval in increments appropriate to the total screen length.
7. At each pump position, the well shall be pumped, overpumped, and backwashed alternately until satisfactory development has been attained as demonstrated by reduction in turbidity and stabilization of water quality parameters.

The advantages (+) and disadvantages (–) of this method are listed below:

+ Reversing the direction of flow reduces bridging between large particles, and the inflow then moves the fine material into the well for withdrawal.
+ It effectively removes fines from the formation and filter pack.
– The pump position or suction line must be changed to cover the entire screen length.

- Submersible pumps suitable to perform these operations may not be available for small diameter (1 inch or less) monitoring wells.
- It is not possible to remove sediment from the well unless particle size is small enough to move through the pump.

For additional information on well development, consult the references included in Section 8 of this procedure.

5.7 SPECIAL SITUATIONS

5.7.1 Development of Low Yield Wells

Development procedures for monitoring wells in low-yield (<0.25 gallons per minute), water-bearing zones are somewhat limited. Due to the low hydraulic conductivity of the materials, surging of water in and out of the well casing is difficult. Also, the entry rate of water is inadequate to remove fines from the well bore and the gravel pack when the well is pumped. Additionally, the process may be lengthy because the well can be easily pumped dry and the water level is very slow to recover.

Follow the procedures for mechanical surging and bailing for low yield wells. During surging and bailing, wells in low yield formations should be drawn down to total depth twice, if possible. Development can be terminated, however, if the well does not exhibit 80 percent recovery after 3 hours.

5.7.2 Development of 2-inch Wells

It is easier to develop monitoring wells that are large in diameter than small diameter wells. Mechanical surging or bailing techniques that are effective in large diameter wells are much less effective when used in wells 2 inches or less in diameter. Mechanical surge blocks and bailers have a high potential for damaging a small diameter well. As a result, the CTO Manager shall obtain approval from the QA Manager or Technical Director prior to installing groundwater monitoring wells with inside diameters of 2 inches or less.

Develop two-inch or smaller diameter wells by surging with a specially designed, hand-operated surge block or by pumping with a bladder or airlift pump. Information related to development of wells 2 inches or less in diameter shall be included in the CTO work plan.

6. Records

Well development information should be documented in indelible ink on well development monitoring forms (Attachment I-C-2-1). Copies of this information shall be sent to the CTO Manager and to the project files. The CTO Manager shall review all well development logs on a minimum monthly basis.

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-F, *Equipment Decontamination.*

9. Attachments

Attachment I-C-2-1: Well Development Record

Attachment I-C-2-1
Well Development Record

WELL DEVELOPMENT LOG

PROJECT	WELL ID	SITE	PREPARED BY

METHOD
- OVERPUMPAGE ☐
- BAILER ☐
- SURGE BLOCK ☐
- AIR LIFT ☐
- OTHER _____

INITIAL WATER LEVEL:
INITIAL TOTAL DEPTH:

FINAL WATER LEVEL:
FINAL TOTAL DEPTH:

REMARKS:

*CAPACITY OF CASING (GALLONS/LINEAR FOOT)

1" - 0.012
2" - 0.16
4" - 0.65
6" - 0.1.47

*VOLUME BETWEEN CASING AND HOLE (GALLONS/LINEAR FOOT) (ASSUMING 40% POROSITY)

1" CASING AND 2" HOLE - 0.013
2" CASING AND 6" HOLE - 0.52
2" CASING AND 8" HOLE - 0.98
4" CASING AND 10" HOLE - 1.37
4" CASING AND 12" HOLE - 2.09

*The two volumes for the saturated portion of the well must be added together to obtain one unit well volume.

DEVELOPMENT LOG:					CUMULATIVE WATER REMOVED	WATER QUALITY							COMMENTS
DATE	TIME	METHOD	ELAPSED TIME	FLOW RATE (gpm)	GALLONS	pH	TEMP (ºC)	SP. COND (mS/cm)	DO (mg/L)	ORP (mV)	TURBIDITY (ntu)	SALINITY (ppt)	

DO dissolved oxygen
ORP oxidation-reduction potential

Monitoring Well Sampling

1. Purpose

This standard operating procedure describes the monitoring well sampling procedures to be used by United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

None.

4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that these standard groundwater sampling activities are followed during projects conducted under the NAVFAC Pacific ER Program. The CTO Manager or designee shall review all groundwater sampling forms on a minimum monthly basis. The CTO Manager is responsible for ensuring that all personnel involved in monitoring well sampling shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for ensuring that all project field staff follow these procedures.

Field sampling personnel are responsible for the implementation of this procedure.

Minimum qualifications for sampling personnel require that one individual on the field team shall have a minimum of 1 year experience with sampling monitoring wells.

The field sampler and/or task manager is responsible for directly supervising the groundwater sampling procedures to ensure that they are conducted according to this procedure, and for recording all pertinent data collected during sampling. If deviations from the procedure are required because of

anomalous field conditions, they must first be approved by the QA Manager or Technical Director and then documented in the field logbook and associated report or equivalent document.

5. Procedures

5.1 PURPOSE

This procedure establishes the method for sampling groundwater monitoring wells for water-borne contaminants and general groundwater chemistry. The objective is to obtain groundwater samples of aquifer conditions with as little alteration of water chemistry as possible.

5.2 PREPARATION

5.2.1 Site Background Information

Establish a thorough understanding of the purposes of the sampling event prior to field activities. Conduct a review of all available data obtained from the site and pertinent to the water sampling. Review well history data including, but not limited to, well locations, sampling history, purging rates, turbidity problems, previously used purging methods, well installation methods, well completion records (including depth of screened interval), well development methods, previous analytical results, presence of an immiscible phase, historical water levels, and general hydrogeologic conditions.

Previous groundwater development and sampling logs give a good indication of well purging rates and the types of problems that might be encountered during sampling, such as excessive turbidity and low well yield. They may also indicate where dedicated pumps are placed in the water column. To help minimize the potential for cross-contamination, well purging and sampling, and water level measurement collection shall proceed from the least contaminated to the most contaminated as indicated in previous analytical results. This order may be changed in the field if conditions warrant it, particularly if dedicated sampling equipment is used. A review of prior sampling procedures and results may also identify which purging and sampling techniques are appropriate for the parameters to be tested under a given set of field conditions.

5.2.2 Groundwater Analysis Selection

Establish the requisite field and laboratory analyses prior to water sampling. Decide on the types and numbers of QA/quality control (QC) samples to be collected (Procedure III-B, *Field QC Samples [Water, Soil]*), as well as the type and volume of sample preservatives, the number of sample containers (e.g., coolers), and the quantity of ice or other chilling materials. The sampling personnel shall ensure that the appropriate number and size sample containers are brought to the site, including extras in case of breakage or unexpected field conditions. Document the analytical requirements for groundwater analysis in the project-specific work plan.

5.3 GROUNDWATER SAMPLING PROCEDURES

Groundwater sampling procedures at a site shall include: (1) measurement of well depth to groundwater; (2) assessment of the presence or absence of an immiscible phase; (3) assessment of purge parameter stabilization; (4) purging of static water within the well and well bore; and (5) obtaining a groundwater sample. Each step is discussed in sequence below. Depending upon specific field conditions, additional steps may be necessary. As a rule, at least 24 hours should separate well development and well sampling events.

5.3.1 Measurement of Static Water Level Elevation

Measure the depth to standing water and the total depth of the well to the nearest 0.01 foot to provide baseline hydrologic data, to calculate the volume of water in the well, and to provide information on the integrity of the well (e.g., identification of siltation problems). Mark each well with a permanent, easily identified reference point for water level measurements whose location and elevation have been surveyed.

Before purging the well, measure water levels in all of the wells within the zone of influence of the well being purged. Measure water levels twice in quick succession and record each measurement. This will provide a water level database that describes water levels across the site at one time (a synoptic sampling). Measure the water level in each well immediately prior to purging the well.

The device used to measure the water level surface and depth of the well shall be sufficiently sensitive and accurate in order to obtain a measurement to the nearest 0.01 foot reliably. An electronic water level meter will usually be appropriate for this measurement; however, when the groundwater within a particular well is highly contaminated, an inexpensive weighted tape measure can be used to determine well depth to prevent adsorption of contaminants onto the meter tape. The presence of light, non-aqueous phase liquids (LNAPLs) and/or dense, non-aqueous phase liquids (DNAPLs) in a well requires measurement of the elevation of the top and the bottom of the product, generally using an interface probe. Water levels in such wells must then be corrected for density effects to accurately determine the elevation of the water table.

5.3.2 Decontamination of Equipment

Establish a decontamination station before beginning sampling. The station shall consist of an area of at least 4 feet by 2 feet covered with plastic sheeting and be located upwind of the well being sampled and far enough from potential contaminant sources to avoid contamination of clean equipment. The station shall be large enough to fit the appropriate number of wash and rinse buckets, and have sufficient room to place equipment after decontamination. One central cleaning area may be used throughout the entire sampling event. The area around the well being sampled shall also be covered with plastic sheeting to prevent spillage. Further details are presented in Procedure I-F, *Equipment Decontamination*.

Decontaminate each piece of equipment prior to entering the well. Also conduct decontamination prior to sampling at a site, even if the equipment has been decontaminated subsequent to its last usage. This precaution is taken to minimize the potential for cross-contamination. Additionally, decontaminate each piece of equipment used at the site prior to leaving the site. It is only necessary to decontaminate dedicated sampling equipment prior to installation within the well. Do not place clean sampling equipment directly on the ground or other contaminated surfaces prior to insertion into the well. Dedicated sampling equipment that has been certified by the manufacturer as being decontaminated can be placed in the well without onsite decontamination.

5.3.3 Detection of Immiscible Phase Layers

Complete the following steps for detecting the presence of LNAPL and DNAPL, as necessary, before the well is evacuated for conventional sampling:

1. Sample the headspace in the wellhead immediately after the well is opened for organic vapors using either a photoionization detector or an organic vapor analyzer (flame ionization detector), and record the measurements.

2. Lower an interface probe into the well to determine the existence of any immiscible layer(s), LNAPL and/or DNAPL, and record the measurements.
3. Confirm the presence or absence of an immiscible phase by slowly lowering a clear bailer to the appropriate depth, then visually observing the results after sample recovery.
4. In rare instances, such as when very viscous product is present, it may be necessary to utilize hydrocarbon- and water-sensitive pastes for measurement of LNAPL thickness. This is accomplished by smearing adjacent, thin layers of both hydrocarbon- and water-sensitive pastes along a steel measuring tape and inserting the tape into the well. An engineering tape showing tenths and hundredths of feet is required. Record depth to water, as shown by the mark on the water-sensitive paste, and depth to product, as shown by the mark on the product-sensitive paste. In wells where the approximate depth to water and product thickness are not known, it is best to apply both pastes to the tape over a fairly long interval (5 feet or more). Under these conditions, measurements are obtained by trial and error, and may require several insertions and retrievals of the tape before the paste-covered interval of the tape encounters product and water. In wells where approximate depths of air-product and product-water interfaces are known, pastes may be applied over shorter intervals. Water depth measurements should not be used in preparation of water-table contour maps until they are corrected for depression by the product.

If the well contains an immiscible phase, it may be desirable to sample this phase separately. Sections 5.3.5.1 and 5.3.5.2 present immiscible phase sampling procedures. It may not be meaningful to conduct water sample analysis of water obtained from a well containing LNAPLs or DNAPLs. Consult the CTO Manager and QA Manager or Technical Director if this situation is encountered.

5.3.4 Purging Equipment and Use

The water present in a well prior to sampling may not be representative of *in situ* groundwater quality and shall be removed prior to sampling. Handle all groundwater removed from potentially contaminated wells in accordance with the investigation-derived waste (IDW) handling procedures in Procedure I-A-6, *Investigation-Derived Waste Management*.

Purging shall be accomplished by removing groundwater from the well at low flow rates using a pump. According to the U.S. Environmental Protection Agency (EPA) (EPA 1996), the rate at which groundwater is removed from the well during purging ideally should be less than 0.2 to 0.3 liters/min. The EPA further states that wells should be purged at rates below those used to develop the well to prevent further development of the well, to prevent damage to the well, and to avoid disturbing accumulated corrosion or reaction products in the well. The EPA also indicates that wells should be purged at or below their recovery rate so that migration of water in the formation above the well screen does not occur.

Realistically, the purge rate should be low enough that substantial drawdown in the well does not occur during purging. The goal is minimal drawdown (less than 0.1 meter) during purging (EPA 1996). The amount of drawdown during purging should be recorded at the same time the other water parameters are measured. Also, a low purge rate will reduce the possibility of stripping volatile organic compounds (VOCs) from the water, and will reduce the likelihood of mobilizing colloids in the subsurface that are immobile under natural flow conditions.

The sampler shall ensure that purging does not cause formation water to cascade down the sides of the well screen. Wells shall not be purged to dryness if recharge causes the formation water to cascade down the sides of the screen, as this will cause an accelerated loss of volatiles. This problem should be anticipated. Water shall be purged from the well at a rate that does not cause recharge water to be excessively agitated unless an extremely slow recharging well is encountered where complete evacuation is unavoidable.

In high yield wells (wells that exhibit 80 percent recovery in less than 2 hours), purging shall be conducted at relatively low flow rates and shall remove water from the entire screened interval of the well to ensure that fresh water from the formation is present throughout the entire saturated interval. In general, place the intake of the purge pump 2 to 3 feet below the air-water interface within the well to allow purging and at the same time minimize disturbance/overdevelopment of the screened interval in the well. During the well purging procedure, collect water level and/or product level measurements to assess the hydraulic effects of purging. Sample the well when it recovers sufficiently to provide enough water for the analytical parameters specified.

Low yield wells (those that exhibit less than 80 percent recovery in less than 2 hours) require one borehole volume of water to be removed. Allow the well to recover sufficiently to provide enough water for the specified analytical parameters, and then sample it.

Evaluate water samples on a regular basis (approximately every 5 minutes) during well evacuation and analyze them in the field preferably using a multi-parameter meter and flow-through cell for temperature, pH (indicates the hydrogen ion concentration – acidity or basicity), specific conductivity, dissolved oxygen (DO), oxidation reduction potential (ORP), turbidity, salinity, and total dissolved solids (TDS). Take at least five readings during the purging process. These parameters are measured to demonstrate that the natural character of the formation water has been pumped into the well. Purging shall be considered complete when three consecutive sets of field parameter measurements stabilize within approximately 10 percent (EPA 2006). However, suggested ranges are ±0.2 degrees Celsius for temperature, ±0.1 standard units for pH, ±3 percent for specific conductance, ±10 percent for DO, and ±10 millivolts for redox potential (ASTM 2001). This criterion may not be applicable to temperature if a submersible pump is used during purging due to the heating of the water by the pump motor. Enter all information obtained during the purging and sampling process including drawdown, into a groundwater sampling log (Figure I-C-3-1). Complete all blanks on this field log during sampling.

In cases where an LNAPL has been detected in the monitoring well, insert a stilling tube of a minimum diameter of 2 inches into the well prior to well purging. The stilling tube shall be composed of a material that meets the performance guidelines for sampling devices. Insert the stilling tube into the well to a depth that allows groundwater from the screened interval to be purged and sampled, but that is below the upper portion of the screened interval where the LNAPL is entering the well screen. The goal is to sample the aqueous phase (groundwater) while preventing the LNAPL from entering the sampling device. To achieve this goal, insert the stilling tube into the well in a manner that prevents the LNAPL from entering the stilling tube. However, sampling groundwater beneath a NAPL layer is not generally recommended due to the fact that the interval with residual NAPL saturation is often unknown and the NAPL can be mobilized into the well from intervals below the water table.

One method of doing this is to cover the end of the stilling tube with a membrane or material that will be ruptured by the weight of the pump. A piece of aluminum foil can be placed over the end of the stilling tube. Slowly lower the stilling tube into the well to the appropriate depth and then attach it firmly to the top of the well casing. When the pump is inserted, the weight of the pump breaks the foil covering the end of the tube, and the well can be purged and sampled from below the LNAPL layer. Firmly fasten the membrane or material that is used to cover the end of the stilling tube so that it remains attached to the stilling tube when ruptured. Moreover, the membrane or material must retain its integrity after it is ruptured. Pieces of the membrane or material must not fall off of the stilling tube into the well. Although aluminum foil is mentioned in this discussion as an example of a material that can be used to cover the end of the tube, a more chemically inert material may be required, based on the site-specific situation. Thoroughly decontaminate stilling tubes prior to each use. Collect groundwater removed during purging, and store it on site until its disposition is determined based upon laboratory analytical results. Storage shall be in secured containers, such as U.S. Department of Transportation-approved drums. Label containers of purge water with the standard NAVFAC Pacific ER Program IDW label.

The following paragraphs list available purging equipment and methods for their use.

5.3.4.1 BAILERS AND PUMPS

Submersible Pump: A stainless steel submersible pump may be utilized for purging both shallow and deep wells prior to sampling groundwater for volatile, semivolatile, and non-volatile constituents. For wells over 200 feet deep, the submersible pump is one of the few technologies available to feasibly accomplish purging under any yield conditions. For shallow wells with low yields, submersible pumps are generally inappropriate due to over stressing of the wells (<1 gallon per minute), which causes increased aeration of the water within the well.

Steam clean or otherwise decontaminate the pump and discharge tubing prior to the placing the pump in the well. The submersible pump shall be equipped with an anti-backflow check valve to keep water from flowing back down the drop pipe into the well. Place the pump intake approximately 2 to 3 feet below the air-water interface within the well and maintain it in that position during purging. Additionally, when pulling the pump out of the well subsequent to purging, take care to avoid dumping water within the drop pipe and pump stages back into the well.

Bladder Pump: A stainless steel and/or Teflon bladder pump can be utilized for purging and sampling wells up to 200 feet in depth for volatile, semivolatile, and non-volatile constituents. Additionally, the bladder pump can be used for purging and obtaining groundwater samples overlain by a LNAPL layer as long as care is taken not to draw the product layer into the bladder pump. Use of the bladder pump is most effective in low to moderate yield wells.

Either a battery powered compressor, compressed dry nitrogen, or compressed dry air, depending upon availability, can operate the bladder pump. The driving gas utilized must be dry to avoid damage to the bladder pump control box. Decontaminate the bladder pump prior to use. Once purging is complete, collect the samples directly from the bladder pump.

Centrifugal or Diaphragm Pump: A centrifugal, or diaphragm, pump may be used to purge a well if the water level is within 20 feet of ground surface. A new, or properly decontaminated, hose is lowered into the well and water withdrawn at a rate that does not cause excessive well drawdown.

GROUNDWATER SAMPLING LOG

WELL NO. _____ LOCATION: _____ PROJECT NO. _____

DATE: TIME: _____ CLIMATIC CONDITIONS: _____

TIDAL CONDITIONS: Rising ☐ Falling ☐ HIGH TIDE: LOW TIDE: CURRENT TIDE:

STATIC WATER LEVEL (FT.) and TIME: _____ TOTAL DEPTH (FT.): _____

WELL PURGING: LENGTH OF SATURATED ZONE: _____ LINEAR FT.

a VOLUME OF WATER TO BE EVACUATED: _____ GALS. (Gals/Linear ft. X linear feet of saturation X 3-casing volumes)

METHOD OF REMOVAL: _____ PUMPING RATE: _____ mL/min

WELL PURGE DATA:

DATE/ TIME	DTW	GALLONS REMOVED	TDS (g/L)	pH	SP. COND. (mS/cm)	D.O. (mg/L)	TURB. (NTU)	TEMP. (°C)	ORP (mV)	SAL (ppt)

SAMPLE WITHDRAWAL METHOD: _____

APPEARANCE OF SAMPLE: COLOR: _____

SEDIMENT: _____

OTHER: _____

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES _____

NUMBER AND TYPES OF SAMPLE CONTAINERS USED: _____

SAMPLE IDENTIFICATION NUMBER(S) _____

DECONTAMINATION PROCEDURES: _____

NOTES: _____

SAMPLED BY: _____

SAMPLES DELIVERED TO: _____ TRANSPORTER: _____

DATE: _____ TIME: _____

CAPACITY OF CASING (GALLONS/LINEAR FOOT)

2"-0.16•4"-0.65•6"-1.47•8"-2.61•10"-4.08•12"-5.87

Figure I-C-3-1: Groundwater Sampling Log

Place the hose bottom approximately 2 to 3 feet below the air-water interface and maintain it in that position during purging.

Air Lift Pump: Airlift pumps are not appropriate for purging or sampling.

Bailer: Avoid using a bailer to purge a well because it can result in aeration of the water in the well and possibly cause excessive purge rates. If a bailer must be used, decontaminate the bailer, bailer wire, and reel as described in Section 5.3.2 prior to its use. Teflon-coated cable mounted on a reel is recommended for lowering the bailer in and out of the well.

Lower the bailer below the water level of the well with as little disturbance of the water as possible to minimize aeration of the water in the well. One way to gauge the depth of water on the reel is to mark the depth to water on the bailer wire with a stainless steel clip. In this manner, less time is spent trying to identify the water level in the well. The QA Manager or Technical Director shall approve use of bailers for purging monitoring wells in advance.

5.3.5 Monitoring Well Sampling Methodologies

5.3.5.1 Sampling Light, Non-Aqueous Phase Liquids (LNAPL)

Collect LNAPL, if present, prior to any purging activities. The sampling device shall generally consist of a dedicated or disposable bailer equipped with a bottom-discharging device. Lower the bailer slowly until contact is made with the surface of the LNAPL, and to a depth less than that of the immiscible fluid/water interface depth as determined by measurement with the interface probe. Allow the bailer to fill with the LNAPL and retrieve it.

When sampling LNAPLs, never drop bailers into a well, and always remove them from the well in a manner that causes as little agitation of the sample as possible. For example, the bailer should not be removed in a jerky fashion or be allowed to continually bang against the well casing as it is raised. When using bailers to collect LNAPL samples for inorganic analyses, the bailer shall be composed of fluorocarbon resin. Bailers used to collect LNAPL samples for organic analyses shall be constructed of stainless steel. The cable used to raise and lower the bailer shall be composed of an inert material (e.g., stainless steel) or coated with an inert material (e.g., Teflon).

5.3.5.2 Sampling Dense, Non-Aqueous Phase Liquids (DNAPL)

Collect DNAPL prior to any purging activities. The best method for collecting DNAPL is to use a double-check valve, stainless steel bailer, or a Kemmerer (discrete interval) sampler. The sample shall be collected by slow, controlled lowering of the bailer to the bottom of the well, activation of the closing device, and retrieval.

5.3.5.3 Groundwater Sampling Methodology

The well shall be sampled when groundwater within it is representative of aquifer conditions and after it has recovered sufficiently to provide enough volume for the groundwater sampling parameters. A period of no more than 2 hours shall elapse between purging and sampling to prevent groundwater interaction with the casing and atmosphere. This may not be possible with a slowly recharging well. Measure and record the water level prior to sampling to demonstrate the degree of recovery of the well. Sampling equipment (e.g., especially bailers) shall never be dropped into the well, as this could cause aeration of the water upon impact. Additionally, the sampling methodology utilized shall allow for the collection of a groundwater sample in as undisturbed a condition as

possible, minimizing the potential for volatilization or aeration. This includes minimizing agitation and aeration during transfer to sample containers.

Sampling equipment shall be constructed of inert material. Equipment with neoprene fittings, polyvinyl chloride bailers, tygon tubing, silicon rubber bladders, neoprene impellers, polyethylene, and viton is not acceptable. If bailers are used, an inert cable/chain (e.g., fluorocarbon resin-coated wire or single strand stainless steel wire) shall be used to raise and lower the bailer. Generally, bladder and submersible pumps are acceptable sampling devices for all analytical parameters. Dedicated equipment is highly recommended for all sampling programs. The following text describes sampling methods utilizing submersible pumps, bladder pumps, and bailers.

Submersible Pumps: When operated under low-flow rate conditions (100 to 300 milliliters [mL]/minute or less), submersible pumps are as effective as bladder pumps in acquiring samples for volatile organic analysis as well as other analytes. The submersible pump must be specifically designed for groundwater sampling (i.e., pump composed of stainless steel and Teflon, sample discharge lines composed of Teflon) and must have a controller mechanism allowing the required low flow rate. Adjust the pump rate so that flow is continuous and does not pulsate to avoid aeration and agitation within the sample discharge lines. Run the pump for several minutes at the low flow rate used for sampling to ensure that the groundwater in the lines was obtained at the low flow rate. Higher pumping rates than 100 to 300 mL/minute may be used when collecting samples to be analyzed for non-volatile constituents, if significant drawdown does not occur.

Bladder Pumps: A gas-operated Teflon or stainless steel bladder pump with adjustable flow control and equipped with Teflon-lined tubing can be effectively utilized to collect a groundwater sample and is considered to be the best overall device for sampling inorganic and organic constituents. Operate positive gas displacement bladder pumps in a continuous manner so that they minimize discharge pulsation that can aerate samples in the return tube or upon discharge. If a bladder pump is utilized for the well purging process, the same bladder pump can also be utilized for sample collection after purging is complete.

Most models of bladder pumps can be operated with a battery powered compressor and control box. The compressor can be powered with either a rechargeable battery pack (provided with the compressor), by running directly off of a vehicle battery (via alligator clips), or by plugging into the vehicle’s direct current connector (cigarette lighter receptacle). When using a vehicle to power a compressor, several precautions should be taken. First, position the vehicle downwind of the well. Second, ensure the purge water exiting the well is collected into a drum or bucket. Finally, connect the compression hose from the well cap to the control box. Do not connect the compression hose from the compressor to the control box until after the engine has been started.

When all precautions are completed and the engine has been started, connect the compression hose to the control box. Slowly adjust the control knobs so as to discharge water at a flow rate (purge rate) that minimizes drawdown in the well, usually around 100 to 300 mL/minute. The compressor should not be set as to discharge the water as hard as possible. The optimal setting is one that produces the required purge rate per minute (not per purge cycle) while maintaining a minimal drawdown.

Prior to sampling volatiles constituents, turn off the vehicle engine, and obtain a flow rate of 100 mL/minute so as not to cause fluctuation in pH, pH-sensitive analytes, the loss of volatile constituents, or draw down of the groundwater table. If necessary (when sampling wells that require

a large sample volume) the vehicle engine may be turned back on after sampling volatile constituents. Higher flow rates (100 to 300 mL/minute) can be used once the samples for the analysis of volatile components have been collected, but should not allow for increased draw down in the well. At no time shall the sample flow rate exceed the flow rate used while purging. Preserve the natural conditions of the groundwater, as defined by pH, DO, specific conductivity, and reduction/oxidation (redox).

For those samples requiring filtration, it is recommended to use in-line high capacity filters after all nonfiltered samples have been collected.

Bailers: A single- or double-check valve Teflon or stainless steel bailer equipped with a bottom discharging device can be utilized to collect groundwater samples. Bailers have a number of disadvantages, however, including a tendency to alter the chemistry of groundwater samples due to degassing, volatilization, and aeration; the possibility of creating high groundwater entrance velocities; differences in operator techniques resulting in variable samples; and difficulty in determining where in the water column the sample was collected. Therefore, use bailers for groundwater sampling only when other types of sampling devices cannot be utilized for technical or logistical reasons. The QA Manager or Technical Director must approve the use of bailers for groundwater sampling in advance.

Thoroughly decontaminate the bailer before being lowering it into the well if it is not a disposable bailer sealed in plastic. Collect two to three rinse samples and discharge them prior to acquisition of the actual sample. Each time the bailer is lowered to the water table, lower it in such a way as to minimize disturbance and aeration of the water column within the well.

The preferred alternative when using bailers for sampling is to use disposable Teflon bailers equipped with bottom-discharging devices. Use of disposable bailers reduces decontamination time and limits the potential for cross-contamination.

Passive Sampling: Passive samplers include passive diffusion bags, HydraSleeve, Snap Sampler, Gore Sorbers, and rigid porous polyethylene samplers. Passive samplers generate minimal waste and purge water, if any. Passive samplers depend on ambient equilibrium with formation water. These are relatively inexpensive, simple to deploy and work well for low-yield wells. However, passive samplers have volume and or analyte limitations and may require consideration of contaminant stratification. Passive samplers should be handled in accordance with the manufacturer's instructions, Army guidance (USACE 2002), or ITRC guidance (ITRC 2007).

5.3.6 Sample Handling and Preservation

Many of the chemical constituents and physiochemical parameters to be measured or evaluated during groundwater monitoring programs are chemically unstable; therefore, preserve samples. The EPA document entitled, *Test Methods for Evaluating Solid Waste – Physical/Chemical Methods, SW-846* (EPA 2007), includes a discussion of appropriate sample preservation procedures. In addition, SW-846 specifies the sample containers to use for each constituent or common set of parameters. In general, check with specific laboratory requirements prior to obtaining field samples. In many cases, the laboratory will supply the necessary sample bottles and required preservatives. In some cases, the field team may add preservatives in the field. Sample containers should be labeled in accordance with Procedure III-E, *Record Keeping, Sample Labeling, and Chain of Custody*.

Improper sample handling may alter the analytical results of the sample. Therefore, transfer samples in the field from the sampling equipment directly into the container that has been prepared specifically for that analysis or set of compatible parameters as described in the CTO-specific work plan. It is not an acceptable practice for samples to be composited in a common container in the field and then split in the laboratory, or poured first into a wide mouth container and then transferred into smaller containers.

Collect groundwater samples and place them in their proper containers in the order of decreasing volatility and increasing stability. A preferred collection order for some common groundwater parameters is:

1. VOCs and total organic halogens (TOX)
2. Dissolved gases, total organic carbon (TOC), total fuel hydrocarbons
3. Semivolatile organics, pesticides
4. Total metals, general minerals (unfiltered)
5. Dissolved metals, general minerals (filtered)
6. Phenols
7. Cyanide
8. Sulfate and chloride
9. Turbidity
10. Nitrate and ammonia
11. Radionuclides

When sampling for VOCs, collect water samples in vials or containers specifically designed to prevent loss of VOCs from the sample. An analytical laboratory shall provide these vials, preferably by the laboratory that will perform the analysis. Collect groundwater from the sampling device in vials by allowing the groundwater to slowly flow along the sides of the vial. Sampling equipment shall not touch the interior of the vial. Fill the vial above the top of the vial to form a positive meniscus with no overflow. No headspace shall be present in the sample container once the container has been capped. This can be checked by inverting the bottle once the sample is collected and tapping the side of the vial to dislodge air bubbles. Sometimes it is not possible to collect a sample without air bubbles, particularly water that is aerated. In these cases, the investigator shall note the problem to account for possible error. Cooling samples may also produce headspace, but this will typically disappear once the sample is warmed prior to analysis. In addition, if the samples are shipped by air, air bubbles form most of the time. Field logs and laboratory analysis reports shall note any headspace in the sample container(s) at the time of receipt by the laboratory, as well as at the time the sample was first transferred to the sample container at the wellhead.

5.3.6.1 SPECIAL HANDLING CONSIDERATIONS

Samples requiring analysis for organics shall not be filtered. Samples shall not be transferred from one container to another because this could cause aeration or a loss of organic material onto the walls of the container. TOX and TOC samples shall be handled and analyzed in the same manner as VOC samples.

Obtain groundwater samples to be analyzed for metals sequentially. One sample shall be obtained directly from the pump and be unfiltered. The second sample shall be filtered through a 0.45-micron membrane in-line filter. Both filtered and unfiltered samples shall be transferred to a container, preserved with nitric acid to a pH less than 2, and analyzed for dissolved metals. Remember to include a filter blank for each lot of filters used and always record the lot number of the filters. In addition, allow at least 500 mL of effluent to flow through the filter prior to sampling. Any difference in concentration between the total and dissolved fractions may be attributed to the original metallic ion content of the particles and adsorption of ions onto the particles.

5.3.6.2 FIELD SAMPLING PRESERVATION

Preserve samples immediately upon collection. Ideally, sampling containers will be pre-preserved with a known concentration and volume of preservative. For example, metals require storage in aqueous media at pH of 2 or less. Typically, 0.5 mL of 1:1 nitric acid added to 500 mL of groundwater will produce a pH less than 2. Certain matrices that have alkaline pH (greater than 7) may require more preservative than is typically required. An early assessment of preservation techniques, such as the use of pH strips after initial preservation, may therefore be appropriate. The introduction of preservatives will dilute samples, and may require normalization of results. Guidance for the preservation of environmental samples can be found in the EPA *Handbook for Sampling and Sample Preservation of Water and Wastewater* (EPA 1982). Additional guidance can be found in other EPA documents (EPA 1992, 1996).

5.3.6.3 FIELD SAMPLING LOG

A groundwater sampling log (Figure I-C-3-1) shall document the following:

- Identification of well
- Well depth
- Static water level depth and measurement technique
- Presence of immiscible layers and detection method
- Well yield
- Purge volume and pumping rate
- Time that the well was purged
- Collection method for immiscible layers
- Sample identification numbers
- Well evacuation procedure/equipment
- Sample withdrawal procedure/equipment
- Date and time of collection
- Well sampling sequence
- Types of sample containers used and sample identification numbers
- Preservative(s) used
- Parameters requested for analysis

- Field analysis data
- Sample distribution and transporter
- Field observations on sampling event
- Name of collector
- Climatic conditions including air temperature

6. Records

Document information collected during groundwater sampling on the groundwater sampling log form in indelible ink (Figure I-C-3-1). Send copies of this information to the CTO Manager and to the project files.

7. Health and Safety

Field personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

ASTM International (ASTM). 2001. *Standard Guide for Sampling Ground-Water Monitoring Wells*. D4448). Reapproved in 2013). West Conshohocken, PA.

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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.

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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.

Soil and Rock Classification

1. Purpose

This section sets forth standard operating procedures for soil and rock classification for use by United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

None.

4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that these standard soil and rock classification procedures are followed during projects conducted under the ER Program and that a qualified individual conducts or supervises the projects. A qualified individual is defined as a person with a degree in geology, hydrogeology, soil science, or geotechnical/civil engineering with at least 1 year of experience classifying soil. Supervision is defined as onsite and continuous monitoring of the individual conducting soil classification. The CTO Manager is responsible for ensuring that all personnel involved in soil and rock classification have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The CTO Manager is responsible for reviewing copies of the field boring log forms on a monthly basis at a minimum. However, it is recommended that initially boring logs are reviewed daily to ensure accuracy.

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for field oversight to ensure that all project field staff follow these procedures.

Field personnel are responsible for the implementation of this procedure.

5. Procedures

5.1 SOIL CLASSIFICATION

The basic purpose of the classification of soil is to thoroughly describe the physical characteristics of the sample and to classify it according to an appropriate soil classification system for the NAVFAC Pacific ER Program. The Unified Soil Classification System (USCS) was developed so that soils could be described on a common basis by different investigators and serve as a "shorthand" description of soil. A classification of a soil in accordance with the USCS includes not only a group symbol and name, but also a complete word description.

Describing soil on a common basis is essential so that soil described by different site qualified personnel is comparable. Site individuals describing soil as part of site activities *must* use the classification system described herein to provide the most useful geologic database for all present and future subsurface investigations and remedial activities at NAVFAC Pacific ER Program sites.

The site geologist or other qualified individual shall describe the soil and record the description in a boring log or logbook. The essential items in any written soil description are as follows:

- Classification group name (e.g., silty sand)
- Color, moisture, and odor
- Range of particle sizes
- Approximate percentage of boulders, cobbles, gravel, sand, and fines
- Plasticity characteristics of the fines
- In-place conditions, such as density/consistency, compaction, amount of induration/cementation or weathering, retention of the parent rock fabric, and structure
- USCS classification symbol

The USCS serves as “shorthand” for classifying soil into 15 basic groups:

GW[1] Well graded (poorly sorted) gravel (>50 percent gravel, <5percent fines)

GP[1] Poorly graded (well sorted) gravel (>50percent gravel, <5percent fines)

GM[1] Silty gravel (>50 percent gravel, >15 percent silt)

GC[1] Clayey gravel (>50 percent gravel, >15 percent clay)

SW[1] Well graded (poorly sorted) sand (>50 percent sand, <5 percent fines)

SP[1] Poorly graded (well sorted) sand (>50 percent sand, <5 percent fines)

SM[1] Silty sand (>50 percent sand, >15 percent silt)

SC[1] Clayey sand (>50 percent sand, >15 percent clay)

[1] If percentage of fine is 5 percent to 15 percent, a dual identification shall be given (e.g., a soil with more than 50 percent poorly sorted gravel and 10 percent clay is designated GW-GC.

ML[2] Inorganic, low plasticity silt (slow to rapid dilatancy, low toughness, and plasticity)

CL[2] Inorganic, low plasticity (lean) clay (no or slow dilatancy, medium toughness and plasticity)

MH[2] Inorganic elastic silt (no to slow dilatancy, low to medium toughness and plasticity)

CH[2] Inorganic, high plasticity (fat) clay (no dilatancy, high toughness, and plasticity)

OL Organic low plasticity silt or organic silty clay

OH Organic high plasticity clay or silt

PT Peat and other highly organic soil

Figure I-E-1 defines the terminology of the USCS. Flow charts presented in Figure I-E-2 and Figure I-E-3 indicate the process for describing soil. The particle size distribution and the plasticity of the fines are the two properties of soil used for classification. In some cases, it may be appropriate to use a borderline classification (e.g., SC/CL) if the soil has been identified as having properties that do not distinctly place the soil into one group.

5.1.1 Estimation of Particle Size Distribution

One of the most important factors in classifying a soil is the estimated percentage of soil constituents in each particle size range. Being proficient in estimating this factor requires extensive practice and frequent checking. The steps involved in determining particle size distribution are listed below:

1. Select a representative sample (approximately 1/2 of a 6-inch long by 2.5-inch diameter sample liner).
2. Remove all particles larger than 3 inches from the sample. Estimate and record the percent by volume of these particles. Only the fraction of the sample smaller than 3 inches is classified.
3. Estimate and record the percentage of dry mass of gravel (less than 3 inches and greater than 1/4 inch).
4. Considering the rest of the sample, estimate, and record the percentage of dry mass of sand particles (about the smallest particle visible to the unaided eye).
5. Estimate and record the percentage of dry mass of fines in the sample (do not attempt to separate silts from clays).
6. Estimate percentages to the nearest 5 percent. If one of the components is present in a quantity considered less than 5 percent, indicate its presence by the term “trace.”
7. The percentages of gravel, sand, and fines must add up to 100 percent. “Trace” is not included in the 100 percent total.

[2] If the soil is estimated to have 15 percent to 25 percent sand or gravel, or both, the words “with sand” or “with gravel” (whichever predominates) shall be added to the group name (e.g., clay with sand, CL; or silt with gravel, ML). If the soil is estimated to have 30 percent or more sand or gravel, or both, the words “sandy” or “gravely” (whichever predominates) shall be added to the group name (e.g., sandy clay, CL). If the percentage of sand is equal to the percent gravel, use “sandy.”

5.1.2 Soil Dilatancy, Toughness, and Plasticity

5.1.2.1 DILATANCY

To evaluate dilatancy, follow these procedures:

1. From the specimen, select enough material to mold into a ball about 1/2 inch (12 millimeters [mm]) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.
2. Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table I-E-1. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

Table I-E-1: Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in specimen.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

5.1.2.2 TOUGHNESS

Following the completion of the dilatancy test, shape the test specimen into an elongated pat and roll it by hand on a smooth surface or between the palms into a thread about 1/8 inch (3 mm) in diameter. (If the sample is too wet to roll easily, spread it into a thin layer and allow it to lose some water by evaporation.) Fold the sample threads and re-roll repeatedly until the thread crumbles at a diameter of about 1/8 inch. The thread will crumble at a diameter of 1/8 inch when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, lump the pieces together and knead it until the lump crumbles. Note the toughness of the material during kneading. Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table I-E-2.

Table I-E-2: Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft.
Medium	Medium pressure is required to roll the thread near the plastic limit. The thread and the lump have medium stiffness.
High	Considerable pressure is required to roll the thread near the plastic limit. The thread and the lump have very high stiffness.

DEFINITION OF TERMS

MAJOR DIVISIONS			SYMBOLS	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS More Than Half of Material is Larger Than No. 200 Sieve Size	GRAVELS More Than Half of Coarse Fraction is Smaller Than No. 4 Sieve	CLEAN GRAVELS (Less than 6% Fines)	GW	Well graded gravels, gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines
		GRAVELS With Fines	GM	Silty gravels, gravel-sand-silt mixtures, non-plastic fines
			GC	Clayey gravels, gravel-sand-clay mixtures, plastic fines
	SANDS More Than Half of Coarse Fraction is Smaller Than No. 4 Sieve	CLEAN SANDS (Less than 6% Fines)	SW	Well graded sands, gravelly sands, little or no fines
			SP	Poorly graded sands, gravelly sands, little or no fines
		SANDS With Fines	SM	Silty sands, sand-silt mixtures, non-plastic fines
			SC	Clayey sands, sand-clay mixtures, plastic fines
FINE GRAINED SOILS More Than Half of Material is Smaller Than No. 200 Sieve Size	SILTS AND CLAYS Liquid Limit is Less Than 50%		ML	Inorganic silts, rock flour, fine sandy silts or clays, and clayey silts with non- or slightly-plastic fines
			CL	Inorganic clays of low to medium plasticity, gravelly clays, silty clays, sandy clays, lean clays
			OL	Organic silts and organic silty clays of low plasticity
	SILTS AND CLAYS Liquid Limit is Greater Than 50%		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts, clayey silt
			CH	inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS			PT	Peat and other highly organic soils

GRAIN SIZES

SILTS AND CLAYS	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		

200 40 10 4 3/4" 3" 12"

U.S. STANDARD SERIES SIEVE — CLEAR SQUARE SIEVE OPENINGS

Figure I-E-1: Unclassified Soil Classification System (USCS)

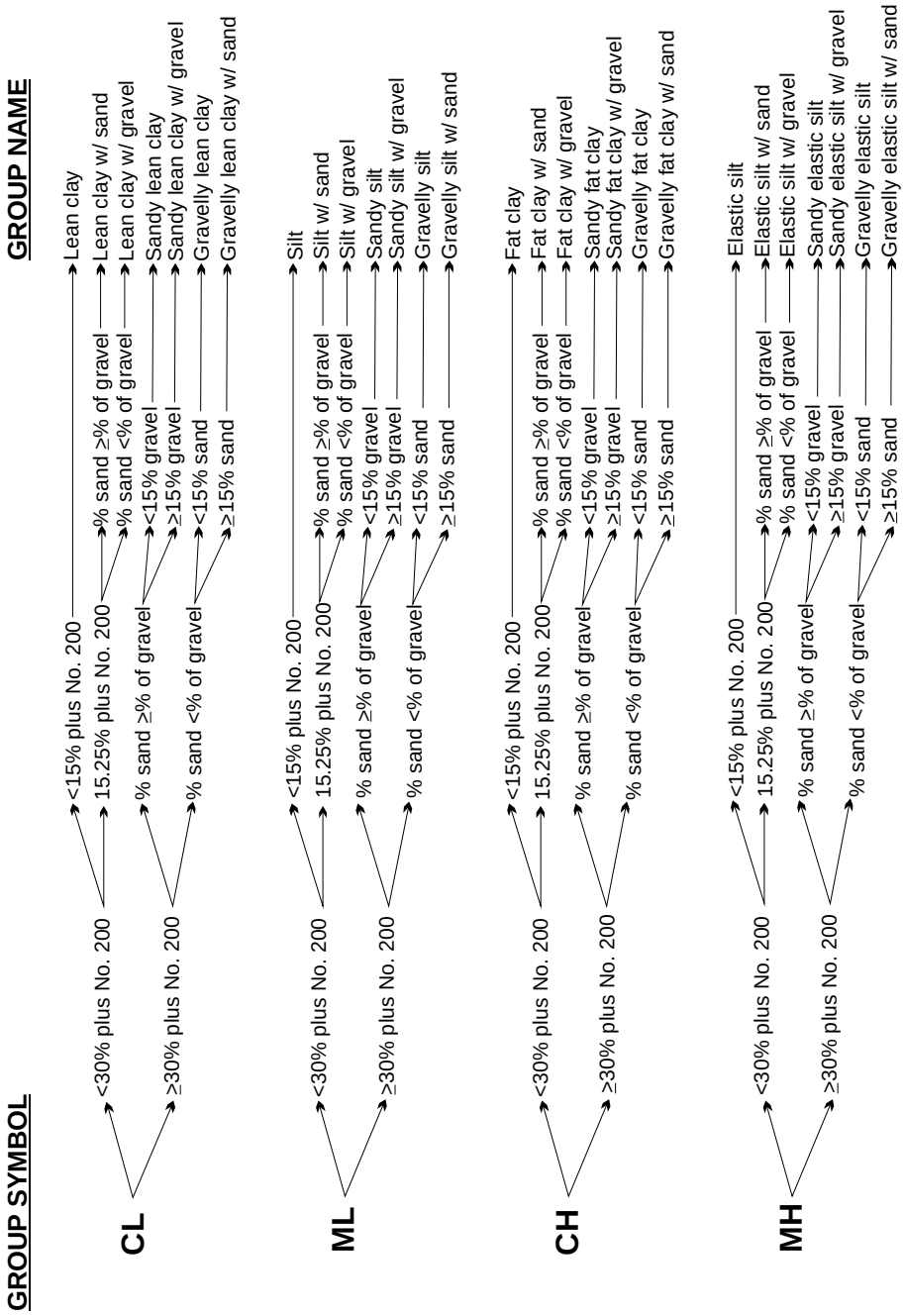

Figure I-E-2: Flow Chart for Fine Grain Soil Classification

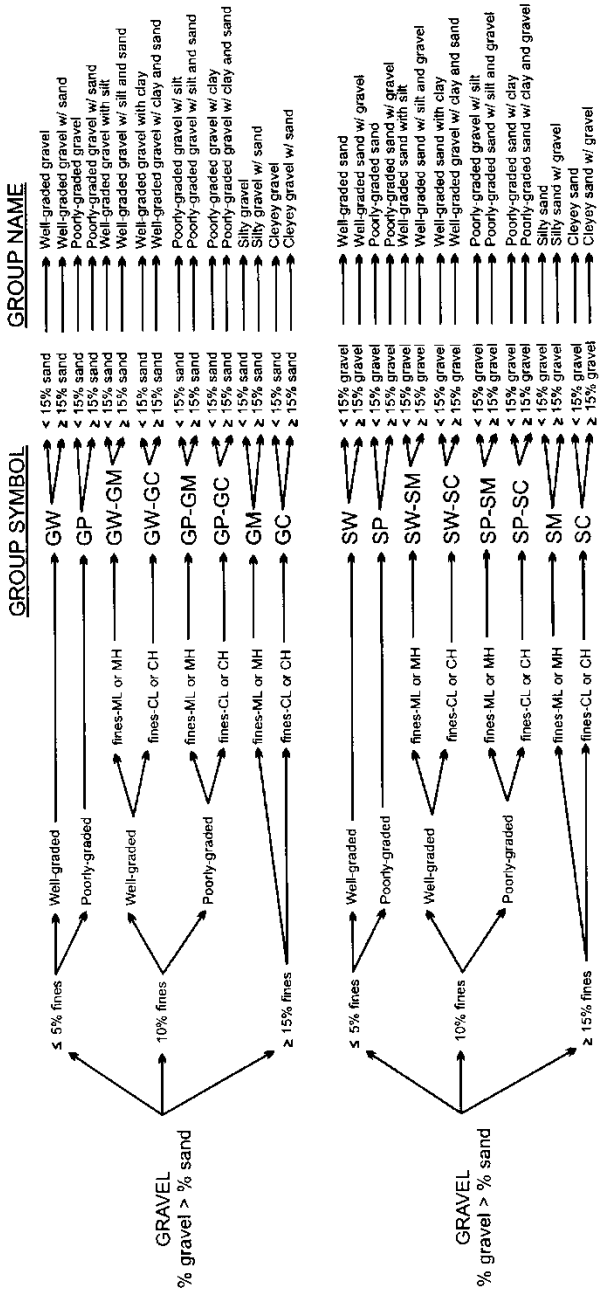

Figure I-E-3: Flow Chart for Soil with Gravel

5.1.2.3 PLASTICITY

The plasticity of a soil is defined by the ability of the soil to deform without cracking, the range of moisture content over which the soil remains in a plastic state, and the degree of cohesiveness at the plastic limit. The plasticity characteristic of clays and other cohesive materials is defined by the liquid limit and plastic limit. The liquid limit is defined as the soil moisture content at which soil passes from the liquid to the plastic state as moisture is removed. The test for the liquid limit is a laboratory, not a field, analysis.

The plastic limit is the soil moisture content at which a soil passes from the plastic to the semi-solid state as moisture is removed. The plastic limit test can be performed in the field and is indicated by the ability to roll a 1/8-inch (0.125-inch) diameter thread of fines, the time required to roll the thread, and the number of times the thread can be re-rolled when approaching the plastic limit.

The plasticity tests are not based on natural soil moisture content, but on soil that has been thoroughly mixed with water. If a soil sample is too dry in the field, add water prior to performing classification. If a soil sample is too sticky, spread the sample thin and allow it to lose some soil moisture.

Table I-E-3 presents the criteria for describing plasticity in the field using the rolled thread method.

Table I-E-3: Criteria for Describing Plasticity

Description	Criteria
Non-Plastic	A 1/8-inch thread cannot be rolled.
Low Plasticity	The thread can barely be rolled.
Medium Plasticity	The thread is easy to roll and not much time is required to reach the plastic limit.
High Plasticity	It takes considerable time rolling the thread to reach the plastic limit.

5.1.3 Angularity

The following criteria describe the angularity of the coarse sand and gravel particles:

- *Rounded* particles have smoothly-curved sides and no edges.
- *Subrounded* particles have nearly plane sides, but have well-rounded corners and edges.
- *Subangular* particles are similar to angular, but have somewhat rounded or smooth edgesand.
- *Angular* particles have sharp edges and relatively plane sides with unpolished surfaces. Freshly broken or crushed rock would be described as angular.

5.1.4 Color, Moisture, and Odor

The natural moisture content of soil is very important. Table I-E-4 shows the terms for describing the moisture condition and the criteria for each.

Table I-E-4: Soil Moisture Content Qualifiers

Qualifier	Criteria
Dry	Absence of moisture, dry to the touch
Moist	Damp but no visible water
Wet	Visible water, usually soil is below water table

Color is described by hue and chroma using the Munsell Soil Color Chart (Munsell 2000). For uniformity, all site geologists shall use this chart for soil classification. Doing so will facilitate correlation of geologic units between boreholes logged by different geologists The Munsell Color Chart is a small booklet of numbered color chips with names like "5YR 5/6, yellowish-red." Note mottling or banding of colors. It is particularly important to note and describe staining because it may indicate contamination.

In general, wear a respirator if strong organic odors are present. If odors are noted, describe them if they are unusual or suspected to result from contamination. An organic odor may have the distinctive smell of decaying vegetation. Unusual odors may be related to hydrocarbons, solvents, or other chemicals in the subsurface. An organic vapor analyzer may be used to detect the presence of volatile organic contaminants.

5.1.5 In-Place Conditions

Describe the conditions of undisturbed soil samples in terms of their density/consistency (i.e., compactness), cementation, and structure utilizing the following guidelines:

5.1.5.1 DENSITY/CONSISTENCY

Density and consistency describe a physical property that reflects the relative resistance of a soil to penetration. The term "density" is commonly applied to coarse to medium-grained sediments (i.e., gravels, sands), whereas the term "consistency" is normally applied to fine-grained sediments (i.e., silts, clays). There are separate standards of measure for both density and consistency that are used to describe the properties of a soil.

The density or consistency of a soil is determined by observing the number of blows required to drive a 1 3/8-inch (35 mm) diameter split barrel sampler 18 inches using a drive hammer weighing 140 pounds (63.5 kilograms) dropped over a distance of 30 inches (0.76 meters). Record the number of blows required to penetrate each 6 inches of soil in the field boring log during sampling. The first 6 inches of penetration is considered to be a seating drive; therefore, the blow count associated with this seating drive is recorded, but not used in determining the soil density/consistency. The sum of the number of blows required for the second and third 6 inches of penetration is termed the "standard penetration resistance," or the "N-value." The observed number of blow counts must be corrected by an appropriate factor if a different type of sampling device (e.g., Modified California Sampler with liners) is used. For a 2 3/8-inch inner diameter Modified California Sampler equipped with brass or stainless steel liners and penetrating a cohesionless soil (sand/gravel), the N-value from the Modified California Sampler must be divided by 1.43 to provide data that can be compared to the 1 3/8-inch diameter sampler data.

For a cohesive soil (silt/clay), the N-value for the Modified California Sampler should be divided by a factor of 1.13 for comparison with 1 3/8-inch diameter sampler data.

Drive the sampler and record blow counts for each 6-inch increment of penetration until one of the following occurs:

- A total of 50 blows have been applied during any one of the three 6-inch increments; a 50-blow count occurrence shall be termed “refusal” and noted as such on the boring log.
- A total of 150 blows have been applied.
- The sampler is advanced the complete 18 inches without the limiting blow counts occurring, as described above.

If the sampler is driven less than 18 inches, record the number of blows per partial increment on the boring log. If refusal occurs during the first 6 inches of penetration, the number of blows will represent the N-value for this sampling interval. Table I-E-5 and Table I-E-6 present representative descriptions of soil density/consistency vs. N-values.

Table I-E-5: Measuring Soil Density with a California Sample – Relative Density (Sands, Gravels)

	Field Criteria (N-Value)	
Description	1 3/8 in. ID Sampler	2 in. ID Sampler using 1.43 factor
Very Loose	0–4	0–6
Loose	4–10	6–14
Medium Dense	10–30	14–43
Dense	30–50	43–71
Very Dense	>50	>71

Table I-E-6: Measuring Soil Density with a California Sampler – Fine Grained Cohesive Soil

	Field Criteria (N-Value)	
Description	1 3/8 in. ID Sampler	2 in. ID Sampler using 1.13 factor
Very Soft	0–2	0–2
Soft	2–4	2–4
Medium Stiff	4–8	4–9
Stiff	8–16	9–18
Very Stiff	16–32	18–36
Hard	>32	>36

For undisturbed fine-grained soil samples, it is also possible to measure consistency with a hand-held penetrometer. The measurement is made by placing the tip of the penetrometer against the surface of the soil contained within the sampling liner or shelby tube, pushing the penetrometer into the soil a distance specified by the penetrometer manufacturer, and recording the pressure resistance reading in pounds per square foot. The values are as follows (Table I-E-7):

Table I-E-7: Measuring Soil Consistency with a Hand-Held Penetrometer

Description	Pocket Penetrometer Reading (psf)
Very Soft	0–250
Soft	250–500
Medium Stiff	500–1,000
Stiff	1,000–2,000
Very Stiff	2,000–4,000
Hard	>4,000

Consistency can also be estimated using thumb pressure using Table I-E-8.

Table I-E-8: Measuring Soil Consistency Using Thumb Pressure

Description	Criteria
Very Soft	Thumb will penetrate soil more than 1 inch (25 mm)
Soft	Thumb will penetrate soil about 1 inch (25 mm)
Firm	Thumb will penetrate soil about 1/4 inch (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very Hard	Thumbnail will not indent soil

5.1.5.2 CEMENTATION

Cementation is used to describe the friability of a soil. Cements are chemical precipitates that provide important information as to conditions that prevailed at the time of deposition, or conversely, diagenetic effects that occurred following deposition. Seven types of chemical cements are recognized by Folk (1980). They are as follows:

1. Quartz – siliceous
2. Chert – chert-cemented or chalcedonic
3. Opal – opaline
4. Carbonate – calcitic, dolomitic, sideritic (if in doubt, calcareous should be used)
5. Iron oxides – hematitic, limonitic (if in doubt, ferruginous should be used)
6. Clay minerals – if the clay minerals are detrital or have formed by recrystallization of a previous clay matrix, they are not considered to be a cement. Only if they are chemical precipitates, filling previous pore space (usually in the form of accordion-like stacks or fringing radial crusts) should they be included as “kaolin-cemented,” “chlorite-cemented,” etc.
7. Miscellaneous minerals – pyritic, collophane-cemented, glauconite-cemented, gypsiferous, anhydrite-cemented, baritic, feldspar-cemented, etc.

The degree of cementation of a soil is determined qualitatively by utilizing finger pressure on the soil in one of the sample liners to disrupt the gross soil fabric. The three cementation descriptors are as follows:

1. Weak – friable; crumbles or breaks with handling or slight finger pressure
2. Moderate – friable; crumbles or breaks with considerable finger pressure
3. Strong – not friable; will not crumble or break with finger pressure

5.1.5.3 STRUCTURE

This variable is used to qualitatively describe physical characteristics of soil that are important to incorporate into hydrogeological and/or geotechnical descriptions of soil at a site. Appropriate soil structure descriptors are as follows:

- *Granular:* Spherically shaped aggregates with faces that do not accommodate adjoining faces
- *Stratified:* Alternating layers of varying material or color with layers at least 6 mm (1/4 inch) thick; note thickness
- *Laminated:* Alternating layers of varying material or color with layers less than 6 mm (1/4 inch) thick; note thickness
- Blocky: Cohesive soil that can be broken down into small angular or subangular lumps that resist further breakdown
- *Lensed:* Inclusion of a small pocket of different soil, such as small lenses of sand, should be described as homogeneous if it is not stratified, laminated, fissured, or blocky. If lenses of different soil are present, the soil being described can be termed homogeneous if the description of the lenses is included
- *Prismatic or Columnar:* Particles arranged about a vertical line, ped is bounded by planar, vertical faces that accommodate adjoining faces; prismatic has a flat top; columnar has a rounded top
- *Platy:* Particles are arranged about a horizontal plane

5.1.5.4 OTHER FEATURES

- *Mottled:* Soil that appears to consist of material of two or more colors in blotchy distribution
- *Fissured:* Breaks along definite planes of fracture with little resistance to fracturing (determined by applying moderate pressure to sample using thumb and index finger)
- *Slickensided:* Fracture planes appear polished or glossy, sometimes striated (parallel grooves or scratches)

5.1.6 Development of Soil Description

Develop standard soil descriptions according to the following examples. There are three principal categories under which all soil can be classified. They are described below.

5.1.6.1 COARSE-GRAINED SOIL

Coarse-grained soil is divided into sands and gravels. A soil is classified as a sand if over 50 percent of the coarse fraction is “sand-sized.” It is classified as a gravel if over 50 percent of the coarse fraction is composed of “gravel-sized” particles.

The written description of a coarse-grained soil shall contain, in order of appearance: Typical name including the second highest percentage constituent as an adjective, if applicable (underlined); grain size of coarse fraction; Munsell color and color number; moisture content; relative density; sorting; angularity; other features, such as stratification (sedimentary structures) and cementation, possible formational name, primary USCS classification, secondary USCS classification (when necessary), and approximate percentages of minor constituents (i.e., sand, gravel, shell fragments, rip-up clasts) in parentheses.

Example: POORLY SORTED SAND WITH SILT, medium- to coarse-grained, light olive gray, 5Y 6/2, saturated, loose, poorly sorted, subrounded clasts, SW/SM (minor silt with approximately 20 percent coarse-grained sand-sized shell fragments, and 80 percent medium-grained quartz sand, and 5 percent to 15 percent ML).

5.1.6.2 FINE-GRAINED SOIL

Fine-grained soil is further subdivided into clays and silts according to its plasticity. Clays are rather plastic, while silts have little or no plasticity.

The written description of a fine-grained soil should contain, in order of appearance: Typical name including the second highest percentage constituent as an adjective, if applicable (underlined); Munsell color; moisture content; consistency; plasticity; other features, such as stratification, possible formation name, primary USCS classification, secondary USCS classification (when necessary), and the percentage of minor constituents in parentheses.

Example: SANDY LEAN CLAY, dusky red, 2.5 YR 3/2, moist, firm, moderately plastic, thinly laminated, CL (70 percent fines, 30 percent sand, with minor amounts of disarticulated bivalves [about 5 percent]).

5.1.6.3 ORGANIC SOIL

For highly organic soil, describe the types of organic materials present as well as the type of soil constituents present using the methods described above. Identify the soil as an organic soil, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soil usually has a dark brown to black color and may have an organic odor. Often, organic soils will change color, (e.g., from black to brown) when exposed to air. Some organic soils will lighten in color significantly when air-dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

Example: ORGANIC CLAY, black, 2.5Y, 2.5/1, wet, soft, low plasticity, organic odor, OL (100 percent fines), weak reaction to HCl.

5.2 ROCK CLASSIFICATION

The purpose of rock classification is to thoroughly describe the physical and mineralogical characteristics of a specimen and to classify it according to an established system. The generalized rock classification system described below was developed for the NAVFAC Pacific ER Program because, unlike the USCS for soils, there is no universally accepted rock classification system. In some instances, a more detailed and thorough rock classification system may be appropriate. Any modifications to this classification system, or the use of an alternate classification system should be considered during preparation of the site work plan. Both the CTO Manager and the QA Manager or

Technical Director must approve any modifications to this classification system, or the use of another classification system.

Describing rock specimens on a common basis is essential so that rocks described by different site geologists are comparable. Site geologists describing rock specimens as a part of investigative activities must use the classification system described herein, or if necessary, another more detailed classification system. Use of a common classification system provides the most useful geologic database for all present and future subsurface investigations and remedial activities at NAVFAC Pacific ER Program sites.

A rock classification template has been designated as shown in Figure I-E-4 to provide a more consistent rock classification between geologists. The template includes the classification of rocks by origin and mineralogical composition. When classifying rocks, all site geologists shall use this template.

The site geologist shall describe the rock specimen and record the description in a borehole log or logbook. The items essential for classification include:

- Classification Name (i.e., schist)
- Color
- Mineralogical composition and percent
- Texture/Grain size (i.e., fine-grained, pegmatitic, aphanitic, glassy)
- Structure (i.e., foliated, fractured, lenticular)
- Rock Quality Designation (sum of all core pieces greater than two times the diameter of the core divided by the total length of the core run, expressed as a percentage)
- Classification symbol (i.e., MF)

Example: Metamorphic foliated schist: Olive gray, 5Y, 3/2, Garnet 25 percent, Quartz 45 percent, Chlorite 15 percent, Tourmaline 15 percent, Fine-grained with Pegmatite garnet, highly foliated, slightly wavy, MF.

6. Records

Document soil classification information collected during soil sampling onto the field boring logs, field trench logs, and into the field notebook. Procedure I-B-1, *Soil Sampling* presents copies of the field boring log form. Copies of this information shall be placed in the project files.

7. Health and Safety

Field Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

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United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual.* EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-B-1, *Soil Sampling.*

9. Attachments

None.

DEFINITION OF TERMS					
PRIMARY DIVISIONS			SYMBOLS		SECONDARY DIVISIONS
SEDIMENTARY ROCKS	Clastic Sediments	CONGLOMERATE		CG	Coarse-grained Clastic Sedimentary Rock types including: Conglomerates and Breccias
		SANDSTONE		SS	Clastic Sedimentary Rock types including: Sandstone, Arkose and Greywacke
		SHALE		SH	Fine-grained Clastic Sedimentary Rock types including: Shale, Siltstone, Mudstone and Claystone
	Chemical Precipitates	CARBONATES		LS	Chemical Precipitates including: Limestone, Crystalline Limestone, Fossiliferous Limestone Micrite and Dolomite
		EVAPORITES		EV	Evaporites including: Anhydrite, Gypsum, Halite, Travertine and Caliche
IGNEOUS ROCKS	EXTRUSIVE (Volcanic)			IE	Volcanic Rock types including: Basalt, Andesite, Rhyolite, Volcanic Tuff, and Volcanic Breccia
	INTRUSIVE (Plutonic)			II	Plutonic Rock types including: Granite, Diorite and Gabbro
METAMORPHIC ROCKS	FOLIATED			MF	Foliated Rock types including: Slate, Phyllite, Schist and Gneiss
	NON-FOLIATED			MN	Non-foliated Rock types including: Metaconglomerate, Quartzite and Marble

Figure I-E-4: Rock Classification System

Equipment Decontamination

1. Purpose

This standard operating procedure describes methods of equipment decontamination for use during site activities by United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

None.

4. Responsibilities

The prime contractor CTO Manager is responsible for identifying instances of non-compliance with this procedure and ensuring that decontamination activities comply with this procedure. The CTO Manager is responsible for ensuring that all personnel involved in equipment decontamination have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for field oversight to ensure that all project field staff follow these procedures.

Field personnel are responsible for the implementation of this procedure.

5. Procedures

Decontamination of equipment used in sampling of various media, groundwater monitoring, and well drilling and development is necessary to prevent cross-contamination and to maintain the highest integrity possible in collected samples. Planning a decontamination program requires consideration of the following factors:

- The location where the decontamination procedures will be conducted
- The types of equipment requiring decontamination
- The frequency of equipment decontamination
- The cleaning technique and types of cleaning solutions appropriate for the contaminants of concern
- The method for containing the residual contaminants and wash water from the decontamination process
- The use of a quality control measure to determine the effectiveness of the decontamination procedure

The following subsection describes standards for decontamination, including the frequency of decontamination, cleaning solutions and techniques, containment of residual contaminants and cleaning solutions, and effectiveness.

5.1 DECONTAMINATION AREA

Select an appropriate location for the decontamination area at a site based on the ability to control access to the area, the ability to control residual material removed from equipment, the need to store clean equipment, and the ability to restrict access to the area being investigated. Locate the decontamination area an adequate distance away and upwind from potential contaminant sources to avoid contamination of clean equipment.

It is the responsibility of the site safety and health officer (SSHO) to set up the site zones (i.e., exclusion, transition, and clean) and decontamination areas. Generally, the decontamination area is located within the transition zone, upwind of intrusive activities, and serves as the washing area for both personnel and equipment to minimize the spread of contamination into the clean zone. For equipment, a series of buckets are set up on a visqueen-lined bermed area. Separate spray bottles containing laboratory-grade isopropyl alcohol (or alternative cleaning solvent as described in the CTO work plan [WP]) and distilled water are used for final rinsing of equipment. Depending on the nature of the hazards and the site location, decontamination of heavy equipment, such as augers, pump drop pipe, and vehicles, may be accomplished using a variety of techniques.

5.2 TYPES OF EQUIPMENT

Drilling equipment that must be decontaminated includes drill bits, auger sections, drill-string tools, drill rods, split barrel samplers, tremie pipes, clamps, hand tools, and steel cable. Decontamination of monitoring well development and groundwater sampling equipment includes submersible pumps, bailers, interface probes, water level meters, bladder pumps, airlift pumps, peristaltic pumps, and lysimeters. Other sampling equipment that requires decontamination includes, but is not limited to, hand trowels, hand augers, slide hammer samplers, shovels, stainless-steel spoons and bowls, soil sample liners and caps, wipe sampling templates, composite liquid waste samplers, and dippers. However, equipment that is shipped pre-packaged from the vendor should not have to be decontaminated prior to first use. Equipment with a porous surface, such as rope, cloth hoses, and wooden blocks, cannot be thoroughly decontaminated and shall be properly disposed of after one use.

5.3 FREQUENCY OF EQUIPMENT DECONTAMINATION

Decontaminate down-hole drilling equipment and equipment used in monitoring well development and purging prior to initial use and between each borehole or well. Down-hole drilling equipment, however, may require more frequent cleaning to prevent cross-contamination between vertical zones within a single borehole. When drilling through a shallow contaminated zone and installing a surface casing to seal off the contaminated zone, decontaminate the drilling tools prior to drilling deeper. Initiate groundwater sampling by sampling groundwater from the monitoring well where the least contamination is suspected. Decontaminate groundwater, surface water, and soil sampling devices prior to initial use and between collection of each sample to prevent the possible introduction of contaminants into successive samples.

5.4 CLEANING SOLUTIONS AND TECHNIQUES

Decontamination can be accomplished using a variety of techniques and fluids. The preferred method of decontaminating major equipment, such as drill bits, augers, drill string, and pump drop-pipe, is steam cleaning. To steam clean, use a portable, high-pressure steam cleaner equipped with a pressure hose and fittings. For this method, thoroughly steam wash equipment, and rinse it with potable tap water to remove particulates and contaminants.

Where appropriate, disposable materials are recommended. A rinse decontamination procedure is acceptable for equipment, such as bailers, water level meters, new and re-used soil sample liners, and hand tools. The decontamination procedure shall consist of the following: (1) wash with a non-phosphate detergent (alconox, liquinox, or other suitable detergent) and potable water solution; (2) rinse in a bath with potable water; (3) spray with laboratory-grade isopropyl alcohol; (4) rinse in a bath with deionized or distilled water; and (5) spray with deionized or distilled water. If possible, disassemble equipment prior to cleaning. Add a second wash at the beginning of the process if equipment is very soiled.

Decontaminating submersible pumps requires additional effort because internal surfaces become contaminated during usage. Decontaminate these pumps by washing and rinsing the outside surfaces using the procedure described for small equipment or by steam cleaning. Decontaminate the internal surfaces by recirculating fluids through the pump while it is operating. This recirculation may be done using a relatively long (typically 4 feet) large-diameter pipe (4-inch or greater) equipped with a bottom cap. Fill the pipe with the decontamination fluids, place the pump within the capped pipe, and operate the pump while recirculating the fluids back into the pipe. The decontamination sequence shall include: (1) detergent and potable water; (2) potable water rinse; (3) potable water rinse; and (4) deionized water rinse. Change the decontamination fluids after each decontamination cycle.

Solvents other than isopropyl alcohol may be used, depending upon the contaminants involved. For example, if polychlorinated biphenyls or chlorinated pesticides are contaminants of concern, hexane may be used as the decontamination solvent. However, if samples are also to be analyzed for volatile organics, hexane shall not be used. In addition, some decontamination solvents have health effects that must be considered. Decontamination water shall consist of distilled or deionized water. Steam-distilled water shall not be used in the decontamination process as this type of water usually contains elevated concentrations of metals. Decontamination solvents to be used during field activities will be specified in CTO WP and site-specific health and safety plan.

Rinse equipment used for measuring field parameters, such as pH, temperature, specific conductivity, and turbidity with deionized or distilled water after each measurement. Also wash new, unused soil sample liners and caps with a fresh detergent solution and rinse them with potable water followed by distilled or deionized water to remove any dirt or cutting oils that might be on them prior to use.

5.5 CONTAINMENT OF RESIDUAL CONTAMINANTS AND CLEANING SOLUTIONS

A decontamination program for equipment exposed to potentially hazardous materials requires a provision for catchment and disposal of the contaminated material, cleaning solution, and wash water.

When contaminated material and cleaning fluids must be contained from heavy equipment, such as drilling rigs and support vehicles, the area must be properly floored, preferably with a concrete pad that slopes toward a sump pit. If a concrete pad is impractical, planking can be used to construct solid flooring that is then covered by a nonporous surface and sloped toward a collection sump. If the decontamination area lacks a collection sump, use plastic sheeting and blocks or other objects to create a bermed area for collection of equipment decontamination water. Situate items, such as auger flights, which can be placed on metal stands or other similar equipment, on this equipment during decontamination to prevent contact with fluids generated by previous equipment decontamination. Store clean equipment in a separate location to prevent recontamination. Collect decontamination fluids contained within the bermed area and store them in secured containers as described below.

Use wash buckets or tubs to catch fluids from the decontamination of lighter-weight drilling equipment and hand-held sampling devices. Collect the decontamination fluids and store them on site in secured containers, such as U.S. Department of Transportation-approved drums, until their disposition is determined by laboratory analytical results. Label containers in accordance with Procedure I-A-6, *Investigation-Derived Waste Management*.

5.6 EFFECTIVENESS OF DECONTAMINATION PROCEDURES

A decontamination program must incorporate quality control measures to determine the effectiveness of cleaning methods. Quality control measures typically include collection of equipment blank samples or wipe testing. Equipment blanks consist of analyte-free water that has been poured over or through the sample collection equipment after its final decontamination rinse. Wipe testing is performed by wiping a cloth over the surface of the equipment after cleaning. Procedure III-B, *Field QC Samples (Water, Soil)* provides further descriptions of these samples and their required frequency of collection. These quality control measures provide "after-the fact" information that may be useful in determining whether or not cleaning methods were effective in removing the contaminants of concern.

6. Records

Describe the decontamination process in the field logbook.

7. Health and Safety

Field Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual.* EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-A-6, *Investigation-Derived Waste Management.*

Procedure III-B, *Field QC Samples (Water, Soil).*

9. Attachments

None.

Direct-Push Sampling Techniques

1. Purpose

This standard operating procedure provides guidance on the use of direct-push techniques for the United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 DIRECT-PUSH TECHNIQUES

Direct-push techniques are methods for subsurface sampling or monitoring that involve the application of downward pressure (usually supplied through hydraulic means) without the benefit of cutting tool rotation to enter soil or rock. A variety of systems are available under several trade names, such as Geoprobe and Strataprobe. Equipment may be skid-mounted, trailered, or mounted directly on the frame of a vehicle.

3.2 MEMBRANE INTERFACE PROBE (MIP)

The membrane interface probe (MIP) is a continuous sampling tool advanced through the soil using a direct-push machine to log contaminant and lithologic data in real-time. A semipermeable membrane on the probe is heated to a temperature of 100 to 120 degrees Celsius. Clean carrier gas is circulated across the internal surface of the membrane carrying volatile organic contaminants, which have diffused through the membrane, to the surface for analysis by gas phase detectors. The MIP system is a timely and cost effective way to delineate volatile organic contaminants (e.g., benzene, toluene, solvents, trichloroethylene, tetrachloroethylene) with depth. The MIP provides real-time semi-quantitative measurements that can be used for optimizing the selection of sampling locations, particularly when using a dynamic work plan. By identifying the depth at which a contaminant is located, a more representative sample of soil or water can be collected. Correlation of a series of MIP logs across a site can provide 2-D and 3-D definition of the contaminant plume. When lithologic data are obtained (electrical conductivity, cone penetration test, hydraulic profiling tool, etc.) with the MIP data, contaminant migration pathways may be defined. The MIP logs provide a detailed record of contaminant distribution in the saturated and unsaturated formations. The MIP system does not provide specificity of analytes; however, it does use three different gas detectors. These detectors are

a flame ionization detector, a photoionization detector, and a version of the electron capture detector. These three detectors allow the investigator to differentiate between certain classes of volatile contaminants such as petroleum fuels and chlorinated solvents. Soil and/or water samples must be collected and analyzed by a laboratory to identify specific analytes and quantitative concentrations. Only volatile organic compounds (VOCs) are detected by the MIP system. Detection limits are subject to the selectivity of the gas detector and the characteristics of the formation being penetrated (e.g., clay and organic carbon content) (ASTM 2012).

3.3 LASER-INDUCED FLUORESCENCE (LIF) TOOL

Laser-induced fluorescence (LIF) tools use the rapid emission of light from an atom or molecule after it has absorbed radiation from collimated and polarized monochromatic light source. LIF is a method for delineating the subsurface location of non-aqueous phase liquid (NAPL) petroleum hydrocarbons and other hydrocarbons using a fiber optic-based laser-induced fluorescence sensor system. The LIF tool uses a technique in which a laser emits pulsed ultraviolet light. The laser, mounted on the cone penetrometer platform, is linked via fiber optic cables to a window mounted on the side of a penetrometer probe. Laser energy emitted through the window causes fluorescence in adjacent contaminated media. The fluorescent radiation is transmitted to the surface via fiber optic cables for real-time spectral data acquisition and spectral analysis on the platform.

The LIF sensor responds to any material that fluoresces when excited by ultraviolet wavelengths produced by the laser, primarily the polynuclear aromatic, aromatic, and substituted hydrocarbons, along with a few heterocyclic hydrocarbons. The excitation energy causes all encountered fluorophores to fluoresce, including some minerals and some non-petroleum organic matter. However, because the sensor collects full spectral information, discrimination among the fluorophores may be accomplished by using the spectral features associated with the data. Soil samples should be taken to verify recurring spectral signatures to discriminate between fluorescing petroleum hydrocarbons and naturally occurring fluorophores.

3.4 HYDRAULIC PROFILING TOOL (HPT)

The hydraulic profiling tool (HPT) is a logging tool that can be used with LIF or MIP tools to better understand the details of soil permeability. The HPT measures the pressure required to inject a flow of water into the soil as the probe is advanced into the subsurface with a direct-push rig. The resulting injection pressure log is an indicator of formation permeability, which can be used to better understand contaminant mobility and migration.

4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that these standard direct-push technique procedures are followed during projects conducted under the ER Program and that a qualified individual conducts or supervises the projects. A qualified individual for subsurface sampling or monitoring using direct-push techniques is defined as a person with a degree in geology, hydrogeology, or geotechnical/civil engineering with at least 1 year of experience supervising soil boring construction using conventional drilling or direct-push techniques. The CTO Manager is responsible for ensuring that all personnel involved in direct-push sampling techniques have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for ensuring that all project field staff follow these procedures.

Field personnel are responsible for the implementation of this procedure.

5. Procedures

Direct-push techniques may be used as a cost-effective alternative to conventional drilling techniques for obtaining subsurface soil and groundwater samples and for monitoring subsurface conditions.

5.1 METHOD SELECTION

Base the decision to use direct-push techniques on: (1) their ability to achieve the required information at the required level of quality control and (2) their cost-effectiveness compared to conventional drilling methods. Major limitations of direct-push techniques are their inability to penetrate rock or cobbles and sometimes a shallow maximum depth of penetration. The capabilities of direct-push systems vary significantly among vendors. Consider these differences in capabilities when evaluating the method for a subsurface exploration program.

Use direct-push techniques to obtain groundwater samples for confirmatory analyses only if the screen placement method protects the screen from clogging during installation and allows the installation of a sand-pack around the exterior of the well screen. If semi-quantitative groundwater data is needed for screening purposes, direct-push tools are the best way to acquire that information.

The MIP can be effective in locating zones where dense nonaqueous phase liquids (DNAPL) may be present as well as dissolved phase concentrations of around 1 mg/L.

The LIF tool can provide accurate information on the location and characteristics of the contaminants encountered in the vadose zone and the saturated zone. Direct-push LIF is limited to soils that can be penetrated with the available equipment. The ability to penetrate strata is based on carrying vehicle weight, density of soil, and consistency of soil. Penetration may be limited by the delicacy of the window in the tool which can be damaged in certain ground conditions (ASTM 1997).

5.2 INSPECTION OF EQUIPMENT

Inspect direct-push equipment prior to use for signs of fluid leakage, which could introduce contaminants to the soil. If at any time during equipment operation, fluid is observed leaking from the rig, cease operations and immediately repair or contain the leak. Collect, containerize, and label soil and other materials affected by the leak for proper disposal (Procedure I-A-6, *Investigation-Derived Waste Management*).

5.3 PREPARATION OF WORK SITE

Inspect the work site prior to commencing operations to ensure that no overhead hazards exist that could impact the direct-push equipment. In addition, clear locations planned for subsurface exploration using geophysical methods, and hand excavate them to a depth of 2 to 3 feet prior to soil

penetration, unless it is certain (by virtue of subsurface clearing activities) that no utilities or other hazardous obstructions will be encountered in the first 2 to 3 feet (Procedure I-B-2, *Geophysical Testing*). Hand excavation may be waived when it is not practical.

Locate the direct-push rig so that it is downslope from the penetration point, if the work is to be performed on a grade. Locate the rig downwind or crosswind of the penetration point, if possible. Cover the area surrounding, and in the vicinity of, the penetration point with plastic. Establish required exclusion zones using plastic tape or cones to designate the various areas.

5.4 EQUIPMENT DECONTAMINATION

Thoroughly decontaminate equipment used for direct-push exploration and sampling in accordance with Procedure I-F, *Equipment Decontamination*, to avoid cross-contamination. Decontaminate sampling tools and downhole equipment between each sampling event and between penetration points. At a minimum, steam clean or wash and rinse the equipment. Collect, containerize, and label all wash and rinse water for proper disposal. Clean equipment (e.g., drive rods and samplers) shall not come into contact with contaminated soils or other contaminated materials. Keep equipment on plastic or protect it in another suitable fashion. Store push rods and other equipment removed from a hole on plastic sheeting until properly decontaminated.

5.5 SOIL SAMPLING

Vendors of direct-push equipment offer a variety of sampling systems designed specifically for their equipment. Both continuous and discreet soil samples may be obtained using sampling equipment similar to that described in Procedure I-B-1, *Soil Sampling*. The preferred methods for soil sampling using direct-push techniques use brass or stainless steel split-tube samplers that are driven through the horizon to be sampled. Disposable polytetrafluoroethylene or acetate sleeves may also be used. However, if the liner appears melted or otherwise damaged upon retrieval from the borehole, do not use for collecting samples that are to be analyzed for VOCs or SVOCs.

5.6 GROUNDWATER SAMPLING

Direct-push vendors offer numerous methods for obtaining groundwater samples. Key differences among methods involve: (1) the maximum well diameter achievable; (2) the ability to protect the well screen from exposure to contaminated overburden soils during installation; (3) the ability to install filter packing around the screen; (4) flexibility in the size, materials of construction, and design of well screens; and (5) the ability to convert sampling points into permanent monitoring wells. The limitations and abilities of a given system must be thoroughly understood and matched to the needs of the project before committing to the collection of groundwater samples using direct-push techniques.

Use direct-push techniques only to collect screening samples unless it is confirmed that the system:

1. Effectively protects the well screen from exposure to contaminated overburden soils during installation
2. Allows the installation of effective packing around the well screen
3. Allows the well screen to be effectively sealed against the downward infiltration of overlying groundwater or surface precipitation

4. Is constructed of materials compatible with the intended sampling and analysis goals of the project
5. Allows the use of a well screen properly sized and slotted for the needs of the project

Additional information on the collection of groundwater samples can be found in Procedures I-C-1, *Monitoring Well Installation and Abandonment*, I-C-2, *Monitoring Well Development*, and I-C-3, *Monitoring Well Sampling.*

It is the responsibility of the CTO Manager to evaluate and determine the appropriateness of direct-push systems prior to committing to their use on any project involving groundwater sampling. As part of this evaluation, it is recommended to obtain concurrence from regulatory authorities in advance for the method selection.

5.7 BOREHOLE ABANDONMENT

Methods for abandoning boreholes created with direct-push systems will vary among vendors. Coordinate the desired method for abandonment with the vendor in the planning stages of the project to ensure proper abandonment.

Some direct-push boreholes will close naturally as the drive rods and sampling tools are withdrawn. This may occur in loose, unconsolidated soils, such as sands. Close all boreholes using one of the procedures described in this procedure, unless natural caving precludes such closure.

The three methods for closing direct-push boreholes are:

1. Add granulated or pelletized bentonite and hydrate in layers, proceeding from the bottom of the hole to the surface.
2. Pour premixed cement/water (or cement/water/bentonite) mixture into the hole.
3. Fill the entire hole with granular or pelletized bentonite and hydrate by means of a previously emplaced water tube that is gradually withdrawn as water is supplied to the bentonite.

The second method is recommended. For shallow holes less than 10 feet in depth, pour a cement/water/bentonite mix directly into the opening using a funnel. For deeper holes, use a conductor (tremie) pipe to carry the grout mix to the far reaches of the borehole. Lower the conductor pipe to within 2 inches of the bottom and gradually withdraw it as grout is added, keeping the lower end of the pipe submerged in grout at all times.

The recommended grout mixture for well abandonment is 7 to 9 gallons of water per 94-pound bag of Portland cement, with 3 percent to 5 percent by weight of powdered bentonite added to the mixture. Commercial products, such as Volcay are acceptable with pre-approval of the CTO Manager and the QA Manager or Technical Director.

Seal boreholes to within 0.5 to 2.0 feet of the surface. Inspect the abandoned borehole after 24 hours to ensure that grout shrinkage does not occur. If significant shrinkage has occurred, re-grout the borehole. Fill the remaining portion of the hole with local topsoil or appropriate paving materials.

6. Records

Document soil classification information collected during soil sampling onto borehole log forms (see Procedure I-B-1, *Soil Sampling*). Fill out all logs with indelible ink. Record information about sampling activities on sample log forms or in the field logbook. Send copies of this information to the CTO Manager and to the project files.

7. Health and Safety

Field personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

ASTM International (ASTM). 1997. *Standard Practice for Cone Penetrometer Technology Characterization of Petroleum Contaminated Sites with Nitrogen Laser-Induced Fluorescence*. D6187-97 (Reapproved 2012). West Conshohocken, PA.

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Procedure I-A-6, *Investigation-Derived Waste Management.*

Procedure I-A-7, *Analytical Data Validation Planning and Coordination.*

Procedure I-B-1, *Soil Sampling.*

Procedure I-B-2, *Geophysical Testing.*

Procedure I-C-1, *Monitoring Well Installation and Abandonment.*

Procedure I-F, *Equipment Decontamination.*

9. Attachments

None.

Procedure I-I
Land Surveying

Land Surveying

1. Purpose

This standard operating procedure sets forth protocols for acquiring land surveying data to facilitate the location and mapping of geologic, hydrologic, geotechnical data, and analytical sampling points and to establish topographic control over project sites for use by United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the *Uniform Federal Policy-Quality Assurance Project Plan* (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 Boundary Survey

Boundary surveys are conducted by Certified Land Surveyors in order to delineate a legal property line for a site or section of a site.

3.2 Global Positioning System (GPS)

A GPS is a system of satellites, computers, and receivers that is able to determine the latitude and longitude of a receiver on Earth by calculating the time difference for signals from different satellites to reach the receiver.

3.3 Waypoint

A waypoint is a reference point or set of coordinates that precisely identify a location.

4. Responsibilities

The prime contractor CTO Manager is responsible for determining the appropriate land surveying protocols for the project and ensuring this procedure is properly implemented. The CTO Manager is responsible for ensuring that all personnel involved in land surveying shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager (FM) is responsible for ensuring that the appropriate protocols are conducted according to this procedure and the project-specific sampling plan. In virtually all cases, subcontractors will conduct these procedures. The FM is responsible for overseeing the activities of the subcontractor and ensuring that sampling points and topographic features are properly surveyed.

Field personnel are responsible for the implementation of this procedure.

5. Procedures

5.1 THEODOLITE/ELECTRONIC DISTANCE MEASUREMENT (EDM)

Follow the procedures listed below during theodolite/EDM land surveying conducted under the NAVFAC Pacific ER Program:

- A land surveyor registered in the state or territory in which the work is being performed shall directly supervise all surveying work.
- An authorized manufacturer’s representative shall inspect and calibrate survey instruments in accordance with the manufacturer's specifications regarding procedures and frequencies. At a minimum, instruments shall be calibrated no more than 6 months prior to the start of the survey work.
- Standards for all survey work shall be in accordance with National Oceanic and Atmospheric Administration standards and, at a minimum, with accuracy standards set forth below. The horizontal accuracy for the location of all grid intersection and planimetric features shall be (±) 0.1 feet. The horizontal accuracy for boundary surveys shall be 1 in 10,000 feet (1:10,000). The vertical accuracy for ground surface elevations shall be (±) 0.1 feet. Benchmark elevation accuracy and elevation of other permanent features, including monitoring wellheads, shall be (±) 0.01 feet.
- Reference surveys to the local established coordinate systems, and base all elevations and benchmarks established on U.S. Geological Survey datum, 1929 general adjustment.
- Reference surveyed points to mean sea level (lower low water level).
- Jointly determine appropriate horizontal and vertical control points prior to the start of survey activities. If discrepancies in the survey (e.g., anomalous water level elevations) are observed, the surveyor may be required to verify the survey by comparison to a known survey mark. If necessary, a verification survey may be conducted by a qualified third party.
- All field notes, sketches, and drawings shall clearly identify the horizontal and vertical control points by number designation, description, coordinates, and elevations. Map all surveyed locations using a base map or other site mapping, as specified by the CTO Manager.
- Begin and end all surveys at the designated horizontal and vertical control points to determine the degree of accuracy of the surveys.

- Iron pins used to mark control points shall be made of reinforcement steel or an equivalent material and shall be 18 inches long with a minimum diameter of 5/8 inch. Drive pins to a depth of 18 inches into the soil.
- Stakes used to mark survey lines and points shall be made from 3-foot lengths of 2-inch by 2-inch lumber and pointed at one end. Clearly mark them with brightly colored weatherproof flagging and biodegradable paint.
- Clearly mark the point on a monitoring well casing that is surveyed by filing grooves into the casing on either side of the surveyed point.

5.2 GLOBAL POSITIONING SYSTEM (GPS) TO CONDUCT LAND SURVEY

Follow the procedures listed below during GPS land surveying conducted under the NAVFAC Pacific ER Program:

- A land surveyor registered in the state or territory in which the work is being performed shall directly supervise all surveying work.
- An authorized manufacturer’s representative shall inspect and calibrate survey instruments in accordance with the manufacturer's specifications regarding procedures and frequencies. At a minimum, instruments shall be calibrated no more than 6 months prior to the start of the survey work.
- Standards for all survey work shall be in accordance with National Oceanic and Atmospheric Administration standards and, at a minimum, with accuracy standards set forth below. The horizontal accuracy for the location of all grid intersection and planimetric features shall be (±) 0.1 feet. The horizontal accuracy for boundary surveys shall be 1 in 10,000 feet (1:10,000). The vertical accuracy for ground surface elevations shall be (±) 0.1 feet. Benchmark elevation accuracy and elevation of other permanent features, including monitoring wellheads, shall be (±) 0.01 feet. Accuracy requirements shall be specified in the project work plan (WP).
- Reference surveys to the local established coordinate systems, and base all elevations and benchmarks established on U.S. Geological Survey datum, 1929 general adjustment.
- All field notes, sketches, and drawings shall clearly identify the horizontal and vertical control points by number designation, description, coordinates, and elevations. Map all surveyed locations using a base map or other site mapping, as specified in the project WP.
- Begin and end all surveys at the designated horizontal and vertical control points (as applicable) to determine the degree of accuracy of the surveys.
- Iron pins used to mark control points shall be made of reinforcement steel or an equivalent material and shall be 18 inches long with a minimum diameter of 5/8 inch. Drive pins to a depth of 18 inches into the soil.
- Stakes used to mark survey lines and points shall be made from 3-foot lengths of 2-inch by 2-inch lumber and pointed at one end. Clearly mark them with brightly colored weatherproof flagging and biodegradable paint.
- Clearly mark the point on a monitoring well casing that is surveyed by filing grooves into the casing on either side of the surveyed point.

5.3 GLOBAL POSITIONING SYSTEM (GPS) TO POSITION SAMPLE LOCATIONS OR LOCATE SITE FEATURES

Experienced field personnel may use a GPS system unit to position sample locations (e.g. grid positioned samples) at a site. The decision to use field personnel or a licensed land surveyor will depend on the objectives of the survey (e.g. vertical elevation is not required) and the levels of precision required. Typically when a level of precision greater than (±) 3 to 5 meters is required, a licensed surveyor will be required. When a level of precision of (±) 3 to 5 meters is sufficient to meet project requirements (i.e., when laying sampling grids, identifying significant site features, or locating features identified in geographic information system [GIS] figures) experienced field personnel may use commercially available, consumer-grade GPS units. Follow the procedures listed below to locate samples or site features using GPS:

- A commercially available GPS unit with wide angle averaging system (WAAS), topographic map display, and waypoint storage capabilities should be used.
- If waypoints are to be imported into a GIS database, the same grid projection system should be used. For Guam this is typically WGS84, Zone 55N. For Hawaii this will either be NAD83 Zone 3 and 4 or WGS84 Zone 5N.
- If a permanent reference point near the site is available, it is recommended that the reference point is surveyed each day the GPS unit is used.
- When laying out a sampling grid from a GIS map, upload the coordinates from GIS to the GPS unit, including coordinates for an easily identified, permanent, nearby feature (i.e., building corner, roadway intersection, or USGS benchmark).
- If during the initial site walk, the permanent feature identified does not overlay within (±) 5 meters as identified in the GPS unit, field corrections of the waypoints should be made.
- Field corrections can be made by adding/subtracting the difference in x,y coordinates between the field measurement of the permanent site feature and the anticipated x,y coordinates. This correction should then be applied to the x,y coordinates for each sampling location to be marked. Corrected x,y coordinates can then be uploaded into the GPS unit.
- Sampling points and site features can then be located in the field using the GPS units “Go To” function. When the distance to the sampling point or feature remains close to zero, the location can be marked.
- If no field corrections to the sampling location need to be made, or if sampling locations are to be surveyed by a licensed surveyor at a later date, no additional waypoints need to be taken. If significant changes to the sampling location are made, GPS coordinates at the corrected location shall be stored and labeled.
- It is recommended that GPS coordinates be uploaded to a storage device such as a personal computer at the end of each day.
- Field logs shall indicate manufacturer and model number for GPS unit used, map datum and projection used, and any field corrections made. If the GPS unit cannot lock onto a WAAS system at the site, this should also be noted.

6. Records

The surveyor shall record field notes daily using generally accepted practices. The data shall be neat, legible, and easily reproducible. Copies of the surveyor's field notes and calculation forms generated during the work shall be obtained and placed in the project files.

Surveyor's field notes shall, at a minimum, clearly indicate:

- The date of the survey
- General weather conditions
- The name of the surveying firm
- The names and job titles of personnel performing the survey work
- Equipment used, including serial numbers
- Field book designations, including page numbers

A land surveyor registered in the state or territory in which the work was done shall sign, seal, and certify the drawings and calculations submitted by the surveyor.

Dated records of land surveying equipment calibration shall be provided by the surveyor and placed in the project files. Equipment serial numbers shall be provided in the calibration records.

7. Health and Safety

Field personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

8. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual.* EM-385-1-1. Includes Changes 1–7. 13 July 2012.

9. Attachments

None.

Data Quality Assessment Report

1. Purpose

This procedure describes the presentation format and information provided in the data quality assessment report (DQAR) under the United States (U.S.) Navy Environmental Restoration (ER) Program for Naval Facilities Engineering Command (NAVFAC), Pacific and is consistent with protocol in the *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories* (DoD QSM) (DoD 2013). The objective of DQAR is to summarize the validated data to the end user. This procedure also establishes the method by which a Contract task Order (CTO) Manager selects and confirms the content of the DQAR. Data validation is addressed separately in Procedure II-A, *Data Validation*.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Responsibilities

The CTO Manager, the QA Manager or Technical Director, and the CTO QA Coordinator are responsible for ensuring that this procedure is implemented by data validation personnel.

Data validation personnel (unless otherwise stated) are responsible for implementing this procedure for all DQARs.

4. Procedure

4.1 INTRODUCTION

The DQAR summarizes the QA/quality control (QC) evaluation of the data according to precision, accuracy, representativeness, completeness, comparability, and sensitivity relative to the project quality objectives (PQOs). The report provides a quantitative and qualitative assessment of the data and identifies potential sources of error, uncertainty, and bias that may affect the overall usability.

The DQAR summary report identifies the level of data validation for each sample and evaluates and summarizes the results of QA/QC data validation for the entire sampling program. Each analytical fraction has a separate section for each of the criteria. These sections interpret specific QC deviations and their effects on both individual data points and the analyses as a whole. The last section presents

a summary of the precision, accuracy, representativeness, completeness, comparability, and sensitivity criteria by comparing quantitative parameters with acceptability criteria defined in the PQOs. Qualitative criteria are also summarized in this section. A DQAR example is provided as Attachment II-S-1.

4.2 PRECISION AND ACCURACY OF ENVIRONMENTAL DATA

Environmental data quality depends on sample collection procedures, analytical methods and instrumentation, documentation, and sample matrix properties. Both sampling procedures and laboratory analyses contain potential sources of uncertainty, error, and/or bias, which affect the overall quality of a measurement. Errors in sample data may result from incomplete equipment decontamination, inappropriate sampling techniques, sample heterogeneity, improper filtering, and improper preservation. The accuracy of analytical results is dependent on selecting appropriate analytical methods, maintaining equipment properly, and complying with QC requirements. The sample matrix also is an important factor in the ability to obtain precise and accurate results within a given media.

Environmental and laboratory QC samples assess the effects of sampling procedures and evaluate laboratory contamination, laboratory performance, and matrix effects. QC samples include: trip blanks, equipment blanks, field blanks, field duplicates, field triplicates, method blanks, laboratory control samples (LCSs), surrogate spikes, matrix spike/matrix spike duplicates (MS/MSDs), laboratory duplicates, and laboratory triplicates.

Before producing the DQAR, the analytical data should be validated according to the NAVFAC Pacific data validation procedures. Samples not meeting the NAVFAC ER Program validation criteria are qualified with a flag, an abbreviation indicating a deficiency with the data. The following are flags used in data validation.

J <u>Estimated</u>. The associated numerical value is an estimated quantity. The analyte was detected but the reported value may not be accurate or precise. The “J” qualification indicates the data fell outside the QC limits, but the exceedance was not sufficient to cause rejection of the data.

R <u>Rejected</u>. The data is unusable (the compound or analyte may or may not be present). Use of the “R” qualifier indicates a significant variance from functional guideline acceptance criteria. Either resampling or re-analysis is necessary to determine the presence or absence of the rejected analyte.

U <u>Nondetected</u>. Analyses were performed for the compound or analyte, but it was not detected. The “U” designation is also applied to suspected blank contamination. The “U” flag is used to qualify any result detected in an environmental sample at a concentration less than 10 times the value of the concentration in any associated blank for common laboratory contaminants and less than 5 times the concentration in any associated blank for all other contaminants.

UJ <u>Estimated/Nondetected</u>. Analyses were performed for the compound or analyte, but it was not detected and the limit of detection (LOD) is an estimated quantity due to poor accuracy or precision. This qualification is also used to flag possible false negative results in the case where low bias in the analytical system is indicated by low calibration response, surrogate, internal standard, or other spike recovery.

Once the data are reviewed and qualified according to the NAVFAC Pacific data validation procedures, the data set is then evaluated using precision, accuracy, representativeness, completeness, comparability, and sensitivity criteria that provide an evaluation of overall data usability. The following is a discussion of the precision, accuracy, representativeness, completeness, and comparability criteria as related to the PQOs.

4.2.1 Precision

Precision is a measure of the agreement or reproducibility of analytical results under a given set of conditions. It is a quantity that cannot be measured directly but is calculated from reported concentrations. Precision is expressed as the relative percent difference (RPD) or percent relative standard deviation (%RSD):

$$RPD = (D1–D2)/\{1/2(D1+D2)\} \times 100$$

$$\%RSD = SD/\{1/3(D1+D2+D3)\} \times 100$$

Where:

D1	=	the reported concentration for primary sample analyses
D2	=	the reported concentrations for duplicate analyses
D3	=	the reported concentrations for triplicate analyses
SD	=	the standard deviation for sample, duplicate and triplicate analyses

Precision is primarily assessed by calculating a RPD from the reported concentrations of the spiked compounds for each sample in the MS/MSD pair. In the absence of a MS/MSD pair, a laboratory duplicate or LCS/laboratory control sample duplicate (LCSD) pair can be analyzed as an alternative means of assessing precision. In some cases, samples from multiple sample delivery groups (SDGs) are within one QC batch and therefore are associated with the same laboratory QC samples. An additional measure of sampling precision may be obtained by collecting and analyzing field duplicate samples, which are compared using the RPD result as the evaluation criteria.

MS and MSD samples are field samples spiked by the laboratory with target analytes prior to preparation and analysis. These samples measure the overall efficiency of the analytical method in recovering target analytes from an environmental matrix. A LCS is similar to a MS/MSD sample in that the LCS is spiked with the same target analytes prior to preparation and analysis. However, the LCS is prepared using a controlled interference-free matrix instead of a field sample aliquot. Laboratory reagent water is used to prepare aqueous LCS. Non-aqueous LCSs are prepared using solid media approved by the American Society for Testing and Materials for their homogeneity. The LCS measures laboratory efficiency in recovering target analytes from either a solid or aqueous matrix in the absence of matrix interferences.

For inorganic analysis, one primary sample is analyzed and accompanied by an unspiked laboratory duplicate. The data reviewer compares the reported results of the primary analysis and the laboratory duplicate and calculates RPDs to assess laboratory precision.

Laboratory and field sampling precision are further evaluated by calculating RPDs for field sample duplicate pairs. The sampler collects two field samples at the same location and under identically controlled conditions. The laboratory then analyzes the samples under identical conditions.

If incremental sampling is performed, laboratory and field sampling precision are evaluated by calculating RSDs for laboratory triplicates and field triplicates. At the subsampling step, one sample is prepared in triplicate per batch. Laboratory triplicate data are used to determine that the samples are being reduced to sufficiently small particle sizes during the grinding process. Field triplicates are collected from different, randomly selected locations to verify that an incremental sample truly represents a decision unit. Field triplicate results are more useful than field duplicates to statistically evaluate sampling precision.

An RPD outside the numerical QC limit in either MS/MSD samples or LCS/LCSD or a %RSD outside the numerical QC limit in the laboratory triplicate indicates imprecision. Imprecision is the variance in the consistency with which the laboratory arrives at a particular reported result. Thus, the actual analyte concentration may be higher or lower than the reported result.

Possible causes of poor precision include sample matrix interference, improper sample collection or handling, inconsistent sample preparation, and poor instrument stability. In some duplicates and/or triplicates, results may be reported in the primary, duplicate, or triplicate samples at levels below the limit of quantitation (LOQ) or non-detected. Since these values are considered to be estimates, RPD exceedances from duplicates or %RSD exceedances from triplicates do not suggest a significant impact on the data quality.

4.2.2 Accuracy

Accuracy is a measure of the agreement of an experimental determination and the true value of the parameter being measured. It is used to identify bias in a given measurement system. Recoveries outside acceptable QC limits may be caused by factors such as instrumentation, analyst error, or matrix interference. Accuracy is assessed through the analysis of MS, MSD, LCS, and samples containing surrogate spikes. In some cases, samples from multiple SDGs are within one QC batch and therefore are associated with the same laboratory QC samples. Surrogate spikes are either isotopically labeled compounds or compounds that are not typically detected in the samples. Surrogate spikes are added to every blank, environmental sample, MS/MSD, and standard, for applicable organic analyses. Accuracy of inorganic analyses is determined using the percent recoveries of MS and LCS analyses.

Percent recovery (%R) is calculated using the following equation:

$$\%R = (A–B)/C \times 100$$

Where:

A	=	measured concentration in the spiked sample
B	=	measured concentration of the spike compound in the unspiked sample
C	=	concentration of the spike

The percent recovery of each analyte spiked in MS/MSD samples, LCS, and surrogate compounds added to environmental samples is evaluated against the acceptance criteria specified by the previously noted documents. Spike recoveries outside the acceptable QC accuracy limits provide an indication of bias, where the reported data may overestimate or underestimate the actual concentration of compounds detected or quantitation limits reported for environmental samples.

4.3 REPRESENTATIVENESS

Representativeness is a qualitative parameter that expresses the degree to which the sample data are characteristic of a population and is evaluated by reviewing the QC results of blank samples and holding times. Positive detects of compounds in the blank samples identify compounds that may have been introduced into the samples during sample collection, transport, preparation, or analysis. The various types of blanks evaluated are discussed below.

A method blank is a laboratory grade water or solid matrix that contains the method reagents and has undergone the same preparation and analysis as the environmental samples. The method blank provides a measure of the combined contamination derived from the laboratory source water, glassware, instruments, reagents, and sample preparation steps. Method blanks are prepared for each sample of a similar matrix extracted by the same method at a similar concentration level.

For inorganic analyses, initial and continuing calibration blanks consist of acidified laboratory grade water, which are injected at the beginning and at a regular frequency during each 12-hour sample analysis run. These blanks estimate residual contaminants from the previous sample or standards analysis and measure baseline shifts that commonly occur in emission and absorption spectroscopy.

Trip blanks are used to identify possible volatile organic contamination introduced into the sample during transport. A trip blank is a sample volatile organics analysis vial filled in the laboratory with reagent-grade water and preserved to a pH less than 2 with hydrochloric acid. It is transported to the site, stored with the sample containers, and returned unopened to the laboratory for analysis.

Equipment blanks consist of analyte-free water poured over or through the sample collection equipment. The water is collected in a sample container for laboratory analysis. These blanks are collected after the sampling equipment is decontaminated and measure efficiency of the decontamination procedure.

Field blanks consist of analyte-free source water stored at the sample collection site. The water is collected from each source water used during each sampling event.

If sample grinding is performed, grinding blanks, which consist of clean solid matrix (such as Ottawa sand), must be prepared (e.g., ground and subsampled) and analyzed in the same manner as a field sample. Grinding equipment must be thoroughly cleaned between the processing of samples and grinding blanks must be processed and analyzed to prevent cross-contamination.

Contaminants found in both the environmental sample and a blank sample are assumed to be laboratory artifacts if the concentration in the environmental sample is less than 10 times the blank value for common laboratory contaminants (methylene chloride, acetone, 2-butanone, and phthalate esters) or 5 times the blank value for other laboratory contaminants.

Holding times are evaluated to assure that the sample integrity is intact for accurate sample preparation and analysis. Holding times will be specific for each method and matrix analyzed. Holding time exceedances can cause loss of sample constituents due to biodegradation, precipitation, volatization, and chemical degradation.

4.4 COMPARABILITY

Comparability is a qualitative expression of the confidence with which one data set may be compared to another. It provides an assessment of the equivalence of the analytical results to data obtained from other analyses. It is important that data sets be comparable if they are used in conjunction with other data sets. The factors affecting comparability include the following: sample collection and handling techniques, matrix type, and analytical method. If these aspects of sampling and analysis are carried out according to standard analytical procedures, the data are considered comparable. Comparability can only be compared with confidence when precision, accuracy, and representativeness are known.

4.5 COMPLETENESS

Completeness is defined as the percentage of acceptable sample results compared to the total number of sample results. Completeness is evaluated to determine if an acceptable amount of usable data were obtained so that a valid scientific site assessment can be completed. Completeness equals the total number of sample results for each fraction minus the total number of rejected sample results divided by the total number of sample results multiplied by 100. The goal for completeness for target analytes in each analytical fraction should be specified in the DoD QSM (DoD 2013) or project planning document.

Percent completeness is calculated using the following equation:

$$\%C = (T - R)/T \times 100$$

Where:

%C	=	percent completeness
T	=	total number of sample results
R	=	total number of rejected sample results

Completeness is also determined by comparing the planned number of samples per method and matrix as specified in the project planning document, with the number determined above.

4.6 SENSITIVITY

Sensitivity is the ability of an analytical method or instrument to discriminate between measurement responses representing different concentrations. This capability is established during the planning phase to meet the data quality objectives (DQOs). It is important that calibration requirements, detection limits (DLs), and project-specific LODs and LOQs presented in the work plan are achieved and that target analytes can be detected at concentrations necessary to support the DQOs. In addition, sample results are compared to method blank and field blank results to identify potential effects of laboratory background and field procedures on sensitivity.

5. References

Department of Defense, United States (DoD). 2013. *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories.* Final version 5.0. Prepared by Department of Defense Environmental Data Quality Workgroup and the Department of Energy Consolidated Audit Program Operations Team. March.

Procedure II-A, *Data Validation*.

6. Attachments

II-S-1: Data Quality Assessment Report Example

Attachment II-S-1
Data Quality Assessment Report Example

DATA QUALITY ASSESSMENT REPORT

SITE INVESTIGATION BUILDING E-13
PEARL HARBOR, CTO XXX

12/1/03

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Glossary

µg/kg	microgram per kilogram
µg/L	microgram per liter
BTEX	benzene, toluene, ethylbenzene, xylenes
DL	detection limit
DQO	data quality objectives
EPA	Environmental Protection Agency, United States
IDL	instrument detection limit
LCS/LCSD	laboratory control sample/laboratory control sample duplicate
LOD	limit of detection
LOQ	limit of quantitation
mg/kg	milligram per kilogram
MS/MSD	matrix spike/matrix spike duplicate
NAS	Naval Air Station
PARCCS	Precision, Accuracy, Representativeness, Comparability, Completeness, Sensitivity
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
QA/QC	quality assurance/quality control
RPD	relative percent difference
RRF	relative response factor
RL	reporting limit
SDG	sample delivery group
%D	percent difference
%R	percent recovery
%RSD	percent relative standard deviation

1. Introduction

A remediation and closure was conducted at Building E-13 at Pearl Harbor, Oahu, Hawaii. This part of the site investigation included the collection and analyses of 141 environmental and quality control (QC) samples. The analyses were performed by the following methods:

- Polynuclear aromatic hydrocarbons (PAHs) by United States Environmental Protection Agency (EPA) SW-846 8270C-SIM
- Polychlorinated biphenyls (PCBs) by EPA SW-846 Method 8082
- Metals by EPA SW-846 Method 6010B/6020/7471A

Analytical services were provided by ZZZZ Laboratories whom performed analyses on the water and soil samples. The samples were grouped into sample delivery groups (SDGs) of up to 20 field samples received by each laboratory. The environmental samples are associated with QA/QC samples designed to document the data quality of the entire SDG or a sub-group of samples within a SDG. Table I is a cross-reference table listing each sample, analysis, SDG, collection date, laboratory sample number, and matrix. All shaded samples in Table I were reviewed under Level D validation guidelines.

One hundred percent of the analytical data were validated according to NAVFAC Pacific Level D data validation procedures. The analytical data were evaluated for quality assurance and quality control (QA/QC) based on the *Department of the Navy Environmental Restoration Program (NERP) Manual* (2006).

This data quality assessment report (DQAR) summarizes the QA/QC evaluation of the data according to precision, accuracy, representativeness, completeness, comparability, and sensitivity (PARCCS) relative to the project quality objectives (PQOs). This report provides a quantitative and qualitative assessment of the data and identifies potential sources of error, uncertainty, and bias that may affect the overall usability.

The DQAR evaluates and summarizes the results of QA/QC data validation for the entire sampling program. Each analytical fraction has a separate section for each of the PARCC criteria. These sections interpret specific QC deviations and their effects on both individual data points and the analyses as a whole. Section 6 presents a summary of the PARCC criteria by comparing quantitative parameters with acceptability criteria defined in the PQOs. Qualitative PARCC criteria are also summarized in this section.

Precision and Accuracy of Environmental Data

Environmental data quality depends on sample collection procedures, analytical methods and instrumentation, documentation, and sample matrix properties. Both sampling procedures and laboratory analyses contain potential sources of uncertainty, error, and/or bias, which affect the overall quality of a measurement. Errors in sample data may result from incomplete equipment decontamination, inappropriate sampling techniques, sample heterogeneity, improper filtering, and improper preservation. The accuracy of analytical results is dependent on selecting appropriate analytical methods, maintaining equipment properly, and complying with QC requirements. The sample matrix also is an important factor in the ability to obtain precise and accurate results within a given media.

Environmental and laboratory QA/QC samples assess the effects of sampling procedures and evaluate laboratory contamination, laboratory performance, and matrix effects. QA/QC samples include: equipment blanks, field duplicates, method blanks, laboratory control samples (LCSs), surrogate spikes, matrix spike/matrix spike duplicates (MS/MSDs), and laboratory duplicates.

Before conducting the PARCC evaluation, the analytical data were validated according to the *Department of the Navy Environmental Restoration Program (NERP) Manual* [2006]). Samples not meeting the Project Procedures Manual acceptance criteria were qualified with a flag, an abbreviation indicating a deficiency with the data. The following are flags used in data validation.

J — Estimated: The associated numerical value is an estimated quantity. The analyte was detected but the reported value may not be accurate or precise. The "J" qualification indicates the data fell outside the QC limits, but the exceedance was not sufficient to cause rejection of the data.

R — Rejected: The data is unusable (the compound or analyte may or may not be present). Use of the "R" qualifier indicates a significant variance from functional guideline acceptance criteria. Either resampling or re-analysis is necessary to determine the presence or absence of the rejected analyte.

U — Nondetected: Analyses were performed for the compound or analyte, but it was not detected. The "U" designation is also applied to suspected blank contamination. The "U" flag is used to qualify any result detected in an environmental sample at a concentration less than 10 times the value of the concentration in any associated blank for common laboratory contaminants and less than 5 times the concentration in any associated blank for all other contaminants.

UJ — Estimated/Nondetected: Analyses were performed for the compound or analyte, but it was not detected and the limit of detection (LOD) is an estimated quantity due to poor accuracy or precision. This qualification is also used to flag possible false negative results in the case where low bias in the analytical system is indicated by low calibration response, surrogate, internal standard, or other spike recovery.

Once the data are reviewed and qualified according to the *Department of the Navy Environmental Restoration Program (NERP) Manual* (2006), the data set is then evaluated using PARCCS criteria. PARCCS criteria provide an evaluation of overall data usability. The following is a discussion of PARCCS criteria as related to the PQOs.

Precision is a measure of the agreement or reproducibility of analytical results under a given set of conditions. It is a quantity that cannot be measured directly but is calculated from reported concentrations. Precision is expressed as the relative percent difference (RPD):

$$RPD = (D1–D2)/\{1/2(D1+D2)\} \times 100$$

Where:

D1 and D2 = the reported concentrations for sample and duplicate analyses.

Precision is primarily assessed by calculating a RPD from the reported concentrations of the spiked compounds for each sample in the MS/MSD pair. In the absence of a MS/MSD pair, a laboratory

duplicate or LCS/LCSD pair can be analyzed as an alternative means of assessing precision. In some cases, samples from multiple SDGs were within one QC batch and therefore are associated with the same laboratory QC samples. An additional measure of sampling precision was obtained by collecting and analyzing field duplicate samples, which were compared using the RPD result as the evaluation criteria.

MS and MSD samples are field samples spiked by the laboratory with target analytes prior to preparation and analysis. These samples measure the overall efficiency of the analytical method in recovering target analytes from an environmental matrix. A LCS is similar to a MS/MSD sample in that the LCS is spiked with the same target analytes prior to preparation and analysis. However, the LCS is prepared using a controlled interference-free matrix instead of a field sample aliquot. Laboratory reagent water is used to prepare aqueous LCS. Non-aqueous LCSs are prepared using solid media approved by the American Society for Testing and Materials (ASTM) for their homogeneity. The LCS measures laboratory efficiency in recovering target analytes from either a solid or aqueous matrix in the absence of matrix interferences.

For inorganics analysis, one primary sample is analyzed and accompanied by an unspiked laboratory duplicate. The data reviewer compares the reported results of the primary analysis and the laboratory duplicate, then calculates RPDs, which are used to assess laboratory precision.

Laboratory and field sampling precision are further evaluated by calculating RPDs for aqueous field sample duplicate pairs. The sampler collects two field samples at the same location and under identically controlled conditions. The laboratory then analyzes the samples under identical conditions.

An RPD outside the numerical QC limit in either MS/MSD samples or LCS/LCSD indicates imprecision. Imprecision is the variance in the consistency with which the laboratory arrives at a particular reported result. Thus, the actual analyte concentration may be higher or lower than the reported result.

Possible causes of poor precision include sample matrix interference, improper sample collection or handling, inconsistent sample preparation, and poor instrument stability. In some duplicate pairs, results maybe reported in either the primary or duplicate samples at levels below the limit of quantitation (LOQ) or non-detected. Since these values are considered to be estimates, RPD exceedances from these duplicate pairs do not suggest a significant impact on the data quality.

Accuracy is a measure of the agreement of an experimental determination and the true value of the parameter being measured. It is used to identify bias in a given measurement system. Recoveries outside acceptable QC limits may be caused by factors such as instrumentation, analyst error, or matrix interference. Accuracy is assessed through the analysis of MS, MSD, LCS, and samples containing surrogate spikes. In some cases, samples from multiple SDGs were within one QC batch and therefore are associated with the same laboratory QC samples. Surrogate spikes are either isotopically labeled compounds or compounds that are not typically detected in the samples. Surrogate spikes are added to every blank, environmental sample, MS/MSD, and standard, for all applicable organic analyses. Accuracy of inorganic analyses is determined using the percent recoveries of MS and LCS analyses.

%R is calculated using the following equation:

$$\%R = (A–B)/C \times 100$$

Where:

A	=	measured concentration in the spiked sample
B	=	measured concentration of the spike compound in the unspiked sample
C	=	concentration of the spike

The percent recovery of each analyte spiked in MS/MSD samples, LCS, and surrogate compounds added to environmental samples is evaluated against the acceptance criteria specified by the previously noted documents. Spike recoveries outside the acceptable QC accuracy limits provide an indication of bias, where the reported data may overestimate or underestimate the actual concentration of compounds detected or quantitation limits reported for environmental samples.

Representativeness is a qualitative parameter that expresses the degree to which the sample data are characteristic of a population and is evaluated by reviewing the QC results of blank samples and holding times. Positive detects of compounds in the blank samples identify compounds that may have been introduced into the samples during sample collection, transport, preparation, or analysis. The QA/QC blanks collected and analyzed are method blanks.

A method blank is a laboratory grade water or solid matrix that contains the method reagents and has undergone the same preparation and analysis as the environmental samples. The method blank provides a measure of the combined contamination derived from the laboratory source water, glassware, instruments, reagents, and sample preparation steps. Method blanks are prepared for each sample of a similar matrix extracted by the same method at a similar concentration level.

For inorganic analyses, initial and continuing calibration blanks consist of acidified laboratory grade water, which are injected at the beginning and at a regular frequency during each 12 - hour sample analysis run. These blanks estimate residual contaminants from the previous sample or standards analysis and measure baseline shifts that commonly occur in emission and absorption spectroscopy.

Trip blanks are used to identify possible volatile organic contamination introduced into the sample during transport. A trip blank is a sample bottle filled in the laboratory with reagent-grade water and preserved to a pH less than 2 with hydrochloric acid. It is transported to the site, stored with the sample containers, and returned unopened to the laboratory for analysis.

Equipment blanks consist of analyte-free water poured over or through the sample collection equipment. The water is collected in a sample container for laboratory analysis. These blanks are collected after the sampling equipment is decontaminated and measure efficiency of the decontamination procedure. Equipment blanks were collected and analyzed for all target analytes.

Field blanks consist of analyte-free source water stored at the sample collection site. The water is collected from each source water used during each sampling event. Field blanks were collected and analyzed for all target analytes.

Contaminants found in both the environmental sample and a blank sample are assumed to be laboratory artifacts if the concentration in the environmental sample is less than 10 times the blank

value for common laboratory contaminants; methylene chloride, acetone, 2-butanone, and phthalate esters or 5 times the blank value for other laboratory contaminants.

Holding times are evaluated to assure that the sample integrity is intact for accurate sample preparation and analysis. Holding times will be specific for each method and matrix analyzed. Holding time exceedances can cause loss of sample constituents due to biodegradation, precipitation, volatization, and chemical degradation.

Comparability is a qualitative expression of the confidence with which one data set may be compared to another. It provides an assessment of the equivalence of the analytical results to data obtained from other analyses. It is important that data sets be comparable if they are used in conjunction with other data sets. The factors affecting comparability include the following: sample collection and handling techniques, matrix type, and analytical method. If these aspects of sampling and analysis are carried out according to standard analytical procedures, the data are considered comparable. Comparability is also dependent upon other PARCC criteria, because only when precision, accuracy, and representativeness are known can data sets be compared with confidence.

Completeness is defined as the percentage of acceptable sample results compared to the total number of sample results. Completeness is evaluated to determine if an acceptable amount of usable data were obtained so that a valid scientific site assessment can be completed. Completeness equals the total number of sample results for each fraction minus the total number of rejected sample results divided by the total number of sample results multiplied by 100. As specified in the PQOs, the goal for completeness for target analytes in each analytical fraction is 90 percent.

Percent completeness is calculated using the following equation:

$$\%C = (T - R)/T \times 100$$

Where:

%C	=	percent completeness
T	=	total number of sample results
R	=	total number of rejected sample results

Completeness is also determined by comparing the planned number of samples per method and matrix as specified in the project planning document, with the number determined above.

Sensitivity is the ability of an analytical method or instrument to discriminate between measurement responses representing different concentrations. This capability is established during the planning phase to meet the DQOs. It is important that calibration requirements, detection limits (DLs), and project-specific LODs and LOQs presented in the work plan are achieved and that target analytes can be detected at concentrations necessary to support the DQOs. In addition, sample results are compared to method blank and field blank results to identify potential effects of laboratory background and field procedures on sensitivity.

The following sections present a review of QC data for each analytical method.

2. Polynuclear Aromatic Hydrocarbons

A total of 58 soil samples were analyzed for PAH by EPA SW-846 Method 8270C-SIM. All PAH data were assessed to be valid with the exception of 17 of the 986 total results, which were rejected based on QC exceedances. This section discusses the QA/QC supporting documentation as defined by the PARCC criteria and evaluated based on the PQOs.

2.1 PRECISION AND ACCURACY

2.1.1 Instrument Calibration

Initial and continuing calibration results provide a means of evaluating accuracy within a particular SDG. Relative response factor (RRF), percent relative standard deviation (%RSD), and percent difference (%D) are the three major parameters used to measure the effectiveness of instrument calibration. RRF is a measure of the relative spectral response of an analyte compared to its internal standard. %RSD is an expression of the linearity of instrument response. %D is a comparison of a continuing calibration instrumental response with its initial response. %RSD and %D exceedances suggest routine instrumental anomalies, which typically impact all sample results for the affected compounds.

The relative response factors met the acceptance criteria of 0.05 in the initial and continuing calibration standards.

The relative standard deviation in the initial calibrations and/or %D between the initial calibration mean relative response factors and the continuing calibration relative response factors were within the acceptance criteria of 15 and 20 percent, respectively.

The %Ds in the initial calibration verification were within the acceptance criteria of 20 percent.

2.1.2 Surrogates

As a result of non-compliant surrogate recoveries, 17 non-detected results in sample BA368 were qualified as unusable (R). Additionally, 136 results in samples BA267, BA338, BA341, BA363, BA364, BA367, BA368, and BA369 were qualified as detected estimated (J) and non-detected estimated (UJ) due to non-compliant surrogate recoveries. The details regarding the qualification of results are provided in the data validation reports.

2.1.3 MS/MSD Samples

As a result of non-compliant MS/MSDs, five results for non-compliant RPDs and 32 results for non-compliant %Rs were qualified as detected estimated (J) and non-detected estimated (UJ). The affected compounds were 2-methylnapthalene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluorene, naphthalene, phenanthrene, and pyrene. The details regarding the qualification of results are provided in the data validation reports.

2.1.4 LCS Samples

As a result of non-compliant LCS/LCSD recoveries, 139 results were qualified as detected estimated (J) and non-detected estimated (UJ). The affected compounds were acenaphthene, benzo(a)anthracene, benzo(a)pyrene, dibenz(a,h)anthracene, fluorene, and pyrene. The details regarding the qualification of results are provided in the data validation reports.

2.1.5 Internal Standards

No data were qualified based on internal standard nonconformances. The recoveries and retention times were evaluated against the acceptance criteria.

2.1.6 Field Duplicate Samples

The field duplicate samples were evaluated for acceptable precision with RPDs for the compounds. The associated data validation narratives provided details regarding criteria exceeded. Sample data were not qualified on the basis of field duplicate precision.

2.1.7 Proficiency Testing Samples

Proficiency testing samples were not performed for the sampling event.

2.1.8 Compound Quantitation and Target Identification

Due to compound quantitation nonconformances (i.e., co-elution of peaks), 29 benzo(b)fluoranthene and benzo(k)fluoranthene detected results in several samples were qualified as detected estimated (J). The details regarding the qualification of results are provided in the data validation reports.

All target compound identifications were found to be acceptable

2.2 REPRESENTATIVENESS

2.2.1 Holding Times

The evaluation of holding times to verify compliance with the method was conducted. All holding times were met.

2.2.2 Blanks

Method blanks were analyzed to evaluate representativeness. The concentration for an individual target compounds in any of the three types of QA/QC blanks were used for data qualification.

If contaminants were detected in a blank, corrective actions were made for the chemical analytical data during data validation. The corrective action consisted of amending the laboratory reported results for organic compounds based on the following criteria. The validation qualifier codes used in the blank summary tables are described below.

- *Results Below or Above the LOQ:* If a sample result for the blank contaminant was less than the LOQ or greater than the sample LOQ and less than 5× the blank value, the sample result for the blank contaminant was amended as a non-detect at the concentration reported in the sample results.
- *No Action:* If a sample result for the blank contaminant was greater than 10× the blank value for common contaminants or 5× the blank value for other contaminants, the result was not amended.

2.2.2.1 METHOD BLANKS

As a result of method blank contamination, one benzo(a)anthracene result was qualified as non-detected (U). The details regarding the qualification of results are provided in the data validation reports.

2.3 COMPARABILITY

The laboratory used standard analytical methods for all of the analyses. In all cases, the method detection limits attained were at or below the reporting limit. Target compounds detected below the reporting limits flagged (J) by the laboratory should be considered estimated. The comparability of the data is regarded as acceptable.

2.4 COMPLETENESS

The completeness level attained for PAH field samples was 98.3 percent. This percentage was calculated as the total number of accepted sample results divided by the total number of sample results multiplied by 100.

2.5 SENSITIVITY

The calibration was evaluated for instrument sensitivity and was determined to be technically acceptable. All laboratory reporting limits met the specified requirements described in the work plan although LOD was elevated for benzo(a)anthracene for one sample due to method blank contamination.

3. Polychlorinated Biphenyls

A total of 20 soil samples were analyzed for PCB as Aroclors by EPA SW-846 Method 8082. All PCB data were assessed to be valid since none of the 140 total results were rejected based on QC exceedances. This section discusses the QA/QC supporting documentation as defined by the PARCC criteria and evaluated based on the PQOs.

3.1 PRECISION AND ACCURACY

3.1.1 Instrument Calibration

Initial and continuing calibration results provide a means of evaluating accuracy within a particular SDG. Percent relative standard deviation (%RSD) and percent difference (%D) are the two major parameters used to measure the effectiveness of instrument calibration. %RSD is an expression of the linearity of instrument response. %D is a comparison of a continuing calibration instrumental response with its initial response. %RSD and %D exceedances suggest more routine instrumental anomalies, which typically impact all sample results for the affected compounds.

Six results were qualified detected estimated (J) and non-detected estimated (UJ). The relative standard deviations in the initial calibrations and/or percent difference between the initial calibration and the continuing calibration concentrations for Aroclor 1016, Aroclor 1221, and Aroclor 1232 were outside the acceptance criteria of 20 and 15 percent, respectively. The affected samples are identified in the data validation reports.

3.1.2 Surrogates

No data were qualified based on surrogate recovery nonconformances. In cases where individual recoveries exceeded criteria, the QC exceedance was judged to have no impact on the data quality and no qualifications were made.

3.1.3 MS/MSD Samples

No data were qualified based on MS/MSD nonconformances. For those SDGs with MS/MSD results, the recoveries were evaluated against the acceptance criteria. In cases where recoveries exceeded criteria, the QC exceedance was judged to have no impact on the data quality and no qualifications were made.

3.1.4 LCS Samples

No data were qualified based on LCS nonconformances. For those SDGs with LCS results, the recoveries were evaluated against the acceptance criteria.

3.1.5 Field Duplicate Samples

The field duplicate samples were evaluated for acceptable precision with RPDs for the compounds. The associated data validation narratives provided details regarding criteria exceeded. Sample data were not qualified on the basis of field duplicate precision.

3.1.6 Proficiency Testing Samples

Proficiency testing samples were not performed for the sampling event.

3.1.7 Compound Quantitation and Target Identification

Due to compound quantitation nonconformances (i.e., %Ds between columns), one Aroclor 1260 result in sample BA245 was qualified as detected estimated (J). The details regarding the qualification of results are provided in the data validation reports.

All target compound identifications were found to be acceptable.

3.2 REPRESENTATIVENESS

3.2.1 Holding Times

The evaluation of holding times to verify compliance with the method was conducted. All holding times were met.

3.2.2 Blanks

As previously discussed in Section 2.2.2, method blanks were analyzed to evaluate representativeness.

3.2.2.1 METHOD BLANKS

No QC issues were associated with the method blanks for this analysis.

3.3 COMPARABILITY

The laboratory used standard analytical methods for all of the analyses. In all cases, the method detection limits attained were at or below the reporting limit. Target compounds detected below the reporting limits flagged (J) by the laboratory should be considered estimated. The comparability of the data is regarded as acceptable.

3.4 COMPLETENESS

The completeness level attained for PCB field samples was 100 percent. This percentage was calculated as the total number of accepted sample results divided by the total number of sample results multiplied by 100.

3.5 SENSITIVITY

The calibration was evaluated for instrument sensitivity and was determined to be technically acceptable. All laboratory LODs and LOQs met the project requirements described in the work plan.

4. Metals

A total of 48 soil samples were analyzed for metals by EPA SW-846 Method 6010B/6020/7471A. All metals data were assessed to be valid since none of the 465 total results were rejected based on QC exceedances. This section discusses the QA/QC supporting documentation as defined by the PARCC criteria and evaluated based on the PQOs.

4.1 PRECISION AND ACCURACY

4.1.1 Instrument Calibration

Initial and continuing calibration verification results provide a means of evaluating accuracy within a particular SDG. Correlation coefficient (r) and percent recovery (%R) are the two major parameters used to measure the effectiveness of instrument calibration. The correlation coefficient indicates the linearity of the calibration curve. %R is used to verify the ongoing calibration acceptability of the analytical system. The most critical of the two calibration parameters, r, has the potential to affect data accuracy across a SDG when it is outside the acceptable QC limits. %R exceedances suggest more routine instrumental anomalies, which typically impact all sample results for the affected analytes.

The correlation coefficients in the initial calibrations and/or percent recoveries in the continuing calibration verifications were within the acceptance criteria of ≥ 0.995 and 90-110 percent, respectively.

4.1.2 MS Samples

As a result of non-compliant MS recoveries, 21 results were qualified as detected estimated (J) and non-detected estimated (UJ). The analytes affected were barium, cadmium, and chromium. The details regarding the qualification of results are provided in the data validation reports.

4.1.3 Duplicate (DUP) Samples

No data were qualified based on duplicate nonconformances. For those SDGs with DUP results, the relative percent differences/differences were evaluated against the acceptance criteria. In cases where

RPDs or differences exceeded criteria, the QC exceedance was judged to have no impact on the data quality and no qualifications were made.

4.1.4 LCS Samples

No data were qualified based on LCS nonconformances. For those SDGs with LCS results, the recoveries were evaluated against the acceptance criteria.

4.1.5 ICP Serial Dilution

No data were qualified based on ICP serial dilution nonconformances. All recoveries were evaluated against the acceptance criteria.

4.1.6 ICP Interference Check Sample

As a result of ICP interference check sample exceedances, 16 results were qualified as detected estimated (J) and non-detected estimated (UJ). The analytes affected were arsenic, cadmium, chromium, and silver. The details regarding the qualification of results are provided in the data validation reports.

4.1.7 Field Duplicate Samples

The field duplicate samples were evaluated for acceptable precision with RPDs for the analytes. The associated data validation narratives provided details regarding criteria exceeded. Sample data were not qualified on the basis of field duplicate precision.

4.1.8 Proficiency Testing Samples

Proficiency testing samples were not performed for the sampling event.

4.1.9 Sample Result Verification

All sample results were found to be acceptable.

4.2 REPRESENTATIVENESS

4.2.1 Holding Times

The evaluation of holding times to verify compliance with the method was conducted. All holding times were met.

4.2.2 Blanks

Method blanks were analyzed to evaluate representativeness. The concentration for an individual target compounds in any of the three types of QA/QC blanks were used for data qualification.

If contaminants were detected in a blank, corrective actions were made for the chemical analytical data during data validation. The corrective action consisted of amending the laboratory reported results for organic analytes based on the following criteria. The validation qualifier codes are described below.

- *Results Below or Above the LOQ:* If a sample result for the blank contaminant was less than the LOQ or greater than the sample LOQ and less 5× the method blank value or the highest

applicable calibration blank value, the sample result for the blank contaminant was amended as a non-detect at the concentration reported in the sample results.

- *No Action:* If a sample result for the blank contaminant was greater than 5× the blank value, the result was not amended.

4.2.2.1 METHOD BLANKS

No QC issues were associated with the method blanks for this analysis.

4.3 COMPARABILITY

The laboratory used standard analytical methods for all of the analyses. In all cases, the method detection limits attained were at or below the reporting limit. Target analytes detected below the reporting limits flagged (J) by the laboratory should be considered estimated. The comparability of the data is regarded as acceptable.

4.4 COMPLETENESS

The completeness level attained for metal field samples was 100 percent. This percentage was calculated as the total number of accepted sample results divided by the total number of sample results multiplied by 100.

4.5 SENSITIVITY

The calibration was evaluated for instrument sensitivity and was determined to be technically acceptable. All laboratory LODs and LOQs met the project requirements described in the work plan.

5.0 Variances in Analytical Performance

The laboratory used standard analytical methods for all of the analyses throughout the project. No systematic variances in analytical performance were noted according to the laboratory SOW.

6.0 Summary of PARCC criteria

The validation reports present the PARCC results for all SDGs. Each PARCC criterion is discussed in detail in the following sections.

6.1 PRECISION AND ACCURACY

Precision and accuracy were evaluated using data quality indicators such as MS/MSD, LCS, and surrogates. The precision and accuracy of the data set were considered acceptable after integration of qualification of estimated results as specifically noted in the data validation reports.

6.2 REPRESENTATIVENESS

All samples for each method and matrix were evaluated for holding time compliance. All samples were associated with a method blank in each individual SDG. The representativeness of the project data is considered acceptable after qualification for blank contamination.

6.3 COMPARABILITY

Sampling frequency requirements were met in obtaining duplicates and necessary field blanks. The laboratory used standard analytical methods for their analyses. The analytical results were reported in correct standard units. Holding times, sample preservation, and sample integrity were within QC criteria. The overall comparability is considered acceptable.

6.4 COMPLETENESS

Of the 1591 total analytes reported, 17 of the sample results were rejected. The completeness for all SDGs is as follows:

Parameter/Method	Total Analytes	No. of Rejects	%Completeness
PAHs	986	17	98.3
PCBs	140	0	100
Metals	465	0	100
Total	**1,591**	**17**	**98.9**

The completeness percentage based on rejected data met the 90 percent DQO goal. A less quantifiable loss of data occurred in the application of blank qualifications.

6.5 SENSITIVITY

Sensitivity was achieved by the laboratory to support the DQOs. Calibration concentrations and reporting limits met the project requirements and low level PAH contamination in the method blanks did not affect sensitivity.

Table 1: Validation Sample Table, SDG 42300

Client ID #	Lab ID #	QC Type	Matrix	Date Collected	Mercury (7470A)	PAH (8270C-SIM)	PCBs (8082)
BA268	AP55206		soil	7-30-03	X		
BA269	AP55207		soil	7-30-03	X		
BA270	AP55208		soil	7-30-03	X		
BA271	AP55209		soil	7-30-03	X		
BA272	AP55210		soil	7-30-03	X		
BA273	AP55211		soil	7-30-03	X		
BA274	AP55212		soil	7-30-03	X		
BA275	AP55213		soil	7-30-03	X		
BA276	AP55214		soil	7-30-03	X		
BA277	AP55215		soil	7-30-03	X		
BA278	AP55216		soil	7-31-03	X		
BA279	AP55217		soil	7-31-03	X		
BA280	AP55218		soil	7-31-03	X		
BA281	AP55219		soil	7-31-03	X		
BA282	AP55220		soil	7-31-03	X		
BA283	AP55221		soil	7-31-03	X		
BA284	AP55222		soil	7-31-03	X		
BA285	AP55223		soil	7-31-03	X		
BA286	AP55224		soil	7-31-03	X		
BA287	AP55225		soil	7-31-03	X		
BA245	AP54789		soil	7-25-03			X
BA246	AP54790		soil	7-25-03			X
BA247	AP54791		soil	7-25-03			X
BA248	AP54792		soil	7-25-03			X
BA249	AP54793		soil	7-25-03			X
BA250	AP54794		soil	7-25-03			X
BA251	AP54795		soil	7-25-03			X
BA252	AP54796		soil	7-25-03			X
BA253	AP54797		soil	7-25-03			X
BA254	AP54798		soil	7-25-03			X
BA255	AP54799		soil	7-25-03			X
BA256	AP54800		soil	7-25-03			X
BA257	AP54801		soil	7-25-03			X
BA258	AP54802		soil	7-25-03			X
BA259	AP54803		soil	7-25-03			X
BA260	AP54804		soil	7-25-03			X
BA261	AP54805		soil	7-25-03			X
BA262	AP54806		soil	7-25-03			X
BA263	AP54807		soil	7-25-03			X
BA264	AP54808		soil	7-25-03			X
BA265	AP54809		soil	7-26-03		X	
BA265DL	AP54809DL	DL	soil	7-26-03		X	

Client ID #	Lab ID #	QC Type	Matrix	Date Collected	Mercury (7470A)	PAH (8270C-SIM)	PCBs (8082)
BA266	AP54810		soil	7-26-03		X	
BA266DL	AP54810DL	DL	soil	7-26-03		X	
BA266DL2	AP54810DL2	DL2	soil	7-26-03		X	
BA267	AP54811		soil	7-26-03		X	
BA245MS	AP54789MS	MS	soil	7-25-03			X

Laboratory QC Samples (Water, Soil)

1. Purpose

This section sets forth the standard operating procedure for identifying the number and type of laboratory quality control (QC) samples that will be analyzed during each contract task order (CTO) associated with the United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific. Laboratory QC analyses serve as a check on the precision and accuracy of analytical methods and instrumentation, and the potential contamination that might occur during laboratory sample preparation and analyses. Laboratory QC analyses include blank, surrogate, blank spike, laboratory control sample (LCS), and matrix spike (MS)/matrix spike duplicate (MSD) analyses. These laboratory QC analyses are discussed in general below.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

3.1 PRECISION

Precision is the degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves. Precision is usually expressed as a standard deviation, variance, or range, in either absolute or relative terms. Examples of QC measures for precision include laboratory duplicates, laboratory triplicates, and matrix spike/matrix spike duplicates.

3.2 ACCURACY

Accuracy is the degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias), components which are due to sampling and analytical operations. Examples of QC measures for accuracy include performance evaluation samples, matrix spikes, LCSs, and equipment blanks.

3.3 MATRIX

A specific type of medium (e.g., surface water, drinking water), in which the analyte of interest may be contained. Medium is a substance (e.g., air, water, soil), which serves as a carrier of the analytes of interest (EPA 2010).

3.4 METHOD BLANK

An analyte-free matrix (water, soil, etc.) subjected to the entire analytical process to demonstrate that the analytical system itself does not introduce contamination.

3.5 MATRIX SPIKE

A sample prepared by adding a known concentration of a target analyte to an aliquot of a specific homogenized environmental sample for which an independent estimate of the target analyte concentration is available. The MS is accompanied by an independent analysis of the unspiked aliquot of the environmental sample. Spiked samples are used to determine the effect of the matrix on a method's recovery efficiency.

3.6 LABORATORY CONTROL SAMPLES AND BLANK SPIKES

A sample of known composition prepared using reagent-free water or an inert solid that is spiked with analytes of interest at the midpoint of the calibration curve or at the level of concern. It is analyzed using the sample preparation, reagents, and analytical methods employed for regular samples.

3.7 SURROGATES

A pure substance with properties that mimic the analyte of interest (organics only). Surrogates are typically brominated, fluorinated, or isotopically labeled compounds unlikely to be found in environmental samples. These analytes are added to samples to evaluate analytical efficiency by measuring recovery.

3.8 INTERNAL STANDARDS

A pure substance added to both samples and laboratory standards at a known concentration with the purpose of providing a basis of comparison in the quantitation of analytes of interest. Internal standards are primarily used to increase the accuracy and precision of analytical methods where the primary source of variability is in sample preparation or sample injection on instrument.

4. Responsibilities

The prime contractor's QA Manager or Technical Director, as well as QC coordinators are responsible for ensuring that sample analytical activities during all CTOs are in compliance with this procedure.

The CTO QC Coordinators and the Laboratory Manager are responsible for identifying instances of non-compliance with this procedure and ensuring that future laboratory analytical activities are in compliance with it.

5. Procedures

Laboratory QC checks include all types of samples specified in the requested analytical methods, such as the analysis of laboratory blank, duplicate, and MS samples. QC requirements are specified in each analytical method and in Appendix B, *Quality Control Requirements*, and Appendix C, *Laboratory Control Sample (LCS) Control Limits and Requirements*, of the *Department of Defense Quality Systems Manual for Environmental Laboratories* Version 5.0 (or most current version)

(DoD QSM). Types of QC samples are discussed in general below. Detailed discussion and minimum QA/QC requirements are presented in the DoD QSM (DoD 2013).

A comprehensive discussion of the minimum number of laboratory QC samples can be found in the *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B, Quality Assurance/Quality Control Compendium: Minimum QA/QC Activities* (DoD 2005b). However, additional QA/QC samples may be necessary based on the project quality objectives. Information pertaining to laboratory QC samples shall be documented in Worksheet 28 Laboratory QC Samples Table of the project UFP QAPP-style planning document.

5.1 LABORATORY BLANKS

Laboratory blank samples are analyzed to assess the degree to which laboratory contamination by reagent or method preparation may have affected sample analytical results. At a minimum, one laboratory blank will be analyzed per matrix per analytical method for each batch of at most 20 samples. In evaluating the blank results, all blank data are reviewed to identify any compounds detected in the blanks. The laboratory shall be contacted to discuss detection of analytes in blank samples only in the event of unusual contamination, but not for common laboratory contaminants at low levels. The following compounds are considered to be common laboratory contaminants: acetone, methylene chloride, 2-butanone, and common phthalate esters. The data for samples analyzed during the same time period as the blank are then evaluated to identify the presence of any contaminants found in the blanks. The presence of the blank contaminants found in associated samples is then evaluated to avoid potential misinterpretation of actual sample constituents. Briefly, as discussed in the data validation procedures, any analyte detected above the LOQ in both the sample and the associated blank is qualified as not detected if the sample concentration is less than five times the blank concentration (5× rule). For common laboratory contaminants (methylene chloride, acetone, 2-butanone, and common phthalate esters), a 10× rule applies.

5.2 LABORATORY REPLICATES (DUPLICATES AND TRIPLICATES)

Replicates are analyzed to evaluate the reproducibility, or precision, of the analytical procedures for a given sample. A replicate is two (duplicates) or three (triplicates) representative portions taken from one homogeneous sample by the laboratory and analyzed in the same laboratory (DoD 2005a). One duplicate sample is analyzed for each batch of twenty samples analyzed in a given matrix. Lab triplicates are assigned by the field team and identified on the chain of custody. The identification of a sample for lab triplicate analysis is typically selected from one of the field triplicates to allow for the evaluation of total study error of the sampling and analysis process. Duplicate analyses are normally performed on sample portions analyzed for inorganic constituents. For organic analyses, duplicate analyses are performed on MS samples (Section 5.5 of this procedure).

5.3 SURROGATES

Surrogate compounds must be added to all samples, standards, and blanks for all organic chromatography methods except when the matrix precludes its use or when a surrogate is not available. Poor surrogate recovery may indicate a problem with the sample composition and shall be reported to the client whose sample produced the poor recovery. Surrogate compounds to be included for organic analysis are specified in each analytical method.

5.4 LABORATORY CONTROL SAMPLES AND BLANK SPIKES

LCSs are used to demonstrate that the laboratory process for sample preparation and analysis is under control.

Analytes selected for spiking of LCSs are usually the same compounds used to spike MS/MSD samples and are representative target compounds. Control limits for LCS recoveries are provided in Appendix C of DoD QSM. If no control limits for LCS recoveries are listed in Appendix C of the DoD QSM for a given analyte, the laboratory's in-house derived control limits should be used.

For wet chemistry methods, a single spike of an appropriate control for each method may be used for LCS analyses (i.e., cyanide, a control standard of sodium cyanide from a source other than that used for calibration may be spiked into water samples and analyzed with the water samples). LCSs should be analyzed at a frequency of one per batch of at most twenty samples analyzed of similar matrix.

5.5 MATRIX SPIKES/MATRIX SPIKE DUPLICATES

MS analyses are conducted by the laboratory to assess the accuracy of specific analytical methods and to provide information on the effect of the sample matrix on the analytical methodology. Spike analyses are performed by adding compounds of known concentration to a sample, an unspiked portion of which has previously been analyzed or is concurrently analyzed. The spiked analytes are representative target compounds for each analytical method performed. The spiked sample results are evaluated with the original sample results to evaluate any effects the matrix has on the analysis. One MS is analyzed for each batch of at most 20 samples of similar matrix. Since MS samples only provide information about the specific sample matrix used for the spike, MS analyses should be performed for each type of matrix collected.

For the MSD, a separate aliquot of the sample is separately spiked and analyzed. As discussed in Section 5.2, results of MSD analyses are expressed as a relative percent difference, which is calculated by dividing the difference in concentration between the MSD and the MS sample analyses by the arithmetic mean of their concentrations. One MSD analysis is required for at most each 20 samples of similar matrix.

Acceptance criteria for both the MS and the MSD are based on historic laboratory performance and are laboratory-specific. As a general rule, the acceptance criteria should be no more stringent than the LCS acceptance criteria.

It is important to note that the UFP QAPP Part 2B, QA/QC Compendium: Minimum QA/QC Activities (DoD 2005b) states that for organic analysis, MS and MSDs are not considered a minimum QC activity as long as surrogate spikes properly mimic the analytes of concern and can identify matrix effects. Project quality objectives should be evaluated to determine if organic MS/MSDs are useful for individual projects.

6. Records

Records of QC samples analyzed during ER Program CTO activities will be maintained on laboratory bench sheets, raw data sheets, in the laboratory computerized data system, and on QC summary forms, as requested. Analytical laboratories maintain records in accordance with their quality assurance manual (QAM) as part of performing environmental analytical work under DoD.

Records shall be maintained in accordance with the analytical laboratory subcontract agreement specifications or the laboratory-specific QAM, whichever is more stringent.

7. Health and Safety

Applicable to laboratory personnel only.

8. References

Department of Defense, United States (DoD). 2005a. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

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———. 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

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Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

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Procedure I-A-8, *Sample Naming.*

Procedure III-D, *Logbooks.*

9. Attachments

Attachment III-E-1, Chain-of-Custody Seal

Attachment III-E-2, Generic Chain-of-Custody/Analytical Request Form

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

Attachment III-E-4, Sample Out-of-Control Form

Attachment III-E-1
Chain-of-Custody Seal

CHAIN-OF-CUSTODY SEAL

CUSTODY SEAL	
Company Name (808) XXX-XXXX	
Sampler's Name/Initials:_____	Date: _____ Time: _____

Attachment III-E-2
Generic Chain-of-Custody/Analytical Request Form

Chain-of-Custody

Control Number: 94H0

Date ____ Page ____ of ____

CTO/DO Manager:
CTO/DO Name:
CTO/DO Number:
Deliver results to the address above or as stated in contract

Cooler No:
QC Level:
TAT:

Bill To:
Company:
Address:

# of containers:
Preservatives:

Sample Disposal
Shipment
Comments:

Sample ID (EPA ID)	Sample ID (Navy RP Use Only)	Date Collected	Time Collected	Lab ID	Matrix/QC: Soil	Water	Other (drum, sludge, etc.)	Field Duplicate (MS/MSD)	TPH 8015B	CLP VOAs	CLP SVOAs	CLP Pesticides	CLP Metals	EPA 8080 (PCBs only)	EPA 8240	EPA 8270	Total Lead by EPA 6010			Extra Volume MS/MSD	HOLD	Total # of Containers
					TOTALS:																	

Samplers Signature — Date — Time

Relinquished By: — Date — Time

Received By: — Date — Time

Relinquished By: — Date — Time

Received By (LAB): — Date — Time

For Lab Use

Lab No.:
Does COC match samples: Y or N
Broken containers: Y or N
Received within holding time: Y or N
COC seal intact: Y or N
Any other problems: Y or N
If problems, Client contacted: Y or N
Date contacted: ___/___/___
Temperature (°C):

Original (white), Lab Copy (yellow), Field Copy (pink)

Generic Chain-of-Custody/Analytical Request Form

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

Chain-of-Custody

Control Number: 96H0HC205

Date 9 / 3 / 96 Page 1 of 1

CTO/DO Manager: Joe Smith
CTO/DO Name: Former Navy Landfill
CTO/DO Number: CTO 0250
Deliver results to the address above or as stated in contract

Cooler No: 413
QC Level: PACDIV Level D
TAT: Normal - per contract

Bill To: CLEAN/RAC Contractor
Company: company name
Address: Oahu, Hawaii

Sample Disposal: by lab
Shipment Method: Express Courier
Comments: PACDIV Level D, Measure Cooler Temperature at Lab

Sample ID (EPA ID)	Sample ID (Navy IRP Use Only)	Date Collected	Time Collected	Lab ID	Soil	Water	Other (drum, sludge, etc.)	Field Duplicate (MS/MSD)	TPH 8015B	CLP VOAs	CLP SVOAs	CLP Pesticides	CLP Metals	EPA 8080 (PCBs only)	EPA 8240	EPA 8270	Total Lead by EPA 6010	Extra Volume MS/MSD	HOLD	Total # of Containers
container # (water):					1	2	2	1	2	2	1			1					2	
Preservatives:					HCL	HCL							HNO3							
HC205		9/6/96	9:35		X				X	X	X	X	X	X						1
HC206		9/6/96	9:50		X				X	X	X	X	X	X						1
HC207		9/6/96	10:15		X				X	X	X	X	X	X						1
HC208		9/6/96	10:25		X				X	X	X	X	X	X						1
HC209		9/6/96	10:45		X				X	X	X	X	X	X						1
HC210		9/6/96	10:55			X		X		X	X									2
HC211		9/6/96	12:50			X			X	X	X	X	X	X						8
TOTALS:					6	8	7	6	6	7	7	6	7	6						16

Samplers Signature — Date — Time
Relinquished By: — Date — Time
Received By: — Date — Time
Relinquished By: — Date — Time
Received By (LAB): — Date — Time

For Lab Use
Lab No.:
Does COC match sample: Y or N
Broken container: Y or N
Received within holding time: Y or N
COC seal intact: Y or N
Any other problems: Y or N
If problems, Client contacted: Y or N
Date contacted: ___/___/___
Temperature (°C):

Original (white), Lab Copy (yellow), Field Copy (pink)

Sample Completed Chain-of-Custody

Attachment III-E-4
Sample Out-of-Control Form

OUT OF CONTROL FORM	Status	Date	Initial
	Noted OOC		
	Submit for CA*		
	Resubmit for CA*		
	Completed		

Date Recognized:	By:
Dated Occurred:	Matrix
Parameter (Test Code):	Method:
Analyst:	Supervisor:

Samples Affected (List by Accession AND Sample No.)

1. Type of Event (Check all that apply)		2. Corrective Action (CA)* (Check all that apply)	
	Calibration Corr. Coefficient <0.995		Repeat calibration
	%RSD>20%		Made new standards
	Blank >MDL		Reran analysis
	Does not meet criteria:		Sample(s) redigested and rerun
	Spike		Sample(s) reextracted and rerun
	Duplicate		Recalculated
	LCS		Cleaned system
	Calibration Verification		Ran standard additions
	Standard Additions		Notified
	MS/MSD		Other (please explain)
	BS/BSD		
	Surrogate Recovery		
	Calculations Error		

	Holding Times Missed	
	Other (Please explain	Comments:

3. Results of Corrective Action	
	Return to Control (indicated with)
	Corrective Actions Not Successful - DATA IS TO BE FLAGGED with _____.

Analyst:	Date:
Supervisor:	Date:
QA Department:	Date:

Sample Handling, Storage, and Shipping

1. Purpose

This standard operating procedure sets forth the methods for use by the United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel engaged in handling, storing, and transporting samples.

2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

3. Definitions

None.

4. Responsibilities

The prime contractor CTO Manager and the Laboratory Project Manager are responsible for identifying instances of non-compliance with this procedure and ensuring that future sample transport activities are in compliance with this procedure.

The Field Manager is responsible for ensuring that all samples are shipped according to this procedure.

Field personnel are responsible for the implementation of this procedure.

The QA Manager or Technical Director is responsible for ensuring that sample handling, storage, and transport activities conducted during all CTOs are in compliance with this procedure.

All field personnel are responsible for complying with Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

5. Procedures

5.1 Handling and Storage

Immediately following collection, label all samples according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*. In addition, when more than one volatile organic analyte

(VOA) vial is used to collect one sample, the chain-of-custody (COC) identification (ID) will be written on the VOA vials (even pre-tared vials) with a ball point pen for that sample. The lids of the containers shall not be sealed with duct tape, but should be covered with custody seals (except pre-tared containers which should have the custody seal placed on the outside of the protective bubble wrap). Wrap glass sample containers on the sides, tops, and bottoms with bubble wrap or other appropriate padding to prevent breakage during transport. When collecting three VOA vials per sample, it is acceptable to wrap all three vials together and store in one plastic bag. Store all glass containers for water samples in an upright position, never stacked or placed on their sides. Samples will be maintained as close to 4 degrees Celsius (°C) as possible from the time of collection through transport to the analytical laboratory, using refrigerators and/or freezers when appropriate. Place all containers into self-sealing bags and into an insulated cooler with wet ice while still in the field. Samples should occupy the lower portion of the cooler, while the ice should occupy the upper portion. Place an absorbent material (e.g., proper absorbent cloth material) on the bottom of the cooler to contain liquids in case of spillage. Ship samples as soon after collection as possible to allow the laboratory to meet holding times for analyses. Check with the laboratory for operating/sample receipt hours prior to all traditional and non-traditional holidays to ensure sample shipment will be received. When not shipping samples directly upon field collection, store samples in a refrigerator or freezer (never freeze water samples) until shipped to the laboratory.

5.2 PACKING

Each cooler must contain a temperature blank (small plastic bottle with sterile water) to confirm cooler temperature upon receipt at the laboratory. Water samples can be used as such, but it is best to include a designated temperature blank bottle, typically supplied by the laboratory with the coolers.

One trip blank must be included in each cooler containing samples for volatile analysis (e.g., volatile organic compounds, total petroleum hydrocarbons-gasoline range organics.

Cooler must be lined completely in ice at the bottom and all four sides. After confirming all project samples are accounted for and labeled correctly, place samples in cooler. Record sample IDs on cooler-specific COC(s). Pack glass containers for water samples in an upright position, never stacked or placed on their sides. Fill all empty space between sample containers with bubble wrap or other appropriate material (not Styrofoam). Place a layer of ice on top of samples and fill all empty space between ice and cooler lid with bubble wrap or other appropriate material.

Place laboratory copies of completed COC(s), and soil permit if applicable, into resealable bag and tape to underside of cooler lid.

5.3 SHIPPING

Follow all appropriate U.S. Department of Transportation regulations (e.g., 49 Code of Federal Regulations [CFR], Parts 171-179) for shipment of air, soil, water, and other samples. Elements of these procedures are summarized below.

5.3.1 Hazardous Materials Shipment

Field personnel must state whether any sample is suspected to be a hazardous material. A sample should be assumed to be hazardous unless enough evidence exists to indicate it is non-hazardous. If not suspected to be hazardous, shipments may be made as described in the Section 5.3.3 for non-hazardous materials. If hazardous, follow the procedures summarized below.

Any substance or material that is capable of posing an unreasonable risk to life, health, or property when transported is classified as hazardous. Perform hazardous materials identification by checking the list of dangerous goods for that particular mode of transportation. If not on that list, materials can be classified by checking the Hazardous Materials Table (49 CFR 172.102 including Appendix A) or by determining if the material meets the definition of any hazard class or division (49 CFR Part 173), as listed in Attachment III-F-2.

All persons shipping hazardous materials must be properly trained in the appropriate regulations, as required by HM-126F, Training for Safe Transportation of Hazardous Materials (49 CFR HM-126F Subpart H). The training covers loading, unloading, handling, storing, and transporting of hazardous materials, as well as emergency preparedness in the case of accidents. Carriers, such as commercial couriers, must also be trained. Modes of shipment include air, highway, rail, and water.

When shipping hazardous materials, including bulk chemicals or samples suspected of being hazardous, the proper shipping papers (49 CFR 172 Subpart C), package marking (49 CFR 172 Subpart D), labeling (49 CFR 172 Subpart E), placarding (49 CFR 172 Subpart F, generally for carriers), and packaging must be used. Attachment III-F-1 shows an example of proper package markings. Refer to a copy of 49 CFR each time hazardous materials/potentially hazardous samples are shipped.

According to Section 2.7 of the International Air Transport Association Dangerous Goods Regulations publication, very small quantities of certain dangerous goods may be transported without certain marking and documentation requirements as described in 49 CFR Part 172. However, other labeling and packing requirements must still be followed. Attachment III-F-2 shows the volume or weight for different classes of substances. A “Dangerous Goods in Excepted Quantities” label must be completed and attached to the associated shipping cooler (Attachment III-F-3). Certain dangerous goods are not allowed on certain airlines in any quantity.

As stated in item 4 of Attachment III-F-4, the Hazardous Materials Regulations do not apply to hydrochloric acid (HCl), nitric acid (HNO_3), sulfuric acid (H_2SO_4), and sodium hydroxide (NaOH) added to water samples if their pH or percentage by weight criteria are met. Hazardous Materials Regulations also do not apply to methanol (MeOH) for soil samples if the percentage by weight criterion is met. These samples may be shipped as non-hazardous materials as discussed below.

5.3.2 Non-hazardous Materials Shipment

If the samples are suspected to be non-hazardous based on previous site sample results, field screening results, or visual observations, if applicable, then samples may be shipped as non-hazardous.

If preservatives (HCl, HNO_3, H_2SO_4, NaOH, or MeOH) are used, ensure their individual pH or percentage by weight criteria, as shown in item 4 of Attachment III-F-4, are met to continue shipping as non-hazardous samples.

When a cooler is ready for shipment to the laboratory, place the receiving laboratory address on the top of the cooler, place chain-of-custody seals on the coolers as discussed in Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*, place soil permit labels on top if applicable, and seal the cooler with waterproof tape.

5.3.3 Shipments from Outside the Continental United States

Shipment of sample coolers to the continental U.S. from locations outside the continental U.S. is controlled by the U.S. Department of Agriculture (USDA) and is subject to their inspection and regulation. A "USDA Soil Import Permit" is required to prove that the receiving analytical laboratory is certified by the USDA to receive and properly dispose of soil. In addition, all sample coolers must be inspected by a USDA representative, affixed with a label indicating that the coolers contain environmental samples, and accompanied by shipping forms stamped by the USDA inspector prior to shipment. In addition, the U.S. Customs Service must clear samples shipped from U.S. territorial possessions or foreign countries upon entry into the U.S. As long as the commercial invoice is properly completed (see below), shipments typically pass through U.S. Customs Service without the need to open coolers for inspection.

In Hawaii, soil sample shipments are typically brought to the courier at the airport where the courier contacts a USDA representative to make an inspection. Alternatively, the contractor may enter into an agreement with the USDA to ship soil samples. In this way, the USDA does not need to inspect each soil sample shipment. If the contractor maintains a Domestic Soil Permit, place the permit label and the soil origination label (Attachment III-F-9) on the top of the cooler. Place a copy of the receiving laboratory's soil permit with the COC inside the cooler. Confirm custody seals were placed on each container (Section 5.1) to ensure proper chain-of-custody control in the event coolers are opened for inspection.

In Guam, shipments can be dropped off directly to the Federal Express branch or to the courier at the airport. Alternatively, the courier can pick up shipments at each site provided that arrangements have been made regarding pickup time and location. USDA inspections occur outside of Guam. The laboratory's soil permit shall be placed with the COC inside the cooler, and the soil origination label (see Attachment III-F-9) should be placed on top of the cooler.

The USDA does not need to inspect water sample shipments.

Completion and use of proper paperwork will, in most cases, minimize or eliminate the need for the USDA and U.S. Customs Service to inspect the contents. Attachment III-F-5 shows an example of how paperwork may be placed on the outside of coolers for non-hazardous materials. For hazardous materials, refer to Section 5.3.1.

In summary, tape the paperwork listed below to the outside of the coolers to assist sample shipments. If a shipment is made up of multiple pieces (e.g., more than one cooler), the paperwork need only be attached to one cooler, provided that the courier agrees. All other coolers in the shipment need only be taped and have address and COC seals affixed.

1. **Courier Shipping Form & Commercial Invoice**. See Attachment III-F-6, and Attachment III-F-7 for examples of the information to be included on the commercial invoice for soil and water. Place the courier shipping form and commercial invoice inside a clear, plastic, adhesive-backed pouch that adheres to the package (typically supplied by the courier) and place it on the cooler lid as shown in Attachment III-F-5.
2. **Soil Import Permit (soil only)**. See Attachment III-F-8 and Attachment III-F-9 for examples of the soil import permit and soil samples restricted entry labels. The laboratory shall supply these documents prior to mobilization. The USDA in Hawaii often 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

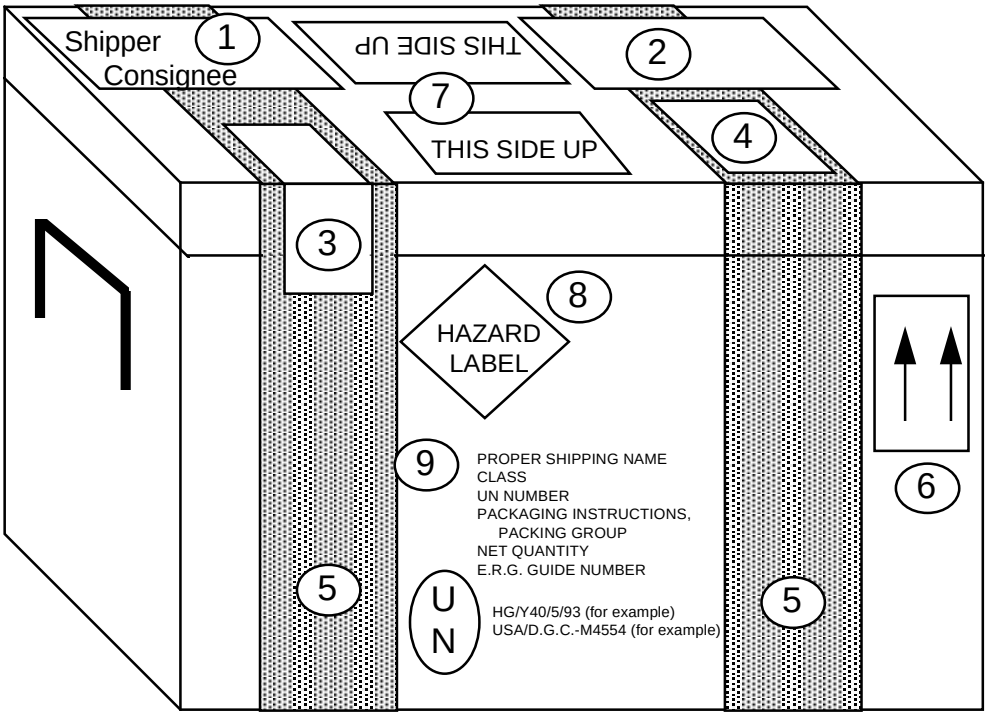
Attachment III-F-6: Commercial Invoice – Soil

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

Attachment III-F-2
Packing Groups

PACKING GROUP OF THE SUBSTANCE	PACKING GROUP 1		PACKING GROUP II		PACKING GROUP III	
CLASS or DIVISION of PRIMARY or SUBSIDIARY RISK	Packagings		Packagings		Packagings	
	Inner	Outer	Inner	Outer	Inner	Outer
1: Explosives	---------- Forbidden (Note A) ----------					
2.1: Flammable Gas	---------- Forbidden (Note B) ----------					
2.2: Non-Flammable, non-toxic gas	---------- See Notes A and B ----------					
2.3: Toxic gas	---------- Forbidden (Note A) ----------					
3. Flammable liquid	30 mL	300 mL	30 mL	500 mL	30 mL	1 L
4.1 Self-reactive substances	Forbidden		Forbidden		Forbidden	
4.1: Other flammable solids	Forbidden		30 g	500 g	30 g	1 kg
4.2: Pyrophoric substances	Forbidden		Not Applicable		Not Applicable	
4.2 Spontaneously combustible substances	Not Applicable		30 g	500 g	30 g	1 kg
4.3: Water reactive substances	Forbidden		30 g or 30 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
5.1: Oxidizers	Forbidden		30 g or 30 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
5.2: Organic peroxides (Note C)	See Note A		30 g or 30 mL	500 g or 250 mL	Not Applicable	
6.1: Poisons - Inhalation toxicity	Forbidden		1 g or 1 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
6.1: Poisons - oral toxicity	1 g or 1 mL	300 g or 300 mL	1 g or 1 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
6.1: Poisons - dermal toxicity	1 g or 1 mL	300 g or 300 mL	1 g or 1 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
6.2: Infectious substances	---------- Forbidden (Note A) ----------					
7: Radioactive material (Note D)	---------- Forbidden (Note A) ----------					
8: Corrosive materials	Forbidden		30 g or 30 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L
9: Magnetized materials	---------- Forbidden (Note A) ----------					
9: Other miscellaneous materials (Note E)	Forbidden		30 g or 30 mL	500 g or 500 mL	30 g or 30 mL	1 kg or 1 L

Note A: *Packing groups are not used for this class or division.*
Note B: *For inner packagings, the quantity contained in receptacle with a water capacity of 30 mL. For outer packagings, the sum of the water capacities of all the inner packagings contained must not exceed 1 L.*
Note C: *Applies only to Organic Peroxides when contained in a chemical kit, first aid kit or polyester resin kit.*
Note D: *See 6.1.4.1, 6.1.4.2 and 6.2.1.1 through 6.2.1.7, radioactive material in excepted packages.*
Note E: *For substances in Class 9 for which no packing group is indicated in the List of Dangerous Goods, Packing Group II quantities must be used.*

Attachment III-F-3
Label for Dangerous Goods in Excepted Quantities

DANGEROUS GOODS IN EXCEPTED QUANTITIES

This package contains dangerous goods in excepted small quantities and is in all respects in compliance with the applicable international and national government regulations and the IATA Dangerous Goods Regulations.

_____
Signature of Shipper

_____ _____
Title Date

_____

_____
Name and address of Shipper

This package contains substance(s) in Class(es) (check applicable box(es))

Class:	2	3	4	5	6	8	9
	o	o	o	o	o	o	o

and the applicable UN Numbers are:

Attachment III-F-4
SW-846 Preservative Exception

Measurement	Vol. Req. (mL)	Container[2]	Preservative [3,4]	Holding Time[5]
MBAS	250	P,G	Cool, 4ºC	48 Hours
NTA	50	P,G	Cool, 4ºC	24 Hours

1. More specific instructions for preservation and sampling are found with each procedure as detailed in this manual. A general discussion on sampling water and industrial wastewater may be found in ASTM, Part 31, p. 72-82 (1976) Method D-3370.

2. Plastic (P) or Glass (G). For metals, polyethylene with a polypropylene cap (no liner) is preferred.

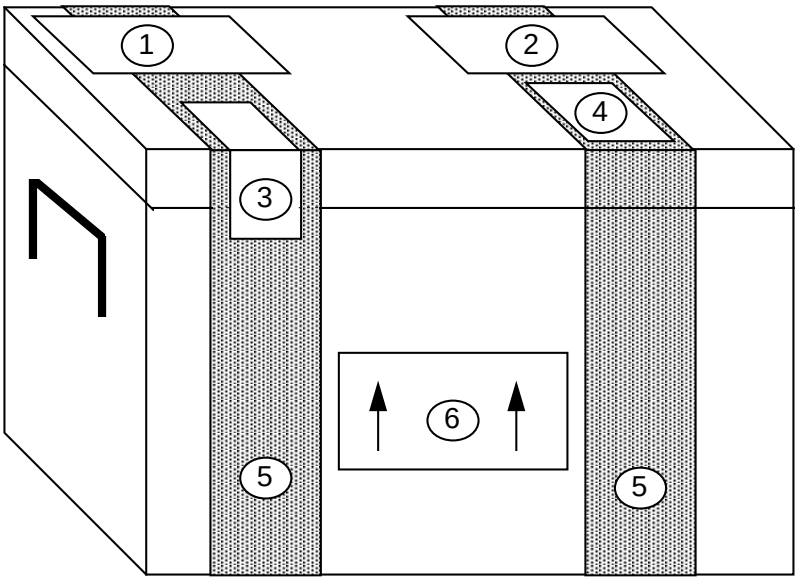
3. Sample preservation should be performed immediately upon sample collection. For composite samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then samples may be preserved by maintaining at 4ºC until compositing and sample splitting is completed.

4. When any sample is to be shipped by common carrier or sent through the United States Mail, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172). The person offering such material for transportation is responsible for ensuring such compliance. for the preservation requirements of Table 1, the Office of Hazardous Materials, Materials Transportation Bureau, Department of Transportation has determined that the Hazardous Materials regulations do not apply to the following materials: Hydrochloric acid (HCl) in water solutions at concentration of 0.04% by weight or less (pH about 1.96 or greater); Nitric acid (HNO_3) in water solutions at concentrations of 0.15% by weight or less (pH about 1.62 or greater); Sulfuric acid (H_2SO_4) in water solutions at concentrations of 0.35% by weight or less (pH about 1.15 or greater); Sodium hydroxide (NaOH) in water solutions at concentrations of 0.080% by weight or less (pH about 12.30 or less).

5. Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of sample under study are stable for the longer time, and has received a variance from the Regional Administrator. Some samples may not be stable for the maximum time period given in the table. A permittee, or monitoring laboratory, is obligated to hold the sample for a shorter time if knowledge exists to show this is necessary to maintain sample stability.

6. Should only be used in the presence of residual chlorine.

Attachment III-F-5
Non-Hazardous Material Cooler Marking Figure for Shipment from outside the Continental United States



1. **AIR BILL/COMMERCIAL INVOICE**
2. **USDA PERMIT (Letter to Laboratory from USDA)**
3. **CUSTODY SEAL**
4. **USDA 2" X 2" SOIL IMPORT PERMIT**
5. **WATERPROOF STRAPPING TAPE**
6. **DIRECTION ARROWS STICKER - TWO REQUIRED**

Attachment III-F-6
Commercial Invoice – Soil

DATE OF EXPORTATION 1/1/94	EXPORT REFERENCES (i.e., order no., invoice no., etc.) <CTO #>
SHIPPER/EXPORTER (complete name and address) Joe Smith Ogden c/o <hotel name> <hotel address>	CONSIGNEE Sample Receipt <Lab Name> <Lab Address>
COUNTRY OF EXPORT Guam, USA	IMPORTER - IF OTHER THAN CONSIGNEE
COUNTRY OF ORIGIN OF GOODS Guam, USA	
COUNTRY OF ULTIMATE DESTINATION USA	

INTERNATIONAL AIR WAYBILL NO.

(NOTE: All shipments must be accompanied by a Federal Express International Air Waybill)

MARKS/NOS	NO. OF PKGS	TYPE OF PACKAGING	FULL DESCRIPTION OF GOODS	QTY	UNIT OF MEASURE	WEIGHT	UNIT VALUE	TOTAL VALUE
	3	coolers	Soil samples for labora analysis only				$1.00	$3.00
	TOTAL NO. OF PKGS.					TOTAL WEIGHT		TOTAL INVOICE VALUE
	3							$3.00
								Check one ☐ F.O.B. ☐ C&F ☐ C.I.F.

THESE COMMODITIES ARE LICENSED FOR THE ULTIMATE DESTINATION SHOWN.

DIVERSION CONTRARY TO UNITED STATES LAW IS PROHIBITED.

I DECLARE ALL THE INFORMATION CONTAINED IN THIS INVOICE TO BE TRUE AND CORRECT

SIGNATURE OF SHIPPER/EXPORTER (Type name and title and sign)

Joe Smith, Ogden	Joe Smith	1/1/94
Name/Title	Signature	Date

Attachment III-F-7
Commercial Invoice – Water

DATE OF EXPORTATION 1/1/94	EXPORT REFERENCES (i.e., order no., invoice no., etc.) <CTO #>
SHIPPER/EXPORTER (complete name and address) Joe Smith Ogden c/o <hotel name> <hotel address>	CONSIGNEE Sample Rece <Lab Name> <Lab Address>
COUNTRY OF EXPORT Guam, USA	IMPORTER - IF OTHER THAN CONSIGNEE
COUNTRY OF ORIGIN OF GOODS Guam, USA	
COUNTRY OF ULTIMATE DESTINATION USA	

INTERNATIONAL AIR WAYBILL NO.

(NOTE: All shipments must be accompanied by a Federal Express International Air Waybill)

MARKS/NOS	NO. OF PKGS	TYPE OF PACKAGING	FULL DESCRIPTION OF GOODS	QTY	UNIT OF MEASURE	WEIGHT	UNIT VALUE	TOTAL VALUE
	3	coolers	Water samples for labo analysis only				$1.00	$3.00
	TOTAL NO. OF PKGS.					TOTAL WEIGHT		TOTAL INVOICE VALUE
	3							$3.00

Check one
☐ F.O.B.
☐ C&F
☐ C.I.F.

THESE COMMODITIES ARE LICENSED FOR THE ULTIMATE DESTINATION SHOWN.
DIVERSION CONTRARY TO UNITED STATES LAW IS PROHIBITED.
I DECLARE ALL THE INFORMATION CONTAINED IN THIS INVOICE TO BE TRUE AND CORRECT
SIGNATURE OF SHIPPER/EXPORTER (Type name and title and sign)

Name/Title	Signature	Date
Joe Smith, Ogden	Joe Smith	1/1/94

Attachment III-F-8
Soil Import Permit

Soil Permit

Permit Number: S-52299

UNITED STATES DEPARTMENT OF AGRICULTURE

Animal and Plant Health Inspection Service

Plant Protection and Quarantine

Issued To: Columbia Analytical Services
(Lee Wolf)
1317 S. 13th Avenue
Kelso, Washington 98626

TELEPHONE: (360) 577-7222

Under the authority of the Federal Plant Pest Act of May 23, 1957, permission is hereby granted to the facility/individual named above subject to the following conditions:

1. Valid for shipments of soil not heat treated at the port of entry, only if a compliance agreement (PPQ Form 519) has been completed and signed. Compliance Agreements and Soil permits are non-transferable. If you hold a Soil Permit and you leave your present employer or company, you must notify your local USDA office promptly.
2. To be shipped in sturdy, leakproof, containers.
3. To be released without treatment at the port of entry.
4. To be used only for analysis and only in the facility of the permittee at Columbia Analytical Services, located in Kelso, Washington.
5. No use of soil for growing purposes is authorized, including the isolation or culture of organisms imported in soil.
6. All unconsumed soil, containers, and effluent is to be autoclaved, incinerated, or heat treated by the permittee at the conclusion of the project as approved and prescribed by Plant Protection and Quarantine.
7. This permit authorizes shipments from all foreign sources, including Guam, Hawaii, Puerto Rico, and the U.S. Virgin Islands through any U.S. port of entry.

JUNE 30, 2006
Expiration Date

Deborah M. Knott
Approving Official DEBORAH M. KNOTT

WARNING: Any alteration, forgery, or unauthorized use of this Federal form is subject to civil penalties of up to $250,000 (7 U.S.C. s 7734(b)) or punishable by a fine of not more than $10,000, or imprisonment of not more than 5 years, or both (18 U.S.C. s 1001).

PPQ FORM 525B (8/94)

Pt. 1 - PERMITTEE

Attachment III-F-9
Soil Samples Restricted Entry Label and Soil Origin Label

U.S. DEPARTMENT OF AGRICULTURE

ANIMAL AND PLANT HEALTH INSPECTION SERVICE

PLANT PROTECTION AND QUARANTINE

HYATTSVILLE, MARYLAND 20782

SOIL SAMPLES

RESTRICTED ENTRY

The material contained in this package is imported under authority of the Federal Plant Pest Act of May 23, 1957.

For release without treatment if addressee is currently listed as approved by Plant Protection and Quarantine.

PPQ FORM 550 *Edition of 12/77 may be used*

(JAN 83)

Soil Samples Restricted Entry Label

SOIL ENCLOSED

Origin of Soil _____

Soil Origin Label

EGLE Michigan Department of Environment, Great Lakes, and Energy

EGLE PFAS Sampling Quick Reference Field Guide[1]

All Items Used During Sampling Event

● Prohibited
• Items or materials that contain fluoropolymers such as ○ Polytetrafluoroethylene (PTFE), that includes the trademarks Teflon® and Hostaflon® ○ Polyvinylidene fluoride (PVDF), that includes the trademark Kynar® ○ Polycholotrifluoroethylene (PCTFE), that includes the trademark Neoflon ® ○ Ethylene-tetrafluoro-ethylene (ETFE), that includes the trademark Tefzel® ○ Fluorinated ethylene propylene (FEP), that includes the trademarks Teflon® FEP and Hostaflon® FEP • Items or materials that contain any other fluoropolymer

Pumps, Tubing, and Sampling Equipment

● Prohibited	■ Allowable	▲ Needs Screening[2]
• Items or materials containing any fluoropolymer (potential items include tubing, valves, or pipe thread seal tape)	• High-density polyethylene (HDPE) • Low-density polyethylene (LDPE) tubing • Polypropylene • Silicone • Stainless-steel • Any items used to secure sampling bottles made from: ○ Natural rubber ○ Nylon (cable ties) ○ Uncoated metal springs ○ Polyethylene	• Any items or materials that will come into direct contact with the sample that have **not** been verified to be PFAS-free ○ Do not assume that any sampling items or materials are PFAS-free based on composition alone

Sample Storage and Preservation

● Prohibited	■ Allowable	▲ Needs Screening[2]
• Polytetrafluoroethylene (PTFE): Teflon® lined bottles or caps	• Glass jars[4] • Laboratory-provided PFAS-Free bottles: ○ HDPE or polypropylene • Regular wet ice • Thin HDPE sheeting • LDPE resealable storage bags (i.e. Ziploc®) that will not contact the sample media[6]	• Aluminium foil[4] • Chemical or blue ice[5] • Plastic storage bags other than those listed as ■ Allowable • Low-density polyethylene (LDPE) bottles

Field Documentation

● Prohibited	■ Allowable	▲ Needs Screening[2]
• Clipboards coated with PFAS • Notebooks made with PFAS treated paper • PFAS treated loose paper • PFAS treated adhesive paper products	• Loose paper (non-waterproof, non-recycled) • Rite in the Rain® notebooks • Aluminium, polypropylene, or Masonite field clipboards • Ballpoint pens, pencils, and Fine or Ultra-Fine Point Sharpie® markers	• Plastic clipboards, binders, or spiral hard cover notebooks • All markers not listed as ■ Allowable • Post-It® Notes or other adhesive paper products • Waterproof field books

Decontamination

● Prohibited	■ Allowable	▲ Needs Screening[2]
• Decon 90® • PFAS treated paper towel	• Alconox®, Liquinox®, or Citranox® • Triple rinse with PFAS-free deionized water • Cotton cloth or untreated paper towel	• Municipal water • Recycled paper towels or chemically treated paper towels

Clothing, Boots, Rain Gear, and PPE

● Prohibited	■ Allowable	▲Needs Screening[2]
• New or unwashed clothing • Anything made of or with: ○ Gore-Tex™ or other water-resistant synthetics • Anything applied with or recently washed with: ○ Fabric softeners ○ Fabric protectors, including UV protection ○ Insect resistant chemicals ○ Water, dirt, and/or stain resistant chemicals	• Powderless nitrile gloves • Well-laundered synthetic or 100% cotton clothing, with most recent launderings not using fabric softeners • Made of or with: ○ Polyurethane ○ Polyvinyl chloride (PVC) ○ Wax coated fabrics ○ Rubber / Neoprene ○ Uncoated Tyvek®	• Latex gloves • Water and/or dirt resistant leather gloves • Any special gloves required by a HASP • Tyvek® suits, clothing that contains Tyvek®, or coated Tyvek®

Food and Beverages

● Prohibited	■ Allowable
• No food should be consumed in the staging or sampling areas, including pre-packaged food or snacks. ■ If consuming food on-site becomes necessary, move to the staging area and remove PPE. After eating, wash hands thoroughly and put on new PPE.	• Brought and consumed only outside the vicinity of the sampling area: ○ Bottled water ○ Hydration drinks (i.e. Gatorade®, Powerade®)

Personal Care Products (PCPs) - for day of sample collection[6]

● Prohibited	■ Allowable	▲Needs Screening[2]
• Any PCPs[6], sunscreen, and insect repellent applied in the sampling area.	PCPs[6], sunscreens, and insect repellents applied in the staging area, away from sampling bottles and equipment followed by thoroughly washing hands: **PCPs[6]:** • Cosmetics, deodorants/antiperspirants, moisturizers, hand creams, and other PCPs[6] **Sunscreens:** • Banana Boat® for Men Triple Defense Continuous Spray Sunscreen SPF 30 • Banana Boat® Sport Performance Coolzone Broad Spectrum SPF 30 • Banana Boat® Sport Performance Sunscreen Lotion Broad Spectrum SPF 30 • Banana Boat® Sport Performance Sunscreen Stick SPF 50 • Coppertone® Sunscreen Lotion Ultra Guard Broad Spectrum SPF 50 • Coppertone® Sport High Performance AccuSpray Sunscreen SPF 30 • Coppertone® Sunscreen Stick Kids SPF 55 • L'Oréal® Silky Sheer Face Lotion 50 • Meijer® Clear Zinc Sunscreen Lotion Broad Spectrum SPF 50 • Meijer® Sunscreen Continuous Spray Broad Spectrum SPF 30 • Meijer® Clear Zinc Sunscreen Lotion Broad Spectrum SPF 15, 30 and 50 • Meijer® Wet Skin Kids Sunscreen Continuous Spray Broad Spectrum SPF 70 • Neutrogena® Beach Defense Water+Sun Barrier Lotion SPF 70 • Neutrogena® Beach Defense Water+Sun Barrier Spray Broad Spectrum SPF 30 • Neutrogena® Pure & Free Baby Sunscreen Broad Spectrum SPF 60+ • Neutrogena® UltraSheer Dry-Touch Sunscreen Broad Spectrum SPF 30 **Insect Repellents:** • OFF® Deep Woods • Sawyer® Permethrin	• Products other than those listed as ■Allowable

[1] This table is not considered to be a complete listing of prohibited or allowable materials. All materials should be evaluated prior to use during sampling. The manufacturers of various products should be contacted in order to determine if PFAS was used in the production of any particular product.

[2] Equipment blank samples should be taken to verify these products are PFAS-free prior to use during sampling.

[3] **For surface water foam samples:** LDPE storage bags may be used in the sampling of foam on surface waters. In this instance, it is allowable for the LDPE bag to come into direct contact with the sample media.

[4] **For fish and other wildlife samples:** Depending on the project objectives, glass jars and aluminum foil might be used for PFAS sampling. PFAS has been found to bind to glass and if the sample is stored in a glass jar, a rinse of the jar is required during the sample analysis. PFAS are sometimes used as a protective layer for some aluminum foils. An equipment blank sample should be collected prior to any aluminum foil use.

[5] Regular ice is recommended as there are concerns that chemical and blue ice may not cool and maintain the sample at or below 42.8˚F (6°C) (as determined by EPA 40 CFR 136 – NPDES) during collection and through transit to the laboratory.

[6] Based on evidence, avoidance of PCPs is considered to be precautionary because none have been documented as having cross-contaminated samples due to their use. However, if used, application of PCPs must be done at the staging area and away from sampling bottles and equipment, and hands must be thoroughly washed after the use of any PCPs prior to sampling.

●- Prohibited ■- Allowable ▲- Needs Screening

MICHIGAN DEPARTMENT OF
ENVIRONMENT, GREAT LAKES, AND ENERGY

GENERAL PFAS SAMPLING GUIDANCE

This document contains an introduction to PFAS, biosecurity recommendations, and general recommendations to decrease the possibility of cross-contamination.

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Acronyms

Acronyms used throughout the **General PFAS Sampling Guidance** document and/or each sampling guidance are as follows:

AFFF ..... Aqueous Film Forming Foam

CAS Number .. Chemical Abstracts Service Number

COC ..... Chain of Custody

DEPA ..... Danish Environmental Protection Agency (Denmark)

EINECS ..... European List of Notified Chemical Substances (European Union)

ENCS ..... Existing and New Chemical Substances Inventory (Japan)

ETFE ..... Ethylene-tetrafluoroethylene

FCMP ..... Fish Contaminant Monitoring Program

FCSV ..... Fish Consumption Screening Values

FDA ..... Food and Drug Administration (United States of America)

FEP ..... Fluorinated Ethylene Propylene

HASP ..... Health and Safety Plan

HDPE ..... High-density Polyethylene

IECSC ..... Inventory of Existing Chemical Substances Produced or Imported in China

ITRC ..... Interstate Technology & Regulatory Council

KECI ..... Korea Existing Chemicals Inventory (South Korea)

KEMI ..... Swedish Chemical Agency (Sweden)

LDPE ..... Low-density polyethylene

LHA ..... Lifetime Health Advisory (United States Environmental Protection Agency)

EGLE ..... Michigan Department of Environment, Great Lakes, and Energy

MDHHS ..... Michigan Department of Health and Human Services

MPART ..... Michigan PFAS Action Response Team

MSDS ..... Material Safety Data Sheet (former reference)

ng/L ..... Nanograms per liter

NZIoC ..... New Zealand Inventory of Chemicals (New Zealand)

PCPs ..... Personal Care Products

PID ..... Photoionization Detector

PFAA ..... Perfluoroalkyl Acids

PFAS..... Per- and Polyfluoroalkyl Substances

PFC ..... Polyfluorocarbons

PFCA..... Perfluoroalkyl Carboxylic Acids

PFOA ..... Perfluorooctanoic Acid

PFOS..... Perfluorooctanesulfonic Acid

PFPE ..... Perfluoropolyethers

PFSA..... Perfluoroalkyl Sulfonic Acids

PICCS ..... Philippine Inventory of Chemicals and Chemical Substances (Philippines)

ppb..... Parts per Billion

PPE ..... Personal Protection Equipment

ppt..... Parts per Trillion

PTFE ..... Polytetrafluoroethylene

PVC ..... Polyvinyl Chloride

PVDF..... Polyvinylidene Fluoride

PVF ..... Polyvinyl Fluoride

QA/QC..... Quality Assurance/Quality Control

QAPP ..... Quality Assurance Project Plan

OECD ..... Organization for Economic Cooperation and Development

SDS ..... Safety Data Sheet

SWAS..... Surface Water Assessment Section (EGLE)

TSCA..... Toxic Substances Control Act (United States)

(US)EPA..... United States Environmental Protection Agency

UV ..... Ultraviolet

VOC..... Volatile Organic Compounds

WRD ..... Water Resources Division (EGLE)

Disclaimer

The Michigan Department of Environment, Great Lakes, and Energy (EGLE) intends to update the information contained within this PFAS Sampling Guidance document as new information becomes available. The user of this PFAS Sampling Guidance is encouraged to visit the Michigan PFAS Action Response Team webpage (Michigan.gov/PFASresponse) to access the current version of this document.

1. Introduction

Per- and polyfluoroalkyl Substances (PFAS) are a human-made class of chemicals considered **emerging contaminants**. The term PFAS is attributed to a large class of fluorinated chemicals composed of many families that have vastly different physical and chemical properties (Buck et al. 2011, Wang et al. 2017). According to the Centers for Disease Control (CDC), over 9,000 PFAS have been identified (ATSDR, 2021; CDC, 2022). The number of compounds continuously changes, as some PFAS are no longer produced due to regulatory and voluntary actions, while new ones are created as alternatives. The carbon-fluorine bond in PFAS is one of the strongest bonds in nature; they are tough to break and resistant to thermal, chemical, and biological degradation.

Note: Emerging Contaminants are chemicals and materials in the environment and present real or potential human health or environmental risks and either

- Do not have peer-reviewed human health standards

  or:

- Standards/regulations are evolving due to new science, new laboratory analytical capabilities, and new knowledge about the chemicals

Due to their unique chemical properties, various PFAS can lower surface tension (act as surfactants), are oil-repelling (oleophobic), and are water-repelling (hydrophobic). Yet, many PFAS with certain functional groups are also relatively water-soluble. They have been used extensively in many industries worldwide for a wide variety of applications. PFAS were first invented in the late 1930s, developed commercially in the 1940s, and started to be more widely used in consumer products from the 1950s as non-stick coatings. Due to their unique chemical properties, PFAS production increased as these chemicals were incorporated into components of inks, varnishes, waxes, firefighting foams, metal plating, cleaning solutions, coating formulations, lubricants, water and oil repellents, paper, and textiles (Paul et al. 2009). Examples of industries using PFAS include automotive, aviation, aerospace and defense, biocides, cable and wiring, construction, electronics, energy, firefighting, food processing, household products, oil and mining production, metal plating, medical articles, paper and cardboard, semiconductors, textiles, leather goods, and apparel (OECD 2013, UNEP 2013). The presence of PFAS in these materials is a potential source of environmental concern.

The presence of PFAS in so many consumer products and commercial materials, combined with low laboratory detection limits (nanograms per liter (ng/L) or parts per trillion (ppt)), has resulted in concerns of potential cross-contamination occurring during the sampling of various environmental matrices. EGLE has promulgated Residential and Nonresidential Drinking Water Criteria under Part 201 for seven PFAS, including perfluorooctanoic acid (PFOA), perfluorooctanesulfonic acid (PFOS), perfluorononanoic acid (PFNA), perfluorohexane sulfonic acid (PFHxS), perfluorohexanoic acid (PFHxA), perfluorobutane sulfonic acid (PFBS), and hexafluoropropylene oxide dimer acid (HFPO-DA, also known as GenX). EGLE has promulgated Groundwater Surface Water Interface Criteria (GSI) for groundwater under Part 201. A summary of these Part 201 cleanup criteria is provided in the table below and can be found on EGLE's website.

PFAS	Residential Drinking Water Criteria[1]	Non-residential Drinking Water Criteria[1]	Groundwater Surface Water Interface Criteria[1]
PFOS	16	16	12
PFOA	8	8	170
PFNA	6	6	30
PFHxS	51	51	210
PFHxA	400,000	400,000	NA
PFBS	420	420	670,000
HFPO-DA	370	370	NA

[1]Units are in nanograms per liter (ng/L) or parts per trillion (ppt); NA = a criterion or value is not available.

The Michigan Rule 57 Water Quality Value (WQV) criteria were developed to protect humans, wildlife, and aquatic life. Potentially complete surface water exposure pathways associated with all Sites and corresponding Rule 57 WQV are:

PFAS	Human Noncancer Value (nondrinking water source)	Human Noncancer Value (drinking water source)	Final Chronic Value	Aquatic Maximum Value	Final Acute Value
PFOS[1]	12	11	140,000	780,000	1,600,000
PFOA[1]	170	66	880,000	7,700,000	15,000,000
PFBS	670,000	8,300	24,000,000	120,000,000	240,000,000
PFHxS	210	59	NA	NA	NA
PFNA	30	19	NA	NA	NA

[1]Units are in nanograms per liter (ng/L) or parts per trillion (ppt); NA = a criterion or value is not available.

2. Purpose and Objectives

The purpose of this document is to provide guidance and information to staff who will:

- Collect or handle PFAS environmental samples.
- Perform subsurface activities such as soil borings, well installation, or well abandonment at PFAS sites.

This document is intended to supplement the EGLE media-specific PFAS sampling guidance documents and is a resource for PFAS sampling.

The objectives of this document are as follows:

- Provide guidance on avoiding PFAS cross-contamination during sampling.
- Improve sampling consistency and data quality.
- Provide guidance to EGLE staff and contractors.

Because PFAS are emerging contaminants and information about their use in various materials is still not readily available, EGLE will update this document as new information becomes available.

NOTE: This guidance does not include specific information for sampling environmental media and should not be used to replace specific sampling guidance documents required for use by EGLE staff.

3. Farm Biosecurity

In the event PFAS sampling occurs on or near a farm, staff need to follow the requirements in this document when conducting sample collection to reduce the likelihood of transporting animal diseases.

3.1 Scheduling

To avoid cross-contamination from previous sampling locations, it is preferable that staff visit only one farm in a day.

3.2 Before Sampling

Staff should review Section 4.2.4. Field Clothing and Personal Protective Equipment (PPE) before going into the field.

Staff must have a clean vehicle, clothing, and boots to visit the sampling location. Before arriving at the farm, staff should call the farm owner to indicate they will be arriving shortly and ask if there are any additional biosecurity requirements for their farm. Once at the farm, staff should park away from any animals and barns, preferably in a designated visitor area or on concrete.

Immediately before exiting the vehicle, place disposable PFAS-free boot covers over the boots. (***NOTE**: Disposable boot covers can be slippery, especially in icy/snowy conditions.*)

3.3 While Sampling

Staff should not approach animal areas unless necessary for testing. If access to an animal area is needed, farm personnel should always accompany staff.

3.4 After Sampling

Dispose of used disposable boot covers at the facility if possible; otherwise, place them in a plastic bag, seal them, and place them in the vehicle trunk to dispose of properly later.

4. General PFAS Sampling

The following sections discuss technical issues such as the need to use PFAS-free water, information about PFAS-free clothing and PPE, and laboratory issues that should be considered when sampling for PFAS.

4.1 Sampling Objectives

Before conducting any PFAS sampling, it is recommended that a project-specific Quality Assurance Project Plan (QAPP) should be developed. The QAPP must meet EGLE's policy and should include the analyte list, method of analysis, environmental matrices, and reporting limits based on the project objectives. All of these considerations will be discussed in more detail in this guidance document.

4.2 PFAS Cross-Contamination Potential Sources

Potential sources of PFAS cross-contamination in the typical sampling environment include water used during drilling or decontamination, materials used within the sampling environment, sampling equipment, field clothing and personal protective equipment (PPE), sun and biological protection products, personal hygiene, and personal care products (PCPs), food packaging, and the environment itself.

Previous sampling guidance documents and literature to date did not evaluate how the use of sampling materials in the field, when used in accordance with industry-standard sampling procedures, may introduce the potential for PFAS cross-contamination during sampling. Upon further review and evaluation in 2021, two scenarios where cross-contamination during sampling may occur are: direct contact with the sampling supplies and equipment and incidental contamination while a sample container is open. Contact with sampling supplies or equipment is the most likely pathway for potential cross-contamination. Materials associated with sampling that have the potential for PFAS cross-contamination have been divided into two main categories and four groups:

- **Category 1:** Items and materials that are *expected to come in direct contact* with the sample. These should not be used when sampling unless it is known or can be shown that they are PFAS-free by collecting an equipment blank (EB) sample before use.
- **Category 2:** Items and materials that are *not expected to come in direct contact* with

the sample. An EB is recommended only for the items and materials that may still have a very low possibility of producing cross-contamination only in unique sampling or weather conditions (i.e., rain).

NOTE: Category 1 items and materials that are made of PFAS and come into contact with samples should be prohibited or otherwise avoided if possible. It is recommended for Equipment Blank samples to be collected for all **Category 1** sampling materials. However, the use of **Category 2** items and materials that may also contain PFAS that do not come into direct contact with the samples has a low risk of resulting in cross-contamination if best practices are used to avoid any contact between PFAS-containing materials and the environmental samples. (Denley 2019, Rodowa 2020)

All of the materials or items discussed in each of EGLE's PFAS Sampling Guidance Documents will be divided into the Allowable (■), Avoid (♦), Prohibited (●), or Needs Screening (△) groups. At the end of this document, several items and materials that need screening are listed in EGLE's PFAS Sampling Quick Reference Field Guide. Additionally, materials and items specific to a particular environmental media or sampling method will be thoroughly explained in that media's sampling guidance document (such as peristaltic pumps for groundwater sampling).

NOTE: If recommended PPE will be used during sampling, **Category 2** materials are not expected to be a source of cross-contamination as long as they do not come into contact with the samples.

- Allowable (■) identifies all items and materials (**Category 1** and **Category 2**) that have been proven not to be sources of PFAS cross-contamination and are considered allowable for sampling.
- Avoid (♦) identifies **Category 2** items and materials that should be avoided and, where alternative, PFAS-free materials should be identified and used, if possible. They are items and materials documented to contain PFAS or that PFAS are used in their manufacture. The use of these sampling materials, however, is sometimes necessary for safety reasons.
- Prohibited (●) identifies **Category 1** items and materials that should not be used during sampling. These items are well-documented to contain PFAS or that PFAS are used in their manufacture.
- Needs Screening (△) identifies items and materials that have the potential to contain PFAS or PFAS that may have been used in their manufacture. Many of these items may be produced by industries where PFAS use has been historically documented. Additionally, there may be items for which there is a lack of available scientific data from the manufacturers to show the items are PFAS-free. For **Category 1** items, a materials screening should be conducted to confirm that they are PFAS-free.

To provide a current, scientific-based approach for PFAS sampling, EGLE has used information from multiple sources to revise the initial PFAS General Sampling Guidance from 2018 to incorporate data from sampling efforts completed in Michigan and throughout the United States regarding the likelihood of cross-contamination during sampling. A key point derived from the reviewed information is listed below. A complete summary of information reviewed and considered as part of this revised document is available in **Appendix A**.

4.2.1 PFAS-Free Water

The term PFAS-free water is defined here as water that does not contain significant concentrations of any compound in a specific PFAS analyte list that is being analyzed at a project-defined level. The significant concentrations depend on project data quality objectives and could, for instance, be less than the laboratory reporting limit, <1/3 the limit of quantitation, or other defined criteria for the specific PFAS compound of interest (ITRC 2022).

NOTE: The confirmation of PFAS-free water should always be performed prior to the commencement of work. Site or public water supplies have been identified in many instances to contain detectable levels of PFAS.

One important consideration for each project is to identify a PFAS-free water source to use for decontamination of sampling and drilling equipment when applicable. The decontamination of sampling tools or small equipment parts can be performed using laboratory-supplied verified PFAS-free water. Other water can only be used for decontamination if it has been analyzed and shown to be PFAS-free, as defined for the project.

The laboratory used for the PFAS analysis should provide certified PFAS-free reagent water to prepare field blanks. The EGLE Lab can supply PFAS-free water for equipment blanks.

4.2.2 Materials Screening

Materials screening should be performed during the Health and Safety Plan (HASP), Sampling Analysis Plan (SAP), QAPP development, or the planning phase of sampling programs. The screening should be performed on all items and materials expected to come into contact with the samples and defined as **Category 1**.

Material screening should include a review of Safety Data Sheets (SDSs; formerly Material SDS [MSDSs]). Make sure the review uses current SDSs because the actual composition of a particular item or material may have changed over time without the manufacturer changing the actual item or material name. All products from the United States or abroad should be screened. Text fragments such as "perfluoro," "fluoro," or "fluorosurfactant" may identify the use of PFAS in specific items or materials.

NOTE: Manufacturers can change the chemical composition of any product. As a result, equipment blank samples should be collected for all materials that will come into direct contact with the sample media, regardless of what category they might be in, to confirm they are "PFAS-free", i.e., will not contaminate samples at detectable levels. **There is no guarantee that materials in the 'Allowable (■)' category will always be PFAS-free.**

Some countries have official national lists of industrial chemicals defined by regulations, such as:

- Toxic Substances Control Act (TSCA) in the United States.
- European List of Notified Chemical Substances and substances pre-registered under the Registration, Evaluation, Authorization, and Restriction of Chemicals (REACH) in the European Union.
- Swedish Chemical Agency (KEMI) in Sweden.
- Domestic Substances List in Canada.
- Inventory of Existing New Chemical Substances Produced or Imported in China
- Existing and New Chemical Substances Inventory in Japan.
- Korea Existing Chemicals Inventory in South Korea.
- New Zealand Inventory of Chemicals in New Zealand.
- Philippine Inventory of Chemicals and Chemical Substances in the Philippines.

The information on these lists includes the chemical names and various identity numbers, usually the Chemical Abstracts Service number (CAS Number) (KEMI 2015). The lists may not contain substantial information due to laws concerning proprietary information, giving the suppliers the right not to name some chemicals. The information is not always sufficient to identify if the items or materials contain PFAS, as many of the PFAS do not have an assigned CAS Number at this time (KEMI 2015). The most recent summary by the Organization for Economic Co-operation and Development (OECD) identified 4,730 PFAS-related CAS numbers (OECD 2018); however, as stated earlier, there are over 9,000 PFAS. For more information on the chemical structure and categorization of PFAS, see Appendix A.

Sometimes, manufacturers provide information about their products online or upon request, which may indicate if PFAS were used in the manufacturing of a particular item or material.

4.2.3 Sampling Equipment

The list of PFAS-containing materials potentially encountered on the site will change based on the specific sampled media and site-specific sampling conditions. For additional details, please review each media-specific PFAS sampling guidance document and EGLE's PFAS Sampling Quick Reference Field Guide. Collection of equipment blanks should also be considered for quality control purposes. In addition to reviewing these documents, please consider the following:

Category 1 materials made of PFAS, both polymers or non-polymers or that could contain residual concentrations of PFAS, are Prohibited (●) if they are expected to come into direct contact with environmental samples. Category 2 materials that do not come into contact with the environmental samples should be Avoided (♦) if possible. The likelihood of potential cross-contamination from Category 2 materials is considered low. However, during extreme weather conditions (e.g., rain), some of these materials may require extra care to prevent possible cross-contamination. A list of known polymers and some of their uses are presented below. (Denly 2019, Rodowa 2020).

- **Polytetrafluoroethylene** (**PTFE**) includes the trademark Teflon® and Hostaflon®, which can be found in many items, including but not limited to the lining of some hoses and tubing, some wiring, certain kinds of gears, and some objects that require the sliding action of parts.
- **Polyvinylidene fluoride** (**PVDF**) includes the trademark Kynar®, which can be found in many items, including but not limited to tubing, films/coatings on aluminum, galvanized or aluminized steel, wire insulators, and lithium-ion batteries.
- **Polychlorotrifluoroethylene** (**PCTFE**) includes the trademark Neoflon®, which can be found in many items, including but not limited to valves, seals, gaskets, and food packaging.
- **Ethylene-tetrafluoroethylene** (**ETFE**) includes the trademark Tefzel®, which can be found in many items, including but not limited to wire and cable insulation covers, films for roofing and siding, liners in pipes, and some cable tie wraps.
- **Fluorinated ethylene propylene** (**FEP**) includes the trademarks Teflon® FEP and Hostaflon® FEP. It may also include Neoflon®, which can be found in many items, including but not limited to wire and cable insulation and covers, pipe linings, and some labware.
- **Perfluoroalkoxy polymer** (**FAP**), which is known to be used in the food packaging industry.
- **Perfluoropolyethers** (**PFPE**) are used as a surface treatment for natural stone, metal, glass, plastic, textiles, leather, and paper and paperboard treatment for food-contact applications.
- **Side-Chain Fluorinated Polymers** such as **fluorinated acrylates**, **methacrylate**, **urethane**, and **oxetane polymers** have been used in surfactants and surface

protection products. These polymers are useful as water-, stain-, and grease-proofing finishes for textile, leather, and paper surfaces.

- ■ Low-density polyethylene (LDPE) bags (e.g., Ziploc®) that do not come into direct contact with the sample media and do not introduce cross-contamination with samples may be used.
- ■ Use materials made of high-density polyethylene (HDPE), polypropylene, silicone, or acetate.
- ■ Glass bottles or containers may be used if they are known to be PFAS-free. However, PFAS have been found to adsorb to glass, especially when the sample is in contact with the glass for a long time (e.g., stored in a glass container). If the sample comes into direct contact with the glass for a short period of time (e.g., using a glass container to collect the sample, then transferring the sample to a non-glass sample bottle), the adsorption is minimal.

NOTE: most analytical methods do not allow the use of glass bottles or the transfer of samples from one container to another.

- ■ Powderless nitrile gloves (which can be found at some hardware and major retail outlets).
- △ Latex gloves should be screened before use.
- △ Some sampling guidance documents allow the use of aluminum foil provided the shiny side is placed away from the sample (e.g., fish tissue sampling guidance). As a precaution, EGLE recommends that aluminum foil not be used unless equipment blank samples confirm it is PFAS-free (Denly 2019, Rodowa 2020).
- △ Low-density polyethylene (LDPE) may be used if an equipment blank has confirmed it to be PFAS-free. LDPE does not contain PFAS in the raw material but may contain PFAS cross-contamination from the manufacturing process.

4.2.4 Field Clothing and Personal Protective Equipment (PPE)

Any field planning and mobilization effort should address the physical, chemical, and biological hazards associated with each PFAS site. The mitigation of potential risks may be documented in a site-specific HASP, SAP, or QAPP. Due to the extensive use of PFAS in many industries and products, PPE may contain PFAS. However, all PPE materials are expected to be **Category 2**. During PFAS investigations, PPE containing PFAS should be Avoided (♦), if possible, especially when a PFAS-free alternative is available. Personal safety is paramount, so staff safety should not be compromised due to fear of using PFAS-containing materials. Any deviation from this guidance, including those necessary to ensure the health and safety of sampling personnel, should be recorded in field notes and discussed in the final report. The development of the HASP or QAPP should consider these factors before mobilization in the field. All HASPs or QAPPs need to address the concern of potential staff exposure to PFAS through PPE.

Globally, textile protective coatings are estimated to be about 50 percent of the total use of PFAS (DEPA 2015). Due to its unique water and oil-repellency properties, PFAS has been used to coat various clothing (i.e., pants, jackets, and t-shirts) and leather products (i.e., boots, shoes, and jackets). Many of these types of clothing and PPE have the potential to be used in the sampling environment.

NOTE: The Danish Ministry of the Environment identified alternative polymer technology as being PFAS-free. Products treated with this technology are water- resistant, but not oil and dirt repellent to the same extent as products treated with PFAS-based agents (DEPA, 2015).

While preparing for sampling, particular focus should be made on clothing advertised as having waterproof, water-repellant, or dirt and/or stain-resistant characteristics. These types of clothing are most likely to have had PFAS used in their manufacturing. PFAS have been widely used in what is known as durable water repellent (DWR) finish for textiles, and it has been shown that PFAS can be released during washing (Schellenberger 2019).

Field Clothing and PPE that should be Avoided (♦), if possible, as they may contain PFAS, include the following:

- ♦ Clothing that has been made with or washed with stain-resistant chemicals.
- ♦ Clothing chemically treated for insect resistance and ultraviolet protection (See **Section 4.2.5** on biological hazards).
- ♦ Clothing or PPE items with any of the brand or product names found to contain PFAS by the Danish Ministry of the Environment and presented in the following table (DEPA 2015).

Table 1 provides a list of field clothing to be Avoided (♦) (DEPA, 2015). However, the manufacturer and/or vendor for the field clothing and/or PPE should be contacted to confirm that these brand or product names still contain PFAS. There have been instances where manufacturers have kept the same brand and/or product name but have changed the chemicals used while manufacturing a particular item.

Table 1. Prohibited Field Clothing and PPE Brand and Product Names
Danish Environmental Protection Agency **– 2015**

Advanced Dual Action Teflon® fabric protector.	Repellan KFC®
Release Teflon®	Rucostar® EEE6
Repel Teflon® fabric protector	UnidyneTM
High-Performance Release Teflon®	Bionic Finish®
High performance Repel Teflon® fabric protector	RUCO-GUARD®
Ultra Release Teflon®	RUCOSTAR®
NK Guard S series	RUCO-COAT®
GreenShield®	RUCO-PROTECT®
Tri-Effects Teflon® fabric protector	RUCOTEC®
Lurotex Protector RL ECO®	RUCO®
Oleophobol CP®	Resist Spills™
	Resists Spills and Releases Stains™
	Scotchgard™ Fabric Protector

[1]This list is not considered to be a complete listing of prohibited materials. All materials should be evaluated before use during sampling.

Field Clothing and PPE that are Allowable (■) to wear within the immediate sampling environment include the following:

- Powderless nitrile gloves.
- Polyvinyl chloride (PVC) or wax-coated fabrics.
- Neoprene.
- Any boots made of polyurethane and/or PVC. If the HASP requires a specific type of boot, such as (steel-toed), and PFAS-free cannot be purchased, PFAS-free overboots may be worn. The overboots must be put on, and hands must be washed after putting the overboots on before the beginning of sampling activities. Overboots may only be removed in the staging area and after the sampling activities have been completed.
- Synthetic and natural fibers (preferably cotton) that are well laundered (more than six times with no fabric softener), clothes, and cotton overalls.

NOTE: There could be many PPE materials used during various sampling events, including hard hats and safety glasses. All clothing and PPE are considered **Category 2** materials.

Field Clothing and PPE that must be evaluated (▲) before wearing within the

immediate sampling environment include the following:

- ▲ Latex gloves.
- ▲ Tyvek suits and clothing containing Tyvek® (EPA PFAS sampling guidance from EPA Region 2 prohibits using Tyvek; available product information suggests Tyvek® may be used if required. Coated Tyvek® requires further evaluation; therefore, EGLE recommends the collection of an Equipment Blank before Tyvek® use). EGLE considers these materials as **Category 2**.

4.2.5 Sun and Biological Protection

Some PFAS sampling guidance documents either restrict the use of sun and biological protection products, provide very few choices, or recommend, without any supporting scientific data, the use of products containing the words “Natural” and/or “Organic” in the product name as a description of the product. Because biological hazards (sunburn, mosquitos, ticks, etc.) may be encountered during sampling, eliminating specific clothing materials or PPE (sunscreens and insect repellants) could pose a health and safety hazard to staff.

Prolonged sun exposure will require sunscreens, which may have included PFAS in their manufacture. Protection against insects may require the use of insect repellant. **Figure 1** contains a detailed list of sunscreens and insect repellants that have been analyzed and found to be PFAS-free as of the date of this document. Note that this is not a comprehensive list of allowable insect repellants or sunscreens; other products may meet the requirements for use. Listing or omission of any product does not imply endorsement or disapproval. Also, there is no guarantee that these products will always remain PFAS-free.

EGLE considers all sun and biological protection products as **Category 2** materials that are not expected to come into contact with the environmental samples.

- ● Sunscreens and insect repellants should not be applied near the sample collection area.
- ■ Hands should be well washed after applying or handling these products, and afterward, powderless nitrile gloves should be worn.

If an insect repellent is not available and staff needs protection against biting insects:

- Tuck pant legs into socks and/or boots to seal the gap between the boots and the pants to reduce the risk of being bitten by ticks.
- Wear well-washed, light-colored clothing to see ticks during field activities easily.
- Light-colored clothing, long sleeves, and large-brimmed hats also prevent sunburn.

NOTE: The words “Natural” and/or “Organic” in the product name or as a descriptor does not mean that it is PFAS-free.

Figure 1. Sunscreen and Insect Repellents[1]

■ Allowable Insect Repellents

OFF Deep Woods

Sawyer Permethrin

■ Allowable Sunscreens

Banana Boat –
- Sunscreen for Men Triple Defense Continuous Spray Sunscreen SPF 30
- Sport Performance Coolzone Broad Spectrum SPF 30
- Sport Performance Sunscreen Lotion Broad Spectrum SPF 30
- Sport Performance Sunscreen Stick SPF 50

Coppertone Sunscreen Lotion Ultra Guard Broad Spectrum SPF 50

Coppertone Sport High-Performance AccuSpray Sunscreen SPF 30

Coppertone Sunscreen Stick Kids SPF 55

L'Oréal Silky Sheer Face Lotion 50+

Meijer Sunscreen Lotion Broad Spectrum SPF 30

Meijer Clear Zinc Sunscreen Lotion Broad Spectrum SPF 15, 30 and 50

Meijer Wet Skin Kids Sunscreen Continuous Spray Broad Spectrum SPF 70

Neutrogena Ultra-Sheer Dry-Touch Sunscreen Broad Spectrum SPF 30

Neutrogena Beach Defense Water + Sun Barrier Lotion SPF 70 & Spray Broad Spectrum SPF 30

Neutrogena Pure & Free Baby Sunscreen Broad Spectrum SPF 60+

[1]This is not considered a complete listing of allowable materials. Some sunscreen and insect repellent testing has been performed using a PFAS screening Method (Peaslee, University of Notre Dame) known as Particle Induced Gamma-Ray Emission (PIGE). Approved gloves should always be used, and the sample should never come into contact with any sunscreen or insect-repellent products.

4.2.6 Personnel Hygiene and Personal Care Products (PCPs)

Several sampling guidance documents recommend that personal hygiene and personal care products (PCPs) (e.g., cosmetics, shampoo, sunscreens, dental floss, etc.) not be used before and on the day(s) of sampling because the presence of PFAS in these products has been documented (OECD 2002, Fujii 2013, Borg and Ivarsson 2017, Denly 2019, Rodowa 2020, Whitehead 2021). However, if EGLE's sampling standard operating procedures (SOP) are followed, these items should not come into contact with the sampling equipment, or the sample being collected. As of the date of this sampling guidance, cross-contamination of samples due to the use of PCPs has not been documented during the collection of thousands of samples. EGLE also considers these materials as **Category 2**, meaning many are used before or within the staging area. However, field personnel should be aware of the potential of cross-contamination if the sampling equipment or samples come into contact with these products. The following precautions should be taken when dealing with personal hygiene or PCPs before sampling:

- Move to the staging area and remove PPE if applying personal care products becomes necessary.
- Wash hands thoroughly after handling or applying PCPs and, when finished, put on a fresh pair of powderless nitrile gloves.

4.2.7 Food Packaging

PFAS has been used by the paper industry as a special protective coating against grease, oil, and water for paper and paperboards, including food packaging, since the late 1950s (Trier et al., 2018). PFAS application for food packaging includes paper products that come into contact with food, such as paper plates, containers, bags, and wraps (OECD, 2002). In January 2016, the Food and Drug Administration (FDA) banned the use of PFAS, which has eight carbon atoms (such as PFOA and PFOS) or more, in food packaging materials. However, PFOA and PFOS or other eight or more carbon chain PFAS may still be detected in food packaging because recycled paper may contain PFAS. Various studies have found up to 57 percent detection frequency in food contact materials such as paper (Trier et al. 2011; Rosenmai et al. 2013; Schaider et al. 2017).

NOTE: Short-chain PFAS have not been banned for use in the manufacturing of contact food materials in the United States.

Pre-wrapped food or snacks (such as candy bars, microwave popcorn, etc.) must not be in the sampling and staging areas during sampling due to PFAS contamination of the packaging. When staff require a break to eat or drink, they should remove their gloves, coveralls, and any other PPE, if worn, in the staging area and move to the designated area for food and beverage consumption. When finished, staff should wash their hands and put on a fresh pair of powderless nitrile gloves at the staging area before returning to the sampling area. EGLE does not anticipate food and snacks becoming a source of

PFAS cross-contamination when media-specific sampling guidance is followed, and proper gloves are used.

- ● Do not handle, consume, or otherwise interact with pre-wrapped food or snacks, carry-out food, fast food, or other items while on-site sampling.
- ■ Move to the staging area and remove PPE before leaving the sampling and staging areas if consuming food on-site becomes necessary.

4.3 PFAS Sampling Procedures

4.3.1 Sample Containers, Handling, and Collection

Any sampling containers provided by the laboratory should be verified as PFAS-free. All bottles used for PFAS sampling must come from the laboratory that will also be performing the PFAS analysis.

> **NOTE:** Head space is allowed and should be used when sampling for PFAS, in order to allow for matrix spike addition or prevent preservatives (i.e., Trizma) from being spilled out. When analyzing for drinking water samples using EPA Method 537.1, Trizma is used as the preservative. EPA Method 533 uses ammonium acetate.

Before sampling, staff may come into contact with textiles and fabrics treated with PFAS, such as carpets and car interiors. Staff should be aware that these materials, and any other surfaces that repel water and are stain-resistant, can potentially be treated with PFAS. However, these are considered **Category 2** materials, and field personnel should be aware of their possible PFAS use. Sample containers and equipment used for sampling should not be stored on or come into contact with materials suspected to contain PFAS.

For all environmental media, hands should be well-washed before sampling. Clean, powderless nitrile gloves must be put on before sample collection, handling of sample containers, and handling sampling equipment. Gloves should be changed periodically and always before collecting the next sample. The sample container must be kept sealed and only open during the sample collection. The sampling container cap or lid should never be placed on any surface unless it is PFAS-free. The sampling container cap or lid must never be placed directly on the ground. A list of materials used in sampling and handling can be found in the EGLE Quick Reference Field Guide at the end of this document.

In the absence of formal EPA guidance for PFAS sample storage, the documentation in EPA Method 533 should be used as a guide for thermal preservation (holding temperature) and holding times for other environmental media samples (except for biota). To limit microbial growth, biota samples such as fish and vegetation are recommended to be kept frozen until the sample is prepared.

If published analytical reference methods other than EPA Method 537.1 or EPA Method

533 are used (i.e., EPA Method 8327, Method 1633), follow the guidelines or requirements in those methods for sample storage, preservation, and hold times. Otherwise, EPA Method 537.1 and Method 533 dictate that samples must be chilled during storage and shipment and not exceed 50°F (10°C) during the first 48 hours after collection.

4.3.2 Sample Shipment

In general, for all environmental media sampled for PFAS, samples must be kept on ice from the time of sample collection to the arrival at the laboratory. All materials used during sample shipment are **Category 2** and, therefore, are not anticipated to result in cross-contamination. The following procedures should be used for sample shipment:

- Regular ice should be used to cool and maintain the sample at or below the proper temperature.
- Chemical or blue ice may be used if it is known to be PFAS-free, the blue ice container is not leaking, and it is certain that the sample is cooled and maintained at or below the proper temperature during collection and through transit to the laboratory.
- Refresh with regular ice, double bagged in LDPE resealable storage bags if needed.
- Fish and other wildlife samples should be placed on dry ice and frozen before shipment to the lab. If fish are frozen, shipping the samples overnight on ice should be acceptable.
- The samples, ice, and chain of custody (COC) should always be bagged in polyethylene (i.e., Ziploc®) bags.
- Chain of Custody and other forms should be single-bagged in LDPE resealable storage bags and taped to the inside of the cooler lid.
- The cooler should be taped closed with a custody seal and shipped by overnight courier.
- Samples must be shipped as soon as possible (e.g., overnight) within one day maximum from collection to ensure the samples arrive within the analytical holding time specified by the lab.
- It is recommended that unused sample bottles be returned to the laboratory and not stored for long periods for future sampling events.

4.3.3 Preferential Sampling Sequence

A preferred sampling sequence should be established before any sampling event to reduce the risk of cross-contamination. In general, the sampling sequence should be such that sampling starts in areas where it is expected or known to be the least contaminated and then move to areas anticipated or identified to be most contaminated. The sampling sequence can be readily determined if analytical results from past sampling events are available.

For many PFAS investigation sites, no PFAS sampling has been conducted before. In these cases, all site information on possible PFAS uses and potential PFAS migration patterns (e.g., upgradient, downgradient) from PFAS sources at the site should be reviewed before the sampling event to help establish the sampling sequence.

Suppose multiple samples (i.e., monitoring wells) will be collected for an area where a particular or potential PFAS release in the environment might have been documented. In that case, samples known to be upgradient from the impacted area should be sampled first, followed by those furthest downgradient from the suspected source. The remaining wells should be progressively sampled from the most distant downgradient to those closer to the known PFAS source.

If no information is available about the site, samples are to be collected in the following order:

1. drinking water (e.g., residential wells)
2. surface water
3. groundwater

4.4 Decontamination Procedures

It is customary with sampling that equipment is decontaminated at the conclusion of the sampling event. If the previous user of the equipment/materials is unknown or it is unclear how the equipment was handled especially rental equipment, the equipment should be decontaminated before sampling.

Disposable Category 1 sampling equipment should be used, especially for sample bottles and other materials used where the sample may be in contact with the sampling equipment for an extended period.

Non-disposable sampling equipment used at multiple sites or sampling locations can become highly contaminated with PFAS. Decontamination procedures must be implemented to prevent cross-contamination, especially between individual sample locations. It is customary to decontaminate sampling equipment at the end of the sampling event, whether the event is a single sampling location or several sites that conclude at the end of the workday.

The sampling guidance documents will provide information about any media-specific decontamination procedures. There are many decontamination methods for non-dedicated **Category 1** sampling equipment, two of which are listed below.

Decontamination Method 1:

- ● Do not use Decon 90®.
- ● Do not put equipment away without decontaminating it.
- ■ Laboratory-supplied PFAS-free deionized water is preferred for decontamination.
- ■ Alconox®, Liquinox®, and Citranox® can be used for equipment decontamination.
- ■ Sampling equipment can be scrubbed using polyethylene or PVC brushes to remove particulates.
- ■ Decontamination procedures should include triple rinsing with PFAS-free water.
- ■ Decontaminate sampling equipment after sampling at each location or the end of the workday.
- ■ Commercially available deionized water in an HDPE container may be used for decontamination if the water is verified to be PFAS-free, as defined in **Section 4.2.1** of this document.
- △ Municipal drinking water may be used for decontamination purposes if it is known to be PFAS-free.

Decontamination Method 2:

1. In a PFAS-free bucket, wash the equipment with a mixture of PFAS-free water and PFAS-free soap (bucket #1).
2. In a second PFAS-free bucket (bucket #2), rinse the equipment with PFAS-free water.
3. A second rinse should be done with PFAS-free water using either a third bucket (bucket #3) or the second bucket (bucket #2) if washed and rinsed.
4. For decontamination of additional equipment, change the decontamination water between cleanings.

4.5 Laboratory Considerations

The PFAS analytical list is available on MPART's website, Michigan.gov/PFASresponse, under Investigations and Sites. This list includes the 18 analytes required to be analyzed for in drinking water samples when using EPA Method 537.1, the 25 analytes for EPA Method 533, and the 34 or 40 analytes (depending on method) that EGLE recommends be analyzed for in all other environmental media. The MPART website should be visited to download the most recent document. Laboratories should be able to analyze and report PFAS results that will meet the project-specific data quality objectives identified in the SAP or QAPP.

Drinking Water Samples

EPA Method 537.1 or Method 533 must be used for testing finished drinking water samples. Other methods are available for non-drinking water samples. Many laboratories refer to the isotope dilution method as 'modified Method 537', however, the EPA does not recognize isotope dilution as an acceptable modification of EPA Method 537.1 for drinking water analysis. EPA Method 533 allows for isotope dilution, and laboratories should be certified through Michigan's Laboratory Certification Program for analysis using Method 537.1 or Method 533. EPA drinking water methods are generally prescriptive, and only limited modifications are allowed because the finished treated drinking water is assumed to be free of significant interferences.

NOTE: EPA Method 537.1 and Method 533 were developed to be used only for finished drinking water samples, and contain specific requirements for sample preservation, shipping storage, and holding times.

EPA Method 537.1 and Method 533 were designed for finished drinking water and use chemical preservation using Trizma® (537.1) or ammonium acetate (533) to buffer the sample and remove free chlorine. Non-chlorinated finished drinking water may also be analyzed using EPA Method 537.1 or EPA Method 533.

Other Environmental Media Samples

EPA Method 1633, 4th Draft is the only published EPA method using isotope dilution for determining PFAS in non-drinking water matrices or other sample media. Other EPA methods, such as Method 8327, may be used. Method 1633, 4th Draft, continues to go through the development and validation process and may be promulgated in 2024. However, EPA recommends using this method, and it is currently the only PFAS method validated for the aqueous matrices of wastewater, surface water, and groundwater. Some commercial laboratories have developed isotope dilution methods based on existing published methods. However, there may be significant differences between SOPs from different commercial laboratories regarding the details of the preparation and analysis of PFAS samples. The laboratory's procedure and certifications should be reviewed to ensure that the laboratory can provide data that meets the project's data quality objectives. EGLE has implemented a laboratory SOP review process. Staff should refer to the EGLE internal share drive to see whether SOPs have been reviewed for the lab they are considering. Please note that EGLE staff or their contractors must have samples come through the EGLE laboratory first (unless it is an analysis unavailable through the EGLE Lab), with an identified overflow contract lab if necessary.

The following non-EPA analytical methods have been published for use in determining PFAS in various media:

- ISO (International Organization for Standardization) Method 25101 (ISO, 2009) - Water quality Determination of PFOA and PFOS - Method for unfiltered samples of drinking water, groundwater, and surface water, using solid phase extraction and liquid chromatography/mass spectrometry (HPLC/MS/MS.)
- ASTM D7979-20 (ASTM, 2020 - Standard Test Method for Determination of Per- and Polyfluoroalkyl Substances in Water, Sludge, Influent, Effluent and Wastewater by Liquid Chromatography-Tandem Mass Spectrometry (LC/MS/MS). This method has been used for the analysis of surface water, sludge, and wastewater for selected PFAS. However, this method has not been evaluated on drinking water matrices. Some commercial laboratories have modified this method and are using isotope dilution.
- ASTM D7968-17a (ASTM, 2017) - Standard Test Method for Determination of Polyfluorinated Compounds in Soil by Liquid Chromatography-Tandem Mass Spectrometry (LC/MS/MS). This method utilizes a quick extraction and is not intended to generate an exhaustive accounting of the content of PFAS in difficult soil matrices.

4.6 Quality Control Samples

4.6.1 Laboratory Quality Control Samples

The QAPP should describe what batch quality control (QC) samples – such as method blank (MB), laboratory control sample (LCS), laboratory control sample duplicate (LCSD), field duplicate (FD), matrix spike (MS), and matrix spike duplicate (MSD) – are prepared for each media type. In some cases, depending on the project, additional QC samples may be required. The QAPP should also reference the laboratory SOP.

4.6.2 Field Quality Control Samples

Field QC samples can be used to evaluate the field equipment and supplies and assess the possibility of cross-contamination during sampling, transport, and storage of samples. For samples such as equipment rinse blanks (EB), field blanks (FB), and trip blanks (TB), the following is required:

- The EB should be collected by passing laboratory-verified PFAS-free water over or through decontaminated field sampling equipment before collecting samples to assess the adequacy of the decontamination process and/or to evaluate potential contamination from the equipment used during sampling. The recommended frequency should be in the QAPP.

- The FB is prepared in the laboratory by placing an aliquot of PFAS-free reagent water in a sample container and treating it as a sample in all respects, including shipment to the sampling site, exposure to sampling site conditions, transfer to a clean sample container in the field, storage, preservation, and all analytical procedures. The purpose of the FB is to determine if method analytes or other interferences are present in the field environment. The recommended frequency should be in the QAPP.

- The TB is a bottle of PFAS-free water that should be prepared in the laboratory, travel from the laboratory to the site, and be transported back to the laboratory without having been exposed to any sampling procedures. Typically, a TB is used for volatile compounds, but it may be recommended for PFAS sampling to assess cross-contamination introduced from the laboratory and during shipping procedures. The recommended frequency should be in the QAPP.

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Appendix A

Many materials that are used during sampling are listed as prohibited in PFAS sampling guidance documents that are published by other federal, state, and civilian organizations, including the United States Navy in 2017, the United States Army in 2018, the Government of Western Australia Department of Environment Regulations in 2016, Cooperative Research Center for Contamination Assessment and Remediation of the Environment in 2017, National Groundwater Association in 2019, and the States of California in 2019, Maine in 2019, and New Hampshire in 2017. Materials prohibited in various sampling guidance documents include reusable ice packs, water-repellent field notebooks, markers, sticky notes, and many others that increase the cost, time, and difficulty of sampling but with no documented benefit or, many times, no analytical data to support the prohibition. Many of the sampling guidance documents are often considered conservative in their approach. EGLE's initial General PFAS Sampling Guidance from 2018 followed a similar, conservative approach since no published research was available that documented the use of various materials and their effect on sample results. However, many prohibited materials included those for which plausible scenarios for the materials to come into direct contact with the environmental samples were difficult to imagine.

Since the publication of many PFAS sampling guidance documents, including Michigan's PFAS Guidance Documents, various states and the Department of Defense have completed extensive sampling programs. In Michigan, for example, extensive PFAS studies, including a statewide sampling of over 1,700 drinking water systems, have been conducted, along with extensive remedial investigations at multiple locations and sampling of thousands of residential wells (MPART, 2020). Samples collected from numerous locations, including drinking water supplies, residential, and monitoring wells, were analyzed for between 14 and 28 PFAS compounds (depending on the analytical method), and many have been reported as non-detect for PFAS. Following a careful review of analytical results for field equipment blanks, field reagent blanks, and laboratory method blanks collected during these sampling events, and after validating a percentage of these samples, EGLE's current conclusion is that there is a low likelihood of systematic PFAS cross-contamination.

Recently, two peer-reviewed publications were published evaluating the potential of cross-contamination from sampling materials due to the potential leaching of PFAS compounds into the samples (Denly, 2019; Rodowa, 2020). Both publications used sampling methods considered worst-case scenarios and more conservative of actual environmentally relevant scenarios. Denly et al., 2019 evaluated a worst-case scenario of water coming into contact with various materials over 24 hours. Rodowa et al., 2020 used heated methanol shaken for 10 minutes. Some of the conclusions that can be taken from these publications are as follows:

1. Not all materials made of PFAS, such as fluorinated polymers (e.g., Teflon), had detectable PFAS compounds.

2. Some materials (e.g., aluminum foil) are not made of PFAS but have a protective layer that could contain PFAS and have shown both detections and no detections.
3. Materials that are often prohibited (e.g., adhesive notepads/notes) in many sampling guidance documents were tested and found to be non-detect in both studies.
4. There were detections and no detections for the same materials (e.g., labels and low-density polyethylene [LDPE] tubing) from different manufacturers. For example, LDPE tubing was non-detect for some samples but had high detections of over 1,000 ppt for other samples.
5. In some cases, materials considered allowable in all PFAS sampling guidance documents (e.g., high-density polyethylene (HDPE)) and not known to be PFAS-containing materials had low, detectable concentrations.
6. When the potential of cross-contamination is evaluated based on actual environmental field conditions, the likelihood of cross-contamination is low, even for materials where PFAS detections were noted and especially for materials that do not come into contact with the samples.
7. The focus should be on the materials that come into direct contact with the environmental samples, such as Category 1. Equipment blank samples should be used to confirm no cross-contamination occurs during sampling. Analysis of field sampling materials, as described in these two publications, should not be used as a substitute for equipment blank samples, which helps verify that sample materials or the combination of materials used in the field have not resulted in cross-contamination.
8. PFAS can be divided into two (2) primary categories: non-polymers and polymers. The non-polymer category includes perfluoroalkyl substances (e.g., compounds in the PFOA and PFOS families) and polyfluoroalkyl substances (PFAS compounds that can partially degrade into other PFAS, like those from the PFOA and PFOS families, often referred to as precursors). The second polymer category includes fluoropolymers, which have a carbon-only polymer backbone with fluorine directly attached to all carbon atoms; perfluoropolyethers, which have a carbon and oxygen polymer backbone with fluorine attached to the carbon; and side-chain fluorinated polymers, which have various components of a non-fluorinated backbone with fluorine side chains attached to the polymer backbone. Polymers generally have very different physical, chemical, and biological properties than non-polymer chemical substances of low molecular weight. PFAS analysis is typically only requested for non-polymer compounds. However, tools have been developed (i.e., particle induced gamma-ray emission [PIGE], combustion ion chromatography) to determine if polymers are present. Commercial laboratories have developed analytical methods for a minimal number of non-polymer PFAS families.

GROUNDWATER PFAS SAMPLING

Guidance

Introduction

This sampling guidance discusses the processes and acceptable items and materials that should be used when sampling groundwater monitoring wells for per- and polyfluoroalkyl substances (PFAS). The guidance primarily addresses the collection of representative water samples from the subsurface saturated zone. In addition, this guidance will be used to support the sampling objectives and procedures based on the Quality Assurance Project Plan (QAPP) developed prior to sampling activities. This guidance assumes staff has basic familiarity with and/or understanding of basic groundwater sampling procedures.

NOTE: Review the **General PFAS Sampling Guidance** document prior to reviewing this guidance document.

This sampling guidance may be varied or changed as required, depending on site conditions, equipment limitations, or limitations imposed by the procedure. The ultimate procedures used should be documented in the final report.

The MDEQ intends to update the information contained within this Groundwater PFAS Sampling Guidance document as new information becomes available. The user of this Groundwater PFAS Sampling Guidance is encouraged to visit the Michigan PFAS Action Response Team (MPART) webpage (www.michigan.gov/PFASresponse) to access the most current version of this document.

PFAS has been detected in groundwater in Michigan at concentrations over 810,000 parts per trillion (ppt). Many commercial laboratories have extremely low PFAS detection limits of about 1 ppt. Therefore, there is a high potential of false positives if proper procedures are not followed during sample collection.

This Groundwater PFAS Sampling Guidance discusses the collection of groundwater samples and methods to prevent cross-contamination that can occur from:

- Field clothing and personal protective equipment (PPE)
- Personal care products (PCPs)
- Food Ppckaging
- Sampling equipment
- Equipment decontamination
- Filtering of surface water
- Sample collection and handling
- Sample shipment

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1. Potential Sources for PFAS Cross-Contamination

Potential sources for PFAS cross-contamination include items and materials used within the sampling environment, such as sampling equipment, field clothing, personal protective equipment (PPE), sun and biological protection products, personal hygiene, personal care products (PCPs), and food packaging. A detailed discussion about potential sources for PFAS cross-contamination is included in the **General PFAS Sampling Guidance**, which should be reviewed before reading this document. However, a high-level summary is presented in this guidance.

All of the items and materials discussed in each of the MDEQ's PFAS Sampling Guidance Documents are divided into three major groups:

- Prohibited (●) identifies items and materials that should not be used when sampling. It is well documented that they contain PFAS or that PFAS are used in their manufacture.

- Allowable (■) identifies items and materials that have been proven not to be sources of PFAS cross contamination and are considered acceptable for sampling.

- Needs Screening (▲) identifies items and materials that have the potential for PFAS cross-contamination due to a lack of scientific data or statements from manufacturers to prove otherwise. These items and materials are further sub-divided into two categories:

    - **Category 1:** Items and materials that <u>will come in direct contact</u> with the sample. These should not be used when sampling unless they are known to be PFAS-free, by collecting an equipment blank sample prior to use.

    - **Category 2:** Items and materials that <u>will not come in direct contact</u> with the sample. These should be avoided, if possible, unless they are known to be PFAS-free by collecting an equipment blank sample prior to use.

Please note that at this time no published research is available that documents the use of various materials and effect on sample results. Therefore, a conservative approach is recommended, and the guidance is based on the collection of multiple environmental samples at various PFAS sites. Sampling staff should take practical and appropriate precautions to avoid items that are likely to contain PFAS at the sampling site as well as avoid specific items during the sampling event.

A general overview of PFAS contamination sources during sampling can be found in **Section 4.2** of the **General PFAS Sampling Guidance**. Any items or materials utilized that are not identified in this guidance or not discussed in **Section 4.2** should be evaluated as described in **Section 4.2.1 of the General PFAS Sampling Guidance**.

Sampling staff should take practical and appropriate precautions to avoid items that are likely to contain PFAS at the sampling site as well as avoid specific items during the sampling event (see below).

1.1 Field Clothing and PPE

Materials, field clothing, and equipment screening should be performed during the QAPP development or the planning phase of sampling programs. The screening should be performed on all items and materials that are expected to come into contact with the samples and are defined as **Category 1.** Due to the extensive use of PFAS in many industries and

products, PPE may contain PFAS. During a PFAS investigation, PPE containing PFAS should be avoided to prevent cross-contamination.

As with any field mobilization, it is the responsibility of all personnel to be aware of the physical, chemical, and biological hazards associated with a particular site. Personal safety is paramount. The safety of staff should not be compromised by fear of PFAS-containing items or materials without any scientific basis. Any deviation from this guidance, including those necessary to ensure the health and safety of sampling personnel, should be recorded in field notes and discussed in the final report.

Any additional field clothing and/or PPE items that might be required for groundwater sampling and not discussed in this sampling guidance should be evaluated as described in **Sections 4.2.1** and **4.2.2** of the **General PFAS Sampling Guidance**.

NOTE: Special attention should be given to clothing that has been advertised as having waterproof, water-repellant, or dirt and/or stain characteristics. They are likely to have PFAS in their manufacturing.

Field sampling during wet weather (e.g., rainfall and snow) should be conducted while wearing the proper field clothing.

- ● Dust and fibers must not be allowed to collect on field clothing or PPE.
- ● Do not use clothing that has been advertised as waterproof, dirt and/or stain repellant that has not been verified to be made of PFAS-free materials.
- ■ Use powderless nitrile gloves
- ■ Only use clothing/PPE that has been verified to be made of PFAS-free materials.
- ▲ Latex gloves should be screened before use.

Powderless nitrile gloves should be changed frequently any time there is an opportunity for cross-contamination. See **Section 5** of this guidance for additional glove instructions.

1.2 Personal Care Products (PCPs)

A number of sampling guidance documents recommend that personal hygiene and PCPs (e.g., cosmetics, shampoo, sunscreens, dental floss, etc.) not be used prior to and on the day(s) of sampling because the presence of PFAS in these products has been documented (OECD, 2002, Fujii, 2013, Borg and Ivarsson, 2017). However, if the MDEQ's sampling SOPs are followed, these items should not come into contact with the sampling equipment or the sample being collected. As of the date of this sampling guidance, cross-contamination of samples due to the use of PCPs has not been documented during the collection of thousands of samples. However, field personnel should be aware of the potential of cross-contamination of the sampling equipment or actual samples would come into contact with these products. The following precautions should be taken when dealing with personal hygiene or PCPs before sampling:

- ● Do not handle or apply PCPs in the sampling area.
- ● Do not handle or apply PCPs while wearing PPE that will be present during sampling.
- ■ Move to the staging area and remove PPE if applying personal care products becomes necessary.
- ■ Wash hands thoroughly after the handling or application of PCPs and, when finished, put on a fresh pair of powderless nitrile gloves.

1.3 Food Packaging

PFAS has been used by the paper industry as a special protective coating against grease, oil, and water for paper and paperboards, including food packaging since the late 1950s (Trier et al., 2018). PFAS application for food packaging includes paper products that come into contact with food such as paper plates, food containers, bags, and wraps (OECD, 2002). Pre-wrapped food or snacks (such as candy bars, microwave popcorn, etc.) must not be in the sampling and staging areas during sampling due to PFAS contamination of the packaging. When staff requires a break to eat or drink, they should remove their gloves, coveralls, and any other PPE, if worn, in the staging area and move to the designated area for food and beverage consumption. When finished, staff should wash their hands and put on a fresh pair of powderless nitrile gloves at the staging area, before returning to the sampling area.

- ● Do not handle, consume, or otherwise interact with pre-wrapped food or snacks, carry-out food, fast food, or other food items while on-site during sampling.
- ■ Move to the staging area and remove PPE prior to leaving the sampling and staging areas if consuming food on site becomes necessary.

2. Groundwater Sampling Equipment

Do not use any equipment that contains any known fluoropolymers including, but not limited to:

- ● Do not use polytetrafluoroethylene (PTFE), that includes the trademark Teflon® and Hostaflon®, which can be found in many items, including but not limited to ball check-valves on certain bailers, the lining of some hoses and tubing, some wiring, certain kinds of gears, lubricant, and some objects that require the sliding action of parts.
- ● Do not use Polyvinylidene fluoride (PVDF), that includes the trademark Kynar®, which can be found in many items, including but not limited to tubing, films/coatings on aluminum, galvanized or aluminized steel, wire insulators, and lithium-ion batteries.
- ● Do not use Polychlorotrifluoroethylene (PCTFE), that includes the trademark Neoflon®, which can be found in many items, including but not limited to valves, seals, gaskets, and food packaging.
- ● Do not use Ethylene-tetrafluoro-ethylene (ETFE), that includes the trademark Tefzel®, which can be found in many items, including but not limited to wire and cable insulation and covers, films for roofing and siding, liners in pipes, and some cable tie wraps.
- ● Do not use Fluorinated ethylene propylene (FEP), that includes the trademarks Teflon® FEP and Hostaflon® FEP, and may also include Neoflon®, which can be found in many items, including but not limited to wire and cable insulation and covers, pipe linings, and some labware.
- ● Do not use low density polyethylene (LDPE) for any items that will come into **direct contact** with the sample media. LDPE can be found in many items, including but not limited to containers and bottles, plastic bags, and tubing.
  - ▲ **However**, LDPE may be used if an equipment blank has confirmed it to be PFAS-free. LDPE does not contain PFAS in the raw material but may contain PFAS cross-contamination from the manufacturing process.
- ■ LDPE bags (e.g., Ziploc®) that **do not** come into direct contact with the sample media and do not introduce cross-contamination with samples may be used.

NOTE: Manufacturers can change the chemical composition of any product. As a result, all materials that will come into direct contact with the sample media (defined as Category 1) should be tested to confirm they are "PFAS-free," i.e. will not contaminate samples at detectable levels. **There is no guarantee that materials in the "Allowable" category will always be PFAS- free.**

●- Prohibited ■- Allowable ▲- Needs Screening

- ■ Use items and materials that are either made of high-density polyethylene (HDPE), polypropylene, silicone, polyvinyl chloride(PVC), or acetate.
- ■ Keep tubing in the original cardboard or bag in which it was shipped.
- ■ Store tubing in a clean location free of dust and fibers.
- ■ Use nylon line, cotton string, or other PFAS-free material when raising and lowering bailers.
- ■ When using bladder pumps, use pumps made of stainless steel with polyethylene bladders.
- ■ Glass bottles or containers may be used if they are known to be PFAS-free, however, PFAS have been found to adsorb to glass, especially when the sample is in contact with the glass for a long period of time (e.g. being stored in a glass container). If the sample comes into direct contact with the glass for a short period of time (e.g. using a glass container to collect the sample, then transferring the sample to a non-glass sample bottle), the adsorption is minimal.
- ▲ In many submersible pumps, the O-Rings do not come into contact with the groundwater sample, and in this case, the O-Rings should be treated as internal pump components. The O-Rings present a low possibility of cross-contamination. Equipment blanks should be collected simulating actual field sampling procedures and not for individual pump components.

Field rental equipment companies offer “PFAS-free” bladder pumps; however, caution is advised, and an equipment rinsate blank is required. Rental equipment should be treated as being contaminated and only used after proper decontamination has been done.

Staff should follow the **MDEQ PFAS Sampling Quick Reference Field Guide** at the end of this document for approved and prohibited items for documenting and sampling groundwater for PFAS.

3. Equipment Decontamination

It is customary with groundwater sampling that the equipment is decontaminated before the sampling event. If the previous user of the equipment is not known, and it is unclear how the equipment was handled—especially rental equipment—decontaminate the equipment before sampling. Any **Category 1** non-dedicated sampling equipment (equipment used for more than one location) must be verified as PFAS free before use.

For non-dedicated **Category 1** sampling equipment, the following materials and procedures must be used for decontamination:

- ● Do not use Decon 90®.
- ■ Laboratory supplied PFAS-free deionized water is preferred for decontamination.
- ■ Alconox®, Liquinox®, and Citranox® can be used for equipment decontamination.
- ■ Sampling equipment can be scrubbed using a polyethylene or Polyvinyl chloride (PVC) brush to remove particulates.
- ■ Decontamination procedures should include triple rinsing with PFAS-free water.
- ■ Commercially available deionized water in an HDPE container may be used for decontamination if the water is verified to be PFAS-free.
- ▲ Municipal drinking water may be used for decontamination purposes if it is known to be PFAS-free.

NOTE: All samples must be collected using PFAS-free High-Density Polyethylene (HDPE), glass, or polypropylene bottles provided by the laboratory, with Teflon®-free caps.

4. Groundwater Sample Collection Methods

4.1 Method summary

Before a well is sampled, stagnant water in the well casing must be removed or purged in order to obtain a representative groundwater sample. The instruments most commonly used for purging by the MDEQ are bailers, submersible pumps, and inertia pumps. MDEQ staff may oversee purging and sampling conducted by noncontact gas bladder pumps, suction-lift pumps, and other pumps, but the MDEQ does not typically use these pumps. The MDEQ typically samples groundwater using bailers, or by low-flow methods utilizing a peristaltic pump.

Prior to purging, the water level in the well and the total depth of the well should be measured, using the procedures described in the QAPP to determine the volume of water in the well. When using a bailer, a minimum of three well volumes should be purged, unless the well runs dry. When using low-flow methods, purging should continue until the selected indicator parameters have stabilized (see **Section 4.7 Low-Flow Methods**).

Once purging is completed or the groundwater in the well recovers, the groundwater pH, temperature, specific conductance, and turbidity should be measured using the procedures described in the QAPP. After the correct sample containers have been prepared, sampling may proceed. Care should be taken when choosing the sampling device, since some devices may affect the integrity of the sample.

NOTE: Purging is mandatory in all cases where there is the potential for the data to be used for enforcement purposes.

Purging and sampling should occur in a progression from the least contaminated well to the most contaminated well, if this information is known; disposable equipment should be used for each well or equipment must be decontaminated prior to use and between each well.

4.2 Calculations

If it is necessary to calculate the volume of water in the well, use the following equation:

Well volume (gallons) = $\pi r^2 h$ (cf)
where:

- r = radius of monitoring well (feet)
- h = height of the water column (feet) (This may be determined by subtracting the depth to the water from the total depth of the well as measured from the same reference point.)
- cf = conversion factor (gallons/linear foot) = 7.48 gal/ft^3

If the diameter of the monitoring well is known, standard conversion factors can be applied to simplify the equation above. Monitoring well diameters are typically two, three, four, or six inches.

Well volumes, in gallons per linear foot, for these common monitoring well diameters are as follows:

Well diameter	2-inches	3-inches	4-inches	6-inches
Volume (gal/ft.)	0.1632	0.3672	0.6528	1.4688

The volume of water in the well can then be calculated by multiplying the appropriate value of gallons per linear foot by the height of the water column in feet (h).

This well volume is typically tripled to determine the volume to be purged.

4.3 Preparation Procedures

The success of any sampling effort depends on thorough preparation. The following steps should be followed in preparing for groundwater well sampling:

1. Determine the extent of the sampling effort, the sampling methods to be used, and the types and quantities of equipment and supplies needed.
2. Develop and implement a site-specific sampling plan.
3. Prepare the schedule and coordinate with the laboratory, staff, contractors, and the regulated facility, as appropriate.
4. Obtain necessary sampling and monitoring equipment and supplies.
5. Decontaminate or preclean equipment, and ensure that it is in working order.
6. Perform a general site survey prior to site entry in accordance with the site-specific Health and Safety Plan (HASP), if appropriate.
7. Identify all monitoring wells to be sampled.
8. Start at the least contaminated well, if known.
9. Powderless nitrile gloves should be changed between each discrete task in the well purging and sampling process.
10. Remove the locking well cap; note the location, time of day, date and general weather conditions in the field logbook or Monitor Well and Groundwater Data Sheets.
11. Remove the well casing cap.
12. Lower the water level measuring device into the well until the water surface is encountered. Refer to the QAPP for specific water level measurement procedures.
13. Measure the distance from the water surface to a known reference measuring point on the well casing or protective barrier post and record the distance in the field logbook or Monitor Well and Groundwater Data Sheets. Alternatively, if no known reference point is available, note that the water level measurement is from the top of the steel casing, top of the riser pipe from ground surface, or some specific position on the well head.
14. Measure total depth of the well and record the depth in the field logbook or Monitor Well and Groundwater Data Sheets.
15. Calculate the volume of water in the well and the volume to be purged using the equations in **Section 4.2 Calculations**.

4.4 Purging Procedures

Wells should be purged to ensure that a representative sample is obtained. Generally, at a minimum, purging of three well volumes is effective. Bailers, submersible pumps, and inertia pumps are the purging devices most commonly used.

NOTE: Reference and utilize the *MDEQ Purge Water Disposal Policy* for detailed purge water disposal procedures.

- ■ Purge water should be containerized, characterized, and properly disposed of. Sample results for the well can be used to assist in waste characterization.

  If no other option is available and only a small volume of purge water has been generated, purge water may be disposed of on the ground near the well.

- ● Do not dispose of purge water in a way that the disposal will exacerbate existing contamination.

4.4.1 Bailers

Bailers are the simplest purging device used and have many advantages. They generally consist of a rigid length of tube, with a ball check-valve at the bottom. A line is used to lower the bailer into the well and retrieve a volume of water.

Manual purging with bailers is best suited to shallow and/or narrow-diameter wells. For deep, larger-diameter wells that require purging large volumes of water, other devices may be more appropriate.

Procedures for purging with a bailer are as follows:

1. Determine the volume of water to be purged as described in **Section 4.2 Calculations.**
2. Attach the line to the bailer and slowly lower the bailer until it is completely submerged. Be careful not to drop the bailer to the water, as it causes turbulence and the possible loss of volatile organic contaminants. On the bailer's first trip down the well, it is good sampling practice to gently lower it to the bottom of the well casing so that the sampler has an adequate length of line in hand to bail the well dry, should it be needed.
3. Pull the bailer out in a manner that the line never touches the ground.
4. Empty the bailer into a graduated pail.
5. Collect and dispose of purge water in accordance with the *MDEQ Purge Water Disposal Policy* and any additional requirements in the site-specific sampling plan. If purge water is disposed of on the ground, this should be done away from the base of the well.

4.4.2 Submersible Pumps

The use of submersible pumps for purging is permissible, provided they are constructed of suitably noncontaminating materials. The chief drawback, however, is possible cross-contamination between wells. Although some units can be disassembled easily to allow surfaces contacted by contaminants to be cleaned, field decontamination may be difficult and require solvents that can affect sample analysis.

NOTE: Submersible pumps may be the only practical sampling device for extremely deep wells (greater than 300 feet of water). Under those conditions, it is recommended that dedicated pump systems be installed to eliminate the potential for cross-contamination of well samples.

The use of submersible pumps in multiple well-sampling programs should be carefully compared to other sampling mechanisms (e.g., bailers, peristaltic pumps). In many cases, a sample can be collected by a bailer after purging with a submersible pump.

Submersible pumps generally use one of two types of power supplies: electric or compressed gas. Electrically powered pumps can run off a 12-volt DC rechargeable

battery, or a 110 or 220-volt AC power supply. Pumps powered by compressed air normally use a small electric or gas-powered air compressor. They may also utilize compressed gas (i.e., nitrogen) from bottles. Differently sized pumps are available for different depth or diameter monitoring wells.

Procedures for purging with a submersible pump are as follows:

1. Determine the volume of water to be purged as described in **Section 4.2 Calculations**.
2. Assemble the pump, hoses, and safety cable, then lower the pump into the well. Make sure the pump is deep enough so that all the water is not evacuated (running the pump dry may cause damage).
3. Determine the volume of water purged by discharging purged water into a graduated pail or by attaching a flow meter to the outlet hose.
4. Use a ground fault circuit interrupter or ground the generator to avoid possible electric shock.
5. Connect the power supply and purge the well until the specified volume of water has been evacuated. If the pumping rate exceeds the well recharge rate, lower the pumping rate, lower the pump further into the well, and continue pumping.
6. Collect and dispose purge waters in accordance with the *MDEQ Purge Water Disposal Policy* and any additional requirements in the site-specific sampling plan. If purge water is disposed on the ground, this should be done away from the base of the well.

4.4.3 Inertia Pumps

Inertia pumps, such as the WaTerra® pump and piston pump, are manually operated. They are the most appropriate to use when wells are too deep to bail by hand, or too shallow, narrow, or inaccessible for a submersible pump. Inertia pumps are made of plastic or stainless steel and may be either decontaminated or discarded.

Procedures for purging with an inertia pump are as follows:

1. Determine the volume of water to be purged as described in **Section 4.2 Calculations.**
2. Assemble the pump and lower it to the appropriate depth in the well.
3. Begin pumping manually, discharging the water into a graduated pail. Purge until the specified volume of water has been evacuated.
4. Collect and dispose purge waters in accordance with the *MDEQ Purge Water Disposal Policy* and any additional requirements in the site-specific sampling plan. If purge water is disposed on the ground, this should be done away from the base of the well.

4.5 Representative Sample Collection

The primary goal in performing groundwater sampling is to obtain a representative sample of the aquifer or water-bearing zone. Groundwater sampling results can be compromised in two primary ways: collecting a non-representative sample or handling the sample incorrectly.

A monitoring well will have little or no vertical mixing of the water, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated, become stagnant, and may no longer be representative of the groundwater quality. Also, stagnant water may contain foreign material inadvertently or deliberately introduced from the surface, resulting in a non-representative sample. To safeguard against collecting non-representative stagnant water, the following guidelines and techniques should be adhered to during sampling:

1. As a general rule, all monitoring wells should be purged prior to sampling; see **Section 4.3 Purging Procedures.** To obtain a representative sample, a minimum of three volumes of water in the well casing should be purged. When using low-flow methods, purging should continue until the selected indicator parameters have stabilized. Indicator parameters typically used in low-flow purging include groundwater pH, specific conductivity, turbidity, temperature, dissolved oxygen and oxidation-reduction potential. The appropriate set of indicator parameters for the specific sampling event should be chosen by the project manager in advance of the sampling event. Alternatively, for low-yielding groundwater formations, the well can be pumped dry. For deeper wells, packers can be used to isolate a portion of the screened interval, minimizing the volume of groundwater that must be purged. In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, purging is not as critical.
2. When purging with a pump, the pump should be set within the screened interval. When sampling a screened well, the sample should also be collected from the same depth within the screened interval at which the pump was set.
3. The well should be sampled as soon as possible after purging.
4. For wells that are pumped or bailed to dryness prior to the purging procedure being completed, the well should be allowed to recover (for up to, but no longer than, 24 hours) prior to collecting a sample.
5. A non-representative sample can also result from excessive pre-pumping of the monitoring well. Stratification of the constituent concentration in the groundwater formation may occur, or heavier-than-water compounds may sink to the lower portions of the aquifer. Excessive pumping can dilute or increase the constituent concentrations relative to those at the sampling point of interest.
6. A sampling methodology must be used that accounts for the effects of aquifer heterogeneities, while minimizing alterations in water chemistry that could result from sampling disturbances. The MDEQ will accept properly conducted purging methods designed to minimize drawdown, by controlling the flow from the well while monitoring stabilization indicator parameters, commonly referred to as low-flow methods. Available low-flow procedures include:

    - United States Environmental Protection Agency (USEPA), Office of Research and Development, Office of Solid Waste and Emergency Responses, EPA/540/S-95/504, April 1996, USEPA Ground Water Issue, *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*, Robert Puls and Michael Barcelona
    - USEPA, Region 1, July 30, 1996, Revision 3, *Low Stress (Low-Flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells*

4.6 Low-Flow Methods

Low-flow sampling involves the slow removal of a minimal amount of water from a well to ensure that stagnant water is removed and that water in the well is representative of water in the formation. The advantage of low-flow sampling is that, when conducted properly, it avoids

disrupting the formation and minimizes turbidity that can be introduced by other purging and sampling devices, such as bailers. Instead of removing a set volume of water from the well, low-flow sampling uses a pump (typically a peristaltic pump), set at a low rate of flow, to continuously remove water until a set of indicator parameters are stabilized.

Flow rates are typically on the order of 100 to 200 milliliters per minute (ml/min) and should never exceed 500 ml/min. Indicator parameters are measured using probes inside a flow through cell and may include pH, specific conductance, dissolved oxygen, oxidation-reduction (redox) potential, temperature, and turbidity. Not all indicators may be used for a specific sampling; staff is most likely to use pH, specific conductivity, temperature, and turbidity.

NOTE: For a detailed discussion of low-flow methods, see USEPA, Office of Research and Development, Office of Solid Waste and Emergency Responses, EPA/540/S-95/504, April 1996, USEPA Ground Water Issue, *Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*, Robert Puls and Michael Barcelona

5. Groundwater Sample Collection Procedures

Groundwater samples can be collected using bailers, submersible pumps, inertia pumps, and peristaltic pumps used for purging. Several factors must be considered when choosing a sampling device, and care should be taken when reviewing the advantages or disadvantages of any one device (see **Section 2 Groundwater Sampling Equipment**). It may be appropriate to use a sampling device different than that used to purge. The most common example of this is the use of a submersible pump to purge and a bailer to sample.

The following considerations should be taken during sample collection to prevent contamination:

- ● Dust and fibers must be kept out of sample bottles.
- ● The sample cap should never be placed directly on the ground during sampling.
  - ▲ If sampling staff must set the sample bottle cap down during sample collection and a second member of the sampling crew (wearing a fresh pair of powderless nitrile gloves) is not available, set the cap on a clean surface (cotton sheeting, HDPE sheeting, triple rinsed cooler lid, etc.).
- ● Do not sample without powderless nitrile gloves.
- ● Regular/thick size markers (Sharpie® or otherwise) are to be avoided; as they may contain PFAS.
- ■ Fine and Ultra-Fine point Sharpie® markers are acceptable to label the empty sample bottle while in the staging area provided the lid is on the sample bottle and gloves are changed following sample bottle labeling.
- ■ Ballpoint pens may be used when labeling sample containers. If ballpoint pens do not write on the sample container labels, preprinted labels from the laboratory may be used.
- ■ Hands should be well washed and gloved.
- ■ Use HDPE or polypropylene sample bottles with Teflon®-free caps, provided by the laboratory.
- ■ Commercialy bought sample bottles used with automatic sampling equipment should be decontaminated prior to sampling and equipment blank samples should be collected using laboratory supplied PFAS-free water.
- ■ Glass bottles or containers may be used if they are known to be PFAS-free, however, PFAS have been found to adsorb to glass, especially when the sample is in contact with the glass for a long period of time (e.g. being stored in a glass container). If the sample comes into direct contact with the glass for a short period of time (e.g. using a glass container to collect

the sample, then transferring the sample to a non-glass sample bottle), the adsorption is minimal.

- ■ Bottles should only be opened immediately prior to sampling.
- ■ Bottles should be capped immediately after collecting the sample.
- ■ Samples should be double bagged using resealable low density polyethelene (LDPE) bags (e.g., Ziploc®).
- ■ Follow any guidance or requirements in the PFAS analytical reference method that will be used for testing samples, for sample collection, storage, preservation, and holding times.
- ■ In the absence of formal USEPA guidance for PFAS groundwater sample storage, the documentation in USEPA Method 537 Rev. 1.1 should be used as a guide for thermal preservation (holding temperature) and holding times for groundwater or other samples. Samples must be chilled during storage and shipment and must not exceed 50°F (10º C) during the first 48 hours after collection. Samples stored in the laboratory must be held at or below 50°F (10°C) until extraction but should not be frozen.

NOTE: USEPA Method 537 Rev. 1.1 was developed for the analysis of finished drinking water samples **only**.

- ■ Groundwater samples should be extracted as soon as possible but must be extracted within 14 days. Extracts must be stored at room temperature and analyzed within 28 days after extraction.
- ▲ Off-brand markers should be known to be PFAS free prior to use.
- ▲ Latex gloves should be screened before use.

5.1 Bailers

1. Complete purging. Measure the groundwater pH, temperature, and specific conductance using the procedures described in the QAPP.
2. Assemble the appropriate sample containers, and label with appropriate sample labels.
3. Attach a nylon or cotton line to the bailer.
4. Lower the bailer slowly and gently into the well, attempt to minimize contact with the casing, and avoid splashing the bailer into the water. Stop lowering at a point adjacent to the screen.
5. Allow the bailer to fill and then slowly and gently retrieve the bailer from the well. Attempt to minimize contact with the casing, to ensure that flakes of rust or other foreign materials are not knocked into the bailer.
6. Remove the cap from the sample container and keep it in a gloved hand (two sample collection personnel may be needed).
7. Begin slowly pouring groundwater from the bailer into the sample container.
8. Replace the well cap once all sample containers are filled.
9. Cap the sample container tightly, label the container, and place the container in a temperature-controlled carrier.
10. Log all samples in the field logbook and on Monitor Well and Groundwater Data Sheets.
11. Package the samples for transport to the analytical laboratory. Complete chain-of-custody records.
12. Properly dispose of the bailer and line.

NOTE: For bailers especially, two sample collection personnel may be needed.

5.2 Submersible Pumps (Low-Flow Sampling)

1. Complete purging, keeping the pump approximately in the middle of the screened interval. Measure the groundwater pH, temperature, and specific conductance using the procedures described in the QAPP.
2. Assemble the appropriate sample containers, and label with the appropriate sample labels.
3. Reduce the purge water flow rate to a manageable sampling rate by adjusting the control box or by attaching a gate valve to the tubing (if not already fitted).
4. If the flow rate cannot be adjusted, run the water down the side of a clean jar and fill the sample containers from the jar.
5. Remove the pump and assembly. Dedicate the tubing to the monitoring well.
6. Replace the well cap once all sample containers are filled.
7. Cap the sample container tightly, label the container, and place it in a temperature-controlled carrier.
8. Log all of the samples in the field logbook and/or the Monitor Well and Groundwater Data Sheets.
9. Package the samples for transport to the analytical laboratory. Complete chain-of-custody records.
10. Decontaminate equipment in accordance with **Section 3 Equipment Decontamination**.

5.3 Inertia Pumps

1. Complete purging, keeping the pump approximately in the middle of the screened interval. Measure the groundwater pH, temperature, and specific conductance using the procedures described in the QAPP.
2. Assemble the appropriate sample containers, and label with appropriate sample labels.
3. Manually regulate the flow rate and discharge the sample from the pump outlet directly into the appropriate sample container.
4. Remove the pump from the well.
5. Replace the well cap once all sample containers are filled.
6. Cap the sample container tightly, label the container, and place it in a temperature-controlled carrier.
7. Log all samples in the field logbook and/or the Monitor Well and Groundwater Data Sheets.
8. Transport the samples to the decontamination zone, and package them for transport to the analytical laboratory. Complete chain-of-custody records.
9. Decontaminate equipment in accordance with **Section 3 Equipment Decontamination**.

5.4 Peristaltic Pumps (Low-Flow Sampling)

1. Determine that the indicator parameters (see **Section 4.4**) have stabilized. Complete purging, keeping the pump approximately in the middle of the screened interval. Record indicator parameters at 3-minute intervals.
2. Assemble the appropriate sample containers, and label with appropriate sample labels.
3. Collect samples.
4. Remove the pump and assembly. Dedicate the tubing to the monitoring well or properly dispose.
5. Replace the well cap once all sample containers are filled.
6. Cap the sample container tightly, label the container, and place it in a temperature-controlled carrier.
7. Log all samples in the field logbook and/or the Monitor Well and Groundwater Data Sheets.
8. Package the samples for transport to the analytical laboratory. Complete chain-of-custody records.
9. Decontaminate equipment in accordance with **Section 3 Equipment Decontamination**.

When the depth to the water table exceeds 25 feet below grade, suction-lift mechanisms, such as peristaltic pumps, cannot be used to sample groundwater. A bladder or submersible pump can be used in the case when groundwater is located deeper than 25 feet below grade. Both of these pumps are submerged beneath the water table and will come into contact with the groundwater being sampled.

6. Field Quality Assurance/Quality Control

Sample blanks and duplicates are the primary means of assuring and assessing quality control during sample collection or transport.

Field blanks consist of:

- **Equipment blanks**
  - Equipment blanks consist of laboratory verified PFAS-free water poured over (for equipment such as static water level indicators) or through (for equipment such as pumps, bailers and flow through cells) the sampling equipment, collected in laboratory-supplied sample containers, and analyzed.
  - Equipment blanks should be collected prior to the first use of sampling equipment in the field (particularly if there is any uncertainty as to whether the equipment is constructed from PFAS containing materials) and occasionally after decontamination.
  - Equipment blanks should be collected from a representative sample of disposable sampling equipment (one bailer from a box, a length of tubing from a roll) to document that these items are not contributing PFAS to groundwater samples.
  - In the field, equipment blanks should be collected at a minimum frequency of one per day (or at a different frequency as specified in the sampling plan).

NOTE: Refer to the specific sampling plan to determine the appropriate number and frequency regarding field quality assurance and quality control.

- **Trip blanks**
  - Trip blanks consist of laboratory-verified PFAS-free water in a laboratory-supplied sample container. Trip blanks travel with the field samples and are analyzed in the same batch.
  - Typically trip blanks are collected to assess the potential cross contamination from VOCs. The current MDEQ minimum analyte PFAS list does not contain PFAS that are volatile.
  - Trip blanks could be used to evaluate the potential cross-contamination present the lab in the containers or deionized water provided from the lab.

- **Field blanks**
  - Field blanks consist of laboratory verified PFAS-free water in a laboratory supplied sample container.
  - A field blank is opened at the sampling site and exposed to ambient conditions for approximately the same amount of time as an actual sampling container (generally 1 to 3 minutes). Alternately, the PFAS—free water can be poured from one sample container into another to mimic sample collection activities. The field blank then travels with the field samples and is analyzed in the same batch.
  - A field blank must be collected once every twenty samples (or at a different frequency as specified in sampling plan) or once during any sampling event, when an ambient source of PFAS (particularly atmospheric) is suspected.
  - If an atmospheric source of PFAS is suspected, collect the equipment blank downwind of the suspected source

- **Field duplicates**
  - Groundwater sample duplicates are two samples collected immediately sequentially from the same well. Duplicate samples should be labeled to prevent anyone, other than the sample collector, from knowing which specific well(s) are being duplicated.
  - Duplicates are analyzed in the same batch and serve as a quality check on the accuracy and precision of sampling procedures.
  - Duplicates are recommended once every ten samples or once per day (whichever is less; or at a different frequency as specified in the sampling plan.

7. Filtration

Filtering of the groundwater samples is sometimes necessary. PFAS can adsorb to particulate matter, and unfiltered samples may result in high biased results. However, the filter material should be carefully evaluated. A study between four different filter materials (PTFE, glass, polyethersulfone [PES], and nylon) found that glass filters adsorbed the least amount of PFAS and nylon adsorbed the most and is therefore not recommended for PFAS sampling.

NOTE: It is recommended that filtering of the samples should **only be performed in the laboratory** in order to reduce the possibility of cross contamination.

The following recommendations should be used when considering filtering of the samples:

- ● **Field filtration of the sample is generally not advised.**
  - ▲ If filtering is absolutely necessary, if specifically requested by a client or for other reasons:
    - ● Do not use any filters that contain any PFAS, such as PTFE filters
    - ● Do not use nylon filters.
    - ■ Glass filters are recommended to be used.
    - ■ Consider use of a centrifuge in the laboratory to reduce the need for sample filtering.

8. Sample Shipment

Once the sample is collected in laboratory-supplied containers, the following recommendations should be used for sample shipment:

- ■ Check the cooler periodically to ensure samples are well iced and at the proper temperature.

- Refresh with regular ice, if needed, double bagged in LDPE resealable storage bags if needed.
- Regular ice should be used to cool and maintain the sample at or below the proper temperature.
  - ▲ Chemical or blue ice may be used if it is known to be PFAS-free and it is absolutely certain that the sample is cooled and maintained at or below the proper temperature during collection and through transit to the laboratory.
- Complete the appropriate Monitor Well and Groundwater Data Sheets.
- Shipping containers should be packed with enough PFAS-free noncombustible, absorbent, cushioning material, such as bubble wrap, to minimize the possibility of breakage.
- Complete a Chain of Custody (COC) form for each separate shipping container. The forms should be hand-carried to the laboratory by the sampler.
- If unable to hand-carry the COC and other forms to the laboratory, forms should be single bagged in LDPE (e.g. Ziploc®) storage bags and taped to the inside of the cooler lid.
- The cooler should be taped closed with a custody seal and, if shipping, shipped by overnight courier.
- Samples should be shipped as soon as possible (e.g. overnight) to ensure the samples arrive within the analytical holding time specified by the lab.

NOTE: Chain-of-custody procedures must be followed and documented.

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Michigan Department of Environmental Quality

MDEQ PFAS Sampling Quick Reference Field Guide[1]

All Items Used During Sampling Event

● Prohibited
• Items or materials that contain fluoropolymers such as ○ Polytetrafluoroethylene (PTFE), that includes the trademarks Teflon® and Hostaflon® ○ Polyvinylidene fluoride (PVDF), that includes the trademark Kynar® ○ Polycholotrifluoroethylene (PCTFE), that includes the trademark Neoflon ® ○ Ethylene-tetrafluoro-ethylene (ETFE), that includes the trademark Tefzel® ○ Fluorinated ethylene propylene (FEP), that includes the trademarks Teflon® FEP and Hostaflon® FEP • Items or materials that contain any other fluoropolymer

Pumps, Tubing, and Sampling Equipment

● Prohibited	■ Allowable	▲ Needs Screening[2]
• Items or materials containing any fluoropolymer (potential items include tubing, valves, or pipe thread seal tape)	• High-density polyethylene (HDPE) • Low-density polyethylene (LDPE) tubing • Polypropylene • Silicone • Stainless-steel • Any items used to secure sampling bottles made from: ○ Natural rubber ○ Nylon (cable ties) ○ Uncoated metal springs ○ Polyethylene	• Any items or materials that will come into direct contact with the sample that have **not** been verified to be PFAS-free ○ Do not assume that any sampling items or materials are PFAS-free based on composition alone

Sample Storage and Preservation

● Prohibited	■ Allowable	▲ Needs Screening[2]
• Polytetrafluoroethylene (PTFE): Teflon® lined bottles or caps	• Glass jars[4] • Laboratory-provided PFAS-Free bottles: ○ HDPE or polypropylene • Regular wet ice • Thin HDPE sheeting • LDPE resealable storage bags (i.e. Ziploc®) that will not contact the sample media[6]	• Aluminium foil[4] • Chemical or blue ice[5] • Plastic storage bags other than those listed as ■ Allowable • Low-density polyethylene (LDPE) bottles

Field Documentation

● Prohibited	■ Allowable	▲ Needs Screening[2]
• Clipboards coated with PFAS • Notebooks made with PFAS treated paper • PFAS treated loose paper • PFAS treated adhesive paper products	• Loose paper (non-waterproof, non-recycled) • Rite in the Rain® notebooks • Aluminium, polypropylene, or Masonite field clipboards • Ballpoint pens, pencils, and Fine or Ultra-Fine Point Sharpie® markers	• Plastic clipboards, binders, or spiral hard cover notebooks • All markers not listed as ■ Allowable • Post-It® Notes or other adhesive paper products • Waterproof field books

Decontamination

● Prohibited	■ Allowable	▲ Needs Screening[2]
• Decon 90® • PFAS treated paper towel	• Alconox®, Liquinox®, or Citranox® • Triple rinse with PFAS-free deionized water • Cotton cloth or untreated paper towel	• Municipal water • Recycled paper towels or chemically treated paper towels

Clothing, Boots, Rain Gear, and PPE

● Prohibited	■ Allowable	▲Needs Screening[2]
• New or unwashed clothing • Anything made of or with: ○ Gore-Tex™ or other water-resistant synthetics • Anything applied with or recently washed with: ○ Fabric softeners ○ Fabric protectors, including UV protection ○ Insect resistant chemicals ○ Water, dirt, and/or stain resistant chemicals	• Powderless nitrile gloves • Well-laundered synthetic or 100% cotton clothing, with most recent launderings not using fabric softeners • Made of or with: ○ Polyurethane ○ Polyvinyl chloride (PVC) ○ Wax coated fabrics ○ Rubber / Neoprene ○ Uncoated Tyvek®	• Latex gloves • Water and/or dirt resistant leather gloves • Any special gloves required by a HASP • Tyvek® suits, clothing that contains Tyvek®, or coated Tyvek®

Food and Beverages

● Prohibited	■ Allowable
• No food should be consumed in the staging or sampling areas, including pre-packaged food or snacks. ■ If consuming food on-site becomes necessary, move to the staging area and remove PPE. After eating, wash hands thoroughly and put on new PPE.	• Brought and consumed only outside the vicinity of the sampling area: ○ Bottled water ○ Hydration drinks (i.e. Gatorade®, Powerade®)

Personal Care Products (PCPs) - for day of sample collection[6]

● Prohibited	■ Allowable	▲Needs Screening[2]
• Any PCPs[6], sunscreen, and insect repellent applied in the sampling area.	PCPs[6], sunscreens, and insect repellents applied in the staging area, away from sampling bottles and equipment followed by thoroughly washing hands: **PCPs[6]:** • Cosmetics, deodorants/antiperspirants, moisturizers, hand creams, and other PCPs[6] **Sunscreens:** • Banana Boat® for Men Triple Defense Continuous Spray Sunscreen SPF 30 • Banana Boat® Sport Performance Coolzone Broad Spectrum SPF 30 • Banana Boat® Sport Performance Sunscreen Lotion Broad Spectrum SPF 30 • Banana Boat® Sport Performance Sunscreen Stick SPF 50 • Coppertone® Sunscreen Lotion Ultra Guard Broad Spectrum SPF 50 • Coppertone® Sport High Performance AccuSpray Sunscreen SPF 30 • Coppertone® Sunscreen Stick Kids SPF 55 • L'Oréal® Silky Sheer Face Lotion 50 • Meijer® Clear Zinc Sunscreen Lotion Broad Spectrum SPF 50 • Meijer® Sunscreen Continuous Spray Broad Spectrum SPF 30 • Meijer® Clear Zinc Sunscreen Lotion Broad Spectrum SPF 15, 30 and 50 • Meijer® Wet Skin Kids Sunscreen Continuous Spray Broad Spectrum SPF 70 • Neutrogena® Beach Defense Water+Sun Barrier Lotion SPF 70 • Neutrogena® Beach Defense Water+Sun Barrier Spray Broad Spectrum SPF 30 • Neutrogena® Pure & Free Baby Sunscreen Broad Spectrum SPF 60+ • Neutrogena® UltraSheer Dry-Touch Sunscreen Broad Spectrum SPF 30 **Insect Repellents:** • OFF® Deep Woods • Sawyer® Permethrin	• Products other than those listed as ■Allowable

[1] This table is not considered to be a complete listing of prohibited or allowable materials. All materials should be evaluated prior to use during sampling. The manufacturers of various products should be contacted in order to determine if PFAS was used in the production of any particular product.

[2] Equipment blank samples should be taken to verify these products are PFAS-free prior to use during sampling.

[3] **For surface water foam samples:** LDPE storage bags may be used in the sampling of foam on surface waters. In this instance, it is allowable for the LDPE bag to come into direct contact with the sample media.

[4] **For fish and other wildlife samples:** Depending on the project objectives, glass jars and aluminum foil might be used for PFAS sampling. PFAS has been found to bind to glass and if the sample is stored in a glass jar, a rinse of the jar is required during the sample analysis. PFAS are sometimes used as a protective layer for some aluminum foils. An equipment blank sample should be collected prior to any aluminum foil use.

[5] Regular ice is recommended as there are concerns that chemical and blue ice may not cool and maintain the sample at or below 42.8˚F (6°C) (as determined by EPA 40 CFR 136 – NPDES) during collection and through transit to the laboratory.

[6] Based on evidence, avoidance of PCPs is considered to be precautionary because none have been documented as having cross-contaminated samples due to their use. However, if used, application of PCPs must be done at the staging area and away from sampling bottles and equipment, and hands must be thoroughly washed after the use of any PCPs prior to sampling.

●- Prohibited ■- Allowable ▲- Needs Screening

SOIL PFAS SAMPLING

Guidance

Introduction

This guidance document discusses the processes, decontamination procedures, and acceptable items and materials for sampling soil for per- and polyfluoroalkyl substances (PFAS). In addition, this guidance will be used to support the sampling objectives and procedures based on any Quality Assurance Project Plan (QAPP) developed prior to sampling activities. This guidance assumes staff has basic familiarity with and/or understanding of basic soil sampling procedures.

NOTE: Review the General PFAS Sampling Guidance prior to reviewing this guidance document.

The Michigan Department of Environmental Quality (DEQ) intends to update the information contained within this PFAS Sampling Guidance document as new information becomes available. The user of this PFAS Sampling Guidance is encouraged to visit the Michigan PFAS Action Response Team webpage (www.michigan.gov/PFASresponse) to access the current version of this document.

Because PFAS compounds can be analyzed at concentrations in the parts per trillion (ppt) range, precautions must be taken to prevent cross-contamination. Field sampling equipment, either rented or not, that is used at multiple sites or sampling locations (also described as non-dedicated equipment), could become highly contaminated with PFAS. If site-specific information is available, sampling should be conducted from the least to the most contaminated locations. Additional guidance on the sampling sequence can be found in **Section 4.3.3** of the **General PFAS Sampling Guidance**.

Soil sampling involves the use of non-dedicated equipment, such as scoops, trowels, shovels, augers and other drilling-related equipment, which could be a source of cross-contamination. Decontamination procedures outlined in this guidance document should be followed to avoid cross contamination and equipment should be verified as PFAS-free.

The site-specific quality assurance document will generally provide the following information:

- Sample collection objectives.
- Locations, number, and volume of samples.
- Types of chemical analyses.
- Specific quality control procedures.
- Additional sampling requirements, as necessary.

This soil sampling guidance document discusses the collection of surface and sub-surface soil samples for PFAS and methods to prevent cross-contamination that can occur from:

- Field clothing and personal protection equipment (PPE)
- Sampling equipment
- Equipment decontamination
- Sample collection and handling
- Sample shipment

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NOTE: Additional information about PFAS testing can be found on the Michigan PFAS Action Response Team (MPART) website: www.michigan.gov/PFASresponse

1. Potential Sources for PFAS Cross-Contamination

Potential sources for PFAS cross-contamination include items and materials used within the sampling environment, such as sampling equipment, field clothing, personal protective equipment (PPE), sun and biological protection products, personal hygiene, personal care products (PCPs), and food packaging. A detailed discussion about potential sources for PFAS cross-contamination is included in the **General PFAS Sampling Guidance**, which should be reviewed before reading this document. However, a high-level summary is presented in this guidance.

All of the items and materials discussed in each of the MDEQ's PFAS Sampling Guidance Documents are divided into three major groups:

- Prohibited (●) identifies items and materials that should not be used when sampling. It is well documented that they contain PFAS or that PFAS are used in their manufacture.

- Allowable (■) identifies items and materials that have been proven not to be sources of PFAS cross contamination and are considered acceptable for sampling.

- Needs Screening (▲) identifies items and materials that have the potential for PFAS cross-contamination due to a lack of scientific data or statements from manufacturers to prove otherwise. These items and materials are further sub-divided into two categories:

    - **Category 1:** Items and materials that <u>will come in direct contact</u> with the sample. These should not be used when sampling unless they are known to be PFAS-free, by collecting an equipment blank sample prior to use.

    - **Category 2:** Items and materials that <u>will not come in direct contact</u> with the sample. These should be avoided, if possible, unless they are known to be PFAS-free by collecting an equipment blank sample prior to use.

Please note that at this time no published research is available that documents the use of various materials and effect on sample results. Therefore, a conservative approach is recommended, and the guidance is based on the collection of multiple environmental samples at various PFAS Sites. Sampling staff should take practical and appropriate precautions to avoid items that are likely to contain PFAS at the sampling site as well as avoid specific items during the sampling event.

A general overview of PFAS contamination sources during sampling can be found in **Section 4.2** of the **General PFAS Sampling Guidance**. Any items or materials utilized that are not identified in this guidance or not discussed in **Section 4.2** should be evaluated as described in **Section 4.2.1**.

Sampling staff should take practical and appropriate precautions to avoid items that are likely to contain PFAS at the sampling site as well as avoid specific items during the sampling event (see below).

1.1 Field Clothing and Personal Protection Equipment (PPE)

A general overview of field clothing and PPE can be found in **Section 4.2.2** from the **General PFAS Sampling Guidance**. Materials, field clothing, and equipment screening should be performed during the QAPP development or the planning phase of sampling programs. The screening should be performed on all items and materials that are expected to come into contact with the samples and are defined as **Category 1**. This Soil Sampling Guidance assumes that the soil samples will be collected in an environment where only Level D protection (such as steel toe

NOTE: Both field clothing and PPE should be kept dust and fiber free.

boots, eye protection, hardhat, etc.) is required by the Health and Safety Plan (HASP). During a PFAS investigation, PPE that contains PFAS should be avoided to prevent cross-contamination.

As with any field mobilization, it is the responsibility of all personnel to be aware of the physical, chemical, and biological hazards associated with a particular site. Personal safety is paramount. Any deviation from this guidance, including those necessary to ensure the health and safety of sampling personnel, should be recorded in field notes and discussed in the final report. Any additional field clothing and/or PPE items that might be required for the soil sampling and not discussed in the Sampling Guidance should be evaluated as described in **Sections 4.2.1** and **4.2.2** of the **General PFAS Sampling Guidance**.

Field sampling during wet weather (e.g., rainfall and snow) should be conducted while wearing the proper field clothing.

- ● Dust and fibers must not be allowed to collect on field clothing or PPE.
- ■ Do not use clothing that has been advertised as waterproof, dirt and/or stain repellant that has not been verified to be made of PFAS-free materials.
- ■ Only use clothing/PPE that has been verified to be made of PFAS-free materials.

Powderless nitrile gloves should be changed frequently any time there is an opportunity for cross-contamination. See **Section 6** of this guidance for additional glove instructions.

1.2 Personal Care Products (PCPs)

A number of sampling guidance documents recommend that personal hygiene and personal care products (PCPs) (e.g., cosmetics, shampoo, sunscreens, dental floss, etc.) not be used prior to and on the day(s) of sampling because the presence of PFAS in these products has been documented (OECD, 2002, Fujii, 2013, Borg and Ivarsson, 2017). However, if the MDEQ's sampling SOPs are followed, these items should not come into contact with the sampling equipment or the sample being collected. As of the date of this sampling guidance, cross-contamination of samples due to the use of PCPs has not been documented during the collection of thousands of samples. However, field personnel should be aware of the potential of cross-contamination if the sampling equipment or actual samples would come into contact with these products.

The following precautions should be taken when dealing with personal hygiene or PCPs before sampling:

- ● Do not handle or apply PCPs in the sampling area.
- ● Do not handle or apply PCPs while wearing PPE that will be present during sampling.
- ■ Move to the staging area and remove PPE if applying personal care products becomes necessary.
- ■ Wash hands thoroughly after the handling or application of PCPs and, when finished, put on a fresh pair of powderless nitrile gloves.

1.3 Food Packaging

PFAS has been used by the paper industry as a special protective coating against grease, oil, and water for paper and paperboards, including food packaging since the late 1950s (Trier et al., 2018). PFAS application for food packaging includes paper products that come into contact with food such as paper plates, food containers, bags, and wraps (OECD, 2002). Pre-wrapped food or snacks (such as candy bars, microwave popcorn, etc.) must not be in the sampling and staging areas during

sampling due to PFAS contamination of the packaging. When staff requires a break to eat or drink, they should remove their gloves, coveralls, and any other PPE, if worn, in the staging area and move to the designated area for food and beverage consumption. When finished, staff should wash their hands and put on a fresh pair of powderless nitrile gloves at the staging area, before returning to the sampling area.

- ● Do not handle, consume, or otherwise interact with pre-wrapped food or snacks, carry-out food, fast food, or other food items while on-site during sampling.
- ■ Move to the staging area and remove PPE prior to leaving the sampling and staging areas if consuming food on site becomes necessary.

2. Soil Sampling Equipment

Soil sampling equipment is categorized into **Category 1** and **Category 2:**

NOTE: As a precautionary action, an equipment rinsate blank should be collected even if the sampling materials are made of materials that are not expected to contain PFAS.

Category 1: Any item that will directly contact with the soil, including shovels, trowels, spoons, bowls, hand augers buckets and extensions, and augers and direct push equipment, including any split spoon or sampling barrels. This equipment has a high likelihood of cross-contamination occurring if the proper decontamination procedures are not followed. These items should be known to be PFAS free.

Category 2: Any item that will not directly contact the soil, including field books, Munsell® color charts, Post-It® Notes, aluminum foil, and recycled paper towels.

Although these items will not directly contact soil samples, cross-contamination may still occur. Every effort should be made to ensure these items are PFAS-free. Be aware that surfaces of this field equipment or the containers in which they are kept may contain PFAS.

Do not use any equipment that contains any known fluoropolymers or that potentially has been cross-contamination with PFAS such as, but not limited to:

- ● Do not use Polytetrafluoroethylene (PTFE) that includes the trademark Teflon® and Hostaflon®, which can be found in many items, including but not limited to the lining of some hoses and tubing, some wiring, certain kinds of gears, and some objects that require the sliding action of parts.
- ● Do not use Polyvinylidene fluoride (PVDF) that includes the trademark Kynar®, which can be found in many items, including but not limited to tubing, films/coatings on aluminum, galvanized or aluminized steel, wire insulators, and lithium-ion batteries.
- ● Do not use Polychlorotrifluoroethylene (PCTFE), that includes the trademark Neoflon®, which can be found in many items, including but not limited to valves, seals, gaskets, and food packaging.
- ● Do not use Ethylene-tetrafluoro-ethylene (ETFE) that includes the trademark Tefzel®, which can be found in many items, including but not limited to wire and cable insulation and covers, films for roofing and siding, liners in pipes, and some cable tie wraps.
- ● Do not use Fluorinated ethylene propylene (FEP), that includes the trademarks Teflon® FEP and Hostaflon® FEP,

NOTE: Manufacturers can change the chemical composition of any product. As a result, all materials that will come into contact with the sample matrices (defined as Category 1) should be tested to confirm they are "PFAS-free", i.e. will not contaminate samples at detectable levels. **There is no guarantee that materials in the 'Allowable' category will always be PFAS-free.**

and may also include Neoflon®, which can be found in many items, including but not limited to wire and cable insulation and covers, pipe linings, and some labware.

- ● Do not use low density polyethylene (LDPE) for any items that will come into **direct contact** with the sample media. LDPE can be found in many items, including but not limited to containers and bottles, plastic bags, and tubing.
  - ▲ **However**, LDPE may be used if an equipment blank has confirmed it to be PFAS-free. LDPE does not contain PFAS in the raw material but may contain PFAS cross-contamination from the manufacturing process.
- ■ LDPE bags (e.g. Ziploc®) that **do not** come into direct contact with the sample media and do not introduce cross-contamination with samples may be used.
- ■ Use items and materials that are either made of high density polyethylene (HDPE), polypropylene, silicone, or acetate.
- ▲ Post-It® Notes should be screened before use.

Staff should follow the **MDEQ PFAS Sampling Quick Reference Field Guide** table for approved and prohibited items for documenting and sampling residential wells for PFAS.

NOTE: Special care and consideration should be given to the field sampling equipment when stored and handled outside the site boundaries or between different sample locations.

Many times, the release of PFAS in the environment occurs concurrently with other chemicals. For example, the release of PFAS present in the aqueous film forming foam (AFFF) is generally associated with the release of flammable liquids, such as jet fuels. As a result, sampling soil for PFAS may occur within plumes of volatile organic compounds (VOCs). For staff protection, the use of a photoionization detector (PID) is recommended to measure VOCs that might be present in the soil. The PID used during PFAS sampling to screen for VOCs may be made of materials that contain PFAS. However, the PID is a **Category 2** field equipment item and will have a very low possibility of cross contamination.

3. Soil Sampling Methods

Soils are usually sampled to define the subsurface geology and presence of aquifers or aquitards (lithology), or to determine the presence or absence of contaminants—in this case, PFAS (chemical analysis).

3.1 Soil Sampling for Lithologic Description

Soil samples are collected to determine the lithologic and physical makeup of the sample (i.e.: clay, sand, gravel, brown, mottled, etc.). This is done to determine the subsurface geologic stratigraphy of the site and help identify possible aquifers and aquitards in the subsurface. Soil can be collected loose or cored.

3.1.1 Loose Soil Samples

A loose soil sample is usually obtained by auger or rotary drilling processes, where the process delivers loose drilled soil to the surface for collection and interpretation. In the auger drilling process, the auger flights deliver soil cuttings to the surface around the auger string. These soils can be collected by a shovel and bagged in LDPE bags (e.g. Ziploc) or piled for later lithologic analysis and entry into a geologic log.

3.1.2 Cored Soil Samples

A cored soil sample is collected with a coring type of mechanism in a way that preserves the soil structure. Most coring mechanisms consist of a steel core barrel with a clear plastic liner (use an acetate or other PFAS-free liner) into which the soil core enters. Once the core barrel is retrieved at the surface, this liner is removed and cut open. The soil core is then sliced open to reveal a clean face. This clean face is examined for lithology and structure.

3.2 Soil Sampling for Chemical Analysis

Soils collected for chemical analysis are usually collected by using the core soil sample method. The soil samples need to be as undisturbed as possible. The requirement of an undisturbed soil sample **excludes** the use of loose auger cuttings or rotary methods of soil collection.

During the soil sampling process, the soil sampling device is removed from the ground. The liner is removed and placed on the cutting board and opened using a liner cutting device. The soil sample is visually inspected, and observations recorded in the site field book. The core is cut open to reveal a "clean" face for sampling. This process avoids the possibility of picking up any contaminants that may have gotten smeared onto the soil surface as the soil core entered the liner.

4. Equipment Decontamination Before Sampling

It is customary with soil sampling that the equipment is decontaminated at the conclusion of the sampling event. If the previous user of the equipment is not known, and it is unclear how the equipment was handled—especially rental equipment—decontaminate the equipment prior to sampling.

Disposable **Category 1** sampling equipment should be used, especially for sample bottles and other materials that are used where the soil sample may be in contact with the sampling equipment for an extended period of time. Field sampling equipment used at multiple sites or sampling locations can become highly contaminated with PFAS. Decontamination procedures should be implemented to prevent cross-contamination, including between individual sample locations.

For non-dedicated **Category 1** sampling equipment, the following items, materials, and procedures should be used for decontamination:

- ● Do not use Decon 90®.
- ■ Laboratory supplied PFAS-free deionized water is preferred for decontamination.
- ■ Alconox®, Liquinox®, and Citranox® can be used for equipment decontamination.
- ■ Sampling equipment can be scrubbed using a polyethylene or Polyvinyl chloride (PVC) brush to remove particulates.
- ■ Decontamination procedures should include triple rinsing with PFAS-free water.
- ■ Commercially available deionized water in an HDPE container may be used for decontamination if the water is verified to be PFAS-free.
- ▲ Municipal drinking water may be used for decontamination purposes if it is known to be PFAS-free.

NOTE: All samples should be collected using PFAS-free High-Density Polyethylene (HDPE), glass, or polypropylene bottles provided by the laboratory, with Teflon®-

5. Sample Collection and Handling

The following considerations should be observed for sample collection:

- ● Dust and fibers must be kept out of sample bottles.
- ● The sample cap should never be placed directly on the ground during sampling.
  - ▲ If sampling staff must set the sample bottle cap down during sample collection and a second member of the sampling crew (wearing a fresh pair of powderless nitrile gloves) is not available, set the cap on a clean surface (cotton sheeting, HDPE sheeting, triple rinsed cooler lid, etc.).
- ● Do not sample without powderless nitrile gloves.
- ● Regular size Sharpie® are to be avoided. Thicker markers may contain PFAS.
- ■ Fine and Ultra-Fine point Sharpie® markers are acceptable.
- ■ Ballpoint pens may be used when labeling sample containers. If ballpoint pens do not write on the sample container labels, preprinted labels from the laboratory may be used.
- ■ Bottles should only be opened immediately prior to sampling.
- ■ Hands should be well washed and gloved.
- ■ Use HDPE, glass, or polypropylene sample bottles with Teflon®-free caps, provided by the laboratory.
- ■ Glass bottles or containers may be used if they are known to be PFAS-free, however, PFAS have been found to adsorb to glass, especially when the sample is in contact with the glass for a long period of time (e.g. being stored in a glass container). If the sample comes into direct contact with the glass for a short period of time (e.g. using a glass container to collect the sample, then transferring the sample to a non-glass sample bottle), the adsorption is minimal.
- ■ Commercially bought sample bottles used with automatic sampling equipment should be decontaminated prior to sampling and equipment blank samples should be collected using laboratory supplied PFAS-free water.
- ■ Samples should be double bagged using resealable low density polyethelene (LDPE) bags (e.g., Ziploc®).
- ■ Follow any guidance or requirements in the PFAS analytical reference method that will be used for testing samples, for sample collection, storage, preservation, and holding times.
- ■ If a published testing method is not used, and in the absence of formal United States Environmental Protection Agency (USEPA) guidance for PFAS sample storage, the documentation in USEPA Method 537 Rev. 1.1 should be used as a guide for thermal preservation (holding temperature) and holding times for soil or other samples. Samples must be chilled during storage and shipment and must not exceed 50°F (10º C) during the first 48 hours after collection.
- ▲ Latex gloves should be screened before use.

NOTE: USEPA Method 537 Rev. 1.1 was developed for the analysis of finished drinking water samples only. It was not designed for soils or other matrices that could cause significant interferences to the method. Other analytical methods such as ASTM D7968-14 or D7968-17a may be better at resolving interferences in soil samples. These methods were developed specifically for other matrices such as soil and sediments.

If site-specific information is available, sampling should be conducted from the least to the most contaminated location. Additional guidance on the sampling sequence can be found in **Section 4.3.3** of the **General PFAS Sampling Guidance**.

If possible, collect PFAS samples prior to collecting non-PFAS samples or field parameters (pH, temperature, etc.).

Powderless nitrile gloves should be changed any time there is an opportunity for cross-contamination during sampling, including, but not limited to:

- Immediately prior to sample collection
- Each time sampling equipment is placed in and then removed from soil at a new location
- Handling of any sample, including quality assurance/quality control (QA/QC) samples
- After the handling of any non-dedicated sampling equipment
- After contact with non-decontaminated surfaces
- After decontamination of sampling equipment
- When judged necessary by field personnel

6. Sample Shipment

The following procedures should be used for sample shipment:

- ■ Regular ice should be used to cool and maintain the sample at or below 42.8°F (6°C).
  - ▲ Chemical or blue ice may be used if it is known to be PFAS-free and it is absolutely certain that the sample is cooled and maintained at or below 42.8°F (6°C) during collection and through transit to the laboratory.
- ■ Check the cooler periodically to ensure samples are well iced and at the proper temperature.
- ■ Refresh with regular ice, if needed, double bagged in LDPE resealable storage bags if needed.
- ■ Chain of Custody and other forms should be single bagged in LDPE (e.g. Ziploc®) storage bags and taped to the inside of the cooler lid.
- ■ The cooler should be taped closed with a custody seal and shipped by overnight courier.
- ■ Samples should be shipped as soon as possible (e.g. overnight) to ensure the samples arrive within the analytical holding time specified by the lab.

7. Equipment Decontamination After Sampling

It is customary to decontaminate soil sampling equipment at the end of the sampling event, whether it is a single sampling location or the conclusion of the workday. This is to ensure sampling equipment is decontaminated ahead of time for the next sampling event.

- ● Do not put equipment away without decontaminating it.
- ■ Do decontaminate sampling equipment after sampling at each location, or at the end of the workday. Follow the decontamination guidelines in **Section 4 (Equipment Decontamination Before Sampling)** of this document.

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Michigan Department of Environmental Quality

MDEQ PFAS Sampling Quick Reference Field Guide[1]

All Items Used During Sampling Event

● Prohibited
• Items or materials that contain fluoropolymers such as ○ Polytetrafluoroethylene (PTFE), that includes the trademarks Teflon® and Hostaflon® ○ Polyvinylidene fluoride (PVDF), that includes the trademark Kynar® ○ Polycholotrifluoroethylene (PCTFE), that includes the trademark Neoflon ® ○ Ethylene-tetrafluoro-ethylene (ETFE), that includes the trademark Tefzel® ○ Fluorinated ethylene propylene (FEP), that includes the trademarks Teflon® FEP and Hostaflon® FEP • Items or materials that contain any other fluoropolymer

Pumps, Tubing, and Sampling Equipment

● Prohibited	■ Allowable	▲ Needs Screening[2]
• Items or materials containing any fluoropolymer (potential items include tubing, valves, or pipe thread seal tape)	• High-density polyethylene (HDPE) • Low-density polyethylene (LDPE) tubing • Polypropylene • Silicone • Stainless-steel • Any items used to secure sampling bottles made from: ○ Natural rubber ○ Nylon (cable ties) ○ Uncoated metal springs ○ Polyethylene	• Any items or materials that will come into direct contact with the sample that have **not** been verified to be PFAS-free ○ Do not assume that any sampling items or materials are PFAS-free based on composition alone

Sample Storage and Preservation

● Prohibited	■ Allowable	▲ Needs Screening[2]
• Polytetrafluoroethylene (PTFE): Teflon® lined bottles or caps	• Glass jars[4] • Laboratory-provided PFAS-Free bottles: ○ HDPE or polypropylene • Regular wet ice • Thin HDPE sheeting • LDPE resealable storage bags (i.e. Ziploc®) that will not contact the sample media[6]	• Aluminium foil[4] • Chemical or blue ice[5] • Plastic storage bags other than those listed as ■ Allowable • Low-density polyethylene (LDPE) bottles

Field Documentation

● Prohibited	■ Allowable	▲ Needs Screening[2]
• Clipboards coated with PFAS • Notebooks made with PFAS treated paper • PFAS treated loose paper • PFAS treated adhesive paper products	• Loose paper (non-waterproof, non-recycled) • Rite in the Rain® notebooks • Aluminium, polypropylene, or Masonite field clipboards • Ballpoint pens, pencils, and Fine or Ultra-Fine Point Sharpie® markers	• Plastic clipboards, binders, or spiral hard cover notebooks • All markers not listed as ■ Allowable • Post-It® Notes or other adhesive paper products • Waterproof field books

Decontamination

● Prohibited	■ Allowable	▲ Needs Screening[2]
• Decon 90® • PFAS treated paper towel	• Alconox®, Liquinox®, or Citranox® • Triple rinse with PFAS-free deionized water • Cotton cloth or untreated paper towel	• Municipal water • Recycled paper towels or chemically treated paper towels

Clothing, Boots, Rain Gear, and PPE

● Prohibited	■ Allowable	▲Needs Screening[2]
• New or unwashed clothing • Anything made of or with: ○ Gore-Tex™ or other water-resistant synthetics • Anything applied with or recently washed with: ○ Fabric softeners ○ Fabric protectors, including UV protection ○ Insect resistant chemicals ○ Water, dirt, and/or stain resistant chemicals	• Powderless nitrile gloves • Well-laundered synthetic or 100% cotton clothing, with most recent launderings not using fabric softeners • Made of or with: ○ Polyurethane ○ Polyvinyl chloride (PVC) ○ Wax coated fabrics ○ Rubber / Neoprene ○ Uncoated Tyvek®	• Latex gloves • Water and/or dirt resistant leather gloves • Any special gloves required by a HASP • Tyvek® suits, clothing that contains Tyvek®, or coated Tyvek®

Food and Beverages

● Prohibited	■ Allowable
• No food should be consumed in the staging or sampling areas, including pre-packaged food or snacks. ■ If consuming food on-site becomes necessary, move to the staging area and remove PPE. After eating, wash hands thoroughly and put on new PPE.	• Brought and consumed only outside the vicinity of the sampling area: ○ Bottled water ○ Hydration drinks (i.e. Gatorade®, Powerade®)

Personal Care Products (PCPs) - for day of sample collection[6]

● Prohibited	■ Allowable	▲Needs Screening[2]
• Any PCPs[6], sunscreen, and insect repellent applied in the sampling area.	PCPs[6], sunscreens, and insect repellents applied in the staging area, away from sampling bottles and equipment followed by thoroughly washing hands: **PCPs[6]:** • Cosmetics, deodorants/antiperspirants, moisturizers, hand creams, and other PCPs[6] **Sunscreens:** • Banana Boat® for Men Triple Defense Continuous Spray Sunscreen SPF 30 • Banana Boat® Sport Performance Coolzone Broad Spectrum SPF 30 • Banana Boat® Sport Performance Sunscreen Lotion Broad Spectrum SPF 30 • Banana Boat® Sport Performance Sunscreen Stick SPF 50 • Coppertone® Sunscreen Lotion Ultra Guard Broad Spectrum SPF 50 • Coppertone® Sport High Performance AccuSpray Sunscreen SPF 30 • Coppertone® Sunscreen Stick Kids SPF 55 • L'Oréal® Silky Sheer Face Lotion 50 • Meijer® Clear Zinc Sunscreen Lotion Broad Spectrum SPF 50 • Meijer® Sunscreen Continuous Spray Broad Spectrum SPF 30 • Meijer® Clear Zinc Sunscreen Lotion Broad Spectrum SPF 15, 30 and 50 • Meijer® Wet Skin Kids Sunscreen Continuous Spray Broad Spectrum SPF 70 • Neutrogena® Beach Defense Water+Sun Barrier Lotion SPF 70 • Neutrogena® Beach Defense Water+Sun Barrier Spray Broad Spectrum SPF 30 • Neutrogena® Pure & Free Baby Sunscreen Broad Spectrum SPF 60+ • Neutrogena® UltraSheer Dry-Touch Sunscreen Broad Spectrum SPF 30 **Insect Repellents:** • OFF® Deep Woods • Sawyer® Permethrin	• Products other than those listed as ■Allowable

[1] This table is not considered to be a complete listing of prohibited or allowable materials. All materials should be evaluated prior to use during sampling. The manufacturers of various products should be contacted in order to determine if PFAS was used in the production of any particular product.

[2] Equipment blank samples should be taken to verify these products are PFAS-free prior to use during sampling.

[3] **For surface water foam samples:** LDPE storage bags may be used in the sampling of foam on surface waters. In this instance, it is allowable for the LDPE bag to come into direct contact with the sample media.

[4] **For fish and other wildlife samples:** Depending on the project objectives, glass jars and aluminum foil might be used for PFAS sampling. PFAS has been found to bind to glass and if the sample is stored in a glass jar, a rinse of the jar is required during the sample analysis. PFAS are sometimes used as a protective layer for some aluminum foils. An equipment blank sample should be collected prior to any aluminum foil use.

[5] Regular ice is recommended as there are concerns that chemical and blue ice may not cool and maintain the sample at or below 42.8˚F (6°C) (as determined by EPA 40 CFR 136 – NPDES) during collection and through transit to the laboratory.

[6] Based on evidence, avoidance of PCPs is considered to be precautionary because none have been documented as having cross-contaminated samples due to their use. However, if used, application of PCPs must be done at the staging area and away from sampling bottles and equipment, and hands must be thoroughly washed after the use of any PCPs prior to sampling.

●- Prohibited ■- Allowable ▲- Needs Screening

PFMW01B Sampling SOP

PFMW01B is a low yield perched monitoring well located near Building 313 to the northwest of (b) (3) [redacted]. The borehole was air cored and then air reamed for well installation. The screened interval from 35.78 to 65.78 ft bgs , or approximately 183 to 213 ft msl (30 ft screened interval) is set in volcanic bedrock consisting of a majority of pahoehoe, with some massive a'a, and welded or loose a'a clinker. The well casing is Schedule 10 stainless steel. Permeable water-bearing features are associated with fractures based on video evaluation of the core hole.

PFMW01B Well Development Data Ranges

Analyte	Round 1 01/28/2025	Round 2 02/04/2025	Round 3 02/07/2025	Round 4 TBD
Specific Conductivity (mS/cm)	0.9 to 4.2	9.1 to 10.9	Not collected, vacuumed by PCS	
RDO (mg/L)	4.1 to 8.6	1.8 to 5.8		
Turbidity (NTU)	34 to 7212	8.1 to 2523		
Temperature (Celsius)	23.7 to 29.3	23.1 to 24.8		
ORP (mV)	138 to 228	138 to 225		
Salinity (PSU)	0.5 to 2.3	5.2 to 6.3		
pH (mV)	-7 to -20	-46 to -55		

Sampling procedures:

1. Thoroughly decontaminate downhole equipment, including a PFAS-free water final rinse before utilizing equipment downhole.
2. Open well cap, record time and take organic vapor measurement.
3. Measure depth to water (DTW) and fuel product as light non-aqueous phase liquid (LNAPL) thickness with and oil-water interface probe (OWIP).
    a. Static water level measured in March 2025 ranged from 52 to 53 ft bgs (51.5 to 52.5 ft btoc)
    b. If LNAPL is detected, measure thickness of product.
        i. Presence to be verified with initial bailer.
        ii. Save LNAPL in a 4-ounce jar, seal and label per SOPs.
4. If there is immiscible product encountered, contact task lead about possibly needing an LNAPL sample per NAVFAC PAC I-C-3.
5. Measure total depth of well.
    a. Note: Steps 6 and 7 should be completed for all sampling events <u>except for the event immediately after initial development</u>. This process was included as final action of the initial development, and this well will be sampled within 1 month of initial development.
6. Evacuate all static water from the water column, recording water removed.
7. Return in 7 days and repeat steps 1 through 5.
8. First bail will be for water quality parameters.
    a. LOWER BAILER SLOWLY to avoid damaging the bailer and disturbing the water surface.

    b. Take a photo of the bailer to document the presence or absence of sheen/LNAPL.
    c. Pour bailer sample into container from the top of the bailer and conduct headspace jar test.
    d. Take screenshot with AT600.
    e. List bailer type, make, model of PFAS free or equivalent in log.
9. Once all parameters are recorded, begin bailing to collect the chemical sample for laboratory analysis.
10. Once all the containers are filled for PFAS, collect and record final DTW with OWIP.
11. Thoroughly decontaminate all equipment, including a final PFAS-free water rinse.
12. Reseat well cap and close and lock well.

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. Standard preparation logs and standard traceability.
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.

GC/MS "Full" Deliverables

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

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

GC "Full" Deliverables

Item #	Deliverable
1	Chain of Custody
2	Sample results with analysis and extraction/preparation dates
3	Summary of MS/MSD/Duplicate recoveries and control limits (listing or link with associated samples)
4	Summary of LCS/LCSD recoveries and control limits (listing or link with associated samples)
5	Method blanks (listing or link with associated samples)
6	Summary of surrogate recoveries
7	Summary of initial calibration data (RF and %RSD, r if applicable)
8	Summary of continuing calibration (%D)
9	Injection logs
10	Extraction/preparation logs
11	Case narrative to discuss anomalies
12	Raw data associated with the summary forms listed above
13	Raw data for item #2 which includes chromatograms, log books, quantitation reports, and spectra

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

General Chemistry "Full" Deliverables

Item #	Deliverable
1	Chain of custody
2	Sample results with analysis and extraction/preparation dates
3	Summary of MS/MSD/Duplicate recoveries and control limits (listing or link with associated samples)
4	Summary of LCS/LCSD recoveries and control limits (listing or link with associated samples)
5	Method blanks (listing or link with associated samples)
6	Summary of initial calibration data (correlation coefficient, r)
7	Summary of continuing calibration (%D or % recovery), if applicable
8	Injection logs
9	Extraction/preparation logs, if applicable
10	Case narrative to discuss anomalies
11	Raw data associated with the summary forms listed above
12	Raw data for item #2, which includes log books, quantitation reports, and spectra

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

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

(b) (3)

[redacted]

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

(b) (3)

[redacted]

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

(b) (3)

[redacted]

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

(b) (3)

[redacted]

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

(b) (3)

[redacted]

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 F:
Multilevel Monitoring Well Supplemental Material

1. Multilevel Well Groundwater Sampling

Groundwater sampling for multilevel wells will be performed in accordance with fluid sampling procedures in Attachment F.1. Due to the well design, purging will not be required prior to collecting groundwater from each zone. The no-purge fluid sampling procedures may also be paired with the monitoring well sampling procedures in accordance with Procedure I-C-3, *Monitoring Well Sampling* (DON 2015) for the zone straddling the water table to demonstrate sampling quality.

Groundwater from a zone will be collected using sampling probes. Sealed sample containers (with up to three auxiliary containers) will be connected to the sampling probe and prepared in accordance with the fluid sampling procedures (Appendix B). The probe will be lowered to a monitoring zone and the containers will be filled with groundwater from the formation. Once sampling containers are filled, the probe and container string will be brought to the surface, and the groundwater will be transferred to the appropriate lab-supplied containers. Excess groundwater samples will be properly disposed of as investigation-derived waste in accordance with Procedure I-A-6, *IDW Management* (DON 2015).

Only the sampling zone straddling the water table will be sampled during the initial groundwater sampling events. Subsequent evaluations will determine whether additional zones should be included, based on results of the per- and polyfluoroalkyl substances (PFAS) sampling and analysis.

1.1 Field Measurements and Protocols

The field port operation status and measurements of zone pressures and groundwater parameters will be recorded on field logs (Attachment F.3). Due to the anticipated higher pressure in deeper monitoring zones, the below additional protocols will be followed:

- Groundwater parameters (specific conductivity, dissolved oxygen, salinity, temperature, redox potential, pH, turbidity, and total dissolved solids) will be collected at least two times (prior to collection of groundwater for sampling containers and at the end of the sampling) during the sampling of a monitoring zone.
- Groundwater parameter measurements will be collected after flushing the sample container string with nitrogen to minimize dissolved oxygen enrichment, especially for monitoring zones at higher groundwater pressures.
- For monitoring zones where higher groundwater pressure causes effervescence in the volume collected, the groundwater will be collected in the sampling containers regardless of effervescence, while minimizing escape of the dissolved-gas bubbles.

1.2 Field Quality Control

Field quality control samples for groundwater, including field blanks, equipment rinsate, and duplicate samples, will be collected according to the procedures described in Procedure III-B, *Field QC Samples (Water, Soil)* (DON 2015). The actual number of multilevel monitoring well zones to be sampled during an event will be determined based on groundwater results from previous events and discussion with the Navy. Proposed sampling at RHM[redacted] is listed in Table F-1.

Table F-1: Field Quality Control conducted for RHM[redacted] single zone

Matrix	Analytical Group	No. of Sampling Locations	No. of Field Duplicates	No. of Matrix Spike/ Matrix Spike Duplicates	No. of Field Blanks	No. of Equipment Blanks
Area B						
RHM[redacted]	PFAS	1	1	0	1	1

no. number

1.3 EQUIPMENT DECONTAMINATION AND OTHER QUALITY CONTROL PROCEDURES

All equipment will be decontaminated in accordance with Procedure I-F, *Equipment Decontamination* (DON 2015). All non-dedicated sampling equipment will be cleaned before and after use. A staging and decontamination area will be established near each well location. Liquid wastes generated during monitoring activities will be captured, containerized in properly labeled United States Department of Transportation–approved 55-gallon drums or other suitable temporary containers, and managed as investigation-derived waste.

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

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

1.4 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 handing 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 handing.
- 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 handing 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.

2. Multilevel Groundwater Well Equipment Containing Fluoropolymers

Table F-2 lists the components that were identified in the multilevel well system to contain fluoropolymers (Viton/fluoroelastomers and Teflon/ polytetrafluoroethylene), which could potentially leach PFAS. The locations of these components are detailed in Attachment F.2.

Table F-2: Multilevel Groundwater Well Equipment Containing Fluoropolymers

Item	Description	Material	Size/info	Assembly/Part	Comments
1	O-ring	FKM	004V75	Measurement Port Valve	Downhole component
2	Bushing/Seal/Support Ring	PTFF	N/A	MOSDAX Sampler	Inside of MOSDAX sampler
3	Seal Insert	PTFF	N/A	Sample Container Valve	Sample Container Valve Seals
4	O-ring	FKM	004V75	Sample Container Valve	For sealing around 1/16” tubing
5	O-ring	FKM	006V75	Sample Container Valve	Inside Sample Container Valve
6	O-ring	FKM	114V75	Sample Container Valve	Inside Sample Container Valve
7	Tubing	FKM	1/16-inch tubing	Inter-connect hose	Inside interconnect hose

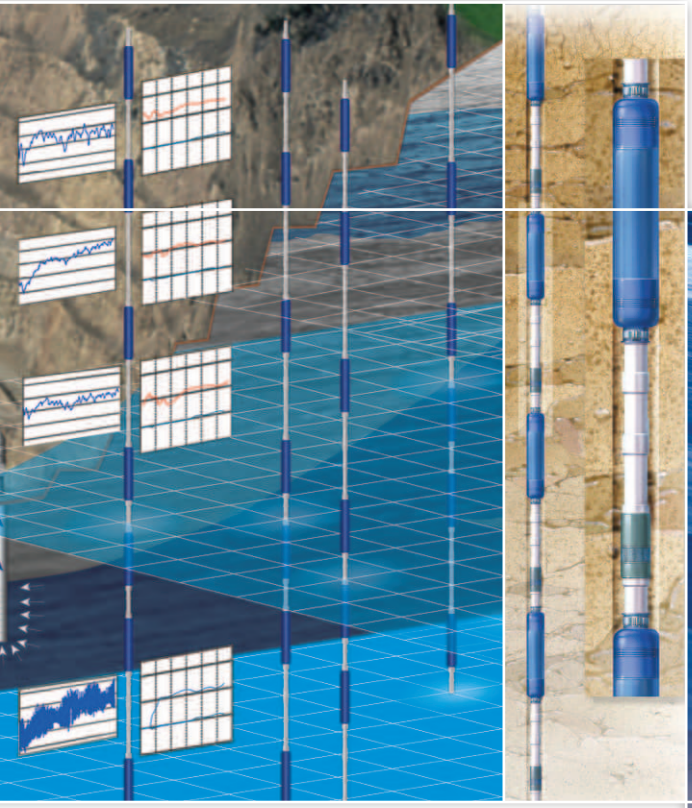
FKM fluoroelastomers
N/A not applicable
PTFF polytetrafluoroethylene

3. References

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

Attachment F.1:
Westbay Documentation

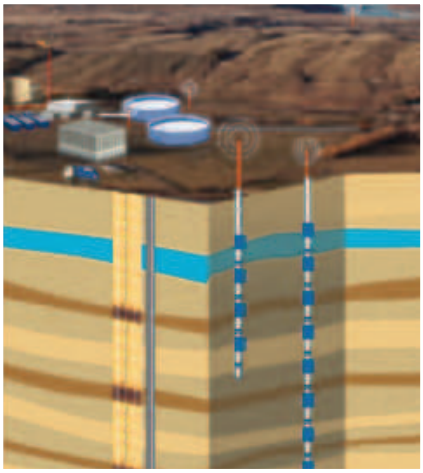
Westbay Instruments



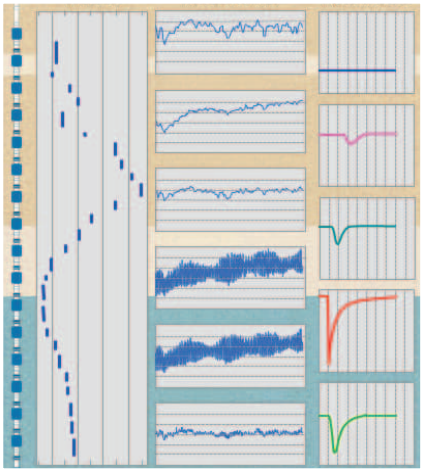
Westbay System

Multilevel Technology for Subsurface Characterization and Monitoring

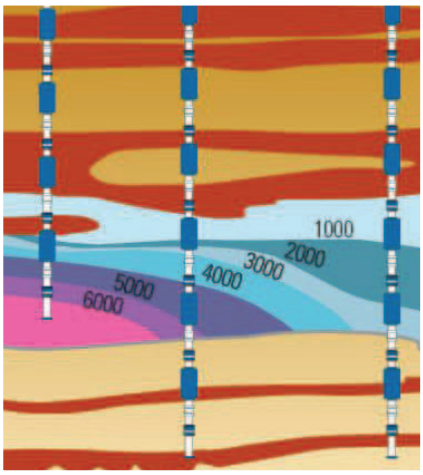
Is Groundwater Monitoring Important?



Environmental monitoring for unconventional oil and gas



4D subsurface characterization using Westbay technology



Characterization of contamination plume using Westbay System

WHY GROUNDWATER MONITORING?

Groundwater is an essential resource of great social, environmental and economic importance. With continuous population growth and industrial expansion impacting the state of groundwater around the world, implementing comprehensive groundwater management strategies is critical.

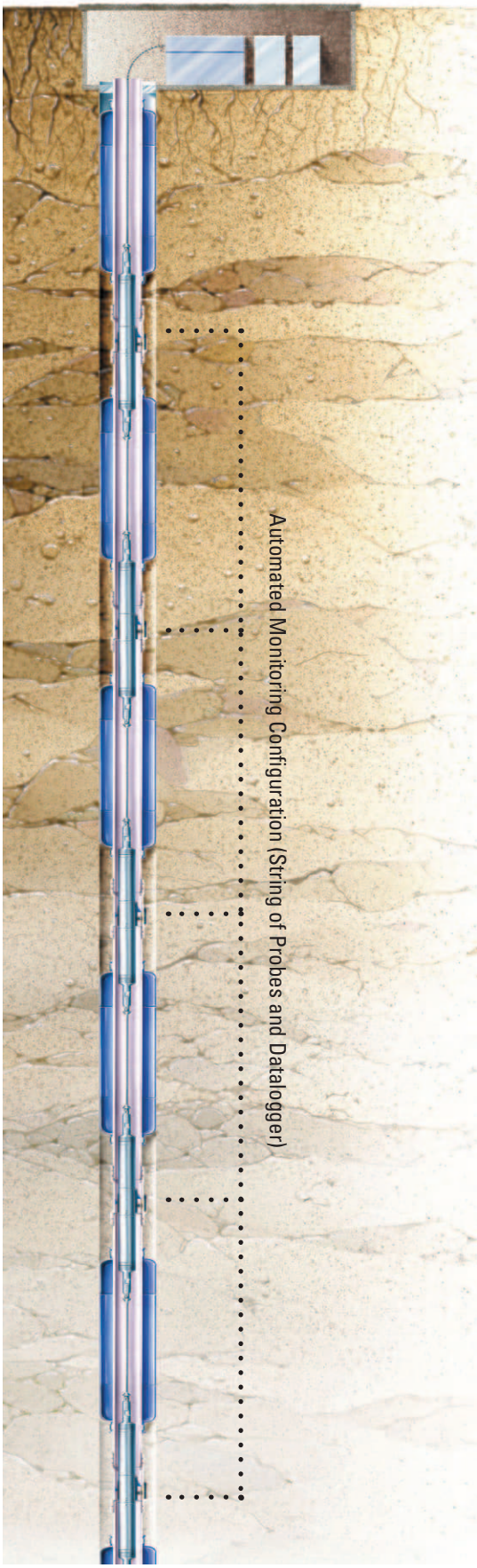
As an essential component of water management, groundwater monitoring networks are designed to optimize the collection of vast amounts of field data during the life of a project. Collection, analysis, and management of water levels and water quality parameters provide fundamental baseline information necessary for identifying potential risks and managing groundwater as a sustainable resource.

Groundwater monitoring networks:

- provide baseline data to map the spatial and temporal distribution of water quality
- identify short-term changes to groundwater flow from pumping, natural recharge and discharge, agricultural and industry use
- isolate impacts to groundwater from contaminant spills and releases
- present early warning of potential risks and the need for mitigation measures
- offer real-time accounting of water use and compliance with regulatory guidelines

OUR SOLUTION

Since 1978, the Westbay* System has provided its clients with a cost-effective, multilevel monitoring technology designed for long-term groundwater monitoring and data acquisition. The Westbay System is designed for collecting subsurface data at any number of discrete positions within a single well. Under even the most complex hydrogeologic conditions, this completely customizable system is a cost-effective, reliable solution that surpasses traditional monitoring methods.



Westbay System

Flexible, industry-tested design offers ***Superior Performance***

OVERVIEW

The Westbay System is a completely versatile, multilevel monitoring technology that allows testing of hydraulic conductivity, monitoring of fluid pressure and collection of fluid samples from multiple zones within a single borehole. Designed for reliability and defensibility, the Westbay System can accommodate a wide variety of borehole conditions including diameter, depth, temperature and chemistry considerations.

Westbay System advantages:

- obtain measurements and samples at any number of discrete locations along a single borehole
- collect samples without purging
- designed for long-term monitoring
- engineered to operate at great depths
- reduced drilling and installation costs, with minimal site disturbance
- removable probes allow for convenient calibration and servicing
- built-in defensible QA/QC procedures

WELL COMPLETIONS

Westbay Systems are engineered with a unique, customizable casing system. The casing system is available in two sizes (MP38 and MP55) and manufactured from plastic or stainless steel to fit various borehole dimensions and operational requirements. Hydraulically-inflated packers and/or backfill provide engineered seals between monitoring zones, preventing unnatural flow and cross-contamination. Valved ports in the zones provide access for monitoring, sampling and hydraulic testing.

Westbay Systems can be installed in a number of different ways to suit geologic conditions, drilling methods, and project objectives.

Completion methods include:

- packers in open borehole
- packers through temporary casing
- packers in a cased well
- packers in cemented and perforated well
- direct backfill

WESTBAY SYSTEM PROBES

A variety of probes are available for use with the Westbay System. Reliable, accurate, and portable wireline-operated probes can be lowered into the casing system and used to:

- measure groundwater pressure
- test hydraulic parameters
- collect samples in-situ
- perform system specific tests

COLLECTING GROUNDWATER SAMPLES

Westbay Systems offer the unique ability to collect discrete fluid samples at formation pressure. For sample collection the probe and sample container are lowered to the desired depth, where the sample is collected into the container. The probe and container are then retrieved to the surface for further analysis.

Westbay System sampling allows you to:

- collect samples with minimal disturbance and without repeated purging
- maintain samples at formation pressure
- monitor pressure during sampling
- document quality assurance

1 PACKERS

- Engineered seal in a range of borehole sizes
- No dedicated inflation lines
- Controlled hydraulic inflation with record of pressure and volume
- Quality control tests to confirm performance at any time after installation

2 MEASUREMENT PORT

- For fluid pressure measurements, fluid sampling and low-k testing

3 PUMPING PORT

- For purging, hydraulic conductivity testing, and quality control testing.

Accurate, reliable long-term monitoring delivers *Definitive Results*

MEASURING GROUNDWATER PRESSURE

Westbay pressure probes can be used to take periodic, manual measurements of in-situ fluid pressures or to automatically monitor pressures using telemetry.

With a single probe, pressures are measured one port at a time. The output from the probes is digitized and transmitted through a rugged but lightweight wireline to a control unit at the surface. By attaching a standard laptop to the interface, data can easily be downloaded and stored for interpretation and analysis.

For automated multilevel measurements of fluid pressures, a string of pressure probes can be distributed down the well with each probe located at a selected measurement port. Each probe has a unique identity, allowing them to be polled individually or simultaneously by the datalogger.

Westbay Systems allow you to:

- measure pressure at multiple locations in a single well
- measure manually or automatically
- redeploy probes in alternate locations
- select from a variety of logging modes
- perform in-situ calibration checks
- document quality assurance

TESTING HYDRAULIC PARAMETERS

Westbay technology provides many effective methods for evaluating and testing the hydraulic characteristics of a site.

Discrete monitoring ports offer the unique ability to observe and record details within a single well.

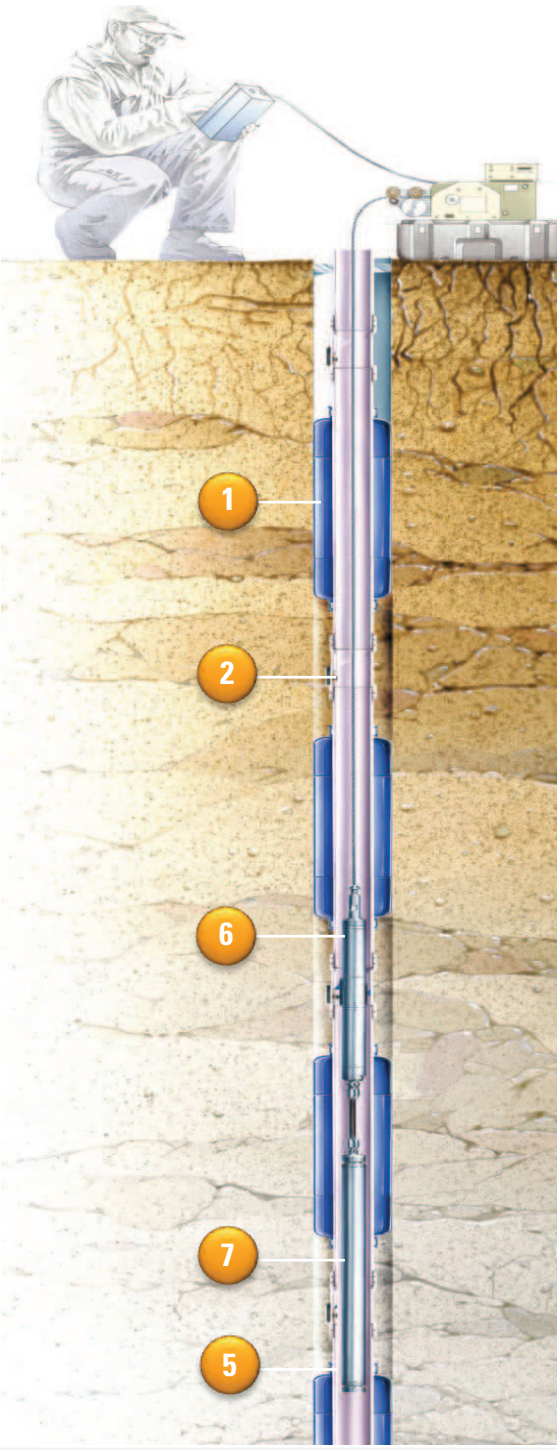
Westbay Systems allow you to:

- observe detailed distributions of groundwater pressures
- observe the effects of pumping tests or changes in barometric pressures
- gain insight into permability variations
- generate a stress in a monitoring zone and observe responses of neighbouring zones and wells

A number of qualitative and quantitative tests can be performed to determine the hydraulic parameters of formation materials or to verify the operation of the system.

- single-zone tests
- slug tests
- pulse-interference tests
- constant-head tests
- vertical interference tests
- cross hole tests
- tracer tests

As part of a complete environmental monitoring project, Westbay Systems are engineered to meet the rigorous demands of a wide range of operations. Westbay Systems provide the highest level data quality necessary to support critical decisions.



4 CENTRAL ACCESS CASING

- Made of plastic (PVC) or stainless steel
- Two sizes: 38 mm [1.5 in], 55 mm [2.2 in]
- Operational capability to depths of 1,200m [4,000 ft]

5 SEALED CONNECTIONS

- All casing connections sealed by o-rings

6 SAMPLER PROBE

- Independently controlled sampling valve
- Silicon strain-guage pressure transducer
- Location/activation mechanism compatible with Westbay System

7 SAMPLE CONTAINER

- Maintains sample pressure during recovery
- Easy to clean

Applications

Groundwater Resource Management	■ Groundwater basin management ■ Manage aquifer recharge operations ■ Seawater intrusion ■ Detailed long-term monitoring
Contaminant Site Investigations	■ Site characterization ■ Plume delineation ■ Remediation design and performance monitoring
Geologic Repositories	■ Site characterization ■ Determine feasibility of underground disposal site
Geotechnical Projects	■ Monitoring of pore pressure, slope stability for tunnels, subsidence and drainage ■ Groundwater pressure monitoring at large dams
Mining	■ Pre-feasibility planning and support ■ Subsurface characterization and monitoring ■ Acid rock drainage assessment and control ■ Monitoring of leach operations ■ Environmental impact assessment and site closure ■ Sub-permafrost groundwater monitoring
Unconventional Oil and Gas	■ Site characterization to reduce risk and minimize regulatory pushback ■ Evaluation of water management alternatives ■ Optimum placement, design and construction of injection wells ■ Compliance monitoring and minimization of cross-contamination ■ Closure design and performance monitoring

Features and Benefits

Features	■ Unlimited number of monitoring zones in a single well ■ Additional data at small incremental cost ■ Sealed monitoring zones ■ Collect water samples without repeated purging ■ Automated pressure monitoring at multiple depths	■ Wide suite of hydraulic test methods ■ Removable and upgradeable probes ■ Improved security ■ Excellent field quality control procedures ■ Custom components available to meet operational requirements
Benefits	■ Improve understanding of hydrogeological conditions and contaminant transport ■ Minimize drilling cost and time ■ Reduce site disturbances	■ Minimize wellbore storage effects ■ Minimize cross-contamination ■ Increase confidence in data ■ Reduce health, safety and environmental risks

Westbay Instruments

Operating worldwide since 1978

Over 2000 wells installed

www.westbay.com

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NOVA METRIX

Multi-Level Groundwater Monitoring with the MP System®

Abstract

Defining the extent of a groundwater contaminant plume in geologic materials requires a three-dimensional array of sampling points. Such an array is commonly installed by placing a single access tube and inlet screen in each of a series of boreholes. With this method, the number of sampling points at a given site is generally limited by the high cost of drilling. An alternative is to install monitoring points at many levels in each borehole. Multi-level monitoring can provide increased data density and therefore an improved understanding of site conditions. This paper describes how the MP System®, one type of multi-level monitoring well, is installed and operated. Field quality control procedures, 1) to verify the integrity of the access tube, inlet valves, and borehole seals, and 2) to confirm the operation of measuring and sampling equipment, are also discussed.

Introduction

When groundwater contaminant plumes are suspected of having significant depth as well as lateral distribution, a three-dimensional array of monitoring points is needed to identify and characterize such plumes. Thus, groundwater data must be obtained from a number of different locations and from a number of different depths at each location. As a result, either a large number of boreholes are required, each with a separate instrument installed, or instruments must be combined and installed at multiple levels in each of a smaller number of boreholes.

Multi-level groundwater monitoring devices have been described by many writers, some discussing the technical benefits and others the advantages to schedules and costs which can result when multi-level monitoring devices are used to reduce the number of boreholes required. Most important, however, are the advantages that accrue from the increased data density and from the field verification procedures that are available. The very fact that one is capable of accessing several different discrete zones in one monitoring well provides a testing and verification capability that is simply not possible in a single-level device such as a standpipe monitor well.

The basic requirements of any groundwater monitoring system are that it provide the user with the ability to measure fluid pressure, purge the monitoring zone, collect fluid samples, and undertake standard hydrogeologic tests, such as permeability tests and tracer tests. In addition, quality assurance plans for groundwater monitoring programs have led to a requirement for periodic testing and calibration of all aspects of groundwater monitoring devices.

Quality assurance plans normally require field verification tests immediately following installation and again at periodic intervals during the operating lifetime of the installation. In fact, few groundwater monitoring devices are designed to allow extensive field verification tests to be carried out. However, some types of multi-level monitoring instruments, such as the MP System® developed by Westbay Instruments Inc., were designed with field verification tests in mind (Patton and Smith, 1986). With such systems, questions of data quality can be readily addressed.

General Description of the MP System

The MP System is a modular multi-level groundwater monitoring device employing a single, closed access tube with valved ports. The valved ports are used to provide access to several different levels of a borehole through a single well casing. The modular design permits as many

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monitoring zones as desired to be established in a borehole. Furthermore, at the time of installation, zones may be added or modified without affecting other zones or significantly complicating the installation. As a result, the number and location of monitoring zones can be decided based on the information obtained during drilling. Only a broad scope of requirements need be defined in advance of drilling.

The MP System consists of casing components, which are permanently installed in the borehole, portable pressure measurement and sampling probes, and specialized tools. The casing components include casing sections of various lengths, regular couplings, two types of valved port couplings with different capabilities, and packers, which seal the annulus between the monitoring zones. The MP System has been used in many different geologic and climatic environments in boreholes ranging from a few feet to over 4,000 ft (1,200 m) in length. The 1.5-inch (38 mm) I.D. MP38 System has been used in the field since 1978, while the 2.25-inch (55 mm) I.D. MP55 System was developed in 1990-91.

Casing Components

The casing components of the MP System are made in either plastic or stainless steel. While the illustrations are of plastic components, the descriptions of operating principles that follow apply to both types of materials. Most of the components referred to are shown in Figures 1 and 2.

Casing

MP casing is supplied in a number of different lengths to provide flexibility in establishing the position of monitoring zones and associated seals in the borehole. Common nominal casing lengths are 2 ft (0.5 m), 5 ft (1.5 m) and 10 ft (3.0 m). Actual casing lengths are less than the nominal lengths to account for the lengths of the couplings. The casing ends are machined to mate with MP System couplings.

Telescoping casing sections are used to protect the casing string from damage when ground movements are anticipated or where measurements of vertical displacements are desired.

Regular Couplings and End Caps

MP regular couplings are used to connect casing lengths where valved couplings are not required. The couplings incorporate O-rings for a positive hydraulic seal. A flexible shear rod provides a tensile connection. No adhesives are used when joining casings and couplings. MP38 regular couplings incorporate an internal, helical shoulder for the accurate location of probes and tools in the well. MP55 regular couplings do not incorporate a helical shoulder.

End caps are placed on the bottom of a casing string. They also incorporate an O-ring seal so that the entire casing string is hydraulically sealed during installation. End caps are frequently used to seal the top of the casing between monitoring periods.

Valved Couplings

There are two types of valved couplings, measurement port couplings and pumping port couplings. Measurement port couplings (or measurement ports) are used where pressure measurements and fluid samples are required. In addition to the features of a regular coupling (including the helical shoulder in the case of MP55), measurement ports incorporate a valve in the wall of the coupling, a leaf spring which normally holds the valve closed, and a cover plate or screen which holds the spring in place. When the valve is opened, an access port is provided for the groundwater to enter the coupling.

Pumping port couplings (or pumping ports) are used where the injection or withdrawal of larger volumes of fluid is desired than would be reasonable through the relatively small measurement port valve (such as for purging or hydraulic conductivity testing). Pumping ports incorporate a sleeve valve, sealed by O-rings, which can be moved to expose or cover slots that allow groundwater to pass through the wall of the coupling. A screen is normally fastened around the coupling outside the slots.

Annulus Seals

When there are many monitoring zones in a single borehole, multiple seals are required to prevent fluid migration from one zone to another along the annular opening between the borehole wall and the casing. Placement of these seals can be difficult with any groundwater monitoring device. However, considerable success has been achieved with three types of well completion used with the MP System, provided each is combined with appropriate drilling and placement methods.

With the MP System, seals can be obtained by: a) backfilling with alternating layers of sand and bentonite or grout, b) using hydraulic (water) inflated packers or c) using packers inside a cased well with multiple screens. Figure 1 illustrates a borehole containing the MP System with packers. Figure 2 illustrates a single measurement zone where the MP System is completed by each of the three common methods. Each sealing method is possible in most environments, but in many situations one method will stand out as the most advantageous.

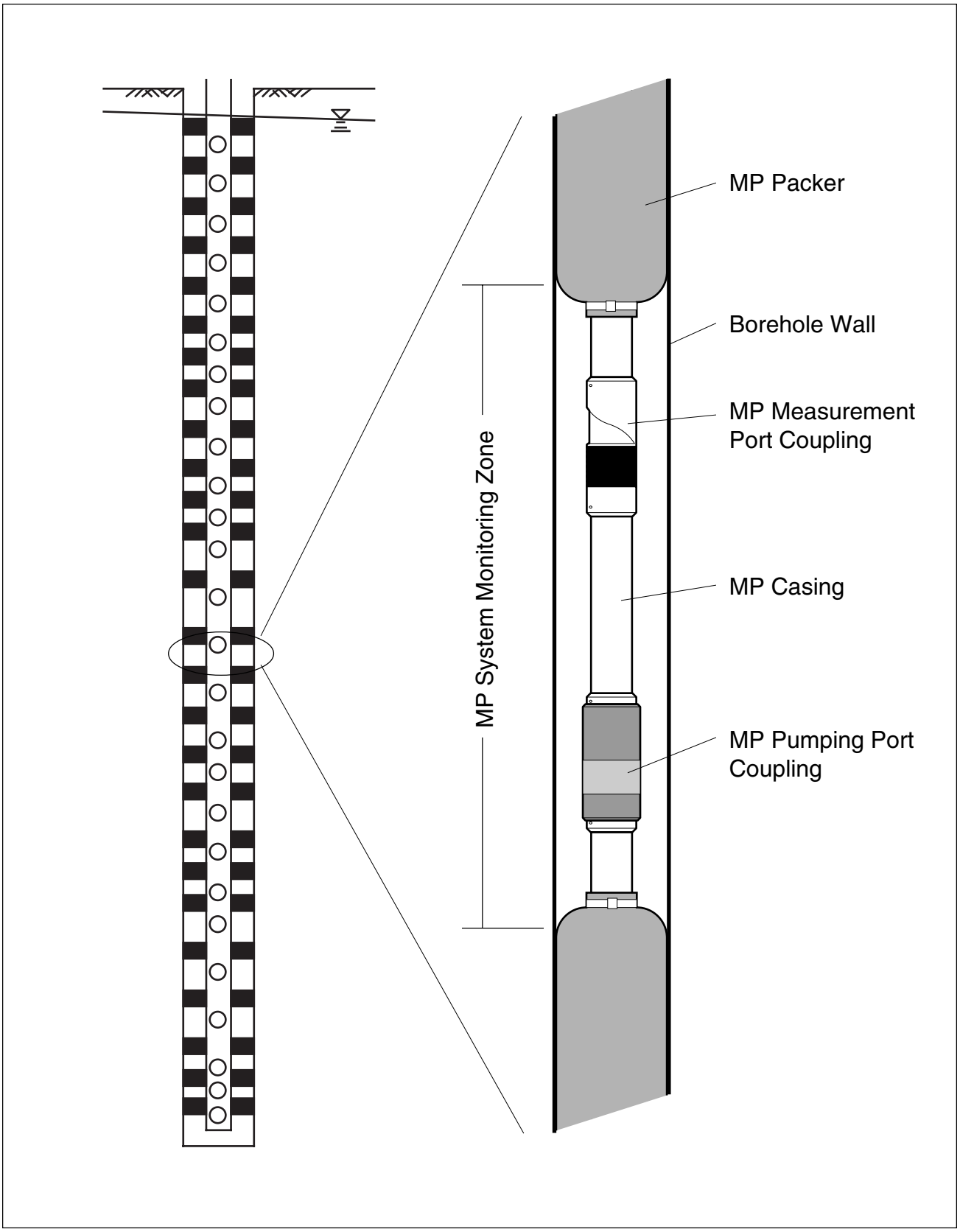

Figure 1. MP System installation with monitoring zones isolated by packers.

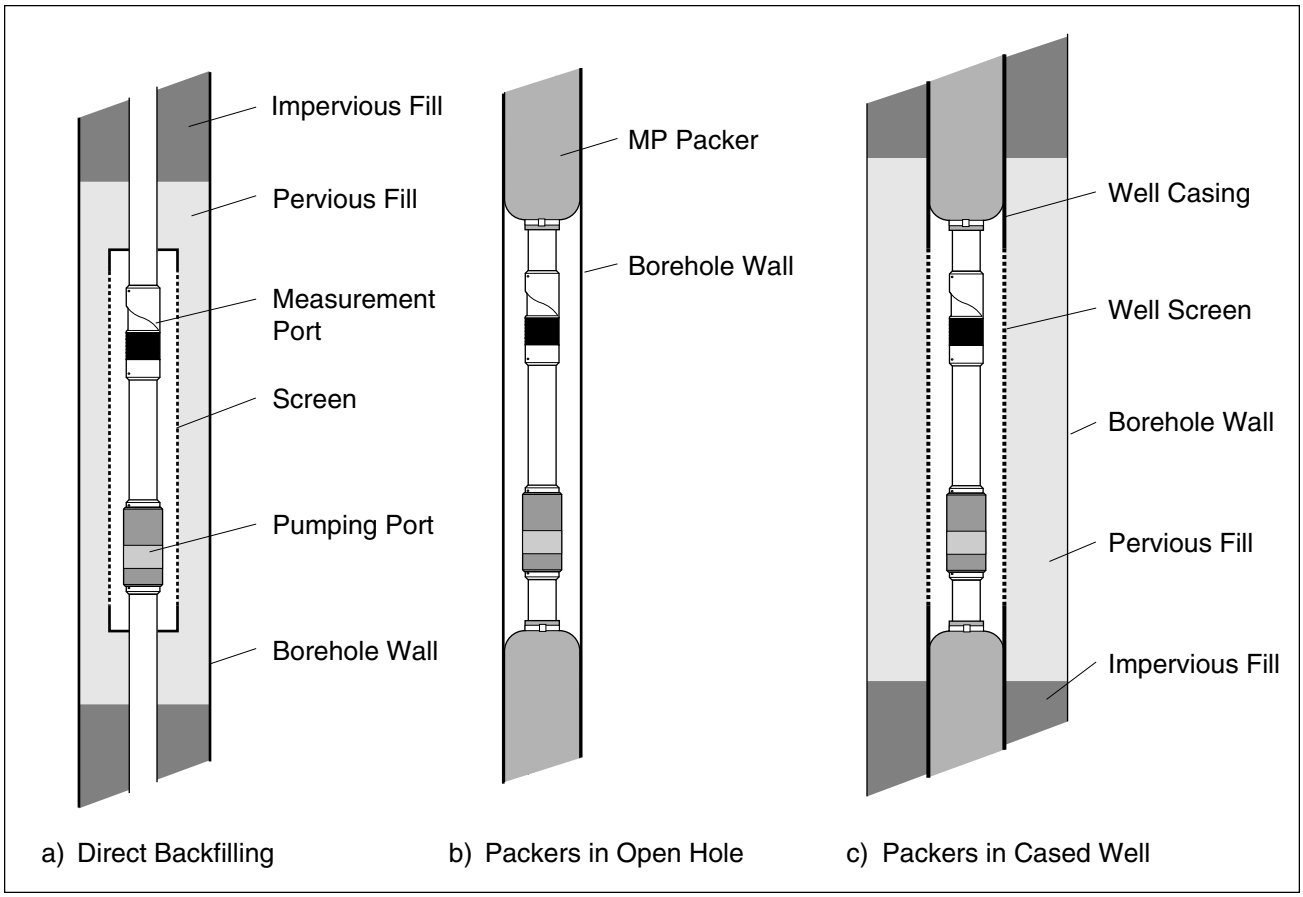

Figure 2. Common completion methods for the MP System.

Direct backfilling (Figure 2a) is recommended for: 1) large diameter boreholes, 2) shallow boreholes, 3) boreholes where little or no fluid circulation is anticipated in the hole during installation (i.e., when near-hydrostatic fluid pressures or low hydraulic conductivity is present over the length of the borehole), and d) where packer gland materials are incompatible with the chemistry of the fluids present.

When direct backfilling is considered and fluid sampling is required, a very clean drilling method must be employed. While the MP System does permit purging of monitoring zones, the small size of the casing (particularly MP38) prevents sufficient energy being generated to develop the monitoring zone.

Backfill seals may include bentonite and / or grout slurries, bentonite chips or pellets or other materials with a relatively low hydraulic conductivity in comparison to that of the natural formations present.

MP casing packers incorporate an expandable gland mounted over a standard length of MP casing. The casing incorporates a one-way valve that allows fluid to travel through the wall of the casing into the packer and prevents this fluid from flowing back out of the packer. Gland lengths are typically 3 ft (~1 m).

Packers in an open borehole (Figure 2b) are typically recommended for: 1) small diameter boreholes (those too small for good quality backfilling to be achieved), 2) deep boreholes, and 3) sealing against significant flows (e.g., flowing artesian conditions) in the borehole. When packers are used, field labour is reduced since packer inflation is generally much faster than backfilling. When using packers, additional measurement ports are installed between monitoring zones. Such additional ports provide additional fluid pressure data for quality assurance (QA) purposes.

Packers in a cased well (Figure 2c) is a completion method that has proven very successful, particularly for environments where available hole sizes are too large for packers and / or where drilling additives, such as mud, must be used. This completion method involves drilling a large diameter hole, typically 12-inch (300 mm) and installing a 4-inch (100 mm) (for MP38) nominal diameter well casing with multiple screens. The well screens are located at all of the desired monitoring levels, based on information gathered during and following

drilling. Layers of backfill are placed to provide filters around the well screens and annular seals between. Each monitoring zone is then developed through the well casing. Following development, MP casing, ports and packers are installed inside the well casing. The MP packers are inflated against the inside of the well casing, providing interior annular seals between the monitoring zones. This completion method provides the ability to properly develop mud from deep mud-rotary boreholes, as well as to service the MP System during the operating life of the monitoring well.

Whenever casing packers are used, whether in open boreholes or cased wells, additional measurement ports are installed between monitoring zones for QA purposes. Measurements and tests carried out through these additional "QA ports" enable an evaluation of the effectiveness of each annulus seal. In open hole installations, such additional ports also provide added information on piezometric pressures in the portions of the borehole between primary monitoring zones.

Screens and Filters

Where both pumping ports and measurement ports are being used and the ports are likely to be surrounded by sand fill or collapsed geologic material, a single well screen is generally placed over both the measurement port coupling and pumping port coupling in each monitoring zone as shown in Figure 2a. The screen helps ensure that the zone influenced by pumping through a pumping port coupling will extend to and include the region surrounding the adjacent measurement port coupling. Screen slot size and length should be chosen with a knowledge of local site conditions. If only fluid pressure measurements are required, a simpler fabric filter tube can be placed over the measurement port coupling and clamped at either end. This filter will help maintain the length of the monitoring zone and protect the measurement port valve from fine particles. The filter material should be compatible with the chemistry of fluids present.

Installation Procedures

Selection of Casing Components

The valved couplings (measurement port couplings and pumping port couplings) allow many monitoring zones to be established in a single borehole. Horizons of hydrogeological interest are targeted on the basis of the best borehole geologic and geophysical logs available. An installation log is prepared showing the locations of the casing components. If only fluid pressures are needed, only a measurement port coupling is required in each monitoring zone. If sampling, fluid withdrawal or fluid injection is anticipated, both a pumping port coupling and a measurement port coupling are recommended in each monitoring zone. This is the case illustrated in Figures 1 and 2.

The casing lengths are chosen based on the desired locations of the monitoring zones and sealing elements. This requires an interpretation of the hydrogeologic conditions anticipated in each borehole. Caliper logs and borehole video can be useful in selecting packer locations.

If consolidation or heave is expected along the borehole axis, telescoping casing sections may be used to minimize the opportunity for compressional or tensile forces to damage the casing.

MP Casing Installation

The downhole MP System components - casing, couplings and packers- are laid out at the site of the proposed monitoring well in accordance with the casing installation log. At that time, any last minute adjustments required to make the positions of the monitoring zones and seals match hydrogeologic details of the borehole are completed and the appropriate revisions made to the installation log.

Next, the required coupling is attached to the top of each length of casing. The casing layout is checked again for compliance with the installation log. Serial numbers of measurement ports, pumping ports and packers are recorded, indicating their position on the installation log. The length of all casing sections is measured and recorded on the log.

The casing string is then assembled by lowering the casing segments into the borehole and attaching each successive segment to the adjacent coupling one at a time. As each successive MP casing section is attached to the string in the well, the section number is checked and recorded on the installation log. The coupling joint is then subjected to an internal hydraulic pressure to verify its hydraulic integrity and the test result is recorded on the log. At intervals during placement of the MP System casing clean water is added to the inside of the MP casing to reduce its buoyancy.

In collapsing soil and poor quality rock, MP casing with packers and screens may be installed through flush-jointed guide tube such as drill rods or casing. Table 1 provides ranges of borehole, casing and guide tube sizes for the MP38 and MP55 Systems. Figure 3 illustrates the major stages of installing through a guide tube:
A) Following completion of drilling, the guide tube is positioned in the hole. All parts of the guide tube, including any shoe attached to the bottom, must be flush on the interior and of sufficient inside diameter to permit the MP components to pass through; B) The MP components are assembled and lowered into the guide

System	I.D.		Max. Depth		Borehole/Casing Size		Min. Guide Tube Size	
	in.	mm	ft	m	in.	mm	in.	mm
Plastic MP38	1.5	38	1,500	450	3-4 1/2	75-115	3	75
Steel MP38	1.5	38	5,000	1,500	4-4 1/2	100-115	4	100
Plastic MP55	2.25	55	4,000	1,200	4 3/4-6 1/4	121-159	4 3/4	121
Steel MP55	2.25	55	6,600	2,000	4 3/4-6 1/4	121-159	4 3/4	121

Table 1. Important dimensions for the MP System.

tube in such a fashion that the packers and ports will be correctly positioned in the hole when the bottom of the MP is resting on the bottom of the borehole; C) The guide tube is pulled back to expose a packer and that packer is inflated. The pulling / inflating sequence is repeated until all of the packers have been inflated. More than one packer may be exposed during each pull of the guide tube, depending upon the stability of the borehole walls.

Casing without packers can be placed in various sizes of boreholes, with or without protective casing, as long as the borehole diameter (and casing) is compatible with the backfilling method. Good backfilling techniques involve the use of one or more tremie pipes.

Once the MP casing has been placed in the borehole, the packers are inflated (see Figure 3) or backfill is placed. If the MP casing was lowered inside a guide tube, the guide tube may be withdrawn all at once or in steps as the packer inflation or backfilling operation proceeds. An incremental casing withdrawal can reduce the opportunity for the borehole wall to loosen and cave prior to the placement of seals.

Packer Inflation

Figure 4a shows the appearance of a casing packer when it has been placed in a borehole before inflation. Figure 4b shows how the MP System casing packers are individually inflated using a packer inflation tool. This tool is lowered down the inside of the MP casing and is located in the correct position by the location arm seating in a coupling adjacent to the packer.

Two small packers (tool packers) are inflated, isolating the short segment of the casing containing the valve for the casing packer. At a pre-set pressure, the tool injection valve opens and water is injected into the casing packer. During inflation the vent-head mechanism on the tool holds open the measurement port beneath the packer. This vents the pressure in the zone below the packer, allowing the packer to square-off without generating unnatural squeeze pressures. Figure 4c shows the inflated MP packer after the inflation tool has been removed. At increments of volume during the inflation process, pumping is stopped and the fluid pressure of the inflation system is measured and recorded. The pressure / volume data is plotted and kept for quality assurance purposes.

Packer inflation proceeds from the bottom of the hole to the top. There are no permanent inflation lines leading to each packer. As a result, there is no limit to the number of packers that can be placed in a borehole apart from the finite limitations of packer length and borehole length.

Purging Monitoring Zones

The strategy for purging the monitoring zones may vary depending on site conditions. Figure 5 shows a typical sequence of events in drilling and completing a monitoring well. Figure 5a shows a typical borehole environment where the invasion of drilling fluids and / or the unnatural circulation of formation fluids has caused groundwater adjacent to the borehole to be nonrepresentative of the formation fluid. Once the casing and annular seals (packer seals are shown in Figure 5b) have been installed, it is usually desirable to remove the nonrepresentative fluid. This removal, or purging, can be done in one of two basic ways: 1) Purging by natural groundwater flow, or 2) Pumping to purge monitoring zones.

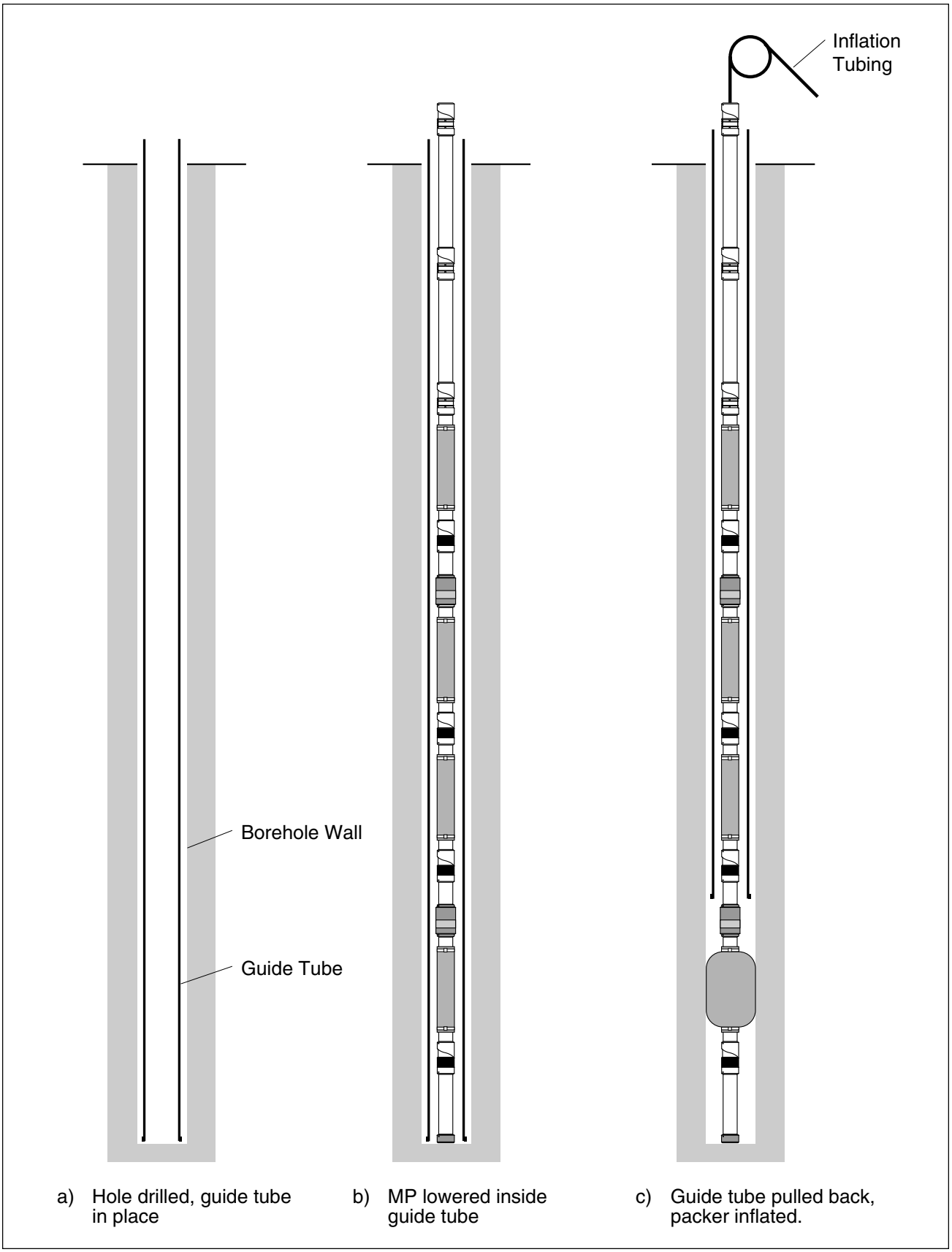

Figure 3. Installation of MP casing through a guide tube.

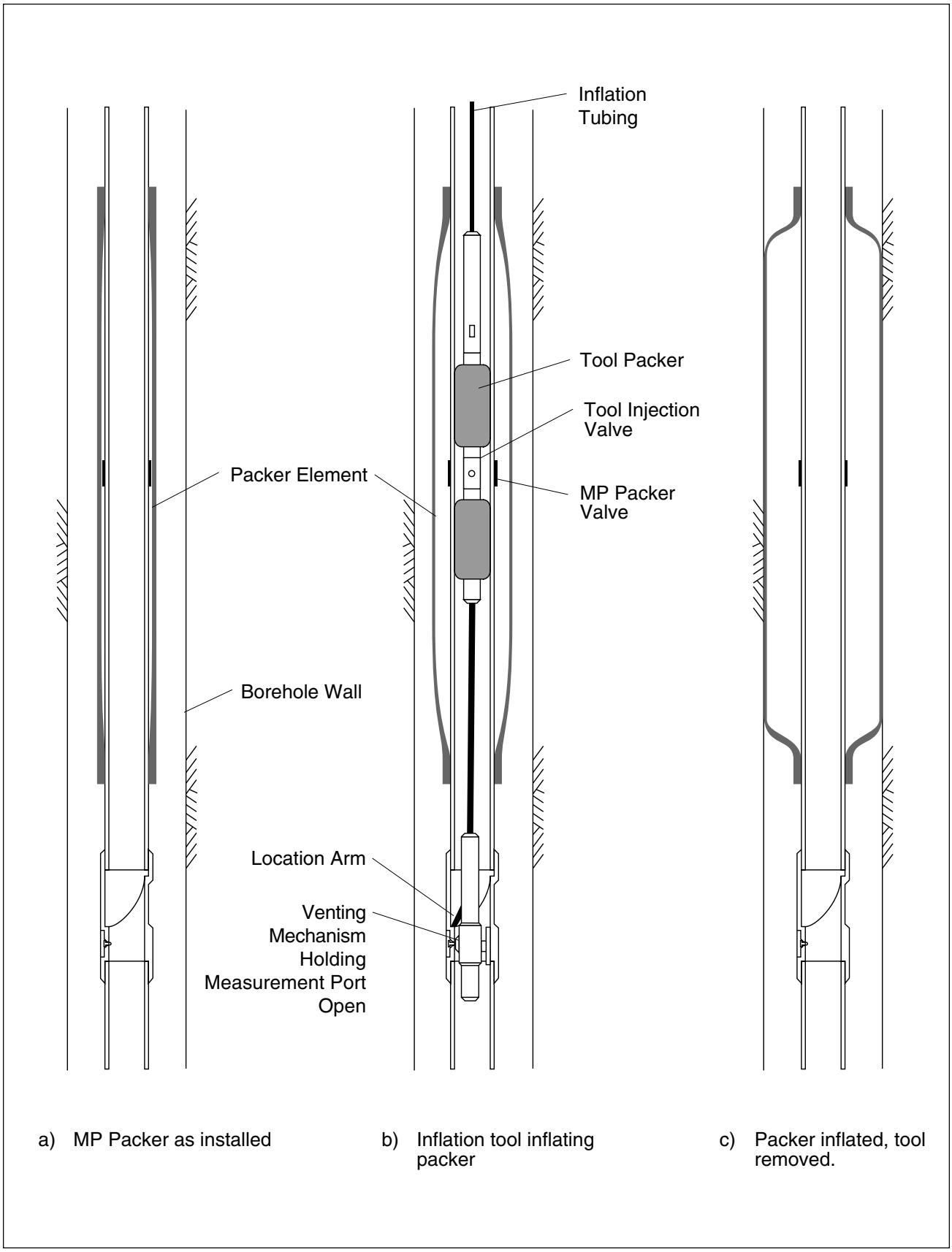

Figure 4. Steps in the inflation of an MP System packer.

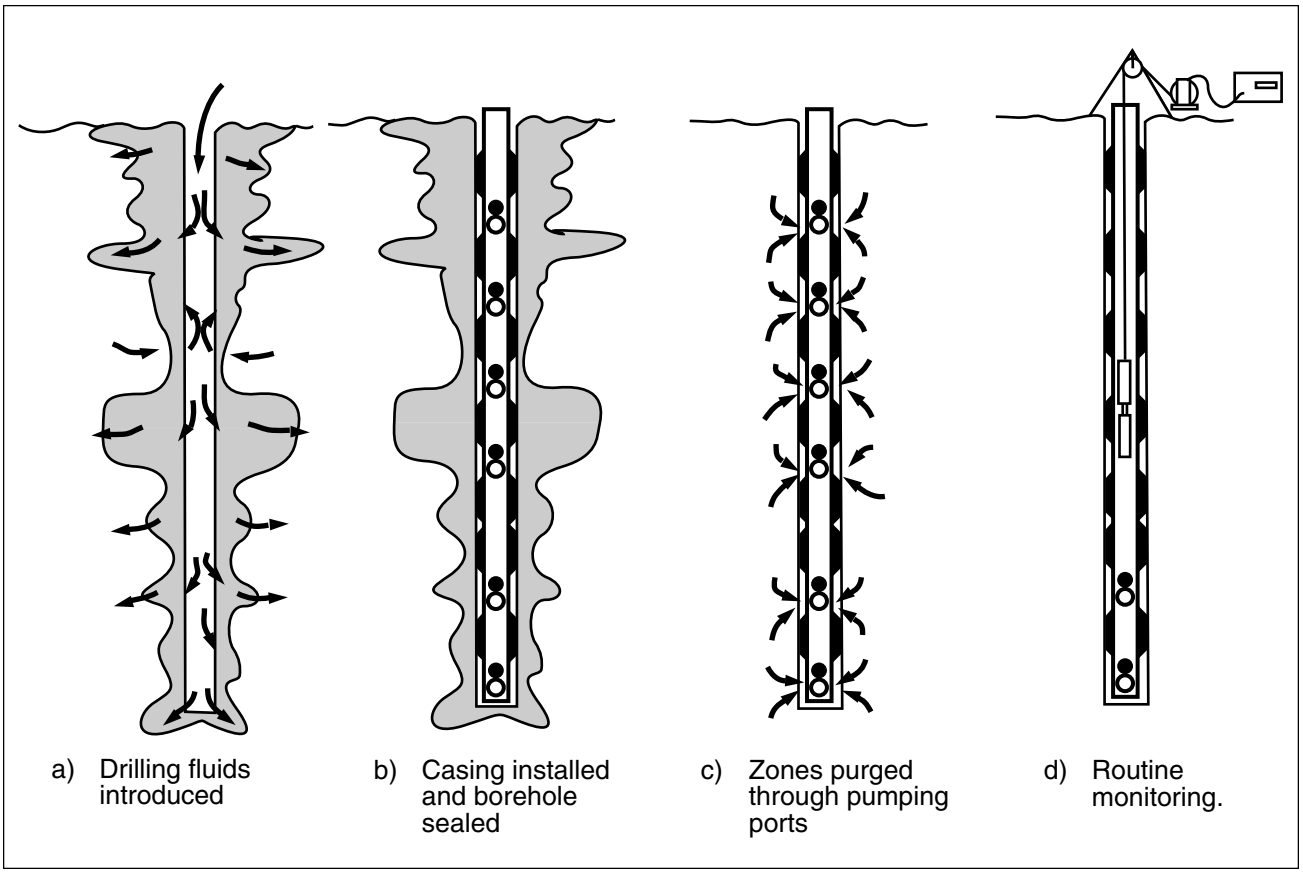

Figure 5. Typical sequence of events in purging monitoring zones.

Purging by natural groundwater flow is attractive, particularly in environments where groundwater flow is understood to be relatively rapid. In such an environment, unnatural fluids introduced during drilling may no longer be adjacent to the borehole by the time the monitoring system has been installed. In such a case, there may be little to be gained from the investment of time and resources to pumping an arbitrary volume of water from each monitoring zone. Rather, fluid samples might be collected over a period of time and analytical results compared in order to evaluate the stabilization of conditions in the monitoring zone.

When purging by natural flow is not acceptable, monitoring zones can be purged by pumping. Zones may be pumped individually or several at a time (as shown in Figure 5c). Individual hydrogeologists and hydrochemists may prefer different purging techniques depending upon local conditions. However, the purging procedures are essentially the same as would be used for a single standpipe piezometer. One procedure which has been successfully used is described below.

1) An acceptable and convenient tracer is added to the drill fluid during drilling.

2) After the casing has been installed and the packers have been inflated, the pumping ports in all or a portion of the monitoring zones are opened with the use of an open / close tool.

3) Fluid from the inside of the MP casing is pumped out of the well. The volume of fluid removed and the pumping time will depend on many factors including: the drilling method, the length of time the hole was left open prior to completion, the hydrogeological conditions in the borehole, and the accuracy required. The use of a tracer can be helpful in determining when the pumping is completed.

4) Once pumping has been completed, all the pumping ports except one are closed with the use of the open / close tool. With one pumping port open, the MP casing is hydraulically identical to a standpipe piezometer. A quantity of fluid may be pumped from inside the MP casing to complete the development of this monitoring zone. Hydrogeologic testing of this zone and its adjacent casing seals can be done at this time. For example, slug tests can be undertaken to obtain transmissivity and storativity values. This

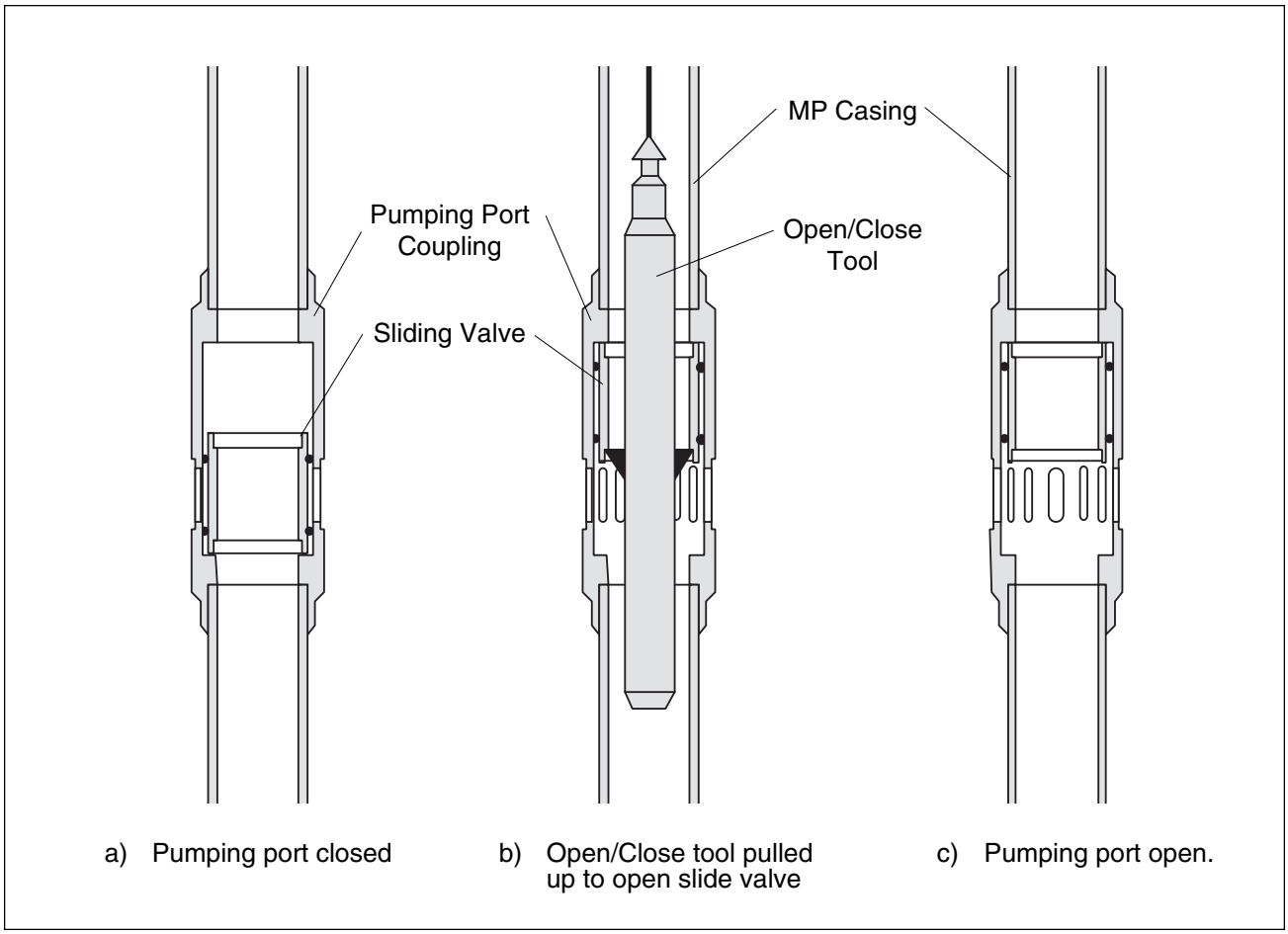

Figure 6. Operation of an MP pumping port.

pumping port can then be closed, the next one opened and the process repeated.

Following purging, the MP System is ready for sampling and for pressure measurements as indicated in Figure 5d.

Operation of the Pumping Ports

To operate the pumping port valve, an open / close tool is used as illustrated in Figure 6. This tool has spring-loaded "jaws" which can be mechanically activated from the surface. The pumping port is shown closed in Figure 6a. To open the valve, the tool is lowered on a wireline with the jaws extended and pointing upward (i.e., so that they will catch on shoulders when the tool is raised). In this condition, the jaws will spring through the couplings as the tool is lowered to just below the desired pumping port coupling. The tool is then pulled up so that the jaws engage the bottom shoulder of the sliding valve. By continuing to pull up on the wireline, the valve can be opened, as in Figure 6b. Once the valve is opened, the jaws can be collapsed into the housing and the tool recovered. With this one valve opened, fluids can be added to or removed from the monitoring interval by injecting or pumping from the MP casing. Other zones may still be monitored in the normal manner using a pressure probe or sampling probe as they will not be hydraulically connected to the interior of the casing.

To close the pumping port coupling, the open / close tool is brought to the surface and the housing is reversed so that the jaws point downward (i.e., the tool will stop on exposed shoulders when the tool is lowered). The tool is lowered to the open pumping port with the jaws collapsed into the housing. Once the tool is located near the pumping port, the jaws are released and the valve is closed by tapping on the top shoulder of the sliding valve with the tool.

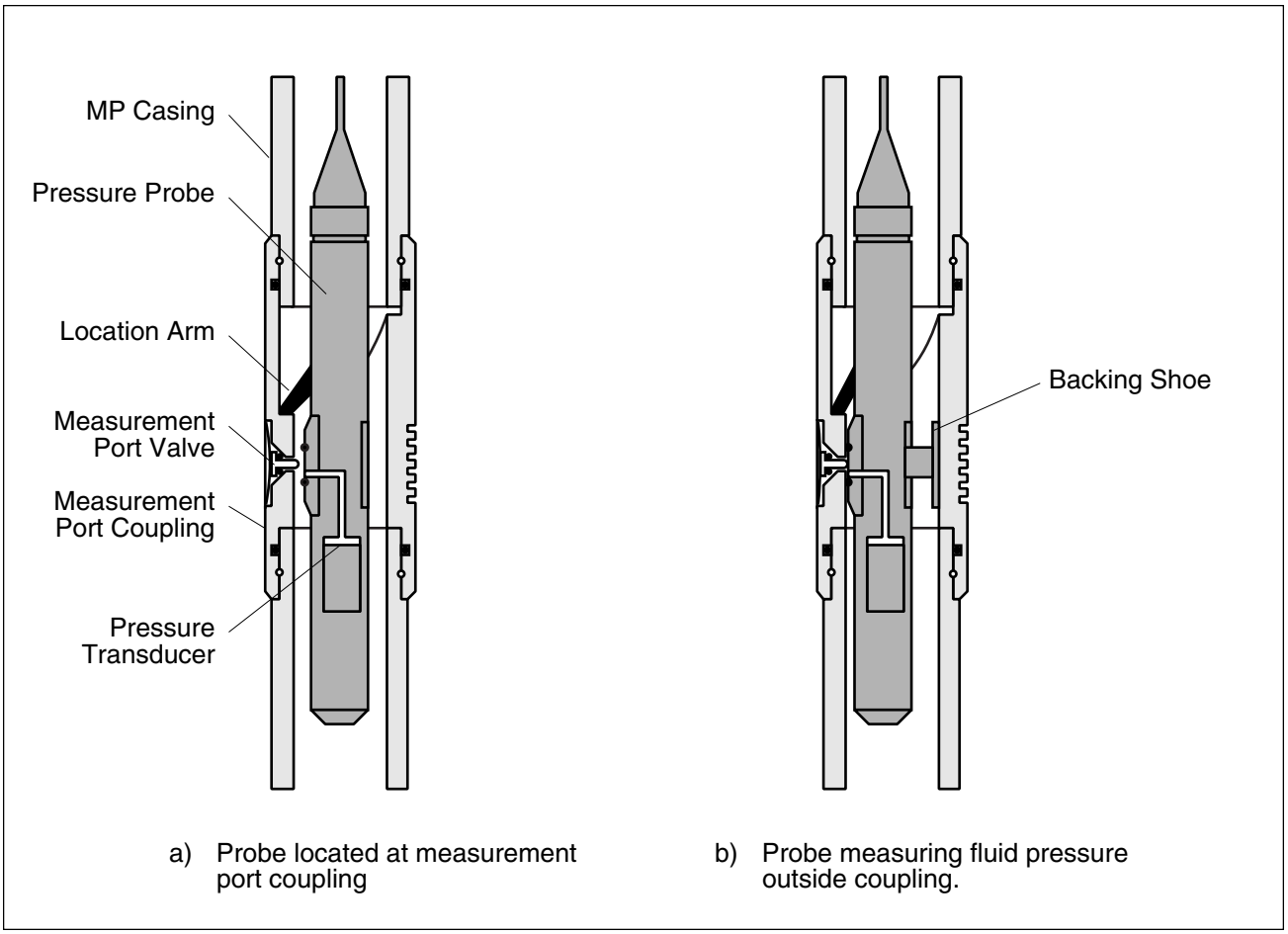

Figure 7. Operation of a pressure probe.

Testing and Monitoring

Fluid Pressure Measurements

Fluid pressure measurements can be made at each location in a borehole where an MP measurement port coupling has been installed. The measurement coupling includes a helical landing ring and a leaf spring valve which is normally closed. The fluid pressure is measured using a MOSDAX® pressure probe which incorporates a location arm, a backing shoe, a face seal, and a fluid pressure transducer. These features are shown on Figure 7. The probe is operated on a cable connected to an interface and portable computer at the top of the monitoring well. Using MProfile™ software, the computer displays the pressure both graphically and digitally, along with transducer temperature, well information and probe status (see Figure 8).

The following procedure is used to make fluid pressure measurements. The probe is lowered to a point below the first measurement port to be accessed (usually the deepest). The location arm is released from within the probe body. The probe is raised to just above the measurement port coupling and then lowered until the location arm rests on the helical landing ring in the coupling. The weight of the probe causes it to rotate into position at the correct depth and orientation to operate the valve (Fig. 7a). At this point the pressure transducer is measuring the fluid pressure inside the MP casing at that depth. This reading will be displayed on the surface computer and is recorded. If convenient, the depth to water inside the MP casing is also measured and recorded at this time as a check on the pressure transducer.

The backing shoe is then activated. It pushes the probe to the wall of the coupling so that the face seal on the probe seals around the measurement port valve at the same time as the face of the probe pushes the valve open. The transducer is now hydraulically connected to the fluid outside the coupling and isolated from the fluid inside the casing (Fig. 7b). The reading displayed on the surface computer will be the fluid pressure in the formation outside the measurement port. The pressure outside the port can be observed as long as desired and recorded as often as desired. After the reading has been recorded, the probe backing shoe is deactivated (retracted) and the valve in the coupling reseals. The probe will again be

Figure 8. Data display on surface computer when using MProfile software to operate a MOSDAX pressure probe.

measuring the fluid pressure inside the MP casing (Fig. 7a). The pressure in the casing is again recorded, for quality assurance purposes.

Measuring Pressure in Low Permeability Environments

Very low permeability environments present a special challenge for measuring fluid pressures. When the routine profiling procedures described above are followed, a stable pressure may be observed through the measurement port. However, the act of opening the port may have been sufficient to change the pressure in the monitoring zone, and if the zone is very tight, that pressure change may not dissipate quickly enough to be observed. In such an environment it is always difficult to determine the validity of a static measurement unless some form of dynamic test is carried out as well. In the case of the MP System, this is done throught the use of a MOSDAX sampler probe. As illustrated in Figure 9a), the MOSDAX sampler incorporates all of the features of a pressure probe, plus a valved passage which is controlled via the surface computer. With the sampling valve closed the probe acts identically to a pressure probe and thus may be used for single-probe profiling. The difference is that once the probe is located and activated (Fig. 9b), the fluid level inside the MP casing may be adjusted to a level slightly higher or lower than the piezometric level in the monitoring zone. The sampling valve is then opened (Fig. 9c), exposing the monitoring zone to the fluid pressure in the MP casing. In very low permeability environments, no water will flow during this time. The sampling valve may be kept open for a specified period of time (such as one minute). The sampling valve is then closed (Fig. 9d) and the pressure recovery in the monitoring zone is recorded vs. time (Fig. 10). Standard analytical methods can be applied to the pressure recovery data in order to determine the apparent pressure in the monitoring zone. The same procedure can be used for testing hydraulic conductivity in low-k zones.

Pressure Monitoring Methods

The two principle methods of monitoring fluid pressure with the MP System are illustrated in Figure 11. Single probe profiling (Fig. 11a) involves an operator

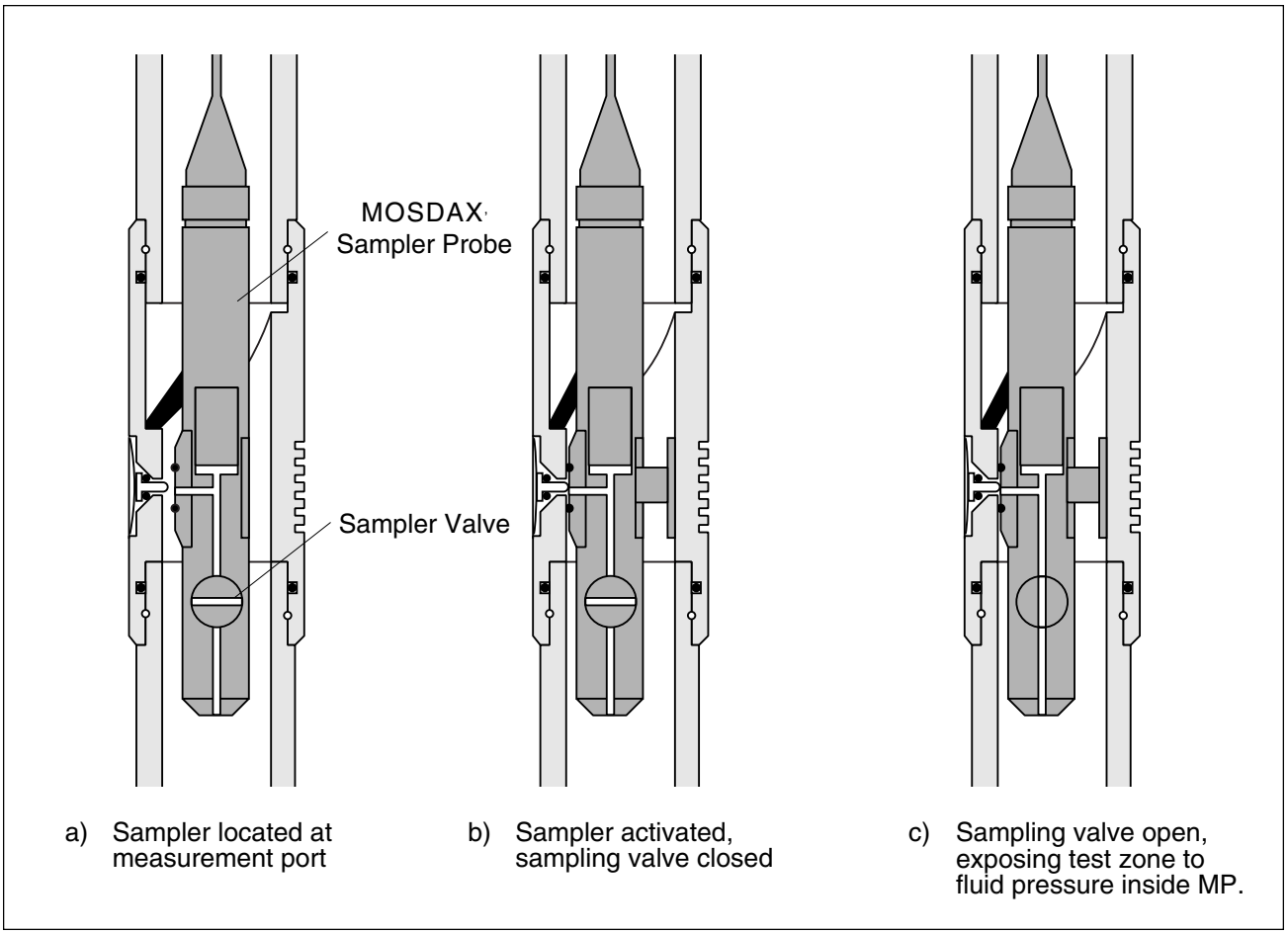

Figure 9. Using a sampler probe for testing hydraulic conductivity and verifying fluid pressure measurements in low permeability environments.

travelling to each well with a set of portable equipment including a pressure probe, cable and reel, interface and computer. The operator manually locates the probe at each measurement port and carries out fluid pressure measurements one at a time. MProfile stores the data on disk with each record tagged as to the location of the probe in the well, date, time, and probe status. Single probe profiling is generally adequate for monitoring fluid pressure up to a frequency of once per month.

When pressure measurements are desired more frequently than is reasonable for single-probe profiling, or when continual observation and recording of unanticipated events is required, the monitoring well can be configured for automated datalogging (Fig. 11b). Any or all of the measurement ports in a well may be selected for automated monitoring. Lengths of cable are made up to span the distance between each probe and the next. The string of probes and cable is assembled and lowered into the well. The datalogger and a computer are attached at the surface and the lowermost probe is located and activated in the appropriate measurement port. The

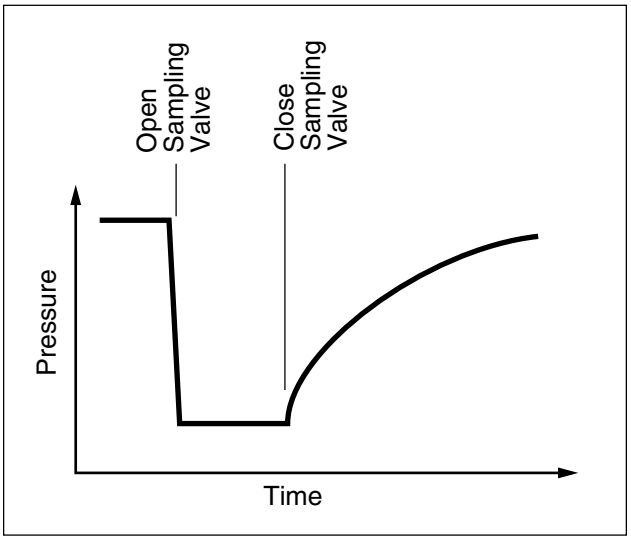

Figure 10. Typical data record from a test in a low permeability zone using sampler.

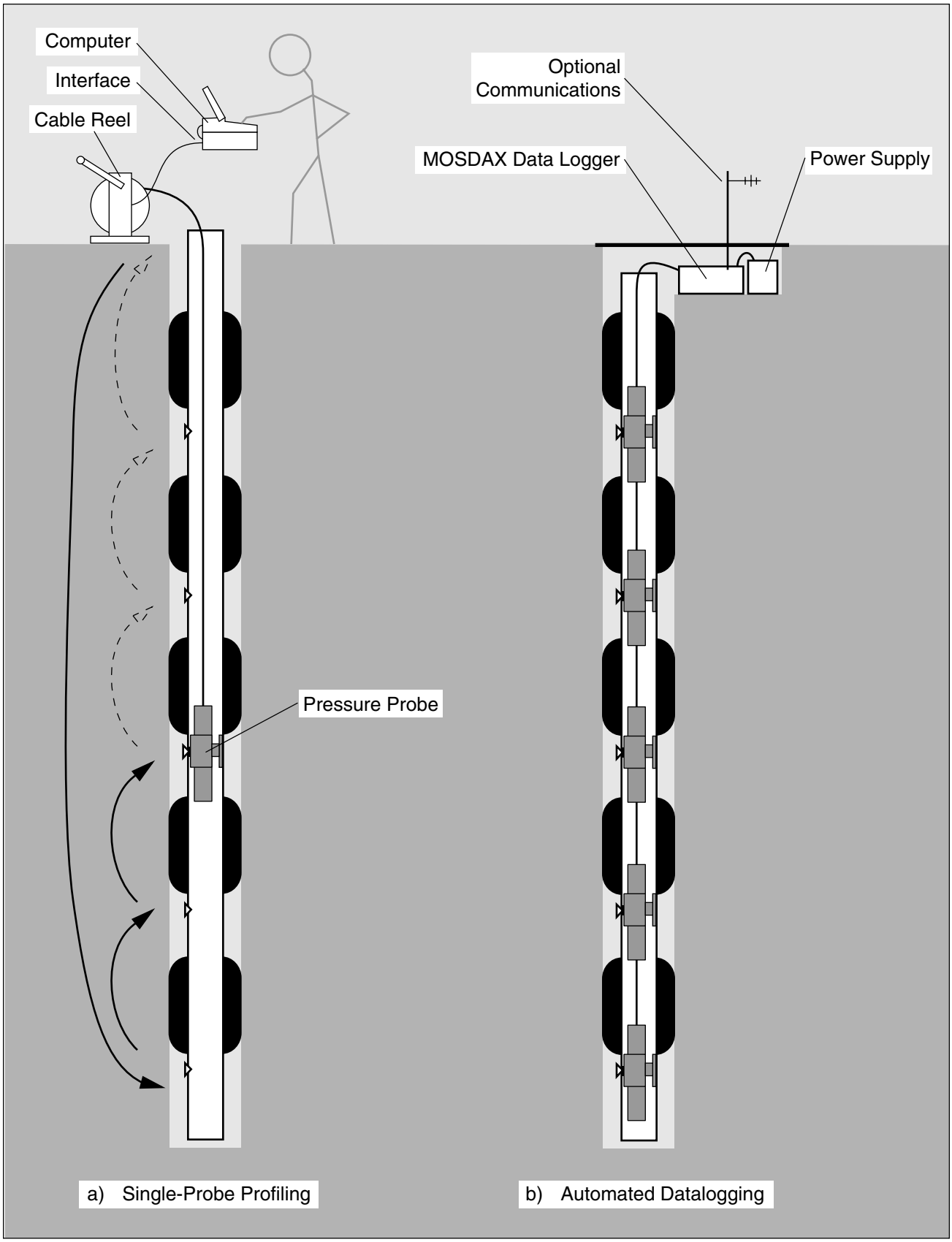

Figure 11. Methods of monitoring fluid pressure with the MP System.

remaining probes are located and activated sequentially from the bottom of the well to the top. Once all of the probes are activated, the computer is used to program the datalogger.

Recording of pressure measurements may be carried out on a simple time basis (e.g., one reading per hour or one per day), or the logger may be programmed to continually scan each probe and record pressures if a specific threshold value is exceeded. Each probe may be assigned an independent threshold (i.e., record data if probe 1's reading changes by 1 ft of water, probe 2 by 3 ft, etc.).

The datalogger may stand unattended, in which case an operator would periodically visit the site to download the stored data, or the datalogger may be connected to a telemetry system such as an RF modem, cell phone system, or landline. When connected to a communication device, a second threshold can be designated for each probe which will cause the logger to transmit an alarm signal to the host computer.

A unique aspect of monitoring in the MP System is that unusual pressure readings can often be verified by means of an in-situ calibration check. When an alarm condition is received, a natural first reaction is to question the validity of the measurement ("is it real, or is it the instrument?"). When datalogging with the MP System, if an alarm were received, the operator can log onto the well via remote communications, deactivate two or more probes including the one causing the alarm and compare their measurements of the fluid pressure within the MP casing. The column of fluid inside the MP casing is independent of all of the monitoring zones and thus serves as a reference pressure source. If the deactivated probes agree on the internal pressure, the alarm condition can be taken to be valid and the probes can be reactivated to resume monitoring. If the probe cauaing the alarm did not agree with the others, instrument error might be suspected. In such a case, an operator could visit the well, remove the string of probes, replace the offending probe and reinstall the string to resume monitoring. The offending probe could then be calibrated and serviced in a laboratory.

Fluid Sampling

Fluid samples are obtained by lowering a sampling probe and sample container to the desired measurement port coupling. As shown on Figure 12, the sampling probe operates in similar fashion to the pressure probe except that a groundwater sample is drawn through the measurement port coupling. Whenever the sampling probe is operated with the sampling valve closed, it is identical to a pressure probe, supplying the same data.

The procedure for taking a groundwater sample is as follows. A clean, empty sample container is attached to the sampling probe. The probe and container are prepared (e.g., evacuated) in a manner suited to the specific project and the sampling valve is closed to prevent the fluid inside the MP casing from entering the sample container. The probe and container are lowered to below the selected measurement port coupling. The location arm is released and the probe is positioned in the measurement port coupling (Fig. 12a). The fluid pressure inside the MP casing is recorded.

The backing shoe is activated and pushes the probe to the wall of the coupling so that the face seal on the probe seals around the measurement port valve at the same time as the face of the probe pushes the valve open. The interior passage of the probe is now hydraulically connected to water outside the coupling (Fig. 12b), but no fluid movement takes place. During this operation the change in fluid pressure is observed at the surface and may be recorded.

The sampling valve in the probe is opened, allowing fluid from outside the measurement port to flow through the probe and enter the sample container (Fig. 12c). The fluid displayed at ground surface drops and then recovers as the fluid in the container builds to formation pressure. Once the container is full, the sampling valve is closed (Fig. 12b), the backing shoe is deactivated (retracted) (Fig. 12a) and the fluid pressure inside the MP casing is once again recorded. The sampling probe and sample container are then pulled to the surface. The sampling probe can then be cleaned, a clean container attached and the procedure repeated.

When using a non-vented sample container, the fluid sample is maintained at formation pressure while the probe and container are returned to the top of the well. Once recovered, there are a variety of methods of handling the sample:

- the sample may be depressurized and decanted into alternate containers for storage and transport,
- the sample container may be sealed and transported to a laboratory with the fluid maintained at formation pressure,
- the sample may be transferred under pressure into alternate pressure containers for storage and transport.

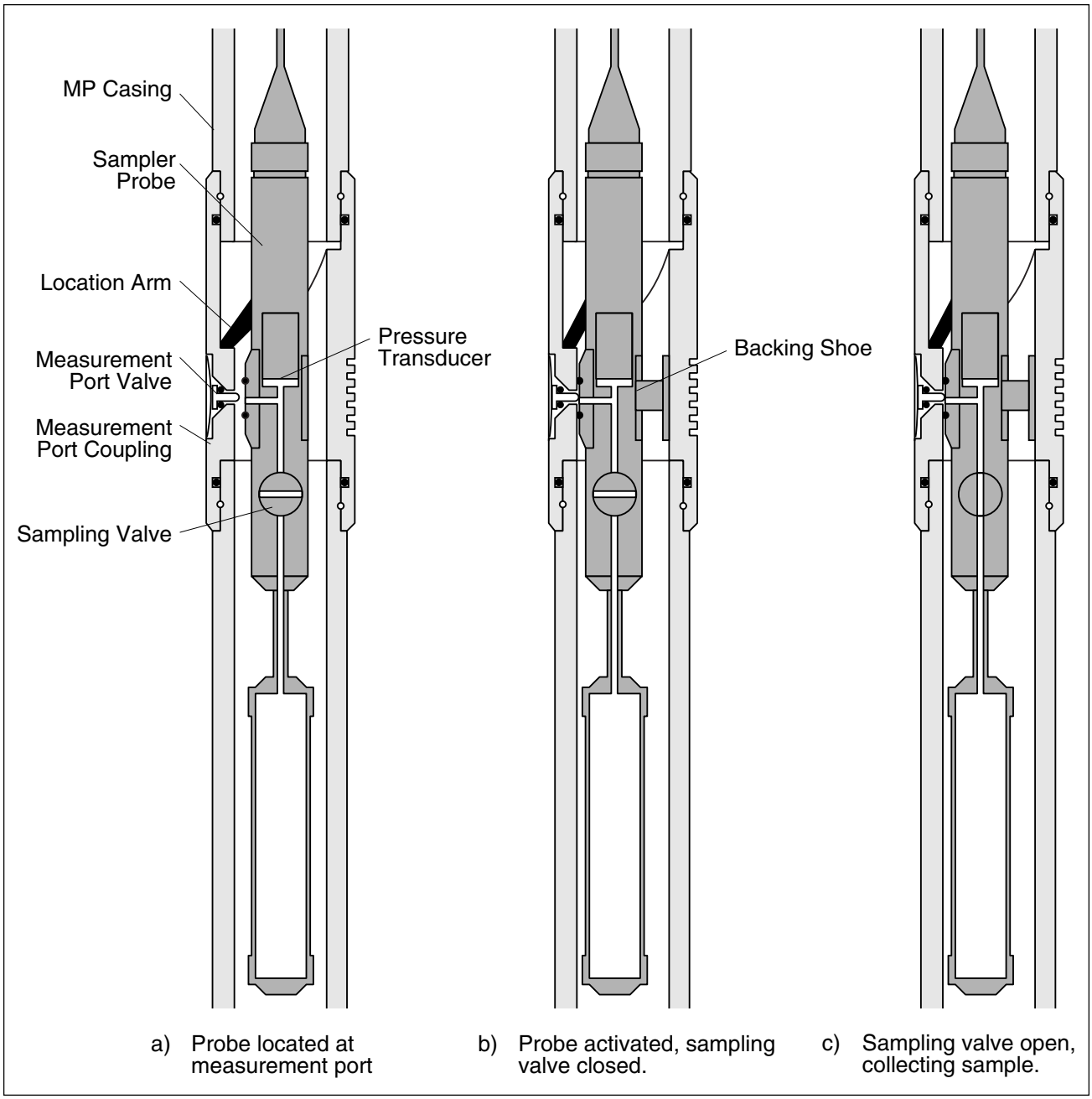

Figure 12. Operation of a sampler probe.

The advantages of this discrete sampling method can be summarized as follows:

1) The sample is drawn directly from formation fluids outside the measurement port. Therefore, there is no need for pumping a number of well volumes prior to each sampling event. Because there is no pumping prior to sampling, the sample is obtained with minimal distortion of the natural groundwater flow regime, the storage and disposal of large volumes of hazardous purge fluids is eliminated, and operator exposure to hazardous fluids is reduced.
2) The lack of pumping means samples can be obtained quickly, even in relatively low permeability environments.
3) The sample travels a short distance into the sample container, typically from 1 to 2 ft (0.3 to 0.6 m), regardless of depth.
4) The risk and cost of storing and disposing of hazardous purge fluids is virtually eliminated.

Hydraulic Conductivity Testing

A variety of different test methods can be employed to measure the hydraulic conductivity of formation materials with the MP System. These include variable head, constant head and pressure-pulse tests.

Variable head tests are the single well test method most commonly used with the MP System. Using these types of tests in the MP System, hydraulic conductivities between 10^{-2} and 10^{-8} cm / sec can be measured.

For variable head tests the valved pumping port couplings are used to provide the hydraulic connection between the interior of the MP riser tube and the test zone. In cases where monitoring zones are to be purged, it is convenient to carry out hydraulic conductivity testing just prior to or following purging. The head (fluid level) inside the MP casing can be adjusted while all port valves are closed, then the selected pumping port can be opened in a controlled manner (pumping port operation is described in the discussion of purging). This allows accurate measurement of both the initial head change and the time at which the head change is applied (t_0). The pumping port valve is opened rapidly (in less than one second), which satisfies the theoretical requirement that an instantaneous head change be applied to the tested zone.

For rising head tests the water level inside the MP casing is bailed or pumped down to a pre-determined level below the static water level in the test zone. For falling head tests the water level is raised to a level above the static water level in the zone to be tested. Measurement equipment is set in place and the pumping port valve is opened. Recovery of the water level in the MP casing is measured and recorded vs. time. A water level tape or pressure transducer is commonly used to record the water level changes. Figure 13 shows a typical record of water levels during a rising head hydraulic conductivity test.

Slug tests are carried out by opening the pumping port coupling at the zone to be tested and allowing the water level in the MP casing to equilibrate to the static water level for that zone with measurement equipment in place. The initial head change is then applied by rapidly lowering a displacement slug (a length of solid rod or sealed pipe) into the water. The recovery of the water level is measured and recorded vs. time. The slug test can be repeated and recorded again when the slug is removed from the water. Figure 14 shows a typical record of water levels during a slug test of hydraulic conductivity.

Data from variable head hydraulic conductivity tests may be analysed using any preferred calculation method. The most commonly used methods are those of Hvorslev (1951), Cooper et al. (1967) and Bouwer and Rice (1976). Selection of these or any other analytical method should be based upon an assessment of how well the test conditions comply with the simplifying assumptions inherent in the analytical method.

In very low permeability environments (hydraulic conductivity less than 10^{-7} or 10^{-8} cm / sec) the formation fluid pressure can be changed with very little fluid movement. As a result, tests can be carried out through the measurement port valve rather than the pumping port valve. Using a sampler probe with a transducer the zone to be tested may be exposed to the fluid pressure inside the MP casing for a period of time (see Fig. 9 and discussion of measuring fluid pressure in low-k environments). The zone may then be shut-in and the recovery of fluid pressure over time measured and recorded. Figure 10 shows a data record from such a test.

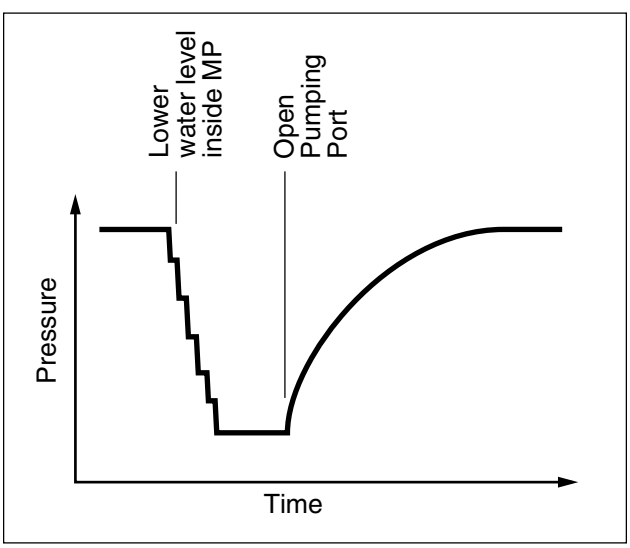

Figure 13. Typical data record from a rising head test.

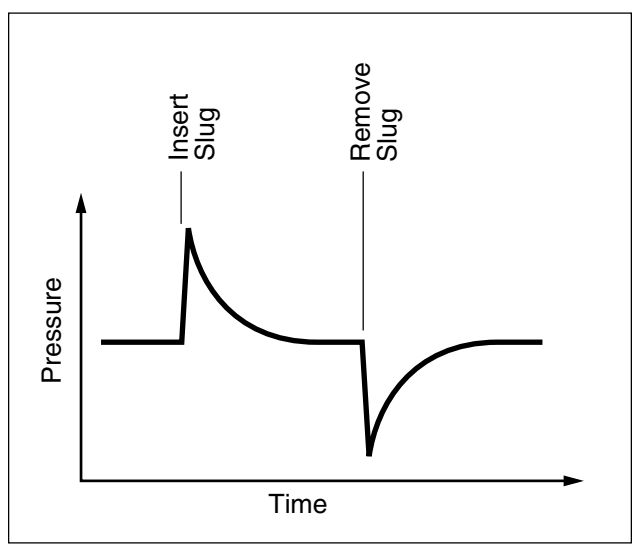

Figure 14. Typical data record from a slug test.

Field Quality Control

There are two distinctive parts to any quality assurance program. The first involves manufacturing and testing procedures which avoid the production or installation of equipment that may result in the collection of erroneous data. The second involves field operational procedures which will ensure that erroneous data are not generated as a result of the failure of any component to function as intended. Although the first part is necessary to allow the installation of useful monitoring wells, the second must also be rigorously applied to identify sources of erroneous and misleading results.

The MP System has many unique features for field quality control which clearly separate it from other types of groundwater monitoring instrumentation. These features are the result of designing components in response to the stringent requirements of users in the fields of nuclear and hazardous waste management.

Quality control tests are carried out at various points during the field use of the MP System and tend to be grouped into three periods: during installation, following installation, and during routine monitoring.

During Installation

During installation of the MP System the following operations form part of the quality control procedures:

Drill core or cuttings and geophysical logs are carefully checked to see that monitoring zones and annular seals are placed at the optimum positions. In cased wells, the well casing is inspected to verify that the interior surfaces are suitable for establishing good quality packer seals and backfill is placed under carefully controlled conditions with frequent measurements of material depths.

Westbay casing components are carefully inspected to see that critical surfaces are undamaged, sealing O-rings are clean and in place, and components are correctly oriented. Serial numbers are recorded along with component position in the installation. These operations link the field quality control to production test results.

As each section of MP casing is attached, the connection is pressurized with water and observed for any signs of leakage. Test results are recorded on the installation log.

During inflation of each MP packer, incremental volumes and pressures are recorded and plotted. These data allow an evaluation of borehole conditions and provide the first indication of the quality of the annular seal obtained.

Following Installation

Immediately following installation further checks are carried out to verify the operation of the system. These include the initial pressure profile which serves to confirm the operation of the inlet valves of the measurement port couplings. Observed head differences across exterior casing seals directly indicate the seal effectiveness. Where such head differences are not observed, the annular seals can be artificially stressed by opening a pumping port in one monitoring zone and withdrawing or adding a slug of water from inside the casing while using the pressure probe to observe the pressure response in the monitoring zone on the other side of the seal. In cased wells and wells in low permeability environments, stresses can be applied through measurement ports in order to evaluate seal integrity.

Additional measurement ports are routinely installed between monitoring zones, further enhancing the ability to carry out thorough quality control tests.

Fluid can be added to packers at any time following installation and the pressure at which further fluid injection occurs can be compared with the injection pressures recorded during the initial inflation.

During Routine Monitoring

A number of quality control checks are built into the routine monitoring procedures.

When measuring fluid pressures, the pressures measured inside the MP casing at each measurement port are recorded immediately before and after the measurement made through the port. These inside casing values serve a number of purposes: 1) comparison of the two values confirms that the transducer was operating the same way after the reading as before, 2) comparison of the inside values from one set of measurements to the next confirms transducer stability over the intervening time period (assuming the water level inside the casing is the same), and 3) if the head of fluid inside the MP casing is known, an in-situ calibration check of head of water versus transducer output is obtained. Any unacceptable changes which show up during monitoring can be checked and corrected through laboratory calibration of the instrument.

Water sampling procedures with the MP System improve quality control because: 1) the short flow path between the formation and the container greatly reduces the surface area contacted by the sample, 2) the contacts between the water sample and the atmosphere are eliminated, 3) observing and recording the water level inside the MP casing during sampling confirms that the sample obtained is from outside the casing, and 4) sampling without purging reduces the disturbance of the

natural system, minimizing unnatural changes in chemistry. Sampling methods can be varied to compare the effects of atmospheric contact versus no atmospheric contact and maintaining the sample under pressure versus allowing depressurization of the sample.

During water sampling, sample blanks and spikes may be collected using identical procedures for sampling, preservation, handling and shipping. Travel blanks and spikes may also be collected using identical procedures for handling, preservation and shipping. The chemical analyses of samples obtained using the MP System may be compared with those of samples collected from the same zone by alternate means.

Finally, the pumping port may be reopened should further purging appear to be desirable.

For both fluid pressure and water quality data, the MP System can provide corroborative data. That is, a high density of data can be obtained in a single installation so that significant changes in piezometric pressure and / or water quality can appear as transitions along a depth profile. Thus, neighboring values will corroborate one another rather than indicating abrupt changes which would cause one to question anomalous values.

Serviceability

In the event that quality control testing should reveal a component which is not operating properly, various steps can be taken to remedy the problem including, if certain cases, removing the MP casing string, replacing faulty components and reinstalling the string.

Table 2. Summary of major quality control aspects of the MP System.

Provides the Ability to Verify	
Well Integrity	✓
Individual Seals	✓
Sample Origin	✓
Fluid Pressures	✓
Well is Serviceable	✓

Summary

The modular nature of the MP System permits a large number of monitoring zones to be accessed through valves placed inside a single closed tube or casing installed in a single borehole. Such a monitoring system can provide a detailed view of the variation of piezometric pressure and water quality with depth. The valved couplings permit purging of the well following installation and allow all standard hydrogeologic tests to be carried out in each zone. Routine sampling is carried out without repeated purging, eliminating the need to store and dispose of large volumes of purge fluid and reducing operator exposure to hazardous fluids. The valves also permit an evaluation of the condition of exterior casing seals at any time after installation. Casing packers allow multiple seals to be established easily and quickly, providing the required hydraulic isolation of each monitoring zone. The modular design of the downhole components means the number and location of monitoring zones and seals can be modified on the basis of the best information available in the field at the time of installation. The exact depth of monitoring zones need not be known when equipment is purchased.

Field quality control procedures have been established which permit the quality of a well installation and the proper operation of testing and sampling procedures and equipment to be routinely verified. Thus, groundwater data and the additional data required to define the quality of the field data can be routinely collected. Furthermore, when a high density of groundwater monitoring zones are installed by using multi-level monitoring wells, the redundant monitoring points can provide important corroborative field data to an extent which is not available with single level monitoring wells. The result is a monitoring system which provides data with a degree of defensibility unattainable with any other monitoring method, single or multi-level.

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Attachment F.2:
2408 Non-Vented Sample Container User Manual

Westbay Instruments

2408 Non-Vented Sample Container

Operation and Maintenance Manual: MP38 Model 2408

Westbay Instruments
7-28-2021

NOTICE

Operation of Westbay System equipment should only be undertaken by qualified instrument technicians who have been trained by Westbay Instruments-authorized personnel.

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3.1	Nov 23, 2016	Dave Larssen	Update part numbers
3.2	May 8, 2018	Dave Larssen	Update part numbers and branding
3.3	June 15, 2021	WRS	Edits and Updates
3.4	July 28, 2021	MR	Update part numbers

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Model 2408 Sample Containers with Carrying Bag and Spare Parts Kit

Safety Information used in this User Guide

A **WARNING** notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

A **CAUTION** notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a CAUTION notice until the indicated conditions are fully understood and met.

GENERAL PRECAUTIONS

Be familiar with, and comply with, all instructions provided in product operations manuals. Manuals can be obtained by contacting Westbay Instruments. The user is responsible for operating all equipment in conformance with all governing codes and regulations, including safety regulations.

The equipment is designed to be installed and operated by users trained in its use and familiar with its operation. It is the responsibility of the user to verify that this equipment is suitable for the intended use and application.

1 INTRODUCTION

The Model 2408 Non-vented Sample Container is constructed of Type 316 stainless steel. It has a capacity of approximately 250ml and has manually operated valves at each end. A maximum of four sample containers can be connected to a Sampler at one time, allowing a total sample volume of 1.0 Liter. Once the sample containers are filled, the fluid samples are maintained at formation pressure. Samples can be transferred to a suitable container or maintained at formation pressure until transported to a laboratory for analyses.

2 CONTAINER PREPARATION

Each sample container has two valve ends that are sealed with an O-ring and held in place by nuts threaded onto the container. The valves are opened and closed using a valve key tool to rotate the valve stem. When the bar of the stem is parallel to the container the valve is open. When the bar of the stem is perpendicular to the container, the valve is closed (see Figures 1 and 2).

Prepare the container for use as follows:

1. Inspect all components, check the O-rings for damage and replace them if necessary. **Do not use the sample container if it is dented or otherwise not suitable for use.**

2. Insert both valve ends into the sample container and secure the nuts **(hand tight).**

3. Connect the container(s) with the Inter-Connect hoses using 9/16-inch and 5/8-inch wrenches. Do not over-tighten.

4. Attach the container(s) to the sampler, making sure that the bottom valve on the bottom container is **CLOSED** and all other valves are **OPEN** before lowering the sampler into the well.

5. Prepare the sampler and containers as outlined on the Groundwater Sampling Field Data Sheet.

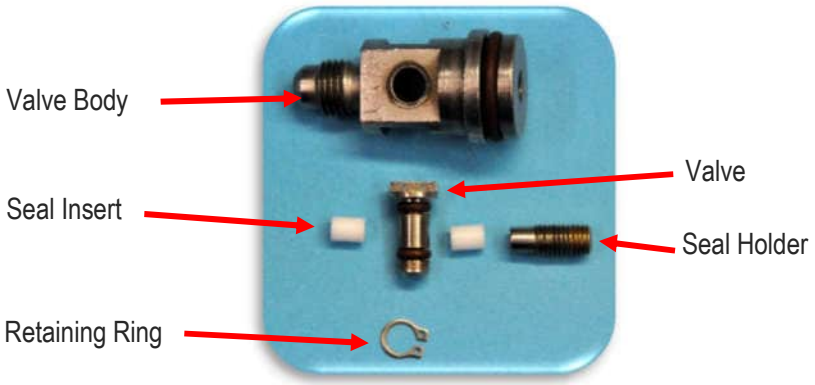
6. **(Optional)** Install the bottom Flow Control Tube to the base of the valve end at the top end of the container as shown in Figure 1. Installation is described below in Section 4.1

WARNING: Fluid samples brought to the surface may be under pressure. The operator must take safety precautions appropriate for the site conditions and comply with all applicable safety requirements. The Westbay sample containers are not approved by Transport Canada or the US DOT for transport while under pressure.

3 CLEANING AND MAINTENANCE

The sample containers should be cleaned and maintained regularly. Always release the pressure in the sample containers before performing any cleaning or maintenance by opening one of the valves with the valve and container pointed in a safe direction. Unthread the valve end nuts and remove the valve ends. This may require some force due to the resistance of the O-ring on the valve ends. The sample container, filling tube and valve ends may be cleaned and rinsed according to the site geochemical sampling work plan. Project-specific procedures for decontaminating the sample containers are the responsibility of the project manager and are not covered here.

3.1 Valve Disassembly

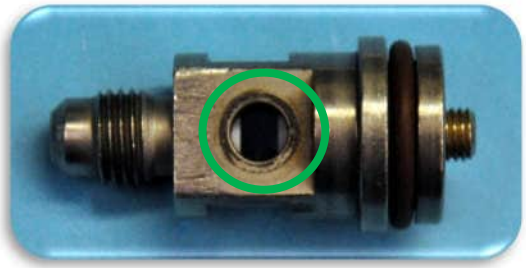


Under normal use the sample container valve ends can be cleaned and rinsed by running fluids through the valve with the valve open. Generally, the valve should not need to be disassembled. If necessary, the valve can be disassembled for cleaning or repair following the procedure below:

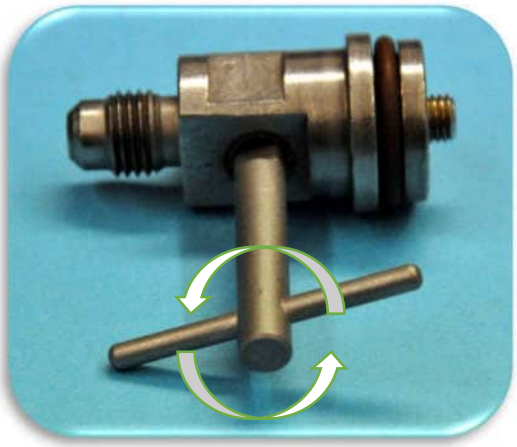
1. Remove the retaining ring from the valve end and push the stem out of the valve body with an Allen key.
2. Remove the seal holder from the bottom of the valve using a 1/8-inch Allen key.
3. Remove the two seal inserts from inside the valve body using the seal assembly tool (Assembly Tool 3).
4. Firmly thread the Assembly Tool 3 into each seal and pull the seal out of the valve body. Discard both seals.

3.2 Valve Reassembly

1. Always use new seals when assembling the valve ends.
2. Use the 1/8-inch Allen key to place a new seal into the valve body. Push the seal until it fits snugly on the far side of the valve stem hole.
3. Place a second new seal into the end of the valve body. Use a 1/8-inch Allen key to thread the seal holder into the valve body and push the seal into place. Do not push the seal too far in.



4. Use the Forming Tool (Assembly Tool 1) to shape the new seals by turning the tool several times in each direction.



5. Once both seals are rounded clean out any plastic shavings.

6. Inspect the O-rings and replace them if damaged or worn.

7. To remove the #006 O-rings, take care to not damage the sealing surfaces of the O-ring groove.

8. Place a new # 006 O-ring into the appropriate groove in the valve stem using the cone tool (Assembly Tool 2). Push the hollow end of the cone tool over the valve stem, apply a small amount of silicon grease to the O-rings, and slide each O-ring over the cone tool and into the appropriate groove on the valve stem.

9. Push the valve stem in place in the valve body. This may require a bit of force but ***be careful not to damage the O-rings.*** Turn the valve stem handle to the open position and once again and clean out any plastic shavings.

10. Place the retaining ring on the valve stem and tighten the inside seal retaining screw until it is snug.

11. Rinse and decontaminate the valves before sampling.

4 SAMPLING LOW-PERMEABILITY ZONES

When sampling from zones with very low permeability the removal of fluid from the zone may temporarily depressurize the zone. Significant depressurizing may cause the packers to be subjected to forces greater than the operating specifications. This may lead to serious damage to the zone, the Westbay casing and/or the packers. Westbay recommends contacting a Westbay technical specialist for consultation when sampling these types of zones and using the Flow Control Tube Part No. 2408S6. The Flow Control Tube slows the container filling process and reduces the pressure decrease in the zone and across the face seal of the probe. If excessive zone depressurization continues, it may be necessary to close the Sampler Probe valve to interrupt the container filling. This will allow the formation pressure to recover sufficiently to allow the sample collection process to continue.

4.1 Installing the Flow Control Tube - 2408S6

The Flow Control Tube must be used in the top valve end of the sample container closest to the sampler. Remove the top valve end of the sample container. Remove the seal holding screw and replace it with the coiled flow control tube. Attach the top valve end to the container. Refer to Figure 2.

5 OPERATING WESTBAY HYDRAULIC PUMPING PORTS

Refer to the Model 2532 MOSDAX Sampler Manual for detailed instructions for operating hydraulic pumping ports.

5.1 Installing the Stainless-Steel Filling Tube – 240800S2

The Stainless-Steel Filling Tube is used when the sample container and a Model 2532 MOSDAX Sampler Probe are used to operate a Westbay Hydraulic Pumping Port. The filling tube is attached to the top valve end of the sample container – replacing the Seal Holder. Use of more than one container is **not recommended** when operating Hydraulic Pumping Ports**.**

Remove the top valve end of the sample container. Remove the seal holding screw and replace it with the filling tube. Attach the top valve end to the container. Refer to Figure 1.

6 SPARE PARTS SUPPLIED

Part Number	Description	Quantity per Container	Quantity per Bag
240810	Valve Key	1	1
240808	Assembly Tool 1	1	1
240809	Assembly Tool 2	1	1
240816 (Formerly 240811)	Assembly Tool 3	1	1
TO-KYH-1/8-B	1/8-inch Allen Key	1	1
2408RRP	Retaining Ring Pliers	1	1
240807	Seal Insert	4	8
240813	Retaining Ring	2	4
OR0067V75	O-ring #006, Viton	8	16
OR114V75	O-ring #114, Viton	4	8
OR004V75	O-ring #004, Viton	8	16
FEP-RT-0.125X0.062	Teflon Tube	2 ft.	4 ft.

7 OPTIONAL PARTS AVAILABLE

Part Number	Description	Quantity per Container	Quantity per Bag
2408S6	Flow Control Tube – coiled stainless-steel	-	1
240800S2	Filling Tube – stainless-steel	-	1

Figure 1. Model 2408 Sample Container

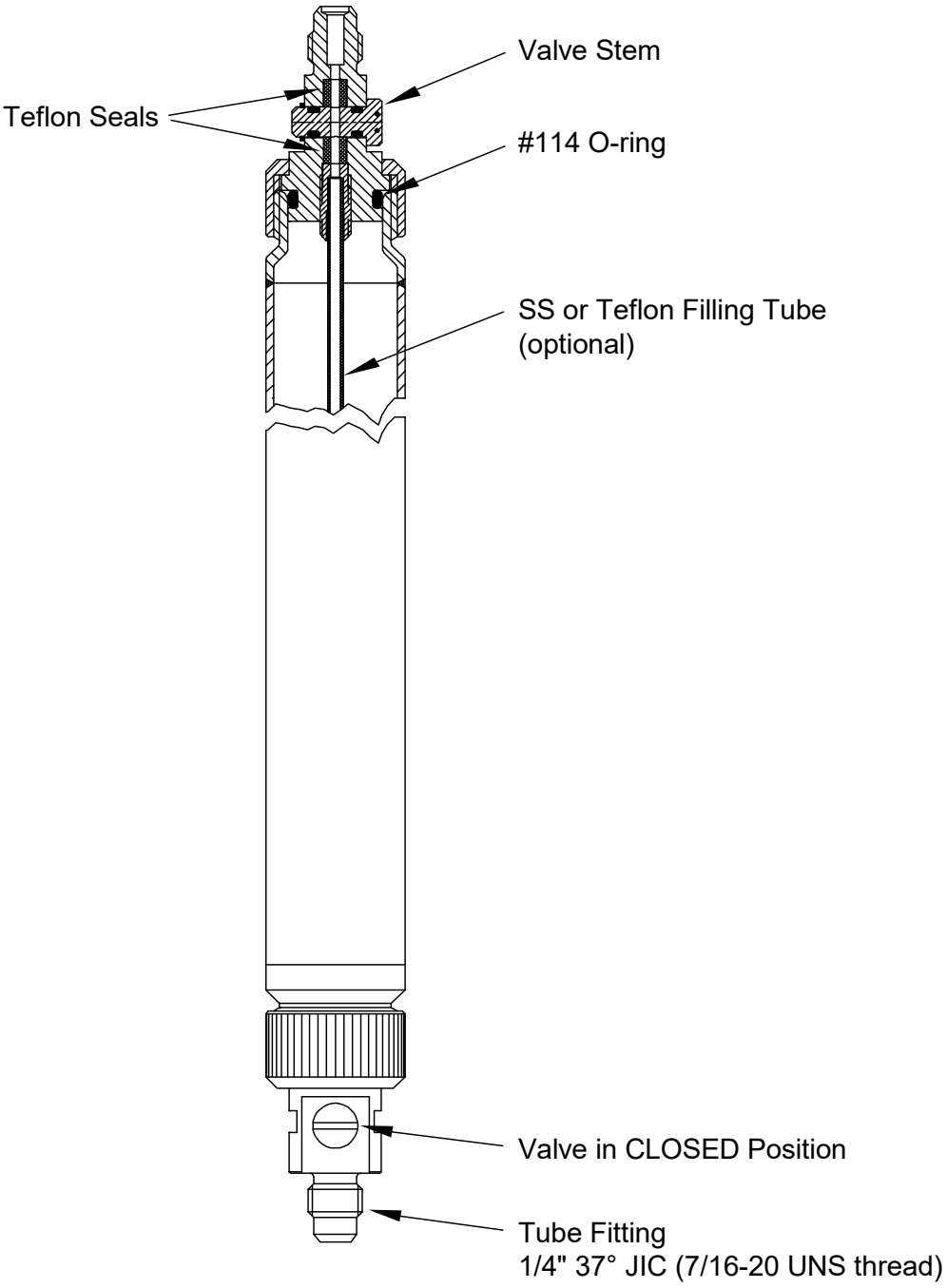
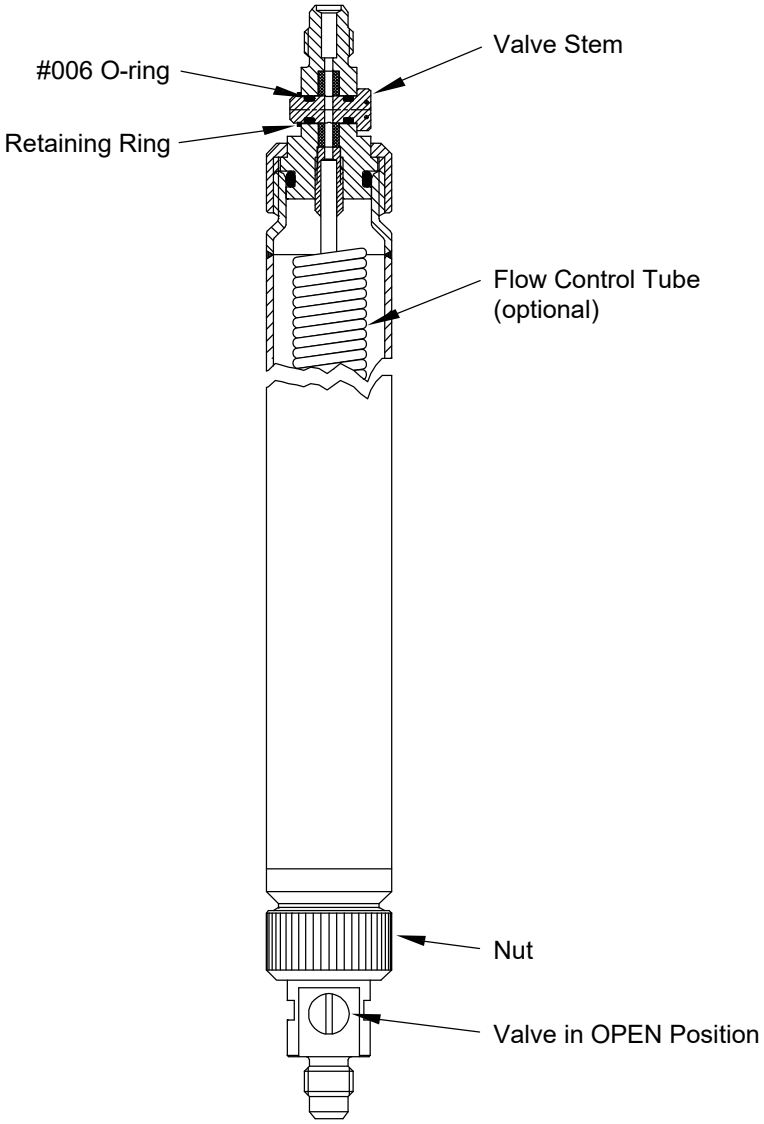


Figure 2. Model 2408 Sample Container with optional Flow Control Tube installed



8 MODEL 2207 INTER-CONNECT HOSES

8.1 Hose Cleaning and Maintenance

Under normal use, the Inter-Connect hoses can be cleaned and rinsed by running fluids through the hose. These should be cleaned and inspected after every use to make sure that they are performing their function properly.

1. They can be replaced when it is deemed necessary by the operator.
2. The Inter-Connect hose uses a Teflon hose liner and #004 Viton O-Rings (provided with the hose at purchase and stocked in the spare parts kit for replacement).

3. If the hose is replaced, the length of the Teflon hose should not exceed the extended length of the Inter-Connect hose.

8.2 Hose Operation

When the Inter-Connect hoses are attached to the sample container valves, care should be taken by the operator to make sure that they are attaching the wrenches to the rotating nut of the Inter-Connect hose and to the wrench flats on the sample container valve. Do not loosen the nut and Inter-Connect hose socket when the sample container is attached to the hose. By doing this, the operator may inadvertently disassemble the Inter-Connect hose causing a leak or a mechanical failure of the hose.

When handling connected sample containers at the surface take care not to over-bend the Inter-Connect hoses. Momentary bending may not damage the hoses, but they are not meant to be bent at angles greater than 180 degrees for more than a few seconds.

8.3 Hose Storage

Hoses should be completely removed from the sample containers when not in use to reduce bending and strain. The hoses should not be stored under any kind of tension or weight or be stored in a way that heavy objects are placed upon them.

Attachment F.3:
Field Logs

Hydraulic Pumping Port Operation

Field Data Sheet

Project: _____ Sampling Zone No(s).: _____ Date: _____

Location: _____ Depth to Water in Westbay: _____ Job No.: _____

Monitoring Well No.: _____ Depth to Water in Target Zone: _____ Operators: _____

Desired Operation (Open or Close)	Surface Preparation					Position Sampler			Pumping Port Operation Checks						Comments
	Face Place A or B	Water in Container?[1] (Y/N)	Container Pressure (psi)[1]	Sampler Function Checks[2]	Sampler Valve Closed Container Valve Open	Lower into Well	Pressurize Container downhole?[3] (Y/N)	Release Arm, Locate in Port	Pressure in Westbay (psia)	Shoe Out, Pressure (psia)	Open Valve	Close Valve	Shoe In, Pressure (psia)	Test for Port Open or Closed	

Notes: 1. Prepare sample container at surface for either low-pressure operation (Bottle A in Figure 3) or pressurized operation (Bottle B in Figure 3).
2. Sampler function checks as described in the Model 2532 Sampler Probe Manual.
3. If pressurizing empty container downhole, lower sampler to >120 m below water, open sampler valve, allow container to fill, close sampler valve.

Westbay Piezometric Pressures/Levels

Field Data and Calculation Sheet

Well No.: _____

Datum: _____

Elev. G.S.: _____

Height of Westbay above G.S.: _____

Elev. top of Westbay Casing: _____

Reference Elevation: _____

Borehole angle: _____

Probe Type: _____

Serial No.: _____

Probe Range: _____

Westbay Casing Type: _____

Sampler Valve Position: _____

Date: _____

Client: _____

Job No.: _____

Location: _____

Weather: _____

Operator: _____

Ambient Reading (P_{atm}) (pressure, temperature, time)

Start: Pressure _____ Finish: _____

Temp _____ _____

Time _____ _____

Note: "Port position" in angled boreholes refer to position along drillhole. True depth (Dp) needs to be calculated using borehole angle and deviation data to calculate zone piezometric level (Dz).

P_{atm} _____ **psi**

Port No.	Port Position From Log (ft)	Port Position From Cable (ft)	True Port Depth "Dp" (ft)	Fluid Pressure Readings					Pressure Head Outside Port (ft) H = (P2-Patm)/w	Piez. Level Outside Port (ft) Dz = Dp - H	Comments
				Inside Casing (P1)	Outside Casing (P2)	Time H:M:S	Probe Temp. (°C)	Inside Casing (P1)			

Notes: w = 0.4335 psi/ft (1.422psi/m) of H_2O Dz = piezometric level in zone Patm = atmospheric pressure H = pressure head of water in zone Dp = true depth of measurement port

Westbay Well Groundwater Sampling

Field Data Sheet

Project: _____

Monitoring Well No.: _____

Sampling Zone No(s).: _____

Ambiant VOCs (ppm): _____

Headspace VOCs (ppm): _____

Date: _____

Start Time: _____ Atm. Reading: _____

End Time: _____ Atm. Reading: _____

Sheet: ____ of ____

Sampled by: _____

Port No.	Run No.	Surface Function Tests (probe in flushing collar)						Position Sampler				Sample Collection Checks (probe located at sampling zone in Westbay casing)								Comments (volume recovered)
		Shoe Out	Close Valve	Check Vacuum	Open Valve	Evacuate Bottles (3-5 psi)	Close Valve	Shoe In-Arm In	Locate Port	Arm Out	Land Probe	Pressure in Westbay ( )	Shoe Out	Zone Pressure ( )	Open Valve	Zone Pressure ( )	Close Valve	Shoe In	Pressure in Westbay ( )	

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 Identification Numbers: _____

Sampling Equipment: _____

Appearance of Sample: COLOR: _____

SEDIMENT: _____

OTHER: _____

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES / NUMBER AND TYPES OF SAMPLE CONTAINERS USED:		
VOAs: N/A	**Amber : N/A**	**Poly** 125 mL unpres HDPE

Westbay Well Groundwater Sampling

Field Data Sheet

Port No.	Run No.	Surface Function Tests (probe in flushing collar)						Position Sampler				Sample Collection Checks (probe located at sampling zone in Westbay casing)								Comments (volume recovered)
		Shoe Out	Close Valve	Check Vacuum	Open Valve	Evacuate Bottles (3-5 psi)	Close Valve	Shoe In-Arm In	Locate Port	Arm Out	Land Probe	Pressure in Westbay ( )	Shoe Out	Zone Pressure ( )	Open Valve	Zone Pressure ( )	Close Valve	Shoe In	Pressure in Westbay ( )	

Appendix G:
Selected Figures from
Final Evaluation Report (NAVFAC Atlantic 2023)

(b) (3)

[redacted]

Figure 1
Current Setup
Pearl Harbor - Red Hill
Collection Tanks

(b) (3)

[redacted]

Figure 1
Current Setup
Pearl Harbor - Building Red Hill
Overview

Appendix H:
Response to Comments

The regulator comments presented in this appendix were made on the June 2024 draft version of the Work Plan and, therefore, the section references and page numbers may no longer be applicable. Initial responses to priority comments were submitted to regulatory agencies in October 2024. The responses to comments have been updated based on the results of the expedited sampling and decisions made during the September 2025 scoping meeting #5. Updates to the responses are noted and provided, where applicable.

Appendix H.1:
DOH

JOSH GREEN, M.D.
GOVERNOR OF HAWAI'I
KE KIA'ĀINA O KA MOKU'ĀINA 'O HAWAI'I

KENNETH S. FINK, MD, MGA, MPH
DIRECTOR OF HEALTH
KA LUNA HO'OKELE

STATE OF HAWAII
DEPARTMENT OF HEALTH
KA 'OIHANA OLAKINO
P. O. BOX 3378
HONOLULU, HI 96801-3378

In reply, please refer to:
File:
210969 AH

August 12, 2024

Ms. Jocelyn Tamashiro
Environmental Remediation Manager
Environmental Restoration, Department of the Navy
Naval Facilities Engineering Command, Hawaii
400 Marshall Road, Building X-11
Pearl Harbor, Hawaii 96860
Sent via e-mail to: jocelyn.tamashiro.civ@us.navy.mil

Facility/Site: Red Hill Bulk Fuel Storage Facility

Subject: Review of Draft Remedial Investigation Work Plan, Per- and Polyfluoroalkyl Substances Release, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Oahu, HI, Pearl Harbor HI FISC Site 30; dated June 2024

Dear Ms. Tamashiro:

The Hawaii Department of Health (HDOH) Hazard Evaluation and Emergency Response (HEER) Office has reviewed the above-referenced document for the Red Hill Bulk Fuel Storage Facility (RHBFSF) site and has the following comments:

General Comments:

1. Throughout the work plan where there are discussions of previous sampling data, concentrations of PFAS compounds are not consistently compared to HDOH Tier 1 (unrestricted) Environmental Action Levels (EALs). Concentrations of PFAS compounds from soil confirmation samples, routine groundwater monitoring, and the September 2023 Baseline Sampling Event had exceedances of HDOH Tier 1 EALs. Thus, please revise the document to ensure consistency in comparison of concentrations of PFAS compounds from past sampling events to current HDOH Tier 1 EALs. Please also note in the text that where "grab" or "discrete" soil sampling methods were conducted rather than Decision Unit Multi-Increment Sampling (DU-MIS) methods required by HDOH, the data may be considered in determining presence of chemicals of potential concern (COPCs), but the data may not be used for final decision-making.

2. HDOH is of the understanding that a formal Preliminary Assessment (PA) and Site Inspection (SI) for PFAS have not occurred at the RHBFSF, and the Navy instead intends to proceed immediately to the Remedial Investigation (RI) phase. This report begins by stating that the intent of the RI is solely to investigate for PFAS associated with known and potential undocumented

AFFF releases at the site. HDOH requests, however, that locations that stored and/or transferred AFFF be included as potential sources, and facilities known to be associated with PFAS contamination, such as wastewater treatment facilities, landfills, plating operations, etc. be included as potential sources as well. Two additional potential sources of PFAS within the RHBFSF that should be investigated include the Oily Waste Disposal Facility (OWDF) site and the Collection, Holding, and Transfer (CHT) Tank. In lieu of a formal PA, the Navy should, at a minimum, conduct a historical review to identify any additional potential PFAS sources within the RHBFSF and include those sites in for further evaluation in the RI.

Groundwater Monitoring

3. HDOH requests that initial sampling of groundwater adhere to the minimum requirements, as agreed upon by the Navy, the EPA, and HDOH during meetings that occurred on July 3, 9, 12, and 17, 2024. Revise all areas of the report detailing groundwater sampling activities to reflect the following requirements:

    a. Wells to be sampled include RHMW-2254, RHP01, RHP02, RHP03, RHP-06, RHP-07, RHP-08, RHMW-06, RHMW-17, RHMW-17S, RHMW-17D, RHP04A, RHP04B, RHP04C, RHP-05, OWDPMW01, RHMW-18, RHMW-20, RHMW-07, RHMW-08, RHMW-21, RHMW-04, RHP-08B, RHP-08C, RHMW01R, RHMW-02, RHMW-03, RHMW-05, OWDFMW03A, OWDFMW03B, OWDFMW08A, and OWDFMW08B.

    b. Sampling of the above groundwater monitoring wells will begin in September and will occur quarterly for at least one year, after which wells to be sampled, and frequency and duration of sampling will be re-evaluated by the Navy, the EPA, and HDOH.

    c. Laboratory analysis of samples obtained from the above groundwater monitoring wells will be EPA method 1633 for 40 PFAS compounds.

4. In addition to analysis via EPA method 1633, HDOH requests that soil and groundwater samples are processed and analyzed for Total Oxidizable Precursors (TOPs) and Total Organic Fluorine (TOF) to calculate a cumulative Hazard Index for PFAS and determine Total PFAS Risk per HDOH HEER Office's updated *Interim Soil and Water Environmental Action Levels (EALs) for Perfluoroalkyl and Polyfluoroalkyl Substances (PFASs)* (2024 HDOH PFAS Guidance) (HDOH, 2024): https://health.hawaii.gov/heer/files/2024/07/PFASEALGuidanceHIDOHApril2024Rev070524.pdf. Further, please require that the laboratory take an MI subsample size of 10 grams for soil analysis. Revise all areas of the work plan that discuss laboratory analysis of soil, sediment, and groundwater samples to include TOPs and TOF analysis in addition to EPA method 1633, and a laboratory subsample size of 10 grams.

5. During the aforementioned meetings, the EPA also requested sampling of groundwater monitoring wells NMW-32, NMW-30, and NMW-12A. The request was made to evaluate PFAS concentrations and provide delineation in the area near (b) (3), and provide delineation of concentrations potentially downgradient of (b) (3) due to concentrations of PFAS exceeding the EPA's maximum contaminant levels (MCLs) during the Navy's September 2023 Baseline Sampling Event. HDOH concurs with EPA's requests and rationale, and notes that concentrations of PFAS also exceeded HDOH Tier 1 (unrestricted) EALs and generated a Total PFAS Risk Hazard Index of >1 during this event. Thus, HDOH also requests that NMW-32, NMW-30, and NMW-12A be included in initial groundwater sampling.

6. Please reconfirm that groundwater monitoring well RHMW2254-01 will be sampled bi-monthly in order to monitor the source water at the (b) (3) as previously confirmed by the Navy in a letter to EPA and HDOH dated June 21, 2024.

Soil Sampling and Analysis

7. HDOH does not accept discrete, or grab, soil sampling as a representative method of sampling that can be used for final decision-making because grab soil sampling has been demonstrated to be unreliable. Thus, HDOH requires that DU-MIS collection of soil samples be conducted in accordance with HDOH guidance. HDOH guidance on DU-MIS can be found in our HDOH HEER Office *Technical Guidance Manual* (TGM) (HDOH, 2008 Interim Final last updated 2024): https://health.hawaii.gov/heer/tgm/. Enclosed is HDOH letter 177334 MR, dated October 28, 2020, which discusses HDOH's position on DU-MIS sampling of soil versus grab soil sampling and the use of HDOH guidance.

Specific Comments:

8. Worksheet #5 (PDF pg. 29): Please revise to depict lines of communication between HDOH and the Navy in an equal position as EPA and delete the "line of authority" from EPA to HDOH. Please also delete the line of communication between HDOH and the Navy's contractor. HDOH should be able to deal directly with the Navy when necessary.

9. Worksheet #8 (PDF pg. 35): Please revise to include the 2024 HDOH PFAS Guidance as guidance that will be used during soil and groundwater sampling and analysis.

10. Worksheet #10, Table 10-1 (PDF pg. 50): For all future reports, all concentrations of PFAS compounds should be compared to EPA MCLs and HDOH Tier 1 (unrestricted) EALs in addition to EPA RSLs. Further, all future reports should include Pre-TOPs, Post-TOPs, and Excess Fluorine hazard indices with a final Total PFAS Risk Hazard Index per sample.

11. Worksheet #10, Section 10.2.8.3 (PDF pg. 51) only includes groundwater monitoring wells RHP01, RHP02, RHP03, RHP06, and RHP07 as wells with concentrations of 6:2 FTS as non-detect with PFOS exceeding screening criteria, leaving out NMW32. Does the omission of NMW32 imply that concentrations of PFAS compounds in this well could be related to the AFFF concentrate release of November 2022 and/or a release of modern formulations of AFFF?

12. Table 10-2 (PDF pg. 52): Revise the table to include concentrations of PFAS obtained during the September 2023 Baseline PFAS Sampling Event.

13. Worksheet #10, Section 10.2.8.4 (PDF pg. 53): Please state that HDOH rescinded the No Further Action status of the Oily Waste Disposal Facility (OWDF) on April 8, 2024, due to information provided via power point presentation during a Navy briefing to HDOH and EPA in February 2024, lessons learned from the November 2021 petroleum release from the RHBFSF, and the requirement for institutional controls documented in an environmental hazard management plan.

14. Worksheet #10, Section 10.4.1 (PDF pg. 55): This section states that the former slop tank was in use from approximately 1963 to the mid to late 1960s. Please revise to reflect the date at which use of the slop tank actually ceased.

15. Worksheet #10, Section 10.4.3 (PDF pg. 58): What is the basis for the conclusion that there are not any ecological receptors associated with Halawa Stream? Include more details on the conclusions gathered from the referenced report, *Red Hill Bulk Fuel Storage Facility Final Technical Report, Pearl Harbor, Hawaii* (DON, 2007).

16. Worksheet #11, Section 11.3 (PDF pg. 60): Project screening levels (PSLs) must include HDOH Tier 1 (unrestricted) EALs and Total PFAS Risk per the 2024 HDOH PFAS Guidance. Revise all sections of the document referring to PSLs to include Total PFAS Risk.

17. Worksheet #11, Section 11.3 (PDF pg. 60): Revise to include PFAS analytical results from the September 2023 Baseline PFAS Sampling Event as a primary decision input.

18. Worksheet #11, Section 11.3 (PDF pg. 60): Revise to include an environmental hazard evaluation per the HDOH HEER Office TGM in addition to a human health risk assessment and ecological risk assessment to be developed from soil, sediment, and groundwater analytical results.

19. Worksheet #11, Section 11.4 (PDF pg. 61): Revise Area B to include the OWDF site and the CHT tank.

20. Worksheet #11, Section 11.6.2 (PDF pg. 62): Include the HDOH HEER Office TGM and HDOH PFAS Guidance to the list of methodologies which will minimize decision errors.

21. Worksheet #12 (PDF pg. 65): Revise collection frequency of equipment rinsate blanks to one per sampling team per day in addition to per matrix.

22. Worksheet #12 (PDF pg. 65) lists relative percent differences (RPDs) of ≤50% for water and ≤100% for soil and sediment under measurement performance criteria, with Section 10.6.1.2 of the HDOH HEER Office TGM as a source for those criteria, which is an incorrect reference. Section 10.6.1 of the HDOH HEER Office TGM discusses field replicates, or duplicates, which states that a field replicate precision of approximately 10-35% is generally established as a data quality objective (DQO) for discrete, or grab, sampling. For DU-MIS methodology, a relative standard deviation (RSD) of <35% is the recommended DQO. Thus, the proposed RPDs must be revised to reflect a maximum RPD of 35% for water, and for soil and sediment, two sets of DU-MIS replicates must be collected to establish an RSD of <35%.

23. Worksheet #13 (PDF pg. 67): A Data Source and Data Generator for the Release Report section cites a document from the HDOH "Hansen's Disease Branch." Please revise to HDOH "HEER Office."

24. Worksheet #14, Section 14.4 (PDF pg. 71): HDOH does not allow for final decision making to be based on discrete, or grab, soil sampling methodology as grab sampling has been demonstrated to be unreliable. HDOH instead requires that soil samples be collected via DU-MIS methodology in accordance with the HDOH HEER Office TGM. Revise all sections discussing soil and sediment sampling to the requirements in Comments 24a and 24b below.

    a. Area A: All soil samples must be obtained via DU-MIS methodology. Source DUs should include the Former AFFF 200 Gallon tank area and slope to the below pavement, the drainage swale, and surge rock/drainage area at the end of the drainage swale. The remainder of the grassy areas within Area A should be perimeter DUs (area west of Building 313, south of Building 313, east of the Former 200-gallon tank with slope DU, and the grassy areas south of the excavated areas alongside the road). The depths of the

surface DUs should be 0-6 inches, and a second vertical DU should be under the surface DUs from 6-12 inches. All locations of borings as proposed within this report for the purpose of determining the vertical extent of residual contamination are acceptable to HDOH. However, these borings should be treated as exploratory borings per the HDOH HEER Office TGM which designate DU intervals along the soil core which are then sampled via MIS methodology. HDOH requires a minimum of 50 increments collected per MI sample, and DU size must not exceed 5,000 sq. ft. (or 100 cubic yards in volume).

b. Area B: All soil samples should be obtained via DU-MIS methodology. All locations of borings as proposed within this report are acceptable to HDOH. However, these borings must be treated as exploratory borings per the HDOH HEER Office TGM which designate DU intervals along the soil core which are then sampled via MIS methodology. Further, each proposed boring location can serve as the center of a surface soil DU, and a separate DU for the CHT tank is required. HDOH requires a minimum of 50 increments collected per MI sample, and DU size must not exceed 5,000 sq. ft. (or 100 cubic yards).

25. Worksheet #14, Section 14.5 (PDF pg. 71): HDOH suggests that the groundwater monitoring wells to be installed into the perched aquifer be 2 inches in size, or large enough to be able to install transducers and/or bail groundwater for sampling purposes, versus a 4 inch well as suggested by HDOH and the Department of Land and Natural Resources for installation of RHMW17 and 17S/17D.

26. Worksheet #14, Section 14.5.2 (PDF pg. 73): Provide dates of logging to HDOH at least 2 weeks prior to allow for attendance at drilling, logging, installation, etc. activities regardless of any scenarios. Please arrange military escorts and/or NAVFAC representatives during such visits.

27. Worksheet #14, Section 14.5.5 (PDF pg. 76): In addition to an elevated PID reading, any olfactory and/or visual indications of free product or gross contamination should be included in the rationales for determining depth to set conductor casing.

28. Worksheet #14, Section 14.5.5 (PDF pg. 76): Please clarify that a conductor casing will be required for all contaminated perched groundwater at any depth where significant inflow to the borehole cannot be prevented by grouting.

29. Worksheet #14, Section 14.5.5 (PDF pg. 76): Revise to reflect one of the following methods of grouting, and ensure all details are included: 1) Ensure that the driller will grout the annular space all around the maximum dimension of the conductor casing with cement-bentonite grout, either by pressure grouting through the conductor casing using a steel tremie pipe placed through a packer assembly, or by pumping through a steel tremie pipe placed on the outside of the conductor casing, or 2) If tremie grouting is conducted, it will be performed in a two-step process; first, the base of the conductor casing will be grouted in place with a 3- to 5-ft-thick cement-bentonite grout plug, then the grout plug will be left undisturbed for a minimum of 24 hours for curing before emplacing grout above the plug to the surface with a steel tremie pipe. Placing the grout in the annular space may be done in stages or lifts with time allowed for the grout to set so as to prevent distortion or collapse of the casing by heat and/or pressure. Following the grouting procedure, the grout will be left undisturbed for a minimum of 24 hours curing.

30. Worksheet #14, Sections 14.6.1.1, 14.6.1.2, and 14.6.1.3 (PDF pgs. 79-80): Provide the rationale behind choosing the flow rate and determining the criteria for the conductor casing. Also, how will inflow and outflow be measured?

31. Worksheet #14, Section 14.6.1.4 (PDF pg. 80): If contaminated soil is encountered, samples must be collected and analyzed for petroleum constituents and PFAS compounds per the HDOH HEER Office TGM and the 2024 HDOH PFAS Guidance. Ensure that the following are also included for analysis: 2-2-methoxyethoxyethanol (EPA method 8270), 2-2-butoxyethoxyethanol (EPA method SW8015C), High resolution GC/FID fingerprint with n-alkanes and isoprenoids (EPA method 8015M), and SVOCs (EPA Method 8270E). In addition to SVOC priority pollutant data, ensure non-target analysis is performed (surfactants, polars, etc.).

32. Worksheet #15 (PDF pg. 89): HDOH does not agree in that analytes without currently available screening values will not be further evaluated. Revise to state that all PFAS compounds, plus TOPs and TOF should be analyzed during all future events to continue gathering data for future use.

33. Worksheet #15 (PDF pg. 89): The 1994 FFA states that state standards must be taken into account at the RI phase and should be addressed as early as possible within the CERCLA process. HDOH does not accept state standards beginning with the feasibility study phase as adequate data would not have been gathered in order to determine potential alternatives. Thus, revise to state that state standards will be used during this RI phase.

34. Worksheet #16 (PDF pg. 97): Revise to include submittal of a Draft Final RI workplan for HDOH and EPA review before proceeding to the Final version of the document. Further, ensure a regulatory review period of 60 days is granted to both EPA and HDOH.

35. Worksheet #16 (PDF pg. 97): HDOH requests that laboratory reports be submitted to both EPA and HDOH as soon as they are received. Further, ensure that raw data from laboratory analysis of samples is included (i.e. EDD files, chromatograms in ASCII files and text files, etc.).

36. Worksheet #21 (PDF pg. 115): Revise to include both the HDOH PFAS Guidance and HDOH HEER Office TGM as sampling references.

37. Worksheet #23 (PDF pg. 119): Revise to include TOPs and TOF as methods for analysis of samples. Further, provide information for the laboratory (name, address, and point of contact) that will be used to analyze obtained samples.

38. Figure 7 (PDF pg. 165): Include On-Site Construction Workers as potential human receptors for Area B.

39. Figure 8 (PDF pg. 167): What was the standard or guidance used to make the “Insignificant” determination for multiple pathways of the conceptual site model? HDOH considers a pathway as Incomplete, Potentially Complete, or Complete, thus revise all “Insignificant” determinations to “Potentially Complete” until data collected through the RI can provide information as to a more appropriate determination.

If you have any questions or should you need a hardcopy of this letter, please feel free to contact me at 808-586-4249 or by email at allison.hutto@doh.hawaii.gov.

Sincerely,

Allison Hutto

Allison Hutto
Remedial Project Manager
Hazard Evaluation and Emergency Response Office
Hawaii Department of Health

cc: Mr. Chris Lichens, EPA, via email.

Enclosure: HDOH Comment Letter 177334 MR (with attachments)

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In reply, please refer to:
File:
177334 MR

October 28, 2020

Jan Kotoshirodo
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Subject: Response to Navy email dated September 9, 2020 regarding the use of discrete sample data for PFAS investigations

Dear Ms. Kotoshirodo:

This letter is in response to your email dated September 9, 2020, requesting clarification of the Hawai'i Department of Health (HDOH), Hazard Evaluation and Emergency Response (HEER) Office acceptance of discrete data as part of a Preliminary Assessment (PA) or Site Investigation (SI) for PFAS, to be carried out by the Navy. In summary, HDOH does not accept the use of discrete sample data for final decision-making as part of an environmental investigation, including under the following circumstances:

1) Establishing the presence or absence of a contaminant above levels of potential concern,
2) Characterizing the extent and magnitude of contamination, or
3) Estimating a mean, contaminant concentration for a targeted exposure area as part of a risk assessment.

The general basis of this position is summarized below. A more in-depth discussion of this issue is provided in the attached letter to the US Environmental Protection Agency dated August 19, 2019 (Attachment 1). Your email was specific to the investigation of soil and sediment contaminated with perfluoroalkyl substances (PFASs). The general unreliability and unacceptability of discrete sample data apply to all contaminants, however, as does the following discussion.

As used in the environmental industry, a "discrete sample" is a small amount of soil or sediment, typically 100 to 300 grams, collected from a single point with an area targeted for investigation. The sample is submitted to a laboratory for analysis, where an attempt to "homogenize" the material might or might not be undertaken. A small subsample of the material, typically one to ten grams, is then collected from a single location and analyzed for targeted contaminants of concern. The resulting data are used to approximate the lateral and vertical extent of contamination above levels of potential concern

and/or used to estimate the mean concentration of the contaminant within a designated, exposure area for assessment of risk.

Although widely used as an integral part of environmental investigations since the 1980s, the consistent reliability of discrete sample data for either site characterization or risk assessment purposes have never been demonstrated in the field. Quite the opposite, as cautioned by field workers as early as the late 1980s and as demonstrated in field research more recently carried out by our office; discrete sample data can be highly unreliable for both aspects of a site investigation (Brewer et al, 2017a,b). This is due to multiple factors, including:

- Inherent, random variability of contaminant concentrations (i.e., contaminant distribution) in soil and sediment between closely located, discrete points,

- Similar random (and unresolvable) variability of contaminant concentration within individual, discrete masses of soil and sediment submitted to a laboratory for analysis, and

- Inadequate number of sample collection points and total sample mass for estimation of a mean contaminant concentration for a targeted area and volume of material.

The implications of these deceptively simple observations are significant – data provided by the laboratory cannot be reliably considered to be representative of the sample provided and the sample provided cannot reliably be assumed to be representative of the immediate area where it was collected. Site characterization errors, reflected in the need for multiple remobilizations with no clear end point and the unexpected discovery of additional contamination outside of areas initially targeted for remediation, are directly tied to these unavoidable attributes of contaminants in soil and sediment. Such errors in sample collection routinely result in significant increases in the time and cost to complete a site investigation, failed remedial actions and, in some cases, considerable overestimation or underestimation of risk and uncertainty in the appropriateness of final decisions.

The science is very clear as fortunately is the solution. Consistently reliable data for particulate media such as soil or sediment are obtained by following a three-step process:

1) Designation of site-specific, risk-based or remediation-based areas and volumes of soil for testing, referred to as "Decision Units (DUs);"

2) Preparation of a single, representative sample for each DU by combining a minimum of 1 to 2 kilograms soil or sediment from a large number of points (default 50) within each DU, referred to in HDOH guidance as a "Multi Increment" sample (MIS); and

3) Proper processing the sample at the laboratory (e.g., air drying and sieving to target particle size) to ensure that a representative subsample that meets minimum mass requirements (e.g., 10g) is collected and tested. The basis and implementation of such "DU-MIS" investigation approaches is discussed in Section 3, 4 and 5 of the HDOH *Technical Guidance Manual* (TGM; HDOH 2016). Links to in-depth, recorded, DU-MIS training webinars on are posted to the HEER Office webpage.

HEER Office staff began raising concerns with the Navy (and USEPA) about reliance on discrete sample data for final decision making as early as 2005. We documented our initial concerns regarding

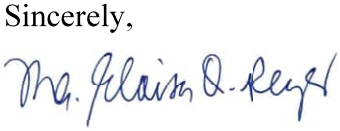
site characterization in a letter to NAVFAC Hawai'i in 2011 (included as an attachment to Attachment 1; USEPA Region 9 cc'd). HEER Office staff began to raise concerns regarding the reliability of discrete sample data for use in risk assessments soon afterwards. Our field study of discrete sample data variability and reliability documented that the mean contaminant concentration estimated for a targeted area could vary dramatically between independent, replicate sets of data (refer to Brewer et al. 2017a, b). This highlighted unseen but potentially significant error in risk assessments that relied on a single set of discrete sample data for final decision-making. We highlighted this concern in a follow-up letter to risk assessors with USEPA Region 9 who assist in NAVFAC-Hawai'i projects dated August 19, 2019 (see Attachment 1; NAVFAC-Hawai'i cc'd). These issues, and an introduction to DU-MIS investigation methods, are summarized in a Fact Sheet published by our office in March 2020 (Attachment 2).

The HDOH Solid and Hazardous Waste Branch (SHWB) informally required the use of DU-MIS data at sites overseen by that office since the publication of initial HEER Office guidance in 2009 and formally adopted a requirement for the use of DU-MIS data in final decision-making in a technical memorandum dated September 23, 2019 (Attachment 3). The HDOH Clean Water Branch (CWB), working in conjunction with the SHWB requires the collection and use of DU-MIS data for all dredged material that is proposed for reuse in upland areas. The CWB also requires the collection of Multi Increment type samples for monitoring of turbidity in surface water during dredging projects (HDOH 2015a, b). The collection of DU-MIS data is also required for disposal of soil by several landfill operators in Hawai'i and is being formally incorporated into landfill permits as those permits come up for renewal.

In conclusion, it has been the position of the HEER Office and HDOH in general for some time that, while discrete sample data can be useful for initial, gross characterization of contaminated soil and sediment and initial assessment of risk (discussed in Section 4 of the HEER TGM), DU-MIS data are required for final decision-making. HDOH guidance allows the use of discrete sample data for initial site characterization and risk assessment purposes, but final decisions should be based on DU-MIS data collected in accordance with the HEER Office TGM. While possible in theory, proposals to rely on discrete sample data for final decisions by a Navy project manager must address the concerns raised above. Note that HDOH has historically not required retesting of sites where discrete sample data were used for final decision-making purposes, although this might be prudent for a small subset of sensitive cases where data variability is suspected to be especially high.

We would welcome the opportunity to discuss the continued use and reliability of discrete soil and sediment sample data and the need for DU-MIS data for confirmation purposes with Navy staff and mutually develop ways to move forward. Please let us know if you would like to schedule a call to discuss this further. You may contact me at maria.reyes@doh.hawaii.gov and Dr. Roger Brewer at roger.brewer@doh.hawaii.gov. Thank you very much for your time and consideration in this matter.

Sincerely,



Maria Eloisa Q. Reyes, Ph.D.
Remedial Project Manager
Hazard Evaluation and Emergency Response Office

Attachments:

1. HDOH letter to USEPA Region 9: Update to 2011 HDOH Memo Regarding Representative Sample Data, dated August 19, 2019
2. HDOH DU-MIS Fact Sheet, April 2020
3. HDOH Solid Hazardous Waste Branch memorandum requiring use of HEER Office *Technical Guidance Manual* for SHWB projects, September 23, 2019

References:

Brewer, R., Peard, J., and Heskett, M. 2017a. A critical review of discrete soil sample reliability: Part 1 – Field study results. *Soil and Sediment Contamination*. Vol 26, No 1. Available from: http://dx.doi.org/10.1080/15320383.2017.1244171

Brewer, R., Peard, J., and Heskett, M. 2017b. A critical review of discrete soil sample reliability: Part 2 – Implications. *Soil and Sediment Contamination*. Vol 26, No 1. Available from: http://dx.doi.org/10.1080/15320383.2017.1244172

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HDOH. 2015b, Applicable Monitoring and Assessment Plan - Helpful Hints and Supporting Information: Hawai‘i Department of Health, Clean Water Branch.

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In reply, please refer to:
File: 2019-387 RB

August 19, 2019

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Subject: Update to 2011 HDOH Memo Regarding Representative Sample Data

Dear Dr Stralka and Dr Black,

This letter addresses questions you raised in a meeting with staff from the Hawaii Department of Health (HDOH), Hazard Evaluation and Emergency Response (HEER) Office earlier this year regarding the acceptance of discrete soil and sediment sample data at contaminated sites in Hawaii. I was unfortunately unable to attend that meeting.

You asked if HDOH accepts discrete soil and sediment sample data for final decision making as part of a human health or ecological risk assessment. A detailed discussion of this issue is provided in Attachment 1. The short answer is "Yes." This is caveated, however, with a condition that individual, discrete samples be collected, processed and tested in accordance with Gy's sampling theory. The total mass and number of samples collected must also meet sampling theory requirements for "infinite particle" media such as soil and sediment. This typically requires the collection and testing of 1-2 kilograms of soil from at least 50 points within a targeted area. Independent, replicate sets of discrete sample data (minimum two) must be collected and tested to demonstrate total sampling precision and the reproducibility of an estimated exposure point (area) concentration. I am unaware of any discrete sample data project in Hawaii that fully meets these conditions.

We left this question open in a June 27, 2011, HDOH technical memorandum that I prepared following a meeting between our staff earlier that year (Attachment 2). In that meeting, we discussed and I think in general agreed on the high potential for error in determining the extent of contamination based on testing of small, individual masses of soil and sediment from "discrete" points. This is due to the inherent, heterogenous nature of contaminants in soil and sediment and the randomness of the concentration reported for a sample collected at a single point. We demonstrated the range of possible error in the use of discrete sample data to estimate

the extent of contamination in a field study of that we carried out in 2014 (see Attachment 1). The results were alarming but not necessarily surprising, given the common recognized disparity between "co-located" discrete samples collected as part of a site investigation.

The potential for significant error associated with estimation of an exposure point concentration based on a single set of discrete sample data was less well understood, since replicate sets of samples are rarely if ever collected to test data reproducibility. Our 2014 field study demonstrated, however, that the error can indeed be very large and that 95% UCLs based on replicate sets of discrete sample data collected from the same exposure area can vary significantly. This occurs in part because the mass of soil tested and/or the number of points considered in the sample data are inadequate to represent the targeted area and volume of soil.

These types of potential errors in the use of discrete sample data to characterize sites and assess risk motivated our office to begin transitioning to the use of "Decision Unit" and "Multi Increment Sample" investigation methods in 2004 and fully implement the use of "DU-MIS" methods in 2009. The science is very clear - DU-MIS sampling methods are far more reliable and efficient for final decision making than discrete sampling methods. This includes both initial site characterization and assessment of risk. The only question in the case of the latter is whether the degree of hidden error inherent in discrete sample data is tolerable in comparison to safety margins built into toxicity factors and estimates of exposure. This would be a useful topic to explore and discuss in more detail for both soil and sediment investigations.

We would be glad to discuss these issues with you and your group in more detail. Please feel free to contact me at your convenience. Perhaps we could begin by reviewing examples of projects where you feel that discrete sample data were adequate for final decision making to initiate discussions? I would be glad to set up a meeting at our office during your next visit to Hawaii. Please contact me at your convenience (roger.brewer@doh.hawaii.gov).

Sincerely,

Roger C. Brewer, PhD
Senior Environmental Scientist

Cc: Keith Kawaoka, Fenix Grange, Maria Reyes (HDOH); Angeles Herrera, John Chesnutt (USEPA 9), Aaron Poentis, Jan Kotoshirodo, Janice Fukumoto (Navy)

Attachment 1: Discrete Sample Data Reliability (August 19, 2019)

Attachment 2: Multi-Increment versus Discrete Soil Samples (HDOH June 27, 2011)

Attachment 1

Discrete Sample Data Reliability

(HDOH August 19, 2019)

Discrete Sample Data Reliability for Use in Site Characterization and Risk Assessment

2011 Technical Memorandum

In the 2011 meeting between USEPA and HDOH staff documented in the 2011 memorandum (Attachment 2), we discussed concerns regarding the reliability of discrete sample data to estimate the lateral and vertical extent of contamination above potential levels of concern as well as the use of the data in human health and ecological risk assessments.

There was general agreement on the potential for error in the use of discrete sample data for general, site characterization purposes. We tentatively concurred with the continued use of discrete sample data to estimate mean, exposure area concentrations in risk assessments pending further research but we questioned the adequacy of small numbers of samples, for example eight or ten, purported in USEPA guidance to be adequate to represent large areas of contaminated soil.

Post-2011 Research and Experience

Our office carried out a detailed field study of discrete sample data variability in soil in 2015 (HDOH 2015; Brewer et al. 2017a,b). The results of that study as well as with additional experience at sites in Hawaii and discussions with international sampling experts are clear – Data provided by laboratories for a discrete soil sample are not reliably representative of the sample provided, and the sample provided is not reliably representative of the immediate area where it was collected. The only question is the degree of potential error in the data and in final, decision making.

Site Characterization

Our field study suggested that the concentration of a contaminant in soil can randomly vary around a single point by a factor of two under relatively ideal circumstances (e.g., arsenic-contaminated wastewater released to fine-grained soils) and as much as several orders of magnitude under scenarios where tiny "nuggets" of the contaminant are present in the soil (e.g., nuggets of PCB-infused tar from waste dielectric oils). The inherent randomness of discrete sample data is predicted in sampling theory for "infinite particulate media" such as soil and sediment and has been known by the mining and agriculture industries for decades. This phenomenon has only been recently "discovered" by the environmental industry, however. This is in large part due to the fact that the repercussions of erroneous data – failed mining ventures and failed crops in the former, are less obvious in assessments of chronic health risk.

Even so, the unreliability of discrete sample data in environmental work is well known to field workers, where completion of a site investigation can take years only for later data to indicate that the extent and mass of contamination present was much greater than initially thought. This has obvious implications on the continued acceptance of discrete sample data by regulatory agencies to assess the final adequacy of remedial actions.

Risk Assessment

The HDOH field study documented similar concerns with the use of a single set of discrete sample data to estimate the true mean for a targeted exposure area of contaminated soil and

subsequent assessment of risk. In one case (Study Site A – Arsenic), the 95% UCL estimated for random sets of 10, discrete samples collected from the area was consistently *higher* than the more reliable mean estimated by triplicate Multi Increment samples collected from the same area. While this might be used to support a conclusion that a 95% UCL based on discrete sample data is "conservative," it has obvious, negative implications for people concerned about potential impacts to their health as well as for parties required to remediate properties that in reality do not pose a significant risk to human health or the environment.

In the second case (Study Site B – Lead), the 95% UCL predicted from random sets of 10, discrete samples collected from the area fell both below and above the "true" mean concentration of lead in the soil based on DU-MIS data. This highlights the fact that a 95% UCL calculated from a single set of discrete samples is, like data for single points, *random within a largely unknown range of possibilities.*

The randomness and unreliability of 95% UCLs based on discrete sample data was particularly highlighted at the third study site (Study Site C – PCBs), where 95% UCLs based on random, 10-sample data sets varied from as low as 4 mg/kg to over 1,000,000 mg/kg. Such error in the estimation of the mean contaminant concentration for a targeted exposure area could only be reliably identified by the collection and comparison of independent, replicate sets of discrete sample data.

Collection of Representative Sample Data

As I discussed in a February 2019 webinar and again in July 2019 (links posted to the HEER Office webinar webpage), risk assessors "almost got it right" in the 1990s. Risk is of course based on the "mean" or "true" concentration of a contaminant within a designated, exposure area, rather than concentrations reported for individual, small masses of soil within the targeted area. These are referred to as "Exposure Area Decision Units" in Section 3 and Section 4 of the HDOH TGM.

The true mean can only be determined by testing of the entire volume of soil in the exposure area. This is of course not feasible. The mean is instead estimated by collecting and testing soil from a number of points within the exposure area. On this point we still agree.

The objective from an analytical standpoint is to estimate the concentration of the targeted contaminant in the total mass of soil collected. Data for individual points have no meaning in terms of assessing risk. The individual points do not reflect the mean for the exposure area, nor does the mass tested by the laboratory, typically one or ten grams, reflect the default mass of soil assumed to be ingested by young children (200 mg/day) or adults (100 mg/day). The concentration of a contaminant reported by a laboratory will vary with respect to the mass of the soil subsample specifically tested by the laboratory. The range of contaminant concentrations reported therefore also has no meaning in terms of risk.

The use of statistical tests to estimate the mean concentration of a contaminant based on a single set of discrete sample data could in theory provide an acceptably accurate answer, with the limitations noted above. The number of points included and the total mass of soil represented by

the data would also need to meet minimum requirements under sampling theory for testing of "infinite particle media." This is discussed in Section 4 of the HEER TGM.

It makes far more sense and allows for far better data precision to simply combine the individual masses of soil collected within a targeted exposure into a single sample, have the laboratory properly process the sample, collect a representative subsample for analysis and report a single concentration. This is the essence of "Decision Unit" and "Multi Increment Sample" investigation methods, which could be more properly described as "Risk Based Site Characterization." Sampling theory and decades of research by field workers and statisticians in the mining and agriculture industries tells us that for typical, environmental investigations, a sample must be collected from a minimum of 50 points or "increments" (to address distributional heterogeneity) and have a minimum mass of 1-2 kilograms (to address compositional heterogeneity). The total precision of the resulting data is assessed through the collection and testing of independent, replicate samples, as discussed in Section 4 of our TGM. In some cases, the collection of a smaller sample from fewer points might yield accurate data, but this would need to be demonstrated on a site-specific basis. Larger samples comprised of more than 50 increments and having a greater, bulk mass might be required in other instances, as seems to routinely be the case for PCBs and soil contaminated with small fragments of lead.

Environmental professionals well experienced in discrete sampling methods but new to sampling theory and DU-MIS methods typically reach a "compromise" point where they conclude that DU-MIS investigation methods are appropriate for some situations and discrete sample investigation methods are appropriate for others. This is usually due to a premature assumption that discrete samples are required to determine the initial extent of contamination. As demonstrated in our field study as well as in thirty years of "failed" confirmation samples, however, discrete sample data are highly prone to "false negatives," that is, underestimation of the actual extent of contamination present. The extent of contamination is far more reliably determined through the designation of well-placed Decision Units and the collection of Multi Increment samples from each DU. We dedicated an entire webinar to this topic in our 2017, six-part training series on DU-MIS investigation methods (recordings posted to HEER YouTube channel).

Risk assessors sometimes retort that they want to know the "range" of contaminant concentrations in soil collected from individual points as part of their decision making. As discussed in our training workshops and publications, however, the concentration reported for a contaminant in soil is entirely dependent on the mass of soil actually extracted by the laboratory. Greater variability and higher concentrations will be reported for smaller and smaller subsamples. At some scale, the "maximum" concentration of a contaminant in soil, if present, will always be "100%" (Brewer et al. 2017b). The concentration of a contaminant reported for a random subsample collected from a single, random, discrete field sample in turn has no bearing whatsoever on risk. It is a random artifact of the mass of soil tested.

Sediment Research

The majority of past research by our office and other entities have focused on improved sampling methods for soil, but it is rational to assume that similar concerns apply to sediment. The only question is again the relative degree of error in the data and in decision making.

Informal studies in Hawaii and discussions with sediment experts in the US and other countries suggests that data for co-located, discrete samples in sediment that was contaminated prior to being deposited are unlikely to vary to the extreme observed at the HDOH PCB study site but could easily vary by an order of magnitude under some scenarios. This seems to be particularly true for PCBs, similar to our findings for soil.

A detailed field study of discrete sample data variability similar in scope to the soil study carried out in 2015 by HDOH is sorely needed. We propose that such a study be jointly carried out with staff from USEPA Region 9 and other government agencies or research institutions to better understand the reliability of discrete sample data for characterization and assessment of contaminated sediment. The HDOH TGM provides a few examples of DU-MIS investigation methods for sediment but more field research in sample collection methods is also needed. The study could explore more efficient ways to collect representative sediment samples in different aquatic environments, including for example the recent advent of "mini Vibracore" sampling tools.

References

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HDOH, 2016, *Technical Guidance Manual*: Hawai'i Department of Health, Office of Hazard Evaluation and Emergency Response, http://www.hawaiidoh.org/

Attachment 2

Use of Multi-Increment versus Discrete Soil Samples in DoD sites in Hawaii (HDOH June 27, 2011)

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In reply, please refer to:
File:
2011-390 MR

July 15, 2011

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400 Marshall Road, Building X-11
Pearl Harbor, Hawaii 96860

Facility/Site: **Department of Defense (DoD) Sites in Hawaii**

Subject: **Use of Multi-Increment versus Discrete Soil Samples in DoD sites in Hawaii**

Dear Ms. Fukumoto:

In recent years, the multi-increment sampling method has been developed to provide another tool to help in environmental investigations. There still seems to be a lot of questions on when and where multi-increment sampling is appropriate to use. Attached is a memorandum from Dr. Roger Brewer summarizing the key points and recommendations on the use of multi-increment versus discrete sampling methods in investigations of DoD sites in Hawaii. In addition to the HDOH Technical Guidance Manual, these recommendations, resulting from the May 18, 2011 meeting with NAVFAC-HI, NAVFAC-PAC, USEPA Region IX, and HDOH, serve as HDOH guidance on how sites are to be investigated using multi-increment samples. Please advise your contractors and other Navy reviewers who need to know how multi-increment sampling is done, of this guidance.

Should there be any questions, please do not hesitate to contact me at 586-7576. Thank you very much for your time and consideration in this matter.

Sincerely,

Ma. Eloisa Q. Reyes

Maria Eloisa Q. Reyes, Ph.D.
Remedial Project Manager
Hazard Evaluation and Emergency Response Office

Attachment

c: John Chesnutt, U.S. EPA Region 9
Christopher Lichens, U.S. EPA Region 9
Daniel Stralka, U.S. EPA Region 9
Ned Black, U.S. EPA Region 9
Rich Howard, TechLaw, Inc.

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In reply, please refer to:
File: EHA/HEER Office

TO: Fenix Grange, Steven Mow and Maria Reyes
Site Discovery, Assessment and Remediation Section
HEER Office

2011-344-RB

FROM: Roger Brewer RCB
Environmental Hazard Evaluation
HEER Office

DATE: June 27, 2011

SUBJECT: Use of Multi-Increment versus Discrete Soil Samples at Department of Defense (DoD) Sites in Hawai'i

This memo summarizes key points and recommendations on the use of multi-increment (MI) samples (MIS) versus discrete soil samples at DoD sites in Hawai'i, following our May 18, 2011, meeting at Pearl Harbor Navy Base with Janice Fukumoto of NAVFAC and Dan Stralka (human health risk assessor), Ned Black (eco risk assessor), John Chestnut (Federal Facilities manager), Chris Lichens (project manager) of USEPA Region IX. The meeting focused on the use of MIS vs discrete samples for risk assessment purposes as well as the use of MIS vs discrete soil samples for site investigation purposes. This memo reflects similar comments regarding the use of discrete soil samples by USEPA contactors for investigation of a former pesticide mixing site within Pearl Harbor Naval Reservation (HDOH 2011a).

The discussion focused on two main points:

A. Use of the 95% UCL of soil data in human health, risk assessments at DoD sites, and
B. Use of data for a small number of discrete soil samples (e.g., <8) for final decision making purposes during the site investigation stage of a project.

HDOH and USEPA Region IX staff agreed on the first point and further agreed that either discrete or MI samples can be used to accomplish this goal during the Risk Assessment stage of a project. USEPA staff pointed out that the concept of Exposure Area Decision Units (DUs) described in the HEER office *Technical Guidance Manual* (TGM) is identical to the concept of exposure areas described in USEPA risk assessment guidance. Both HDOH and USEPA staff emphasized that an adequate number of discrete soil samples must be collected to calculate a viable 95% UCL. USEPA staff pointed out that a minimum of eight samples is required and usually more, depending on the number and variability of discrete sample data points. HDOH staff suggested that MI samples generally provide higher quality data, given the large number of sample ("increment") points incorporated into the final data and enhanced coverage of the targeted DU.

HDOH and USEPA staff disagreed on the use of a small number of discrete soil samples (e.g., less than eight) to initially screen a site for potential soil contamination concerns during the Site Investigation stage of a project. USEPA staff suggested that the maximum concentration of targeted contaminants reported for a small number of samples could be compared to risk-based screening (action) levels and combined with general knowledge of the site history to determine the need for additional actions. HDOH staff pointed out that, based on their experience with both discrete and MI sample data, this approach is prone to "false negatives" and the risk of declaring a contaminated site to be clean. HDOH staff insisted that high quality data be collected for final, decision making purposes in both the Site Investigation and Risk Assessment stages of a project, regardless of whether discrete or MI samples are used. Additional discussion of this issue is provided below.

Use of Discrete vs MI Soil Sample Data in Risk Assessments

USEPA and HEER staff concurred that either discrete or MI soil samples can be used to characterize targeted Exposure Area DUs as part of a risk assessment. This is also discussed in the HEER office Technical Guidance Manual (TGM; HDOH 2009). USEPA staff noted that the concept of a "Decision Units (DU)" to specify a targeted exposure area in the field is consistent with USEPA risk assessment guidance. The targeted Exposure Area DU should be designated at the beginning of the investigation and either discrete or MI samples then collected to characterize the DU.

If discrete soil sample data are used then a 95% UCL be calculated for estimation of Exposure Area ("Point") Concentrations (EAC). This is done in part because the number of available, discrete sample data points is often inadequate to calculate a reliable Exposure Area Concentration based only on the arithmetic mean. Use of the 95% UCL is intended to help address this issue and estimate a more conservative but still reasonable EAC.

If the maximum-reported concentration exceeds the calculated 95% UCL calculated for the DU, the maximum concentration should not be used for final, decision making purposes. Additional discrete samples (or alternative MI samples) should instead be collected to improve the quality of the data and provide a more representative estimate of the 95% UCL. Although this is rarely done for risk assessments, USEPA staff suggested that is it adequate for initial, Site Investigation purposes. As discussed in the following section, this conflicts with guidance in the HEER office TGM and is not recommended for use in either risk assessments or site investigations.

USEPA staff also recommended that a 95% UCL be calculated for estimation of the Exposure Area Concentration if an MIS approach is used to characterize a DU for risk assessment purposes. This is conservative but reasonable for DoD sites. As discussed in our Technical Guidance Manual, this will require the collect of at least three, replicate MI samples in the targeted DU. USEPA staff agreed that replicate samples do not need to be collected in *every* DU to be evaluated in the risk assessment. Statistical evaluation of replicate data for a DU can be applied to other DUs where replicate samples were not collected, provided that the DUs have a similar contaminant history. This is also discussed in our TGM. In some cases it may be prudent to increase the number or increments included in an MI sample and/or increase the number of replicates collected in order to improve the calculation of a 95% UCL.

Use of MIS vs Discrete Soil Samples in Site Investigations

Both USEPA and HEER staff also agreed that either discrete or MI soil samples can be used during the Site Investigation stage of a project. In either case, however, **Decision Units must be designated to specifically denote the area (and volume) of the soil that the samples are intended to represent as part of the initial stage of a Site Investigation.** This is generally not done as part of traditional, discrete sampling approaches.

Much of the discussion with USEPA staff centered on the use of a small number of discrete samples during the Site Investigation stage of a project and use of the data to determine whether or not the project should continue on to the Remedial Investigation stage. Although this was common practice in the past, **the absence of well-thought-out DUs and reliance on a small number of discrete sample points for final, decision making purposes at the Site Investigation stage of a project can lead to multiple problems** (see attached figure; HDOH 2011b), including:

1. Risk of "false negatives" and erroneous declaration of contaminated sites to be clean;
2. Underestimation of the lateral and vertical extent of contaminated soil surrounding significant spill areas;
3. Confusion over sample-size "hot spots" in areas that are otherwise not significantly contaminated ("false positives");
4. Underestimation of contaminant mass for evaluation of soil treatment options.

These problems occur due to the inherent heterogeneity of contaminant concentrations in soil at the scale of a discrete sample or more specifically the discrete sample aliquot actually analyzed by the laboratory (typically one to thirty grams). Attempting to do so opens the potential for "false negatives" ("A" in attached figure) and the erroneous determination of "clean" boundaries within areas of otherwise contaminated soil (i.e., mean fails screening level but individual sample points may fall below this level; see HDOH 2011b).

Focusing on individual, discrete soil samples can also lead to confusion over "false positives" and outlier "hot spots" ("B" in attached figure) within an otherwise area of clean soil (i.e., mean passes screening level but individual sample points may exceed this level). These problems are expressed in the field by the need for multiple, over-excavations of contaminated soil that had initially been identified based on discrete samples data or misguided attempts to excavate isolated, sample-size "hot spots" of contaminated soil in otherwise clean areas (see HDOH 2009, 2011b).

If discrete samples are to be used during the Site Investigation stage of a project, then an adequate number of samples should be collected from designated DUs to calculate a representative, 95% UCL for all targeted contaminants. The 95% UCL should then be used for final, decision making purposes, including the need to carry the advance the DU into the Remedial Investigation stage of the project. If the maximum-reported concentration exceeds the calculated 95% UCL calculated for the DU, then additional discrete samples should be collected until such time that a viable, 95% UCL can be calculated. Use of the maximum-reported concentration of a contaminant from a small number of discrete samples to screen the site is not acceptable. Subsampling of discrete soil samples to be used to calculate a 95% UCL for risk assessment purposes is not necessary, however, although this may decrease inter-sample variability and help generate a more representative UCL.

In some cases it may be necessary to make preliminary decisions for site investigation, risk assessment and/or remedial actions based on a small number of discrete soil samples (e.g., sites with existing, discrete soil data). **In order to ensure that the potential errors outlined above are adequately addressed, recommendations based on discrete sample data should be confirmed by the collection of followup, Multi-Increment (MI) samples in accordance with HEER office guidance** (HEER 2009, 2011b).

As an alternative, and as recommended in our TGM, an MI sample can be collected and used to characterize targeted DUs at the beginning of a site investigation (HDOH 2009). MIS-investigation approaches help to minimize these types of problems by first designating a specific area/volume of soil that the soil sample(s) is intended to represent and then ensuring that an adequate number of sampling points, or "increments," are collected within that area to estimate a representative mean. Multi-increment samples by definition require that a relatively large number of sample points ("increments") be incorporated into the sample in order to provide a better estimation of mean contaminant concentrations up front. The collection of replicate samples within the same DU (or similar DUs) is intended to help verify that the data reported for targeted contaminants is indeed representative of the true mean. If the replicate data are adequately similar (e.g., Relative Percent Difference +/- 35%) then adjustment of data for individual DUs (e.g., calculation of 95% UCLs) isn't strictly necessary.

Subsurface Investigations

Decision Units must be designated for subsurface investigations. This would ideally involve the designation and characterization of individual, subsurface DU layers, with thirty or more increments collected from each layers. **This will require the installation of thirty or more borings for typical, tabular-shaped DUs (i.e., vs DUs that are thicker than they are wide or long).** If this is not practical, for example due to access or budget constraints, then the limitations of the data should be discussed in the investigation report. As discussed in the HEER office TGM, increments are collected and combined from subsurface DU layers in the same manner as done for surface soils. The mass of increments collected from individual cores may require subsampling in the field in order to reduce the final, bulk MI sample to a manageable size (see HDOH 2009, 2011b). This approach can also be used for the investigation of subsurface soils contaminated with volatile chemicals (HDOH 2011c).

For screening level purposes, it may be useful or even necessary to designate targeted layers *within individual borings* as Decision Units. This is commonly done to initially estimate the lateral and/or vertical extent subsurface contamination. As discussed in the HEER office TGM, the *entire core* from the targeted DU layer should be submitted to the lab for subsampling and analysis. In essence this is a "discrete" sample since the core is not subsampled prior to submittal to the lab for processing and analysis. If the cores are too long or otherwise too bulky then they should be subsampled in the field (refer to HEER office TGM). The reduced confidence in the resulting data should be noted and taken into consideration along with the history of the targeted area and the potential for significant contamination to be present. As discussed above, **preliminary decisions based on based on limited discrete sample data should be confirmed by the collection of followup, Multi-Increment (MI) samples and/or additional, more focused borings in areas of particular concern.** Examples include the collection of MI confirmation samples from sidewalls and floors of excavation initially established based on discrete sample data from borings.

References

HIDOH, 2009, *Technical Guidance Manual*: Hawai'i Department of Health, Office of Hazard Evaluation and Emergency Response, http://www.hawaiidoh.org/

HDOH, 2011a, Comments on May 2011 Data Gap Study Work Plan, Former Pesticide Mixing Site, Waipio Peninsula, Waipahu, Hawai'i (internal memo, June 20, 2011): Hawai'i Department of Health, Office of Hazard Evaluation and Emergency Response.

HDOH, 2011b, *Technical Guidance Manual Notes: Decision Unit and Multi-Increment Sample Investigations (March 2011)*: Hawai'i Department of Health, Office of Hazard Evaluation and Emergency Response, http://www.hawaiidoh.org/

HDOH, 2011c, *Use of Decision Unit and Multi-Increment Soil Sample Investigation Approaches to Characterize a Subsurface Solvent Plume, Site CG110, Hickam Air Force Base, Honolulu, Hawai'i* (March 2011), Hawai'i Department of Health, Office of Hazard Evaluation and Emergency Response, http://www.hawaiidoh.org/

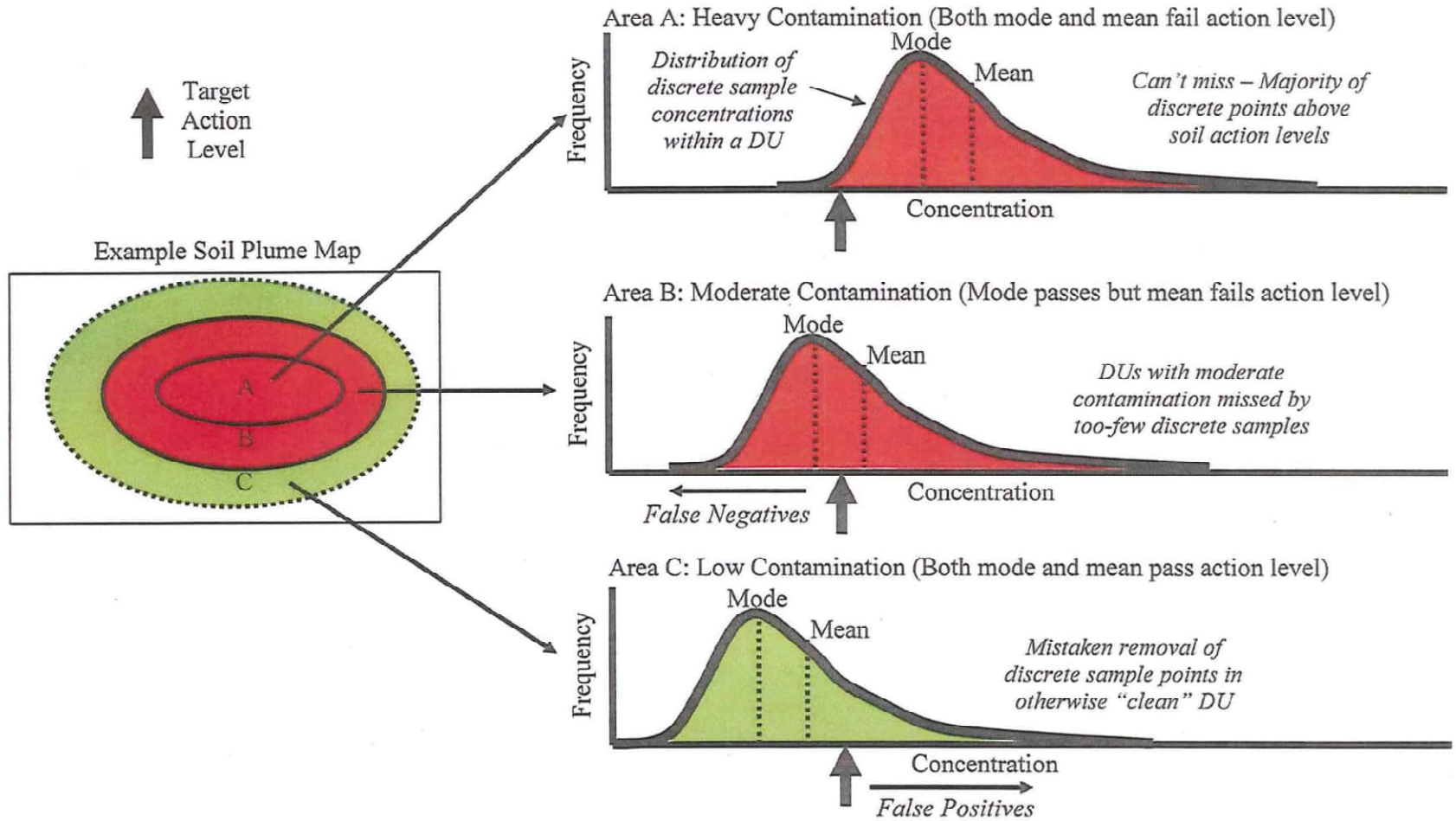


Figure 1 (see also HDOH 2011). Effect of contaminant heterogeneity at the scale of a discrete laboratory subsample on decision making when using a non-representative number of discrete samples or MI increment points. Initial samples likely to fall around the mode. A minimum of thirty to fifty sampling points (discrete or MI) is required to adequately capture the heterogeneity of contaminant distribution within the DU and estimate a representative contaminant mean (and mass). A small number of discrete samples will identify areas of heavy contamination in Scenario A but could underestimate mean concentration and total mass, leading to failed *in situ* remediation. False negatives in Scenario B can lead to an underestimation of contamination extent and failed excavations or *in situ* treatment. False positives in Scenario C lead to unnecessary soil treatment/removal associated with discrete sample points or borings in otherwise clean DUs.

The **Hawai'i Department of Health (HDOH), Hazard Evaluation and Emergency Response Office (HEER Office)** is a state environmental health division whose mission is to protect human health and the environment. The HEER Office provides leadership, support, and partnership in preventing, planning for, responding to, and enforcing environmental laws relating to releases or threats of releases of hazardous substances.

Use of DU-MIS Sampling Methods for Risk-Based Investigation of Contaminated Soil and Sediment

This fact sheet provides government regulators, consultants, property owners and other interested parties with a brief overview of Decision Unit and Multi Increment® Sample (DU-MIS) investigation methods for contaminated soil. (Multi Increment® is registered trademarked of EnviroStat, Inc.) The Fact Sheet focuses on soil, but similar approaches are applied to testing of sediment.

What is DU-MIS?

"Decision Unit" and "Multi Increment Sample" (DU-MIS) investigation methods are a risk-based strategy to test soil and determine if contamination poses a potential threat to human health and the environment. The methods were specifically designed to address concerns related to the unreliability of traditional, discrete sample data. The approach can require additional time and effort at the beginning of a project but will ultimately help to:

- Reduce total project duration and cost;
- Ensure sample data collected are reliable and reproducible;
- Provide a higher degree of confidence that potential risks have been identified and addressed;
- Provide confidence that cleanup actions are only conducted where warranted; and
- Avoid unanticipated delays or even abandonment of projects due to time and cost overruns and lack of a clear endpoint.

DU-MIS investigation methods provide greater confidence in decision making and help to complete environmental projects in a reliable time- and cost-effective manner.

The methods apply to both nonvolatile and volatile contaminants as well as surface and subsurface soils. Similar sampling methods have been used for decades by the mineral exploration and agriculture industries but are relatively new to the environmental industry, where the effects of erroneous data are less evident. Hawai'i first published guidance in 2009.

How is DU-MIS Implemented in the Field?

DU-MIS investigation methods are carried out in a very methodical, step-by-step manner to ensure that the resulting sample data directly answer the questions being asked and are reliably representative of site

conditions. The science behind DU-MIS methods might seem very complex, but implementation in the field is relatively straightforward with some experience.

Step 1: Review the Site History

The first step in "risk-based" investigation is to gain a thorough understanding of the site before samples are collected. This step-by-step process, which includes inspecting the site, talking to people familiar with the site history and compiling existing data, is referred to as "Systematic Planning." The information is summarized in a preliminary "Conceptual Site Model" or "CSM." The CSM is used to design the site investigation.

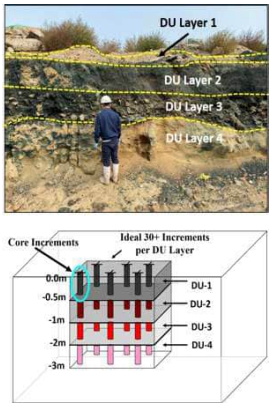
Step 2: Select Areas for Individual Testing

The second step is to designate well-thought-out areas of the site to be individually tested for contamination, referred to as "Decision Units." A DU can be thought of as an area *and volume* of soil that would ideally be sent to a laboratory for testing as a single sample. Each DU is designated to address a specific site investigation question regarding risk assessment or optimization of potential remedial actions. The objective of sample collection is always to determine the mean or "true" concentration of the contaminant for the DU volume of soil *as a whole*.

DUs are designated to answer specific risk or remediation questions. The entire property is often tested.

Risk-based DUs should be selected based on site history and current potential exposure pathways. "Exposure Area" DUs include unpaved areas where children and adults frequently play or work, such as playgrounds, schoolyards, gardens, open areas of commercial and industrial sites and exposed soil at construction sites. These are a very common component of human health risk assessments. The exact size of an Exposure Area DU is necessarily site-specific but normally ranges from a few hundred to a few thousand square meters in area and one hundred to several hundred cubic meters of soil in volume. Assessment of current exposure risk typically focuses on establishing the mean concentration of a contaminant in the upper 10 to 20 centimeters of soil (i.e., surface soil). Assessment of future risk might include the designation and testing of subsurface soil DUs of similar size, assuming the soil could be excavated and spread out at the surface or encountered by workers during construction or utility activities.

Areas of known or suspected, heavily contaminated soil that are almost certain to pose a risk if exposed at the surface should be isolated for separate testing. These are referred to as "Source Area" or "Spill Area" DUs. Source Area DUs are surrounded by anticipated clean, "Boundary DUs" in order to isolate areas of relatively higher contamination and optimize remediation efforts. Successful remediation of contamination can be verified by designation and testing of Exposure Areas DUs in the same locations.



DU Layers are also designated to test subsurface soils.

DUs are designated to characterize both surface soil and, as needed, subsurface soil. Subsurface soil is characterized in terms of stacked, DU Layers. Suspect layers of subsurface soil, identified by site history, initial surface soil data or other observations, should be designated for separate testing in order to bound the vertical extent of the contamination.

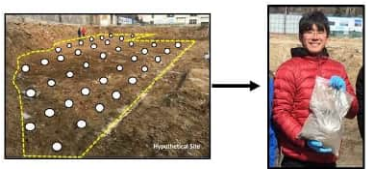
The size and number of DUs designated to characterize a site reflects the "resolution" of the investigation necessary to answer the questions being asked, much like the pixels of a digital photograph.

Five to ten DUs are normally adequate to characterize a simple site. Twenty or more DUs might be required to characterize a complex site.

A very specific, "Decision Statement" that explains the action to be taken when sample data are received is prepared in advance for each DU. This provides a clear pathway forward for subsequent stages of the investigation and helps to expedite overall completion of the project.

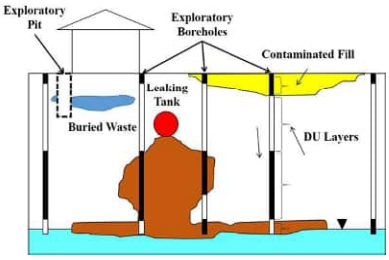
Step 3: Collect a Representative Sample from Each DU Area

Because the collection of the entire volume of soil from a DU and submittal to a laboratory is rarely possible, a representative sample of the soil must instead be collected. The science and statistics behind the collection of a representative sample of soil is complex and involves the need to address both variability between individual particles ("compositional heterogeneity") and variability within the targeted DU ("distributional heterogeneity"). The procedure to collect a sample in the field is, however, relatively straightforward.



A single sample is prepared for each DU by combining small amounts of soil from a large number of points.

A single sample is prepared for each designated DU by collecting and combining small, core-shaped masses of soil from a large number of points within the targeted area. The soil from each point is referred to as an "increment" and the combined increments are referred to as a "Multi Increment (MI)" sample. The sample should be collected from 30 to 75+ points in a systematic, random fashion within the DU area, depending on the nature of the contamination. A default of 50 increments per sample is recommended. Fewer increments might be acceptable for testing of liquid releases (e.g., pesticides). A larger number of increments is required for contaminants present in the soil as clumps or chips (e.g., lead or PCBs). The final mass of the sample must be at least 1 to 3 kilograms or around one liter. Increments are combined in a bottle containing a pre-measured volume of methanol if the sample is to be tested for volatile chemicals.



MI samples can be collected from targeted, DU layers in single, Exploratory Borings for initial investigation of subsurface conditions.

This sample collection method provides a high degree of confidence that that the resulting data will be representative of the targeted area of soil and pertinent to the investigation questions being asked. Just to be certain, however, two additional, independent samples are collected from at least one of the DU areas. These are referred to as "replicate" samples and are used to evaluate the overall precision of the sampling method and reproducibility of the sample data.

Direct-push rigs or excavators can be used to collect increments and prepare MI samples from subsurface DU Layers. If the collection of 50-increment MI samples is not possible due to drilling obstructions or other challenges, then this should be discussed with the overseeing, regulatory agency and the limitations of the resulting data noted. MI sample testing of targeted, DU Layers in individual, "Exploratory Borings" can be useful for very general estimation of the extent and magnitude of subsurface contamination, especially in the case of subsurface petroleum and solvent releases. Be aware, however, that there is a risk of "false negative" results when using this approach and underestimation of contamination and risk. Full, DU-MIS testing of the soil is required for confirmation.

Step 4: Sample Processing and Analysis

Contact the laboratory during the planning phase to ensure the correct sample containers are used and that the laboratory can achieve desired reporting limits and data quality objectives. Select analysis that achieve the desired risk concerns and goals. Avoid testing for unneeded unknowns to keep costs in control. Lead, arsenic, petroleum, PCBs and pesticides like Technical Chlordane and DDT are common contaminants of potential concern.

MI samples to be tested for nonvolatile chemicals are dried, sieved and then carefully subsampled.

Once collected, the sample is sent to a laboratory for processing and testing. The laboratory will not be able to test the entire, 1-2 kg sample. Strict protocols must be followed in order to collect a representative subsample for testing. The sample is normally air dried for 24 to 48 hours and then passed through a sieve to remove large rocks and other debris. A sectoral splitter is then used to collect a representative subsample (third photo in figure). Although more prone to error, the sample can also be spread into a thin layer and a subsample manually collected from a large number of points, similar to how the original sample was collected in the field.

These steps help to ensure that the laboratory data are representative of the sample submitted and that the sample submitted is representative of the targeted DU area. The laboratory is also instructed to collect and test independent, triplicate subsamples from 10% of the samples submitted in order to verify that the subsampling method utilized is reliable and the data generated are reproducible. (Note that this is not necessary for samples preserved in methanol for VOC analysis.)

Step 5: Data Review and Decision Making

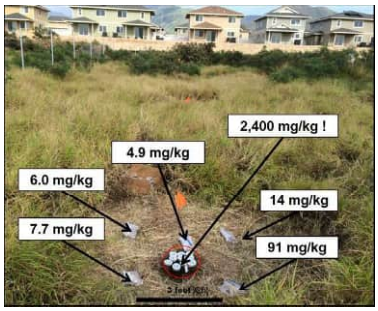
When the laboratory data are received, a review of the overall reliability of the data is made based on field and laboratory replicate samples and other quality control measures. If the replicate data are very different and the problem is determined to be at the laboratory, then determination of the source of error and retesting of the samples might be required. If the problem is determined to be related to the method used to collect the samples in the field, then the sampling process will be reviewed and the collection of new samples might be required. Error associated with sample collection and laboratory testing decreases as experience is gained.

Once the data are determined to be usable, then data for each DU can be directly compared to risk-based screening levels and decisions can be made on the need for cleanup or other soil management actions. The need to collect additional samples should be minimal, assuming that DUs were properly designated at the beginning of the project and DU questions and decision statements were properly prepared ahead of time.

Why are DU-MIS Sampling Methods Necessary?

Guidance for the investigation of contaminated sites published by the USEPA in the 1980s focused on the collection and testing of individual, small masses of soil from single points referred to as “discrete” samples. The authors noted that this method would only be reliable if the concentration of a contaminant in soil was very uniform both within a sample and between closely spaced samples.

Scientists and field workers began to warn in the early 1990s that this was not the case. Data for co-located samples often varied widely and randomly, as did data for duplicate subsamples tested by the laboratory. This caused confusion in the field regarding the extent of contamination above levels of potential concern and in the assessment of risk. The need to repeatedly remobilize field teams for sample collection and the discovery of additional contamination after remediation was thought to be completed caused some projects to drag on for years and in some cases to be abandoned due to the lack of a clear endpoint.



Contaminant concentrations can vary dramatically between co-located, discrete samples and even within the same sample.

A thorough field study of the reliability of discrete sample data for testing of environmental sites was, surprisingly, not carried out until 2015 – thirty years after the first USEPA site investigation guidance was published (Brewer et al. 2017). The field study verified contaminant concentrations can vary dramatically and randomly between samples collected just a few centimeters from each other and even within an individual sample. Statistical analysis of replicate sets of discrete samples can predict very different risks associated with mean contaminant concentrations for targeted exposure areas.

These factors are the primary cause of failed remediation attempts, project delays and cost overruns, and the later discovery of significant contamination in areas earlier declared to be "clean." The mineral exploration and agricultural industries recognized the same problems many years ago. Gold exploration companies often went bankrupt when the amount of gold present in a discovery turned out to be far less than predicted by the samples collected or more commonly when large accumulations of gold were overlooked due to erroneous sample data. Farmers realized the unreliability of discrete sample data very quickly, as crop yields failed to meet expectations or large sums of money were unnecessarily spent on fertilizer or other field amendments.

The result was the development in the 1950s of the Theory of Sampling by Pierre Gy, which serves as the basis of the DU-MIS methods described in this fact sheet. Errors in sample data and decision making are less obvious in the environmental industry, but DU-MIS methods are being continually improved in order to make the investigation, assessment and remediation of contaminated soil as efficient and reliable as possible.

Where can I get more information on DU-MIS methods and Gy's Theory of Sampling?

Refer to the HEER Office website and *Technical Guidance Manual* (https://health.hawaii.gov/heer/) for further information about this fact sheet and the basis and implementation of Decision Unit and Multi Increment Sample investigation methods or contact:

Hawai'i Department of Health, Hazard Evaluation and Emergency Response Office
2385 Waimano Home Road, Pearl City, HI 96782
Telephone: (808) 586-4249

Field study of the nature and reliability of discrete sample data:

Brewer, R., Peard, J. and M. Heskett. 2017a. A critical review of discrete soil sample reliability, Part 1 – Field study results: Soil and Sediment Contamination, Vol. 26 (1).

Brewer, R., Peard, J. and M. Heskett. 2017b. A critical review of discrete soil sample reliability, Part 2 – Implications: Soil and Sediment Contamination, Vol. 26 (1).

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In reply, please refer to:
File:

TO: Interested Parties

THROUGH: Elizabeth Galvez, Acting Program Manager
Hazard Evaluation and Emergency Response (HEER) Office

FROM: Lene Inchinotsubo, Acting Chief
Solid and Hazardous Waste Branch (SHWB)

DATE: September 23, 2019

SUBJECT: **Use of HEER Office Environmental Action Level Guidance and HEER Office *Technical Guidance Manual* for Characterization and Remediation of Contaminated Properties Overseen by the SHWB**

This memorandum supersedes and takes precedence over a July 15, 2005, SHWB memorandum titled, *Use of May 2005 Environmental Action Levels ("EALs") at Leaking Underground* Storage *Tank sites* (Attachment I). The 2005 memorandum recommended reference to soil and groundwater EALs published by the HEER Office earlier that year for use at underground storage tank (UST) sites overseen by the SHWB but also allowed reference to action levels published in 1995 by the SHWB. In August 2013, SHWB adopted HEER Office EALs as "alternative site-specific action levels" as referenced in state UST regulations. The HEER Office EALs and subsequent updates have since been fully adopted by the SHWB for use at contaminated properties overseen by the SHWB, including, but not limited to, UST sites, and use of the 1995 action levels is no longer permitted (HDOH 2017a).

Parties involved in soil and groundwater investigation projects overseen by the SHWB are furthermore, advised to refer to the HEER Office *Technical Guidance Manual* (TGM) for the design and implementation of filed activities (HDOH 2016). The HEER Office TGM incorporates updates and takes precedence over information published in the UST *Technical Guidance Manual* prepared by the SHWB (HDOH 2000). In particular, guidance for testing of soil, groundwater, and soil vapor presented in the HEER Office TGM replaces guidance in Section 7 (Sampling and Analysis) of the 2000 SHWB UST TGM. Guidance specific to the installation of groundwater monitoring wells at UST sites presented in Appendix 7-E of the 2000 SHWB TGM can, however, be referred to in coordination with the overseeing project manager from the SHWB (Attachment 2). Note that the HEER Office EAL guidance similarly supersedes and takes precedence over guidance specific to the preparation of risk assessments presented in Section 5 of the 2000 SHWB-UST TGM, which was also adopted in August 2013.

Reference to the HEER Office guidance documents must take into account updates to SHWB regulations. Related technical documents published by both the SHWB and HEER Office should also

be referred to as appropriate and approved by SHWB project managers. This includes the "Clean Fill" guidance prepared jointly by the SHWB and HEER Office and used for testing of imported and exported fill material as well as soil stockpiles (HDOH 2017b, and updates).

The HEER Office TGM does not serve as a replacement for testing requirements presented in other SHWB guidance and regulations. The HEER Office TGM in particular does not discuss requirements for testing and disposal of non-soil wastes overseen by the SHWB. Explicit guidance on management of active UST facilities is also not provided in the HEER Office TGM.

The SHWB intends to prepare addendums to the HEER Office TGM that addresses these and related subjects in the future. In the interim, the SHWB has prepared the attached, Question & Answer section to discuss use of the HEER Office TGM in projects overseen by this office.

References

HDOH, 2000, Hawaii Underground Storage Tank Technical Guidance Manual: Hawai'i Department of Health (March 2000):): Hawai'i Department of Health, Solid and Hazardous Waste Branch. http://health.hawaii.gov/shwb/ust-tgm/.

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PVT, 2016, *Landfill Policies and Procedures for All Users*: PVT Land Company, Limited, August 2016.

SUBJECT: Use of HEER Office *Environmental Action Level* guidance and HEER Office *Technical Guidance Manual* for Characterization and Remediation of Contaminated Properties Overseen by the Solid and Hazardous Waste Branch – Common Questions and Answers

Q-1: How is the HEER Office TGM different from the 2000 SHWB UST TGM?

The HEER Office TGM provides an extensive update to sample collection and test methods for soil and sediment, as well as expanded guidance on the testing of indoor air and soil vapors for volatile chemicals. Updates to the guidance are coordinated with and reviewed by SHWB staff.

Guidance for testing of soil, groundwater, and soil vapor presented in the HEER TGM (HDOH 2016), in particular, updates guidance presented in Section 7 (Sampling and Analysis) of the 2000 SHWB UST TGM. Guidance presented for the installation of groundwater monitoring wells at UST sites included in Section 7 of the 2000 SHWB TGM can still be referred to, however. This information will be incorporated into future updates of the HEER TGM.

Q-2. Are discrete soil sampling methods described in the original SHWB TGM still acceptable for final decision making at contaminated sites overseen by the SHWB?

No. Data based on advanced and more reliable, Decision Unit-Multi Increment Sample (DU-MIS) investigation methods should be collected and used for final decision making at contaminated sites overseen by the SHWB. Existing discrete sample data can be used to design initial remediation plans, if desired. DU-MIS data collected in accordance with the HEER Office TGM should then be collected and used to confirm the adequacy of remedial actions.

Q-3. Do SHWB sites that were characterized and granted a No Further Action Status based on discrete sample data need to be reopened and retested?

No. Experience at sites where both discrete and Multi Increment sample data have been collected primarily highlights the inefficiency and unreliability of discrete sample data for site characterization. This led to significant, unnecessary delays and expenditures for completion of many projects. Additional confirmation testing using more reliable, DU-MIS methods could, however, be beneficial as part of property transactions or redevelopment at complex sites where localized areas of contaminated soil might have been inadvertently overlooked. This can help avoid delays in proposals for offsite reuse or disposal of soil after a project has already been initiated.

Q-4. The collection of Multi Increment subsurface soil samples from thirty or more borings at active gas stations and similar facilities will not be practical in some cases, due to limited access, underground tanks and utilities, and other difficulties. Can traditional, discrete soil samples be collected instead?

No. The collection of traditional discrete soil samples has been demonstrated to be unreliable for the characterization of both surface and subsurface soils. This is due to the heterogenous nature of contaminants in soil at the scale of a discrete sample and the mass tested by the laboratory. As discussed in Section 4 of the HEER TGM, data will not be reliably representative unless "Decision Unit" areas and volumes of soil are specified and a 1-2kg sample of soil is collected from at least 30 to 50 points within the targeted DU. This cannot be avoided.

Consider the use of "Single Borehole DU" investigation methods described in Sections 3.3.4 and 4.2.8.2 of the HEER Office TGM for cases where the collection of proper DU-MIS sample data from subsurface soils is not feasible. Under this method, single boreholes are used to approximate the lateral and vertical extent of subsurface contamination, in a similar manner as typically done in the past at active gas stations. A continuous core of soil is extracted from each borehole, and the core is divided into continuous depth intervals for testing. A single 1-2kg sample is then collected from multiple points within each targeted interval. In some cases, the entire targeted core interval can be collected and submitted to the laboratory for MIS processing and testing.

This approach works well for the general approximation of the extent and magnitude of subsurface petroleum contamination, which can be easily identified in single cores, although the representative concentration and mass of contamination present will be difficult to reliably estimate. A more detailed investigation might be required for in situ treatment of contamination once high-risk areas have been identified. For testing of volatile chemicals, small plugs of soil are collected from the entire length of the targeted core interval and either combined in methanol in the field for submittal to the laboratory or encapsulated and immediately frozen for extraction in methanol at the laboratory.

Q-5. Are DU-MIS data required for reuse or disposal of soil (or sediment) at municipal landfills in Hawaii or hazardous waste landfills on the mainland?

Requirements for the use of DU-MIS data for soil and similar material will be progressively incorporated into landfill disposal permits as those permits are renewed. Be aware that some municipal landfills, and the PVT Construction and Demolition Waste landfill on the island of O'ahu, already require that the collection of soil sample data follow methods described in the HEER Office TGM (Attachment 3; PVT 2016). This is in part to ensure that landfill workers are not inadvertently exposed to high levels of contaminants in soil that is brought to the landfill for disposal or for use as cover material.

If soil is designated for disposal to a landfill or reuse at another off-site location, then the generator must make a hazardous waste determination in accordance with 40 CFR §262.11, as incorporated and amended in §11-262.1-1, Hawai'i Administrative Rules (HAR). Refer also to Section 2 of the joint SHWB-HEER Office "Clean Fill" guidance for additional information (HDOH 2017b).

Q-6. Are default, Decision Unit (DU) areas and volumes presented in the HEER Office TGM and the joint, HEER-SHWB "Clean Fill Guidance" (HDOH 2017b) strict requirements or can alternative DU volumes be applied to sites overseen by the SHWB?

The default DU areas and volumes of soil presented in the HEER Office TGM and joint HEER-SHWB *Clean Fill Guidance* are intended to expedite testing and clearing of soil for unrestricted reuse in residential neighborhoods, schools, medical facilities and other sensitive locations or reuse at commercial/industrial properties. This will help to avoid potential fines for offsite transportation and placement of contaminated soil. The SHWB considers soil that exceeds the most stringent (Tier 1) Environmental Action Levels (EALs) for unrestricted use to be a "waste," as defined in Hawaii Revised Statutes, Chapter 342H. Proposal of alternative DU volumes for testing and reuse of soil is allowed on a site-by-site basis, provided that adequate justification is presented in a workplan to the SHWB for review and approval.

Q-7. Are DU-MIS data required for characterization of non-soil material, including municipal or industrial waste or recyclable material not related to soil?

The collection of DU-MIS data for reuse or disposal of non-soil material is encouraged to the extent practicable. This is because data related to past, "discrete" sampling methods has been demonstrated to be unreliable and can lead to concerns regarding landfill worker exposure and offsite migration of contaminants in surface runoff or leachate.

DU-MIS data are now routinely collected for waste incinerator ash, for example. Reliable, Multi Increment samples for solids (e.g., waste sandblast grit) can often be collected from containerized waste by simply transferring the waste to another container and periodically collecting individual sample increments during this process. Sampling tubes and other tools can be used to collect representative samples of containerized, liquid waste.

Additional SHWB guidance on the use of DU-MIS methods for characterization of non-soil waste is anticipated in the future.

Attachment 1

Use of May 2005 Environmental Action Levels ("EALs") at Leaking Underground Storage Tank sites (July 2005)

(includes subsequent updates to EALs and use for characterization and disposal of soil and sediment under all SHWB programs)

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In reply, please refer to:
File: EHA/HEER Office

TO: Interested Parties

FROM: Steven Chang, Chief
Solid & Hazardous Waste Branch

DATE: July 15, 2005

SUBJECT: Use of May 2005 Environmental Action Levels ("EALs") at Leaking Underground Storage Tank sites

The Hazard Evaluation and Emergency Response (HEER) office has recently published a technical document entitled, *Screening For* ***Environmental Concerns at Sites With Contaminated Soil and Groundwater*** **(Interim Final - May 2005). Environmental Action Levels (EALs) presented** in this document represent an update to action levels presented in the 1995 document, *Risk-Based Corrective Action and Decision Making at Sites With Contaminated Soil and Groundwater,* prepared by the Solid and Hazardous Waste Branch (December 1995, revised June 1996). Formal revision of the 1995 action levels as presented in Hawai'i Administrative Rules (HAR) Section 11-281-78 (UST Site Cleanup Requirements) is currently underway. It is anticipated that this process will be completed in early 2006.

In the interim, the Solid and Hazardous Waste Branch has prepared this Question & Answer sheet to discuss use of the May 2005 EALs at Leaking Underground Storage Tank sites.

Q: How are the May 2005 EALs different from the 1995 Action Levels?

A: The May 2005 EALs reflect more recent toxicological data and take into account additional exposure pathways and environmental concerns. Action levels for petroleum-related chemicals are not significantly different from those presented in the 1995 RBCA document with the exception of ethylbenzene and Total Petroleum Hydrocarbons (TPH). In the case of ethylbenzene, groundwater action levels were updated to reflect more recent data for the protection of aquatic habitats. For sites that do not threaten a source of drinking water, the groundwater action level for ethylbenzene increased from 140 ug/L to 290 ug/L (sites within 150m of a surface water body) and 300 ug/L (sites not within 150m of a surface water body). This change, coupled with use of an alternative model for leaching of chemicals from soil, increased soil action levels for ethylbenzene by up to one order of magnitude.

The 1995 soil action levels for Total Petroleum Hydrocarbons (TPH) were retained for use in the May 2005 EALs. Action levels for nuisance concerns (odors, staining, etc.) were also added, however. This issue was not specifically addressed in the 1995 document. The

additional action levels will be most useful at sites being redeveloped for residential purposes. For example, soil impacted with TPH-gasoline at a concentration of 2,000 mg/kg (1995 action level) could pose potential odor concerns if exposed at the ground surface or encountered during landscaping or utility work. An action level of 100 mg/kg is incorporated into the May 2005 EAL document to address this concern. An additional, nuisance-based action level of 500 mg/kg is presented for both TPH-diesel ("middle distillates") and heavier oils ("residual fuels"). Exceeding these concentrations of TPH in exposed or shallow soils indicates that nuisance concerns may exist and a more site-specific, field-based assessment of this issue should be carried out.

A third update to the 1995 RBCA document that may affect leaking underground tank sites is the inclusion of EALs for additional polynuclear aromatic hydrocarbon compounds (PAHs). A list of targeted PAHs that should be tested for at petroleum releases is provided in Chapter 2 of the May 2005 document. These compounds are often found in waste oil and to a lesser extent in diesel-range fuels. The addition of the compounds to the lookup tables reflects updates to the USEPA Preliminary Remediation Goals (PRGs) as well as other USEPA guidance.

Reference to the additional PAHs is not likely to affect the scope of cleanup required for contaminated soils. Many of the EALs for PAHs in groundwater are very low, however, and may even be below normal laboratory method reporting limits. (In cases where the EAL is below the laboratory method reporting limit, the reporting limit should be used for screening purposes.) This is primarily because these PAHs are highly toxic to aquatic organisms. At a "Tier 1" screening level, the EAL document assumes that contaminated groundwater at a site could migrate to a body of surface water and impact sensitive aquatic habitats. This is especially a concern for highly mobile chemicals (e.g., chlorinated solvents). PAHs are not significantly mobile in groundwater, however, and unlikely to migrate more than a few tens of meters from the original release area. Once it can be established that PAH-contaminated groundwater is not likely to migrate to a body of surface water, consideration of the EALs for PAHs in groundwater cleanup plans is no longer needed (e.g., based on groundwater monitoring data and length versus age and length of plume). Proper management of contaminated groundwater (and soil) during site future redevelopment activities will be required, however.

Q: Am I now required to use May 2005 EALs at Leaking Underground Storage Tank sites?

A: No. Use of the May 2005 EALs is entirely optional on the part of the party responsible for investigating, assessing and cleaning up contaminated sites.

Q: Can I use the May 2005 EALs at Leaking Underground Storage Tank sites if I so desire?

A: Yes. The May 2005 EALs are primarily a compilation of published information that would be normally accessible for use in a "site-specific" environmental risk assessment. HAR Section 11-281-78 (UST Site Cleanup Requirements) allows for the use of approved, "site-specific" action levels at leaking underground storage tank sites provided that all potential environmental concerns are addressed. The updated EALs meet this requirement. Action levels from the 1995 document and the 2005 document should not be mixed, however.

Either one document or the other should be referred to unless otherwise approved by the Solid and Hazardous Waste Branch.

Q: **Should I use the May 2005 EALs at Leaking Underground Storage Tank sites, even if this is not required?**

A: This depends on the nature and status of the site. A review of cleanup levels at sites that have already been closed or at sites where cleanup levels have already been approved is not necessary.

As indicated above, the May 2005 EALs may be used at sites where investigation and cleanup actions are still underway via a "site-specific" environmental risk assessment. Updated EALs for ethylbenzene may reduce the scope of cleanup needed at many sites, especially where cleanup is being driven by groundwater protection concerns. At sites being redeveloped for residential purposes, additional screening of TPH levels in shallow soils for potential nuisance concerns (odors, staining, etc.) is prudent. This allows the property owner and developer to identify areas where potential cleanup of contaminated soils beyond typical toxicity and leaching concerns may be needed and helps avoid unexpected delays and disposal costs during redevelopment. Although final action levels for petroleum-related releases are not significantly affected, the updated EALs also take into account potential vapor intrusion concerns and subsequent impacts to indoor air.

Q: Can I still use the 1995 Action Levels?

A: Yes. The 1995 action levels (and 1996 updates) can be used until such time that HAR Chapter 11-281 ("Underground Storage Tanks"), including HAR Section 11-281-78 (UST Site Cleanup Requirements), is formally revised (anticipated early 2006). As discussed above, action levels from the two documents should not be mixed except as discussed in the May 2005 document (e.g., soil action levels for high rainfall areas).

The May 2005 EAL document will be revised and updated on a regular basis. Comments and suggestions from the general public are welcome at any time. Updates will be posted to this website and notification sent to persons on the EAL mailing list. Workshops to present and discuss the EALs will also be held periodically. To provide comments or be included on the mailing list for updates and workshop announcements, please contact:

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Attachment 2

Hawaii Underground Storage Tank Technical Guidance Manual (March 2000), Appendix 7-e: Recommended Sampling and Analysis Procedures (water)

[redacted]

WATER SAMPLING

Surface Water Sampling

Representative concentrations of the contaminants of interest in water samples should be assured by taking the following precautions in obtaining field samples.

1. Prior to the initial sampling, decontamination procedures should be followed on all equipment [redacted] to prevent the introduction of contaminants by outside sources.

2. Samples from shallow depths can be readily collected by merely submerging the sample container. The container's mouth should be positioned so that it faces upstream, while the sampling personnel are standing downstream so as not to stir up any sediment that may contaminate the sample.

3. To avoid aeration of the sample, the sample container should be held at an angle so that the stream of water flows down the side. The sample container should be filled until it overflows and the lid carefully screwed on. Zero headspace in the sample container should be ensured by inverting the vial and carefully tapping on the cap. If air bubbles appear, remove the cap and add enough sample water to produce an inverted meniscus. Cap and repeat the check for air bubbles.

4. Collecting a representative sample at depth or from a larger body of surface water is difficult but not impossible. Samples should be collected near the shore if possible. If boats are used, the body of water should be cross-sectioned, and samples should be collected at various depths across the water in accordance with the specified sample location plan. For this type of sampling, a weighted-bottle sampler is used to collect samples at any predetermined depth. The sampler consists of a glass bottle, a weighted sinker, a bottle stopper,

and a line that is used to open the bottle and to lower and raise the bottle during sampling. The procedure for use is as follows:

a. Gently lower the sampler to the desired depth so as not to remove the stopper prematurely.

b. Pull out the stopper with a sharp jerk of the sampler line.

c. Allow the bottle to fill completely, as evidenced by the cessation of air bubbles.

d. Raise the sampler and cap the bottle.

e. Wipe the bottle clean. The bottle can also be used as the sample container.

5. Samples for volatiles should be placed in three 40 mL volatile organic analysis (VOA) bottles provided by the analytical laboratory. These sample bottles are screw-top vials with Teflon-lined silicone septa. Sample bottles should not be rinsed prior to sampling, and should be placed in the ice chest immediately after labeling.

6. Duplicate samples, when collected, should be taken immediately after the field sample. Decontamination procedures are not necessary between sampling for the field sample and the duplicate.

7. Field samples, field duplicates, and trip blanks should be labeled in sequence and individually placed in plastic bags to prevent cross-contamination. Chain of custody and sample analysis request forms should accompany each shipment of samples to the laboratory, listing the analyses to be performed and the QA/QC criteria for laboratory duplicates and matrix spikes. All samples should be packed in a cooler on blue ice (at 4°C) in such a way as to prevent breakage. A thermometer should be placed in the cooler during transport.

Groundwater Sampling. Groundwater samples should be obtained from monitoring wells in accordance with the procedures set forth in this section. All monitoring wells intended for use in groundwater sampling programs are required to be designed and constructed in accordance with Department of Health (DOH) guidelines set forth in this section and the HIDOH document titled draft *Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan* dated December 1996. An example groundwater monitoring well construction design is provided in Figure 7E.2. DOH does not set restrictions on the minimum

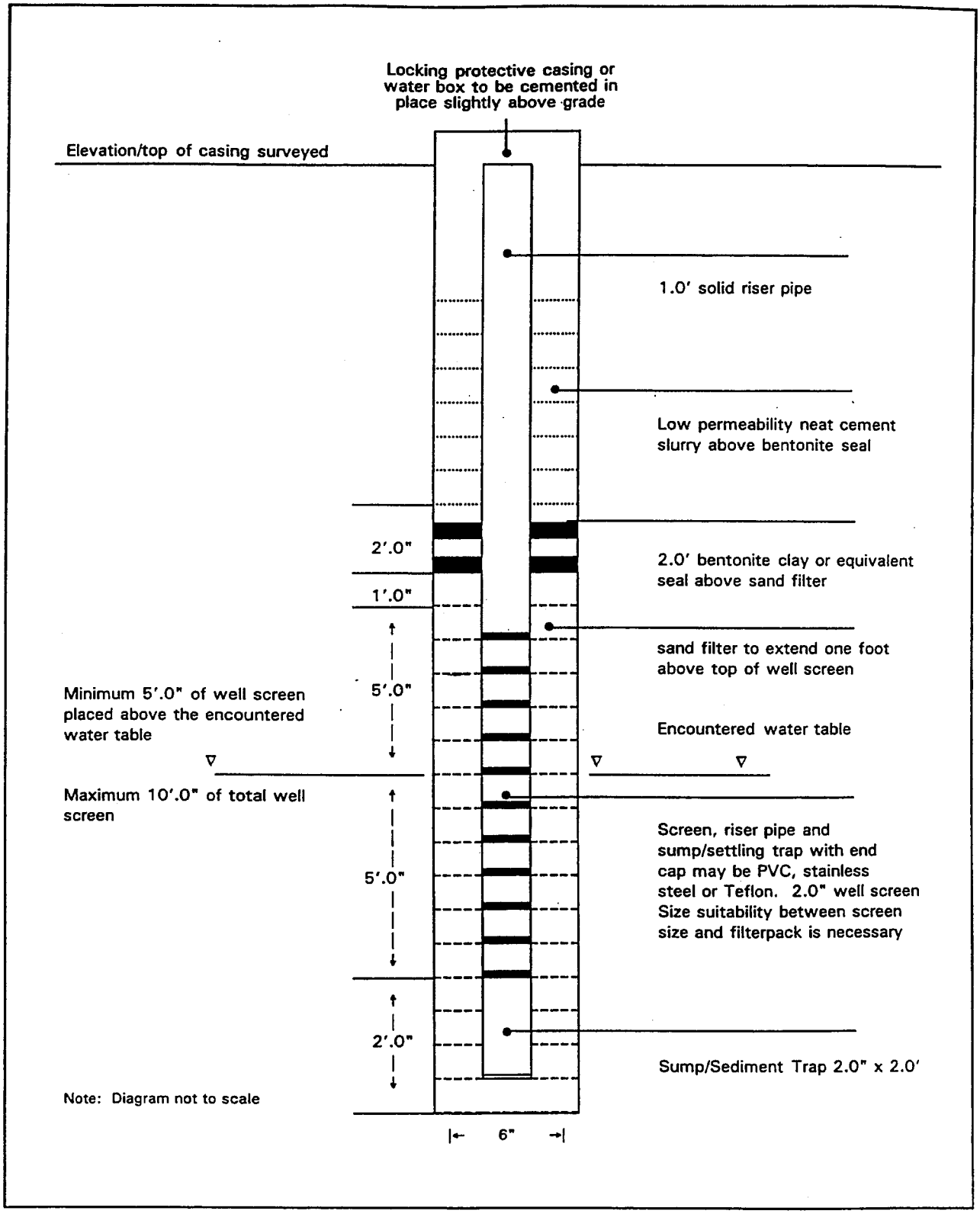

Figure 7E.2 Example Ground-water Monitoring Well Construction Detail

allowable diameter of a monitoring well provided that the well is constructed in accordance with the above-stated guidelines. While the diameter of a monitoring well strongly effects the present and future **utility** and **efficiency** of the well, DOH does not consider well diameter to cause a significant negative bias on the **quality** of groundwater samples extracted from the well, provided that standard sampling procedures are adhered to. DOH also does not place restrictions on the use of push-type devices (e.g., Geoprobe, Stratoprobe, etc.) to install small-diameter monitoring wells, again provided that the wells are designed and constructed in accordance with DOH-recommended guidelines.

As noted, small-diameter wells have distinct advantages but site-specific considerations must be taken into account before deciding on the well diameter most appropriate for a given site. Problems reported to DOH regarding the use of small-diameter wells include difficulties in installing wells in soils or sediments with intermixed, consolidated rock; difficulties in obtaining adequate sample volumes in low permeability soils or sediments; clogging of wells over time; and difficulties in locating the vadose-zone/groundwater interface so that well screens can be properly positioned.

Monitoring wells should be constructed in accordance with the specifications provided in Figure 7E.2. Wells should be developed (bailed, pumped, surged) until a constant minimum turbidity is achieved. Excessive turbidity of water removed from a well may affect sample integrity and may indicate improper well installation. Monitoring well placement should be specified in the sample location plan.

Filtering of Groundwater Samples

Unless otherwise directed by DOH, groundwater samples that are to be tested for non-volatile constituents (Henry's Law Constant $\leq 10^{-5}$ atm-m^3/mol and a molecular weight $\geq$ 200 grams/mol) should be filtered if there is any evidence of turbidity in the samples (e.g., turbidity > 5 NTU), refer to Table 7E.1. Turbidity should be measured in the field during sampling as needed. Filtering of the samples should take place prior to the addition of a preservative in order to prevent leaching of otherwise sorbed-phase contaminants from suspended sediment. Filter pore sizes should be no smaller than 0.45 microns. The methods and equipment used to filter groundwater samples should be clearly described in the text of the groundwater sampling report presented to DOH for review and incorporation into the public file for the facility.

Filtering of samples that are to be tested for volatile contaminants (Henry's Law Constant > 10^{-5} atm-m^3/mol and a molecular weight < 200 gm/mol) should be avoided in order to minimize the loss of contaminants due to volatization during sampling. Based on published partitioning data for low molecular weight, non-surface reactive contaminants (e.g., volatile compounds), the contribution of

Contaminant	[2]Volatile?	[3]OK to Composite Soil Samples?	[4]OK to Filter Groundwater Samples?	OK to Collect Sample With Vacuum-Type Pump?
[1]COMMON UST-RELATED CONTAMINANTS				
Benzene	yes	NO	NO	[5]YES(see note)
Toluene	yes	NO	NO	[5]YES(see note)
Ethylbenzene	yes	NO	NO	[5]YES(see note)
Xylene (mixed)	yes	NO	NO	[5]YES(see note)
Benzo(a)pyrene	no	YES	YES	YES
Acenaphthene	yes	NO	NO	[5]YES(see note)
Fluoranthene	no	YES	YES	YES
Naphthalene	yes	NO	NO	[5]YES(see note)
PCE	yes	NO	NO	[5]YES(see note)
1,1 DCE	yes	NO	NO	NO
Vinyl Chloride	yes	NO	NO	NO
TCE	yes	NO	NO	[5]YES(see note)
1,1,1 TCA	yes	NO	NO	[5]YES(see note)
PCBs (1260 Arochlor)	no	YES	YES	YES
TPH-residual fuels	no	YES	YES	YES
TPH-middle distillates	yes	[6]NO (see note)	[6]NO (see note)	YES
TPH-gasolines	yes	[6]NO (see note)	[6]NO (see note)	YES
[7]OTHER CONTAMINANTS				
Acetone	yes	NO	NO	[5]YES(see note)
Chlorobenzene	yes	NO	NO	[5]YES(see note)
Chloroform	yes	NO	NO	[5]YES(see note)
4,4 DDD	no	YES	YES	YES
4,4 DDE	no	YES	YES	YES
4,4 DDT	no	YES	YES	YES
Di-n-octyl phthalate	no	YES	YES	YES
Ethylene glycol	no	YES	YES	YES
Methylene chloride	yes	NO	NO	[5]YES(see note)
2,3,7,8 TCDD (Dioxin)	no	YES	YES	YES
Chlordane	no	YES	YES	YES
Carbon tetrachloride	yes	NO	NO	[5]YES(see note)

1. Refer to recommended chemical analysis for UST closure and release response (Table 7.2, DOH Technical Guidance Manual - August 1992).
2. Defined as Henry's Law Constant > 0.00001 m^3-atm/mole and molecular weight < 200 gm/mol.
3. For biased-sampling actions, analytical results from composited samples should be multiplied by the number of samples composited to determine the maximum possible contaminant concentration in any one sample. This adjusted value should be used for comparison to applicable DOH action levels.
4. Minimum filter size 0.45μ.
5. Multiply laboratory analytical results by a factor of two for volatile contaminants.
6. Soil and groundwater samples to be tested for TPH may be composited or filtered for release verification purposes only. Any detection of TPH in the samples constitutes a release and requires followup action.
7. Contact DOH for information on contaminants not listed.

Table 7E.1 Allowance for Compositing Soil Samples

sorbed or colloidal phases of these contaminants to total contaminant concentration can be expected to be insignificant. If the collection of highly turbid groundwater samples cannot be avoided at a site (e.g., due to the placement of the monitoring well in clayey, oversaturated lagoonal sediments), then an in-line filter should be used to minimize sample disturbance. Again, this should be clearly described and justified in the text of the report.

Water Level Measurements. Water level measurements are routinely required as part of the sampling program. Collection of water elevations on a continuing basis is important for determining if horizontal and vertical flow gradients have changed since the initial site characterization. A change in hydrologic conditions may necessitate modifications in the design of the ground-water monitoring system or of the corrective action technology being implemented.

The field measurements should include depth to standing water and total depth of the well. This information is required to calculate the volume of stagnant water in the well and to provide a check on the integrity of the well (e.g., identify siltation problems). Each well should have a permanent, easily identified reference point from which its water level measurement is taken. The reference points should be established by an accurate survey and typically located and marked at the north side and top of the well casing with the locking cap removed or on the apron, and, where applicable, the protective casing.

Measure the static water level before removing water from the well for purging or sampling. The well should be allowed to stabilize for a minimum of 24 hours after development of the well or any other withdrawal procedures before a water level measurement is taken. The device used to detect the water level surface must be sufficiently sensitive so that a measurement to ± 0.01 foot can be reliably obtained. The water level reading should be recorded on the ground-water sampling data sheet in Figure 7E.3. Three methods of measuring the water level in a well are described below:

1. Electric tape

   Note: The electric tape method should not be used in wells containing free product unless electrical connections are intrinsically safe (explosion proof).

   a. Turn on the switch. Check the batteries by inserting the probe (the tip) into water and noting if the contact between the probe and the water surface is registering clearly.

   b. Rinse the probe with distilled water.

SITE INFORMATION:

Site Name, Date:

Location: _____

UST Facility ID Number: ___ -- ___ ___ ___ ___ ___ ___ Owner/Operator: _____

SAMPLER INFORMATION:

Name: _____ Phone Number: _____

Organization: _____

WELL INFORMATION:

Well Number: _____ Well Location: _____

Depth to Water: _____ ft. Depth of Well: _____ ft. Water Column Height: _____ ft.

Well Diameter: _____ in.

VOLUME OF WATER TO BE REMOVED DURING PURGING:

V = * (D) 2 * 0.041
V = one well volume (gal)
H = height of water column (ft)
D = inside diameter of well (in.)

Well volume, V = _____ gal

V * 3 well volumes = _____ gal V * 5 well volumes = _____ gal

COLLECT SPECIFIC CONDUCTIVITY, TEMPERATURE AND pH MEASUREMENTS INITIALLY AND AFTER EVERY WELL VOLUME IS PURGED

TIME	SPEC. COND.	TEMP	pH	COMMENTS

SAMPLE INFORMATION:

Sample numbers:	Time of Collection:	Total Pre-Sampling Time:

Figure 7E.3 Ground-water Sampling Data Sheet

c. Slowly lower the probe into the well by pulling cable from the hand-held reel.

d. Continue lowering until the bulb lights up, the beeper beeps, or the ammeter needle deflects, indicating that the water table has been reached.

e. Measure the length of cable in the well from a datum point (the top of the casing) or other reference point (look for a mark on or in the casing or some type of "v" etched into the casing) to the nearest 0.01 foot. Subtract this length (depth to the water table) from the reference elevation to determine the water level elevation.

f. Raise the probe until contact with the water has been broken. Lower the probe once again in order to check the measurement reading.

g. Rinse the cable and probe with distilled water.

Note: Multiphase probes are available which audibly indicate the relative position of both nonaqueous phase liquids and aqueous phase liquids. Operation is similar to that of the single phase electric tape probe discussed above.

2. Popper

a. Measure the length of the popper.

b. Rinse the line and popper with distilled water.

c. Lower the popper into the well.

d. Listen for the "pop." You may have to raise and lower the popper several times to make sure you have found the water level.

e. Read the tape measurement from a datum point (the top of the casing) or other prescribed point (look for a mark on or in the casing or some type of "v" etched into the casing) to the nearest 0.01 foot. Add the length of the popper to arrive at the depth to water.

f. Raise the tape approximately 1 foot. Lower the tape once again and repeat steps "d" and "e" in order to check the reading.

g. Subtract the depth to water from the reference point elevation to obtain the water level elevation.

h. Rinse the line and popper with distilled water.

3. Coated tape

Note: The coated tape usually has a weight attached to the end, and it may be necessary to add or subtract the length of the weight from the total water level elevation. Know which type of tape measuring device you intend to use before going into the field.

a. Rinse the lower few feet of the tape with distilled water and dry.

b. Chalk the lower few feet of the tape by drawing the tape across a piece of colored carpenter's chalk.

c. Lower the tape into the well until you hear or feel the tape reach the water surface. Lower the tape a few inches into the water.

d. Read the tape measurement from a datum point (the top of the casing) or other prescribed reference point (look for a mark on or in the casing or some type of "v" etched into the casing) to the nearest 0.01 foot. Record the reading.

e. Withdraw the tape from the well and observe the lower end of the tape. The demarcation between the wetted and unwetted portions of the chalked tape should be apparent.

f. Subtract this value (item d) from the elevation of the top of the casing (from reading item c). This difference is the depth to the water surface.

g. Subtract the depth to water from the elevation at the top of the casing to obtain the water level elevation.

h. Record the well location and number, depth to groundwater, depth to bottom of the monitoring well, reference point used, and other pertinent data on the groundwater sampling data sheet.

i. Rinse the tape with distilled water.

If the presence of free product is indicated, the thickness of the free product layer can be determined using a tape coated with water and hydrocarbon indicator pastes or an intrinsically safe electronic interface probe. In the case of the former,

a steel tape coated with water indicator paste on one side and hydrocarbon indicator paste on the other is lowered into the monitoring well. This should be done so there is as little disturbance of the water surface as possible. The hydrocarbon indicator paste should coat a length of the steel tape that is 2 to 4 inches greater than the estimated thickness of the product. The thickness of the product is measured to the nearest 0.01 foot. As for the interface probe, this instrument is operated similarly to the electric tape device explained above except a different signal should result when product is encountered.

All equipment should be constructed of inert materials and should be decontaminated prior to use at another well to avoid cross- contamination.

Well Purging. The goal in sampling ground-water monitoring wells is to obtain samples that are representative of the aquifer or ground water in question. A representative sample is a volume of water taken from a well whose physical and chemical properties are accurately interpreted to be indicative of conditions in the ground water. Water that stands within a monitoring well for a long period of time may become unrepresentative of the ground water because chemical change may cause water quality alterations. Even if the stored water in the monitoring well may be unchanged from the time it entered the well, the stored water may not be representative of ground water at the time of sampling. In order to obtain a representative sample, the stored water must be removed, or purged, from the monitoring well before samples are collected. The following procedures should be followed for purging monitoring wells.

1. Wells screened in low permeability formations (wells that can be purged dry):

    a. Pump or bail the well dry.

    b. Allow the well to recover after purging.

    c. Purge the well a second time, if time permits.

    d. Collect the sample as soon as there is a sufficient volume of water for the intended analyses; the well does not need to fully recover.

2. Wells screened in high permeability formations:

    a. Pump or bail three to five well volumes.

    b. Do not pump a well dry if the recharge rate causes the formation water to vigorously cascade down the sides of the screen and

causes an accelerated loss of volatiles. Purge the well volumes at a rate that does not cause recharge water to be excessively agitated.

c. Test the ground water for pH, temperature, and specific conductance (see the Field Measurements section below for sampling procedures) after every well volume, or after every 10 minutes, whichever comes first. The pH, temperature, and specific conductance should stabilize with time. This stabilization indicates that water is now being drawn from the aquifer and not from the vincity of the casing. If stabilization occurs before pumping or bailing three to five well volumes, continue to pump or bail until three to five complete well volumes have been purged.

d. Introduce as little air and turbulence into the formation as possible in order to prevent alteration of the samples.

Calculation of the well volume is accomplished by using the following formula:

$$V = (H)(D^2)(C)$$

where:
- V = one well volume, gallons
- H = height of water column, feet
- D = inside diameter of well, inches
- C = 0.041 gallons/(inches)^2 (feet)

The volume in gallons calculated by the above equation must be multiplied by the number of well volumes necessary to adequately purge the well.

Purging of monitoring wells can be accomplished with Teflon or stainless steel PVC bailers or with bladder, peristaltic, gas-lift, centrifugal, or venturi pumps. All pump components that may be exposed to the water, including the discharge tubing, should be constructed of Teflon, stainless steel, or PVC. Some of these pumps cause volatilization and produce high pressure differentials, which result in variability in the analysis of pH, specific conductance, metals, and volatile organic samples. They are, however, acceptable for purging the wells if sufficient time is allowed to let the water stabilize prior to sampling. Do not use purged water for samples since the water is aerated in the purging process.

When purging equipment must be reused, it should be decontaminated, following the same procedures as those required for the sampling equipment. Steps should be taken to prevent surface soils from coming into contact with the purging equipment and lines, which could introduce contaminants into the well. The purged ground water must be stored in a specified waste drum until the water

samples are analyzed and appropriate disposal procedures are determined. The purged water may NOT be dumped on the ground.

Field Measurement Procedures

Several water quality parameters are subject to rapid change when the groundwater is removed from its natural environment and exposed to the atmosphere. Therefore, temperature, specific conductance, and pH must be measured on an unfiltered sample at the time of sample collection.

Field personnel should familiarize themselves with the manufacturer's instructions for use of the pH, temperature, and/or specific conductance meter(s) before going to the field and collecting samples. Calibration of any field-test probes or kits should be done at the beginning of each use according to the manufacturer's specifications.

Temperature.

1. Rinse the thermometer or temperature meter probe with distilled water.

2. Immerse the thermometer or probe into the sample. The thermometer or probe must not be placed in sample containers containing groundwater samples for laboratory analysis.

3. Wait for the temperature reading to stabilize (this may take about a minute).

4. Read and record the temperature to the nearest 0.5°C (or °F). Read the thermometer while it is immersed in the sample.

5. Rinse the thermometer or probe with distilled water.

Specific Conductance.

1. Set up and calibrate the conductivity meter according to the manufacturer's instructions.

2. The specific conductance cell can become coated with oil and other materials. It is essential that the cell be thoroughly rinsed and, if necessary, cleaned between samples.

3. Set the range selector to the desired range for measurement.

4. Measure the temperature of the sample with a thermometer (as above) and set the temperature selector on the conductivity meter to the measured temperature (if required). Whenever possible, samples should be analyzed at 25°C. If samples are analyzed at different temperatures, temperature corrections must be made and resulting specific conductance reading reported at 25°C.

5. Rinse the probe with distilled water.

6. Place the probe into the sample and move it up and down several times to remove the air bubbles inside the cell casing. Rotate the cell slowly in the sample until the reading stabilizes (some meters may require different procedures).

7. Read and record the conductivity measurement. Remember to multiply the reading by the range the dial is set to (see No. 2).

8. Rinse the probe with distilled water.

9. If necessary, correct the measurement to the standardized 25°C.

pH.

1. Set up and calibrate the pH meter with the proper buffer solution according to the manufacturer's instructions.

2. Rinse the electrode thoroughly with distilled water. Coatings of oily material or particulate matter can impair electrode response. These coatings can usually be removed by gentle wiping or detergent washing, followed by rinsing with distilled water. An additional treatment with hydrochloric acid (1:9) may be necessary to remove any remaining film.

3. Immerse the electrode into the sample and if possible gently swirl.

4. Wait for the reading to stabilize.

5. Read and record the pH to the nearest 0.1 unit.

6. Remove the electrode from the sample and rinse the electrode with distilled water.

7. Store the electrode in the buffer solution (following the manufacturer's recommended storage procedure). The electrode should never be allowed to dry out, since it could damage the electrode.

Sampling Procedures. Special care must be taken in order to prevent cross-contamination when carrying sampling equipment from one well to another. The sampling equipment must be cleaned thoroughly prior to sampling each monitoring well. The effects of cross contamination can be minimized by sampling the least contaminated wells first and progressing to the more contaminated ones. Dedicated sampling devices for each well may be desirable in certain cases where the potential for cross-contamination is extremely high.

The decontamination procedure is as follows:

1. Steam clean or scrub equipment with a nonphosphate detergent.

2. Rinse twice with distilled water.

Equipment and procedures that minimize sample agitation and reduce or eliminate contact with the atmosphere during sample transfer must be used in order to eliminate the loss of volatile constituents from the sample. For collecting samples, a Teflon or stainless steel bailer is acceptable as is a gas-actuated positive displacement pump or a submersible pump. Airlift pumps should not be used. Sampling equipment should be constructed of inert materials. Equipment with neoprene fittings, PVC bailers, tygon tubing, silicon rubber bladders, neoprene impellers, polyethylene, and viton are not acceptable. If bailers are used, an inert line, cable, or chain should be used to raise and lower the bailer.

Vacuum-type (e.g., peristaltic) pumps may be used to collect groundwater samples with the following constraints: 1) the pump is operated at a low flow rate (generally < 200ml/minute); 2) contaminants of concern must have a Henry's Law Constant of less than or equal to 0.03 atm-m^3/mol (refer to Table 7E.2); and 3) a 50% sampling loss is assumed for volatile contaminants. Unless otherwise directed or approved by DOH, concentrations of volatile contaminants should be reported as the laboratory analytical results for the contaminant multiplied by two (i.e., following the assumption that 50% of the contaminant was lost during the sample collection).

When sampling for volatile organics, evaluate the area around the sampling point prior to sample collection for possible contamination from air routes. Products that may contaminate the ground-water samples include perfumes, cosmetics, suntan lotions, and automotive products such as gasoline, starting fluids, and carburetor cleaners. Avoid contact of sampling equipment with surface soils surrounding the monitoring wells. Sampling equipment may be laid on polyethylene sheeting.

Before collecting the water sample, mark the sample bottles to be used for the ground-water sample with a waterproof pen. Label the bottle with the name, or identification, of the monitoring well, the date, time the sample was collected, and the sampler's name.

Samples for volatiles should be placed in three 40 mL VOA bottles provided by the analytical laboratory. These sample bottles are screw-top vials with Teflon-lined silicone septa. Sample bottles should not be rinsed prior to sampling.

Procedures for sampling using bailers:

1. Put on latex or surgical gloves.

2. Rinse the bailer and line with distilled water. Use of a disposable bailer and new line at each sampling interval is preferred.

3. Lower the bailer slowly into the monitoring well. Once the bailer has contacted and entered the ground water, allow the bailer to fill with the ground-water sample.

4. Gently raise the bailer out of the monitoring well (do not allow the bailer rope to touch the ground--use plastic sheeting).

5. Empty the bailer into the sample bottles, using a slow, steady stream. Open, or uncap, one volatile organics analyses vial at a time. Fill the VOA vial so that it is slightly overflowing and a positive, or convex, meniscus is formed. Cap immediately. Turn the VOA vial upside down and tap the vial gently. Check for air bubbles. If air bubbles are found, uncap bottle and allow gas to escape, then create a positive meniscus. The bottle should be emptied and refilled as the preservative would be lost. Keep trying until no air bubbles are found in the VOA vial. Any air bubbles in the VOA vial could aerate the sample and void the analysis.

6. Duplicate samples, when collected, should be taken immediately after the field sample.

7. Record all pertinent sampling data on the ground-water sampling data sheet (Figure 7E.3).

8. Decontaminate the bailer. Cut off and discard any of the line that came in contact with the ground water. Decontaminate the remaining line.

9. Place the sample bottles in baggies to prevent cross contamination. If the sample is highly contaminated, wrap the sample bottle in aluminum foil before placing in a baggie.

10. Place the samples in a 4°C cooler with ice. VOA vials may get too cold when they are placed against the ice, and may freeze and crack. Therefore, care should be taken when placing the VOA vials inside the cooler. A thermometer should be placed in the cooler during transport.

11. Carefully remove gloves. Do not touch the outside of the gloves where they may have been contaminated by the ground water. Place the gloves in a designated garbage bag, or a baggie, for proper disposal. Gloves should be changed for each sampling site.

The procedure for sampling using bladder pumps is the same as the procedure for bailers with the exception of the following steps:

1. Positive gas displacement bladder pumps should be operated in a continuous manner so that they do not produce pulsating samples that are aerated in the return tube or upon discharge.

2. When collecting samples where volatile constituents or gases are of interest using a positive gas displacement bladder pump (or a submersible pump), pumping rates should not exceed 100 mL/minute. Higher rates can increase the loss of volatile constituents and can cause fluctuation in pH and pH-sensitive analytes. Samples should be placed in an ice chest maintained at 4°C with blue ice. A thermometer with a protected bulb should be carried in each ice chest.

Attachment 3

Landfill Policies and Procedures for All Users: PVT Land Company, Limited, August 2016

PVT LAND COMPANY LIMITED
87-2020 Farrington Highway • Waianae, Hawaii 96792 • Tel: 808 668-4561 • FAX:808 668-1368 • www.pvtland.com

LANDFILL POLICIES AND PROCEDURES FOR ALL USERS

Enforcement of Policies. Compliance with PVT's policies and procedures is mandatory. PVT reserves the right to deny access to the landfill to any customer, user, transporter or driver who is not in good standing.

Landfill Hours. Landfill hours of operation on Monday through Friday are from 7:00 am to 4:00 pm. The last load of the day must be on the scale by 3:00 pm and scaled out no later than 3:30 pm; no exceptions. Landfill hours of operation on Saturday are 7:00 am to 1:30 pm. The last load of the day must be on the scale by 1:00 pm. and scaled out no later than 1:30 pm; no exceptions. Unless otherwise notified, landfill hours shall not include Sundays and holidays (see PVT website (www.pvtland.com) for Holiday Schedule). Landfill hours of operation are subject to change without notice; PVT reserves the right to close the landfill at any time for any purpose, including but not limited to rain, high winds, and repair and maintenance.

Permitted Materials. User may only dispose at the landfill: (1) materials which originate from construction or demolition sites, including concrete, hollow tile, bituminous concrete, asphaltic pavement, wood, glass, masonry, roofing, siding, plaster, dirt, rock, stumps, boulders and brush, as defined in Chapter 342H, Hawaii Revised Statutes, and Title 11, Administrative Rules Chapter 58.1, Solid Waste Management Control, as may be amended, (2) petroleum-contaminated soil with required Agreement and pre-approval, (3) contaminated soil from construction and demolition operations with required Agreement and pre-approval, (4) petroleum-based liquids for solidification and (5) asbestos waste. Permitted materials will only be accepted with the required Agreements and pre-approvals

Prohibited Materials. User shall not dispose at the landfill: (1) household waste, garbage, commercial solid waste or industrial solid waste as defined in HAR 11-58.1-03, (2) regulated hazardous wastes and TSCA-regulated PCB contaminated materials, (3) pesticide containers, (4) bulk green waste (grass, leaves, tree trimmings, etc.), loads of land clearing debris or C&D waste containing more than 10 percent green waste, (5) whole tires or car parts, (6) free liquids and liquids products, including paints, solvents, sealers or adhesives (except liquids accepted for solidification), (7) white goods, (8) contaminated C&D loads, and (9) lead-acid batteries.

As stated, household wastes, including household hazard wastes are prohibited. For information on the proper disposal of household wastes, please call the City and County of Honolulu Refuse Division at 808-523-4774. THESE WASTES WILL NOT BE ACCEPTED AT PVT:

Living Room	Kitchen	Bathroom	Storage Shed
glass cleaner rug	oven cleaner	toilet bowl cleaner	oil based paint
shampoo	ammonia drain	disinfectant	paint thinners
insecticides flea	cleaner floor	mildew remover	lacquer, varnish
collar flea bomb	stripper metal	home perm.	adhesives
furniture polish	polish insect spray	medicine	epoxies
rubber cement	rodent killer roach	nail polish remover	paint stripper
mothballs	poison	lice/flea shampoo	photographic chemicals
		bleach	herbicides
			pesticides
			insect repellent

Garage:
Motor oil, antifreeze, car batteries, brake/transmission fluid, engine degreasers, carburetor cleaners, gasoline, gunk remover, cleaning solvents of any type are all deemed unacceptable.

User Responsibilities. User is responsible for screening, examining and inspecting all of User's loads to verify that no load contains any prohibited materials. PVT assumes no responsibility for screening, examining or inspecting any loads delivered by User, except that PVT reserves the right to examine, screen and/or inspect any load at any time. If any load contains any prohibited materials, User is responsible for the removal of such loads or prohibited materials, and any additional fees for the processing and removal of such loads and prohibited materials, as determined by PVT.

Pre-approval of all Permitted Materials. All materials to be landfilled must be approved by PVT prior to acceptance. User shall submit to PVT the completed and executed Request for Clearance form (available on PVT's website (www.pvtland.com) or at PVT's office) no less than seven (7) business days prior to commencement of the demolition or scheduled hauling of Permitted Materials to the landfill. Failure to comply with this paragraph may result in the denial of acceptance for disposal at the landfill. PVT reserves the right to inspect all demolition sites and contaminated soil sites prior to the acceptance of Permitted Materials.

PVT's Right of Rejection. PVT reserves the right to reject any load where PVT believes, for any reason, said load may contain Prohibited Materials. PVT reserves the right to reject any load which may be a violation of its solid waste permit or any laws, rules or regulations (federal, state or local) now or hereafter in effect, or any load which would adversely impact the landfill.

Rev. 8/2016

POLICIES AND PROCEDURES FOR DRIVERS WHILE AT THE LANDFILL

Speed Limits. The speed limit at the landfill is 15 miles per hour. This speed limit will be strictly enforced.

PVT Instructions. Drivers of all vehicles must follow the instructions of PVT spotters and other PVT employees.

Vehicle noise. All customer-owned vehicles must be operating with fully functional mufflers and be in a good state of repair while on the landfill. Quiet operating techniques and practices must be followed. There shall be no engine braking. Vehicle horns may not be used except in the event of an emergency. Drivers must turn-off their engines while queuing for the scale house or while parked at the landfill.

Cover Loads. Drivers of non-household vehicles must cover their loads.

Lualualei Naval Road. Lualualei Naval Road is owned by the United States Navy. The Navy has posted no parking signs along the road. Drivers and operators of all vehicles should obey the posted signs and should refrain from stopping and/or parking along the shoulders of Lualualei Naval Road.

Landfill parking. Drivers are not permitted to park at the landfill except in the area designated for drivers to make phone calls to dispatchers, finish paperwork or wait for the next job. All vehicles must leave the landfill at the close of operating hours; there is no overnight parking. In the event that a customer's vehicle breaks down and cannot be driven from the landfill, PVT may in its discretion allow the vehicle to remain at the landfill for up to 24 hours subject to the terms and conditions of an executed Temporary Parking Agreement. Under no circumstances shall a vehicle remain for more than 24 hours; if the vehicle is not removed, PVT will have the vehicle removed from the landfill at the owner's expense.

Unloading at the landfill. Drivers are required to unload their loads at the landfill as directed by spotters or other PVT employees. If a driver is unable to unload debris from the truck, trailer or bin, PVT may in its discretion assist with the removal of debris from the truck, trailer or bin subject to the terms and conditions of an executed Additional Services Agreement.

POLICIES AND PROCEDURES FOR ASBESTOS DISPOSAL

Landfill hours. The landfill will only accept asbestos on Tuesdays and Thursdays from 7:00 am to 1:30 pm. All asbestos loads must be scheduled twenty-four (24) hours before delivery. Last asbestos loads must be on the scale by 1:30 pm. Last hand unloads for asbestos loads must be on the scale by 1:30 pm. Scheduled loads that are not received by the required time will require re-scheduling for future delivery and acceptance. Landfill hours of operation are subject to change without notice; PVT reserves the right to close the landfill at any time for any purpose, including but not limited to rain, high winds, and repair and maintenance.

Permitted Asbestos Materials. User may dispose non-friable and friable asbestos, such as roofing, ceiling and insulating materials, and fixed asbestos, with required Agreements and pre-approvals.

Asbestos Containment and Labelling. All asbestos containing material ("ACM") that is brought into landfill is required to be prepared for disposal as though the ACM were friable, even if it has been determined to be non-friable. All ACM must be thoroughly wet down or encapsulated prior to containment by the operator preparing the debris for disposal. All ACM must be double bagged or double wrapped in plastic with a minimum thickness of six (6) millimeters, or contained in sealed drums or barrels. All bagged, wrapped, or contained ACM must display asbestos hazard warning labels, as well as labels that have the owner's name, address and telephone number. Any chemical (e.g., solvent used to remove VAT mastic) added to the ACM waste must be pre-approved by the landfill's Operation Manager prior to acceptance for disposal.

Asbestos Pre-approval. PVT will accept ACM on a prearranged basis only. A Request for Clearance Number form and an Asbestos Notification of Demolition and Renovation form must be completed and submitted to the PVT Office in advance of any ACM being accepted for disposal. All asbestos loads must be scheduled twenty-four (24) hours before delivery and accompanied by a properly executed Asbestos Waste Shipment Record. Each Asbestos Waste Shipment Record must be signed by both the operator and transporter hauling the ACM to the landfill. No disposal will be allowed without a complete Asbestos Waste Shipment Record. All other applicable State and Federal Regulations concerning this waste stream must be met prior to acceptance of this waste stream for disposal. It is the responsibility of the User to know and comply with these regulations.

Asbestos Contractors and Transporters. All asbestos contractors and transporters must have an active account with PVT. All contractors and transporters must provide a local telephone number for emergency purposes.

Asbestos Disposal. Each asbestos load accepted for disposal will be escorted and directed where to unload. The PVT escort will stand a safe distance away from the unloading area and truck, while viewing the load disposal. The transporter must make every reasonable effort to avoid the release of any ACM at the landfill. A qualified individual must accompany the load and observe disposal. If the asbestos load breaks open upon disposal and ACM is exposed, the qualified individual must cover the exposed area promptly. All asbestos will be covered at the end of the day. No bags will be left exposed.

Asbestos Records. The Weigh Master for PVT will be responsible for signing the Asbestos Waste Shipment Record, printing a tag and returning copies to the driver.

PVT's Right of Rejection. PVT reserves the right to reject any load where PVT believes, for any reason, said load may contain Prohibited Materials. PVT reserves the right to reject any load which may be a violation of its solid waste permit or any laws, rules or regulations (federal, state or local) now or hereafter in effect, or any load which would adversely impact the landfill.

POLICIES AND PROCEDURES FOR CONTAMINATED SOIL

Landfill hours. The landfill will only accept contaminated soil from 7:00 am to 3:00 pm, Monday through Saturday. All contaminated soil loads must be scheduled twenty-four (24) hours before delivery. The last contaminated soil load must be on the scale by 3:00 pm. Monday through Friday, and by 1:00 pm Saturday. Scheduled loads that are not received by the required time will require re-scheduling for future delivery and acceptance. Landfill hours of operation are subject to change without notice; PVT reserves the right to close the landfill at any time for any purpose, including but not limited to rain, high winds, and repair and maintenance.

Permitted Contaminated Soil. User may dispose petroleum-contaminated soil and contaminated soil from construction and demolition operations with required Agreements and pre-approvals.

Contaminated Soil Pre-approval. PVT will accept contaminated soil on a prearranged basis only. Only contaminated soil from known sources will be accepted for disposal. Generators must provide reliable documentation describing the nature and source of the contamination. The following forms must be completed and submitted to the PVT Office in advance of any contaminated soil being accepted for disposal: Request for Clearance Number and Soil Profile Sheet. The Soil Profile Sheet must be signed by both the generator and the transporter hauling the contaminated soil to the landfill. All contaminated soil loads must be scheduled twenty-four (24) hours before delivery. All other applicable State and Federal Regulations concerning this waste stream must be met prior to acceptance of this waste stream for disposal. It is the responsibility of the generator to know and comply with these regulations.

Contaminated Soil Testing Requirements. All potentially contaminated soil must be tested prior to acceptance for disposal. All soil that may have been impacted by contamination or that was generated as a result of a remedial activity for contamination must be tested. Testing must be designed to screen for potential constituents and their concentrations in the soil. Sampling and analysis of contaminated soil shall be performed in accordance with the Department of Health, Office of Hazard Evaluation and Emergency Response ("HEER") Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan, as updated ("TGM"). Persons conducting the sampling must be qualified and experienced environmental professionals. Soil samples must be collected so as to be representative of the soil to be disposed. *See, e.g.,* TGM Section 4, Soil Sample Collection Approaches; *see also* "Guidance for the Evaluation of Imported and Exported Fill Material, Including Contaminant Characterization of Stockpiles," HEER, October 2011. Soil samples must be collected and analyzed so as to provide accurate information on the soil to be disposed. *See, e.g.,* TGM Section 11, Handling and Analysis of Samples. The following chemical testing is required where appropriate to the potential source of contamination:

- Toxicity Characteristic Leaching Procedure (TCLP) for Resource Conservation and Recovery Act (RCRA) metals, including arsenic, cadmium, chromium and lead
- Ignitability
- Total metals for RCRA metals, including arsenic, cadmium, chromium and lead.
- Total petroleum hydrocarbons (TPH), including TPH as gasoline, TPH as diesel, and/or -TPH as oil as appropriate
- Benzene, toluene, ethylbenzene, xylenes (BTEX)
- Polynuclear aromatic hydrocarbons (PAHs)
- Polychlorinated biphenyl's (PCBs)
- Halogenated volatile organic compounds (HVOCs)
- Toxic Equivalent (TEQ) dioxins
- Technical chlordane and other organochlorinetermiticides
- Other contaminants for which HEER has set Environmental Action Levels (EALs)

Additional testing and/or supplemental information on the soil may be requested on a case-by case basis.

Contaminated Soil Documentation Requirements. Documentation of the sampling methods and analytical results must be submitted with the Request for Clearance Number and the Soil Profile Sheet.

PVT's Right of Rejection. PVT reserves the right to reject any load where PVT believes, for any reason, said load may contain Prohibited Materials. PVT reserves the right to reject any load which may be a violation of its solid waste permit or any laws, rules or regulations (federal, state or local) now or hereafter in effect, or any load which would adversely impact the landfill.

POLICIES AND PROCEDURES FOR PETROLEUM-BASED LIQUIDS FOR SOLIDIFICATION

Landfill hours. The landfill will only accept petroleum-based liquids from 7:00 am to 2:00 pm, Monday through Friday. All petroleum-based liquid loads must be scheduled twenty-four (24) hours before delivery. The last petroleum-based liquid load must be on the scale by 2:00 pm. Scheduled loads that are not received by the required time will require re-scheduling for future delivery and acceptance. Landfill hours of operation are subject to change without notice; PVT reserves the right to close the landfill at any time for any purpose, including but not limited to rain, high winds, and repair and maintenance.

Permitted Petroleum-Based Liquids. User may dispose liquid wastes containing only known sources of petroleum products for solidification ("petroleum-based liquids") with required Agreements and pre-approvals.

Petroleum-Based Liquids Pre-approval. PVT will accept petroleum-based liquids on a prearranged basis only. Only petroleum-based liquids from known sources will be accepted for solidification. Generators must provide reliable documentation describing the origin and contaminant anticipated in the petroleum-based liquids. The following forms must be completed and submitted to the PVT Office in advance of any petroleum-based liquids being accepted for solidification: Request for Clearance Number and Solidification Profile Sheet. All petroleum-based liquids must be scheduled twenty- four (24) hours before delivery. All other applicable State and Federal Regulations concerning this waste stream must be met prior to acceptance of this waste stream for solidification and disposal. It is the responsibility of the generator to know and comply with these regulations.

Petroleum-Based Liquids Testing Requirements. All petroleum-based liquids must be tested prior to acceptance for solidification. Sampling and analysis of petroleum-based liquids shall be performed in accordance with the Department of Health, Office of Hazard Evaluation and Emergency Response ("HEER") Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan, as updated ("TGM"). Persons conducting the sampling must be qualified and experienced environmental professionals. Samples must be collected and analyzed so as to provide accurate information on the petroleum-based liquids for solidification. *See, e.g.,* TGM Section 11, Handling and Analysis of Samples. The following chemical testing is required where appropriate to the potential source of contamination:

- TCLP for RCRA 8 metals
- Volatile organic compounds
- Semivolatile organic compounds
- PCBs
- Pesticides
- Herbicides
- TPH

Additional testing and/or supplemental information on the petroleum-based liquids may be requested on a case-by case basis.

Petroleum-Based Liquids Documentation Requirements. Documentation of the sampling methods and analytical results must be submitted with the Request for Clearance Number and the PVT Solidification Profile Sheet.

PVT's Right of Rejection. PVT reserves the right to reject any load where PVT believes, for any reason, said load may contain Prohibited Materials. PVT reserves the right to reject any load which may be a violation of its solid waste permit or any laws, rules or regulations (federal, state or local) now or hereafter in effect, or any load which would adversely impact the landfill.

Appendix H.1.1:
Navy Responses to DOH Comments
February 2026

Project Title: Draft Remedial Investigation Work Plan Per- and Polyfluoroalkyl Substance Release (June 2024)
at Building 313 Red Hill Bulk Fuel Storage Facility
Joint Base Pearl Harbor-Hickam Oahu HI
Reviewer: Allison Hutto, DOH
Date: August 2024

Item	Section No.	Comment
General Comments		
1	General	Throughout the work plan where there are discussions of previous sampling data, concentrations of PFAS compounds are not consistently compared to DOH Tier 1 (unrestricted) Environmental Action Levels (EALs). Concentrations of PFAS compounds from soil confirmation samples, routine groundwater monitoring, and the September 2023 Baseline Sampling Event had exceedances of DOH Tier 1 EALs. Thus, please revise the document to ensure consistency in comparison of concentrations of PFAS compounds from past sampling events to current DOH Tier 1 EALs. Please also note in the text that where "grab" or "discrete" soil sampling methods were conducted rather than Decision Unit Multi-Increment Sampling (DU-MIS) methods required by DOH, the data may be considered in determining presence of chemicals of potential concern (COPCs), but the data may not be used for final decision-making.
Response (October 2024): The Navy is conducting this PFAS Remedial Investigation (RI) in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as the Federal Lead Agency, consistent with the Department of Defense policy as presented in ASD(EI&E) – Per- and Polyfluoroalkyl Substances (PFAS) (osd.mil). The Navy will conduct the CERCLA human health risk assessment using the Environmental Protection Agency's (EPA's) November 2023 Regional Screening Level (RSL) update, as described in ASD(EI&E) – Per- and Polyfluoroalkyl Substances (PFAS) (https://www.acq.osd.mil/eie/eer/ecc/pfas/pfas101/rsl.html). The DoD conducts PFAS site characterizations following nationally accepted standard operating procedures, which include collecting a sufficient number of discrete soil samples (greater than or equal to 10) in an exposure unit to calculate a statistically relevant 95 percent upper confidence limit of the mean (UCL), which is used as the exposure point concentration (EPC) in the CERCLA risk assessment. This methodology is accepted nationally for final decision-making.		
Updated Response (February 2026): As discussed and agreed upon during Scoping Meeting No. 5 (September 10–11, 2025), DOH acknowledged that they did not require DOH Tier 1 (unrestricted) EALs to be considered project screening levels (PSLs) in the work plan but requested that EALs be presented in comparison to other relevant screening criteria that the Navy has used to develop PSLs for this project. The DOH requested that the EALs be presented in the main document rather than in an appendix. The Navy agreed and has revised the current work plan to present the following potential PFAS screening criteria in tabular format for comparison: DOH Tier 1 (unrestricted) EALs, Navy Ecological Screening Values, EPA RSLs, and DoD-approved screening values in Table 14-1 for soil and Table 14-2 for groundwater. Note that the Navy's October 2024 response cited the EPA's November 2023 RSLs, which were applicable at that time; however, the current project screening levels are provided in Worksheet #15, and have been updated in accordance with the January 2025 Office of the Assistant Secretary of Defense (OSD) Memorandum, *Investigating Per- and Polyfluoroalkyl Substances within the DoD Cleanup Program* (https://www.acq.osd.mil/eie/eer/ecc/pfas/pfas101/rsl.html). These screening levels incorporate the November 2024 residential soil and tap water EPA RSLs using a target cancer risk of 1×10^{-6} and a hazard quotient of 0.1. Historical PFAS data presented in the work plan are compared to current DoD-approved screening levels. DOH Tier 1 PFAS EALs are included in the work plan for informational and comparative purposes in Worksheet #14 Section 14.12 but are not used as screening levels comparisons in this investigation. The Navy is currently proposing to use a high-resolution site characterization technique, as discussed in Scoping Meeting No. 5. Summaries of the scoping meetings, including Scoping Meeting No. 5, are presented in Worksheet #9 of the Revised Draft Work Plan (February 2026). As discussed during the scoping meeting, once the areas of highest concentrations of PFAS in soil are identified, the Navy will evaluate the need to potentially conduct high-density sampling in lieu of MIS. For further clarification, high-resolution site characterization techniques may include activities such as continuous vertical sampling in soil delineation boreholes to identify clay and silt stratigraphy that is the most likely to adsorb PFAS constituents and present potential secondary source for continued leaching to groundwater. Samples for chemical analysis by Method 1633 will be biased toward clays and silts and will provide a more representative sample of the potential secondary source, due to the heterogeneous nature of the valley fill. The valley fill at Area A and Area B consists of boulders, cobbles, gravel, sand, silt and clay, and PFAS is not expected to adsorb to boulder, cobble, gravel, and sand to the same extent as PFAS will adsorb to silt and clay.		
2	General	DOH is of the understanding that a formal Preliminary Assessment (PA) and Site Inspection (SI) for PFAS have not occurred at the RHBFSF, and the Navy instead intends to proceed immediately to the Remedial Investigation (RI) phase. This report begins by stating that the intent of the RI is solely to investigate for PFAS associated with known and potential undocumented AFFF releases at the site. DOH requests, however, that locations that stored and/or transferred AFFF be included as potential sources, and facilities known to be associated with PFAS contamination, such as wastewater treatment facilities, landfills, plating operations, etc. be included as potential sources as well. Two additional potential sources of PFAS within the RHBFSF that should be investigated include the Oily Waste Disposal Facility (OWDF) site and the Collection, Holding, and Transfer (CHT) Tank. In lieu of a formal PA, the Navy should, at a minimum, conduct a historical review to identify any additional potential PFAS sources within the RHBFSF and include those sites in for further evaluation in the RI.

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Response (October 2024): The Red Hill Bulk Fuel Storage Facility (RHBFSF) was evaluated for potential PFAS sources as part of the Preliminary Assessment (PA) for PFAS at Joint Base Pearl Harbor-Hickam (JBPHH) National Priority List (NPL) Sites (DON 2023), and no potential sources of PFAS other than the original fire suppression system associated with the former slop tank area, and the November 2022 release were identified, both in Area A. A summary of the PA has been added as Section 10.2.8.2 of the WP. As reflected in the PA, neither the Former OWDF nor the CHT were wastewater treatment facilities, landfills, or plating operations, and were not identified as potential PFAS sources. In addition, a historical timeline of PFAS usage compared to RHBFSF activities is presented in Section 10.4.2.1 and a discussion of potential sources of PFAS at the RHBFSF based on this timeline.		
Updated Response (February 2026): The historical timeline of PFAS usage compared to RHBFSF activities is now covered in Section 10.5.2.1 and Section 10.5.2.2.		
Groundwater Monitoring		
3	General	"HDOH requests that initial sampling of groundwater adhere to the minimum requirements, as agreed upon by the Navy, the EPA, and HDOH during meetings that occurred on July 3, 9, 12, and 17, 2024. Revise all areas of the report detailing groundwater sampling activities to reflect the following requirements: a. Wells to be sampled include RHMW-2254, RHP01, RHP02, RHP03, RHP-06, RHP-07, RHP-08, RHMW-06, RHMW-17, RHMW-17S, RHMW-17D, RHP04A, RHP04B, RHP04C, RHP-05, OWDPMW01, RHMW-18, RHMW-20, RHMW-07, RHMW-08, RHMW-21, RHMW-04, RHP-08B, RHP-08C, RHMW01R, RHMW-02, RHMW-03, RHMW-05, OWDFMW03A, OWDFMW03B, OWDFMW08A, and OWDFMW08B. b. Sampling of the above groundwater monitoring wells will begin in September and will occur quarterly for at least one year, after which wells to be sampled, and frequency and duration of sampling will be re-evaluated by the Navy, the EPA, and HDOH. c. Laboratory analysis of samples obtained from the above groundwater monitoring wells will be EPA method 1633 for 40 PFAS compounds."
Response (September 6, 2024): a. The Navy agrees with the list of wells to be sampled. However, as discussed in the August 27 Scoping Meeting #3, it was agreed that wells OWDFMW01 and OWDFMW04A will be sampled, well OWDFMW05A will be sampled in place of RHP08C, and well OWDFMW02A will be sampled for one round. b. The Navy agrees that groundwater sampling will begin in September 2024 and will occur quarterly for at least one year. c. The Navy agrees that the groundwater samples will be analyzed by EPA method 1633 for 40 PFAS.		
Backcheck Comment (September 11, 2024): Comment partially resolved. Please revise response b. to "The Navy agrees that groundwater sampling will begin in September 2024 and will occur quarterly for at least one year, after which wells to be sampled, and frequency and duration of sampling will be reevaluated by the Navy, the EPA, and HDOH." The HEER Office also wants to clarify the fact that discussions between the Navy, EPA, and HDOH regarding initial groundwater sampling began before the 2024 HDOH HEER Office PFAS Guidance was finalized in July 2024. In an effort to expedite initial groundwater sampling and remain consistent with previous discussions, the HEER Office agreed solely to analysis via EPA method 1633 for these four events. However, all other samples outside of the initial groundwater sampling must be analyzed for Total Oxidizable Precursors (TOPs) and Total Organic Fluorine (TOF) in addition to EPA method 1633 in order to assess for Total PFAS Risk per our PFAS guidance. This request for TOPs and TOF in addition to EPA method 1633 and the use of our PFAS guidance is reflected throughout the remainder of the HEER Office comments on the Draft Remedial Investigation (RI) Work Plan (WP) (Comments 4, 9, 10, 16, 20, 32, 36, and 37). To proceed with initial groundwater sampling to begin in September 2024, please state the above revised response.		
Response (September 23, 2024): The response to Comment 3, item b. has been revised to: "The Navy agrees that groundwater sampling will begin in September 2024 and will occur quarterly for at least one year, after which wells to be sampled, and frequency and duration of sampling will be reevaluated by the Navy, EPA, and HDOH." This has been added to the end of WP Section 17.5. The Navy will not conduct this RI in accordance with the HDOH Interim PFAS Guidance (HDOH April 2024) with respect to the analyses of Total Oxidizable Precursors (TOP) and Total Organic Fluorine (TOF) for the following reasons: 1. Section 9 of the HDOH PFAS guidance, April 2024, indicates that there is no standard method accepted by EPA for analyzing for TOP. "*Ensure that the laboratory selected for testing of samples is able to process samples using Total Oxidizable Precursors (TOPs) methods. Current methods utilized by laboratories are proprietary but in general follow the approaches described in published literature (e.g., Houtz and Sedlak 2012). The USEPA is working with commercial laboratories to develop a Standard Operating Procedure (SOP) procedure."* 2. This is also true for analytical methods for TOF.		

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3. As a result, there are no laboratories that are DoD ELAP-accredited for analytical methods associated with TOPs and TOF at this time.		
Updated Response (February 2026): As of publication of the Revised Draft Work Plan (February 2026), all expedited quarterly groundwater sampling was completed, and results have been incorporated into Section 10.4 of the work plan.		
4	General	In addition to analysis via EPA method 1633, DOH requests that soil and groundwater samples are processed and analyzed for Total Oxidizable Precursors (TOPs) and Total Organic Fluorine (TOF) to calculate a cumulative Hazard Index for PFAS and determine Total PFAS Risk per DOH HEER Office's updated Interim Soil and Water Environmental Action Levels (EALs) for Perfluoroalkyl and Polyfluoroalkyl Substances (PFASs) (2024 DOH PFAS Guidance) (DOH, 2024): https://health.hawaii.gov/heer/files/2024/07/PFASEALGuidanceHIDOHApril2024Rev070524.pdf. Further, please require that the laboratory take an MI subsample size of 10 grams for soil analysis. Revise all areas of the work plan that discuss laboratory analysis of soil, sediment, and groundwater samples to include TOPs and TOF analysis in addition to EPA method 1633, and a laboratory subsample size of 10 grams.
Response (October 2024): Comment acknowledged. The Navy follows DoD policy for conducting PFAS investigations, specifically DoD policy *Establishing a Consistent Methodology for the Analysis of Per- and Polyfluoroalkyl Substances in Matrices Other than Drinking Wate*r (OSD Memorandum May 2024). For a definitive analysis of PFAS in matrices other than drinking water, the DoD uses U.S. Environmental Protection Agency (EPA) Method 1633 for definitive decision-making. The TOP assay is not included in the standard EPA 1633 methodology nor is it a standardized EPA preparation method. Furthermore, for decision making purposes at CERCLA Sites, the Navy uses laboratories that hold DoD ELAP accreditation for method, matrix, and analyte. No laboratories are DoD ELAP-accredited to conduct TOP Assay and subsequent analysis by EPA 1633; therefore, the Navy cannot use the TOP Assay for definitive decision-making at CERCLA sites at this time. While the EPA has recently released an Adsorbable Organo Fluorine method – EPA Method 1621, using this method for definitive decision-making is also inconsistent with the policy cited above. Additionally, the Navy is not aware of any laboratory that holds current DoD ELAP accreditation for EPA Method 1621, so this method will not be used to analyze the samples. The laboratory will subsample according to its DoD ELAP-accredited method and the Navy will request the lab aliquot 10 grams for solid samples, which is in accordance with the method.		
Updated Response (February 2026): The Navy continues to follow DoD policy for conducting PFAS investigations, specifically DoD policy *Establishing a Consistent Methodology for the Analysis of Per- and Polyfluoroalkyl Substances in Matrices Other than Drinking Wate*r (ASD Memorandum May 2024). In accordance with this policy, the project will use EPA Method 1633, Revision A (December 2024), *Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS*, as the sole method for definitive PFAS decision-making. As discussed in the October 2024 response to comment, under DoD policy the TOP Assay/EPA Method 1621 (Adsorbable organic fluorine/AOF) cannot be used for definitive CERCLA decision-making and are therefore not incorporated into this investigation. Accordingly, TOP/TOF analysis will not be used for the purposes of use in for regulatory compliance, risk assessment, or comparison to a project screening or action level, which includes the evaluation of Total PFAS Risk following HDOH TGM guidance. Potential risks associated with PFAS at the site will be evaluated using the EPA CERCLA human health and ecological risk assessment framework and done in accordance with DoD policy and applicable federal guidance. Although some laboratories currently hold DoD ELAP accreditation for EPA Method 1621 in aqueous matrix, the method is not designated under DoD policy for definitive CERCLA decision-making. EPA Method 1633, Revision A specifies a maximum dry-weight sample mass of 5 grams for soil and sediment samples; all laboratory subsampling and analysis will be conducted in accordance with the EPA method and the laboratory's DoD ELAP–accredited procedures.		
5	General	During the aforementioned meetings, the EPA also requested sampling of groundwater monitoring wells NMW-32, NMW-30, and NMW-12A. The request was made to evaluate PFAS concentrations and provide delineation in the area near (b) (3) and provide delineation of concentrations potentially downgradient of (b) (3) due to concentrations of PFAS exceeding the EPA's maximum contaminant levels (MCLs) during the Navy's September 2023 Baseline Sampling Event. DOH concurs with EPA's requests and rationale, and notes that concentrations of PFAS also exceeded DOH Tier 1 (unrestricted) EALs and generated a Total PFAS Risk Hazard Index of >1 during this event. Thus, DOH also requests that NMW-32, NMW-30, and NMW-12A be included in initial groundwater sampling.
Response (October 2024): The Navy and regulators have agreed to sample a set of approximately 33 wells located within the Facilities' boundary quarterly for 1 year, as described in comment #3. After 1 year of quarterly monitoring, the Navy will re-evaluate the data and may consider additional step-out monitoring well sampling, depending on the results from the on-site groundwater wells.		
Updated Response (February 2026): Groundwater results from the expedited quarterly sampling events indicated that PFAS was delineated to the PSLs west and southwest of the Facility, in the direction of NMW32, NMW30, and NMW12A, thus sampling of these wells was not added to the future sampling requirements in the Revised Draft Work Plan. Those results did indicate that PFAS was not delineated to the north and east of RHP01, RHP02, and RHP03. The Revised Draft Work Plan		

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(February 2026) proposes installing two basal aquifer groundwater monitoring wells in City and County of Honolulu rights-of-way located in the Halawa Industrial Park to delineate PFAS in the basal aquifer to PSLs to the north; and one basal aquifer groundwater monitoring well to the east of RHP01 along [redacted] (b) (3) within the Facility.		
6	General	Please reconfirm that groundwater monitoring well RHM[redacted] (b) (3) will be sampled bi-monthly in order to monitor the source water at the [redacted] (b) (3) as previously confirmed by the Navy in a letter to EPA and HDOH dated June 21, 2024.
Response (September 6, 2024): The Navy confirms that the Navy is sampling the source water from the [redacted] (b) (3) for PFAS (analyzed by EPA methods 537.1 and 533) every other month under the Extended Drinking Water Monitoring Program. This sampling program does not include collecting a sample from the monitoring point (RHM[redacted] (b) (3)), rather the sample of the same water is collected from a port in the US Navy Well [redacted] (b) (3) pump station.		
Comment Resolved (September 12, 2024).		
Soil Sampling and Analysis		
7	General	DOH does not accept discrete, or grab, soil sampling as a representative method of sampling that can be used for final decision-making because grab soil sampling has been demonstrated to be unreliable. Thus, DOH requires that DU-MIS collection of soil samples be conducted in accordance with DOH guidance. DOH guidance on DU-MIS can be found in our DOH HEER Office Technical Guidance Manual (TGM) (DOH, 2008 Interim Final last updated 2024): https://health.hawaii.gov/heer/tgm/. Enclosed is DOH letter 177334 MR, dated October 28, 2020, which discusses DOH's position on DU-MIS sampling of soil versus grab soil sampling and the use of DOH guidance.
Response (October 2024): Comment acknowledged. As noted in previous correspondence with the DOH, the Navy understands that there are technically sufficient data to support that discrete sampling for PFAS can meet appropriate accuracy and reproducibility for PFAS compounds. The Navy believes that any issues regarding sample coverage and laboratory subsampling can be adequately addressed using an appropriate design for selecting discrete sample locations and by following EPA Method 1633 and DoD QSM requirements.		
Updated Response (February 2026): See updated response to comment #1.		
Specific Comments		
8	Worksheet #5, Page 29	Please revise to depict lines of communication between DOH and the Navy in an equal position as EPA and delete the "line of authority" from EPA to DOH. Please also delete the line of communication between DOH and the Navy's contractor. DOH should be able to deal directly with the Navy when necessary.
Response (October 2024): Worksheet #5 has been revised as suggested.		
9	Worksheet #8, Page 35	Please revise to include the 2024 DOH PFAS Guidance as guidance that will be used during soil and groundwater sampling and analysis.
Response (October 2024): Refer to response to comments #4 and #7. For the reasons described in the responses cited, the Navy will not conduct the RI sampling and analysis in accordance with the 2024 DOH PFAS Guidance.		
10	Worksheet #10, Table 10-1, Page 50	For all future reports, all concentrations of PFAS compounds should be compared to EPA MCLs and DOH Tier 1 (unrestricted) EALs in addition to EPA RSLs. Further, all future reports should include Pre-TOPs, Post-TOPs, and Excess Fluorine hazard indices with a final Total PFAS Risk Hazard Index per sample.
Response (October 2024): The RI human health risk assessment will continue to use the EPA RSLs for screening purposes as the RSLs represent risk-based concentrations considering only the relationship between exposure and risk; this is consistent with OSD policy *Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program,* August 24, 2023, and online updates. In addition, the RI ecological risk assessment will use the ecological screening values in the Navy Emerging Chemicals Workgroup Issue Paper. Both are described and presented in Worksheet #15 of the work plan. Use of MCLs in the screening assessment in a risk assessment does not provide an accurate evaluation of risk, as the MCL is developed considering not only the potential health risk but also the level of treatment possible for the contaminant in question. The Navy will follow DoD policy OSD Memorandum *Prioritization of Department of Defense Cleanup Actions to Implement the Federal Drinking Water Standards for Per- and Polyfluoroalkyl Substances Under the Defense Environmental Restoration Program,* September 2024, on integrating the MCL values into the CERCLA process. It is not the Navy's policy to use Pre-TOPs, Post-TOPs, and Excess Fluorine hazard indices with a final Total PFAS Risk Hazard Index per sample to evaluate risk from PFAS. These methods do not have clear DQOs for evaluating risk, and the methods are considered screening methods with potential use in identifying areas to collect definitive data or as sensitivity analyses around ERA results on definitive data. Additionally, refer to response to comment #4.		

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Updated Response (February 2026): See updated response to comment #1 regarding use of the DOH PFAS EALs and see comment #4 regarding inclusion of TOPS/TOF analysis. Consistent with DoD policy, *Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program*, January 2024 and CERCLA risk assessment process, EPA risk-based screening levels (i.e., EPA RSLs) and Navy-approved ecological screening values are used as the PFAS screening values. The MCLs are not used as primary risk-based screening levels; however, when the analytical limitations prevent comparison to EPA RSLs and an MCL has been established, the MCL is used as the groundwater PSL. The risk assessment will adhere to the established CERCLA risk assessment process and will use the most current and DoD-approved toxicity/screening values at the time of evaluation. Refer to Worksheet #15 for selection of PSLs.		
11	Worksheet #10, Section 10.2.8.3, Page 51	Section 10.2.8.3 (PDF pg. 51) only includes groundwater monitoring wells RHP01, RHP02, RHP03, RHP06, and RHP07 as wells with concentrations of 6:2 FTS as nondetect with PFOS exceeding screening criteria, leaving out NMW32. Does the omission of NMW32 imply that concentrations of PFAS compounds in this well could be related to the AFFF concentrate release of November 2022 and/or a release of modern formulations of AFFF?
Response (October 2024): Well NMW32 will not be included at this time, because it is located offsite and results from the September 2023 sampling event show PFAS at concentrations that exceed all wells sampled within the Facility, which suggests a different source.		
Updated Response (February 2026): See updated response to comment #5.		
12	Worksheet #10, Table 10-2, Page 52	Revise the table to include concentrations of PFAS obtained during the September 2023 Baseline PFAS Sampling Event
Response (October 2024): A new Table 10-3 has been added to include the September 2023 baseline sampling results.		
Updated Response (February 2026): The September 2023 baseline sampling results are now presented in Table B-3.		
13	Worksheet #10, Section 10.2.8.4, Page 53	Please state that DOH rescinded the No Further Action status of the Oily Waste Disposal Facility (OWDF) on April 8, 2024, due to information provided via power point presentation during a Navy briefing to DOH and EPA in February 2024, lessons learned from the November 2021 petroleum release from the RHBFSF, and the requirement for institutional controls documented in an environmental hazard management plan.
Response (October 2024): The following text has been added to Section 10.2.8.6 (renumbered from Section 10.2.8.4): "DOH rescinded the NFA status of the OWDF in a letter dated April 8, 2024. The letter also described the anticipated requirement for institutional controls that would be documented in an environmental hazard management plan, which may be prepared after completion of the ongoing site assessment and environmental hazard evaluation."		
Updated Response (February 2026): The October 2024 response is no longer applicable. The previous Section 10.2.8.6 which described the history of the former OWDF has been removed from the Revised Draft Work Plan (February 2026). The CSM was revised to focus on known or potential PFAS sources. The OWDF investigation did not address PFAS.		
14	Worksheet #10, Section 10.4.1, Page 55	This section states that the former slop tank was in use from approximately 1963 to the mid to late 1960s. Please revise to reflect the date at which use of the slop tank actually ceased.
Response (October 2024): The requested date information has not been located/identified during the record search/research conducted to date.		
15	Worksheet #10, Section 10.4.3, Page 58	What is the basis for the conclusion that there are not any ecological receptors associated with Halawa Stream? Include more details on the conclusions gathered from the referenced report, Red Hill Bulk Fuel Storage Facility Final Technical Report, Pearl Harbor, Hawaii (DON, 2007).
Response (October 2024): The following information has been added to the Section 10.4.2.3: "As referenced in the RHBFSF technical report (DON 2007), the southern segment of the Halawa Stream is approximately 665 feet to the north of the RH Facility. Halawa Stream was listed on the impaired water's list, based upon the visual assessment of nutrients and turbidity. USEPA's Watershed Assessment Tracking & Environmental Results System indicates that the Halawa Stream is completely impaired to support aquatic life. Elements considered impaired include nutrients, pathogens, turbidity, and exotic species. Potential sources are identified as urban runoff/storm sewers, other urban runoff, and other natural sources (TEC and AMEC 2005). In addition, the main portion of South Halawa Stream along the northern site perimeter is concrete-lined, channelized, and does not support sensitive habitat, according to the *Remedial Investigation Phase II, Red Hill Oily Waste Disposal Facility* (Earth Tech 1999). The concrete-lined segment runs for at least 4,200 feet into the valley, along the entire perimeter of Red Hill. Since most of the stream is concrete-lined and impaired for the support of aquatic life, it is not considered a potential ecological receptor for this Site (TEC and AMEC 2005). However, South Halawa Stream located near		

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Area A is not channelized, and a potential exists for surface water run-off during storm events from Area A to flow toward the stream due to the local topography. The current proposed sampling includes surface soils which will be used to assess the potential for PFAS-contaminated soils being transported off the site toward South Halawa Stream during storm events. If PFAS are found in site surface soils, then an evaluation will be made to determine if off-site sampling is necessary. The preliminary risk evaluation concluded that there were no significant exposure pathways for ecological receptors and no sensitive species were noted in the immediate vicinity of the Facility.		
Updated Response (February 2026): Site-specific exposure pathways are presented in Section 10.5.3 of the Revised Draft Work Plan (February 2026), which represents the Navy's understanding of ecological exposure pathways associated with South Halawa Stream at the time of publication. The October 2024 response is no longer applicable.		
16	Worksheet #11, Section 11.3, Page 60	Project screening levels (PSLs) must include DOH Tier 1 (unrestricted) EALs and Total PFAS Risk per the 2024 DOH PFAS Guidance. Revise all sections of the document referring to PSLs to include Total PFAS Risk.
Response (October 2024): PFAS investigations conducted under the Navy's Environmental Restoration program are required to follow current DoD policy, which indicates risk assessments will be evaluated using EPA RSLs that are derived from final, peer-reviewed toxicity values. In accordance with current DoD policy, which describes the currently approved peer-reviewed toxicity values recommended for use within the DoD, these PFAS include hexafluoropropylene oxide dimer acid, perfluorobutanesulfonic acid (PFBS), perfluorobutanoic acid (PFBA), perfluorohexanesulfonic acid (PFHxS), PFHxA, perfluorononanoic acid (PFNA), PFOS, PFOA, Bis(trifluoromethylsulfonyl) amine, and perfluoropropanoic acid. Toxicity data will be re-evaluated as new guidance is published, and appropriate peer-reviewed toxicity values will be used following applicable DoD guidance (DoD 2023; 2024). Refer to response to comment #4. The methods for assessing Total PFAS Risk presented in the 2024 DOH guidance do not rely on standardized peer-reviewed methods and will not be used in the CERCLA RI to evaluate risk.		
Updated Response (February 2026): See updated responses to comments #1, #4, and #10.		
17	Worksheet #11, Section 11.3, Page 60	Revise to include PFAS analytical results from the September 2023 Baseline PFAS Sampling Event as a primary decision input.
Response (October 2024): The September 2023 Baseline PFAS Sampling results are already included under the second to last bullet point, "PFAS analytical results collected from response and compliance activities."		
Updated Response (February 2026): The September 2023 Baseline PFAS sampling results are now included under the third to last bullet point, "COPCs analytical results collected from response and compliance activities."		
18	Worksheet #11, Section 11.3, Page 60	Revise to include an environmental hazard evaluation per the DOH HEER Office TGM in addition to a human health risk assessment and ecological risk assessment to be developed from soil, sediment, and groundwater analytical results.
Response (October 2024): The Red Hill PFAS RI human health and ecological risk assessments will be conducted in accordance with CERCLA guidance, rather than the guidance in the DOH HEER Office TGM.		
19	Worksheet #11, Section 11.4, Page 61	Revise Area B to include the OWDF site and the CHT tank.
Response (October 2024): The Navy does not recommend revising the Area B site boundary to include the former OWDF at this time. The former OWDF is subject to its own, separate investigation. Although some wells that belong to the former OWDF will be sampled under this RI to delineate potential PFAS in perched and basal groundwater, the former OWDF itself does not fall under the scope of this RI.		
Updated Response (February 2026): As shown on Figure 3 of the Revised Draft Work Plan (February 2026), the boundary of Area B has been extended to the western edge of the Facility and encompasses the former OWDF and CHT tank.		
20	Worksheet #11, Section 11.6.2, Page 62	Include the DOH HEER Office TGM and DOH PFAS Guidance to the list of methodologies which will minimize decision errors.
Response (October 2024): The Navy reviewed the DOH PFAS guidance and has chosen not to use it based on conflicts with DoD policies. Refer to response to comments #4, #7, #10, and #16 regarding DOH PFAS guidance. Applicable sections of the DOH TGM for environmental sampling have been included. This is listed in Section 11.6.2.		
21	Worksheet #12, Page 65	Revise collection frequency of equipment rinsate blanks to one per sampling team per day in addition to per matrix.

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Response (October 2024): Comment acknowledged. The Navy recognizes the importance of assessing the adequacy of decontamination procedures, and the heighted concern for evaluating cross contamination when sampling for PFAS. The project plan is to collect equipment rinsates at a minimum of 5 percent of primary samples per matrix (i.e., collected or 1 per 20 samples collected) to have a definitive frequency goal of sampling and analyzing equipment blanks. The collection frequency is consistent with other CERCLA projects conducted by the Navy under the CLEAN program at Joint Base Pearl Harbor-Hickam.		
22	Worksheet #12, Page 65	Worksheet #12 (PDF pg. 65) lists relative percent differences (RPDs) of ≤50% for water and ≤100% for soil and sediment under measurement performance criteria, with Section 10.6.1.2 of the HDOH HEER Office TGM as a source for those criteria, which is an incorrect reference. Section 10.6.1 of the HDOH HEER Office TGM discusses field replicates, or duplicates, which states that a field replicate precision of approximately 10-35% is generally established as a data quality objective (DQO) for discrete, or grab, sampling. For DU-MIS methodology, a relative standard deviation (RSD) of <35% is the recommended DQO. Thus, the proposed RPDs must be revised to reflect a maximum RPD of 35% for water, and for soil and sediment, two sets of DUMIS replicates must be collected to establish an RSD of <35%.
Response (September 6, 2024): Comment Acknowledged. The Navy recognizes the importance of collecting representative samples and implements sampling protocols and best practices when conducting environmental sampling to minimize sampling error. The MPCs in the WP are reflective of those typically used for soil and water for PFAS (and other analytes) field duplicate evaluation for investigations conducted by the Navy under the CLEAN program at Joint Base Pearl Harbor-Hickam. In addition, the field duplicate RPD MPCs in the WP are consistent with Navy SOPs for non-PFAS chemicals.		
Backcheck Comment (September 12, 2024): Comment not resolved. For groundwater, if duplicates obtained result in an RPD above 35%, then the HEER Office requests 1) additional sampling of that well and 2) a discussion of the steps taken to limit errors during sample processing and analysis included in monitoring reports and/or RI reports. For soil and sediment, the HEER Office reiterates its request for DU-MIS methodology which requires triplicates that would produce RSDs. An RSD between 35% and 50% indicates moderate data precision, an RSD between 50% and 100% indicates poor data precision, and an RSD above 100% indicates very poor data precision. If soil and/or sediment triplicates result in an RSD above 35%, then the HEER Office requests that recommendations per Section 4, Appendix L, Section L.3.3, Table L-1 (https://health.hawaii.gov/heer/tgm/section-04/#table-l-1) be followed and included as a discussion in the RI reports. Further, please provide a copy of the guidance or policy that the Navy's CLEAN Program uses regarding field duplicate evaluation for investigations of PFAS in soil and water. To proceed with initial groundwater sampling to begin in September 2024, please state that the Navy will adhere to the requests listed above for groundwater sample duplicates with an RPD above 35%. The soil and sediment RSD portion of the comment and the copy of Navy guidance may be addressed in the RTCs for the entire Draft RI WP.		
Response (September 23, 2024): The Navy understands the importance of minimizing sampling error and will follow standardized methods for doing so as discussed in WP Section 11.6.3, and data quality usability will be assessed and presented in the RI report as detailed in Worksheet #37. However, achieving field duplicate RPDs below 35% is unlikely for all samples and analytes at the low PFAS concentrations observed in previous sampling events due to statistical limitations. In addition, requiring additional sampling or resampling based solely on field duplicate RPDs greater than the WP MPC is not typical of the DQO process and should not be absolutely required. The following text was added to footnote "c" to clarify evaluation of the groundwater RPDs in Worksheet #12: "For analytes measured above the LOQ, the MPC is 50%. Results below the LOQ or non-detected are estimates, and RPD exceedances at these levels don't significantly impact data quality. For field duplicates above the LOQ, if RPDs exceed 50%, no qualification is necessary, but RPDs and absolute differences should be noted in the data validation summary. Discussions of RPDs > MPC will be included in the data usability assessment as described in Worksheet #37. Assessment of field duplicate precision will be evaluated in the context of detected concentrations, reporting limits, and screening levels." There is no general DoD policy or guidance that defines the RPD MPCs for field duplicates; it is defined in each WP. NAVFAC and DoD data validation SOPs were used as the basis for developing RPD MPCs; these SOPs suggest RPD MPCs of 50% for water and 100% for soil. The field duplicate MPCs in the WP reflect those consistently used and accepted in remedial investigations conducted by the Navy at Joint Base Pearl Harbor-Hickam. In the notes to Worksheet #12 of the work plan, the citation for the DoD data validation procedures (c. Per Section II, *Data Validation Procedures* [DON 2015]) is provided, and the citation of the DOH TGM has been removed. Further response for inclusion of DU-MIS soil sampling and HDOH PFAS TGM guidance in the WP are forthcoming in the full response to comments.		
Updated Response (February 2026): See updated response to comment #1 regarding inclusion of DU-MIS and HDOH PFAS TGM guidance.		
23	Worksheet #13, Page 67	A Data Source and Data Generator for the Release Report section cites a document from the DOH "Hansen's Disease Branch." Please revise to DOH "HEER Office.
Response (October 2024): On Worksheet #13, "Hansen's Disease Branch" has been revised to "HEER Office".		

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24	Worksheet #14, Section 14.4, Page 71	DOH does not allow for final decision making to be based on discrete, or grab, soil sampling methodology as grab sampling has been demonstrated to be unreliable. DOH instead requires that soil samples be collected via DU-MIS methodology in accordance with the DOH HEER Office TGM. Revise all sections discussing soil and sediment sampling to the requirements in Comments 24a and 24b below. a. Area A: All soil samples must be obtained via DU-MIS methodology. Source DUs should include the Former AFFF 200 Gallon tank area and slope to the below pavement, the drainage swale, and surge rock/drainage area at the end of the drainage swale. The remainder of the grassy areas within Area A should be perimeter DUs (area west of Building 313, south of Building 313, east of the Former 200-gallon tank with slope DU, and the grassy areas south of the excavated areas alongside the road). The depths of the surface DUs should be 0-6 inches, and a second vertical DU should be under the surface DUs from 6-12 inches. All locations of borings as proposed within this report for the purpose of determining the vertical extent of residual contamination are acceptable to DOH. However, these borings should be treated as exploratory borings per the DOH HEER Office TGM which designate DU intervals along the soil core which are then sampled via MIS methodology. DOH requires a minimum of 50 increments collected per MI sample, and DU size must not exceed 5,000 sq. ft. (or 100 cubic yards in volume) b. Area B: All soil samples should be obtained via DU-MIS methodology. All locations of borings as proposed within this report are acceptable to DOH. However, these borings must be treated as exploratory borings per the DOH HEER Office TGM which designate DU intervals along the soil core which are then sampled via MIS methodology. Further, each proposed boring location can serve as the center of a surface soil DU, and a separate DU for the CHT tank is required. DOH requires a minimum of 50 increments collected per MI sample, and DU size must not exceed 5,000 sq. ft. (or 100 cubic yards).
Response (October 2024): MIS sampling will not be performed, as the Navy Policy for sampling of PFAS-contaminated media is to perform discrete sampling. See response to comment #7.		
Updated Response (February 2026): See updated response to comment #1.		
25	Worksheet #14, Section 14.5, Page 71	HDOH suggests that the groundwater monitoring wells to be installed into the perched aquifer be 2 inches in size, or large enough to be able to install transducers and/or bail groundwater for sampling purposes, versus a 4 inch well as suggested by HDOH and the Department of Land and Natural Resources for installation of RHMW17 and 17S/17D.
Response (September 6, 2024): 2-inch diameter monitoring wells greatly restrict the utility of the wells. It can be difficult to get tools and equipment down small-diameter wells (e.g., Aquatrol 600, development pump). If the well borehole is deviated sufficiently, tools and equipment may not fit or become stuck rendering the well useless. A 4-inch diameter well reduces the likelihood of these tools and equipment getting stuck and is more accommodating for running downhole tools. 4-inch diameter wells also provide more flexibility for future work and use of analytical tools. We have experienced many issues running tools down 2-inch diameter wells and the cost savings are insignificant. For these reasons, the Navy recommends continued installation of the more versatile 4-inch monitoring wells.		
Comment Resolved (September 12, 2024).		
26	Worksheet #14, Section 14.5.2, Page 73	Provide dates of logging to HDOH at least 2 weeks prior to allow for attendance at drilling, logging, installation, etc. activities regardless of any scenarios. Please arrange military escorts and/or NAVFAC representatives during such visits.
Response (September 6, 2024): Comment acknowledged. The Navy will provide HDOH a minimum notice of 2-week notice prior to drilling, logging, well installation, etc. However, actual dates may change based on operations. The Navy requests a minimum of 1 week notice from HDOH prior to site visits to coordinate access, escorts, etc.		
Comment Resolved (September 12, 2024).		
27	Worksheet #14, Section 14.5.5, Page 76	In addition to an elevated PID reading, any olfactory and/or visual indications of free product or gross contamination should be included in the rationales for determining depth to set conductor casing.
Response (September 6, 2024): Section 14.5.5 has been revised to state that any perched groundwater will be cased off with conductor casing as a conservative measure. This will eliminate any chance of potential PFAS from an upper perched zone contaminating the basal aquifer. Section 14.6 outlines contamination scenarios, including elevated PID readings, olfactory and/or visual indications of free product. The text in Section 14.5 refers to Section 14.6, and currently states “If conductor casing is required due to contaminated soil or the presence of 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		

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the interval of 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."		
Comment Resolved (September 12, 2024).		
28	Worksheet #14, Section 14.5.5, Page 76	Please clarify that a conductor casing will be required for all contaminated perched groundwater at any depth where significant inflow to the borehole cannot be prevented by grouting
Response (September 6, 2024): Section 14.5.5 has been revised to state that any perched groundwater will be cased off with conductor casing. This will eliminate any chance of potential PFAS from an upper perched zone contaminating the basal aquifer.		
Comment Resolved (September 12, 2024).		
29	Worksheet #14, Section 14.5.5, Page 76	Revise to reflect one of the following methods of grouting, and ensure all details are included: 1) Ensure that the driller will grout the annular space all around the maximum dimension of the conductor casing with cement-bentonite grout, either by pressure grouting through the conductor casing using a steel tremie pipe placed through a packer assembly, or by pumping through a steel tremie pipe placed on the outside of the conductor casing, or 2) If tremie grouting is conducted, it will be performed in a two-step process; first, the base of the conductor casing will be grouted in place with a 3- to 5-ft-thick cement bentonite grout plug, then the grout plug will be left undisturbed for a minimum of 24 hours for curing before emplacing grout above the plug to the surface with a steel tremie pipe. Placing the grout in the annular space may be done in stages or lifts with time allowed for the grout to set so as to prevent distortion or collapse of the casing by heat and/or pressure. Following the grouting procedure, the grout will be left undisturbed for a minimum of 24 hours curing.
Response (September 6, 2024): Conductor annular space will be grouted by either cement-bentonite grout or neat cement grout by pumping through a steel tremie pipe placed on the outside of the conductor casing. The base of the conductor casing will be grouted in place with a 3- to 5-ft-thick cement-bentonite grout plug, then the grout plug will be left undisturbed for a minimum of 24 hours for curing before emplacing grout above the plug to the surface with a steel tremie pipe. Placing the grout in the annular space may be done in stages or lifts with time allowed for the grout to set so as to prevent distortion or collapse of the casing by heat and/or pressure. Following the grouting procedure, the grout will be left undisturbed for a minimum of 24 hours for curing. Section 14.5.5 has been revised accordingly.		
Comment Resolved (September 12, 2024).		
30	Worksheet #14, Sections 14.6.1.1, 14.6.1.2, and 14.6.1.3, Pages 79-80	Provide the rationale behind choosing the flow rate and determining the criteria for the conductor casing. Also, how will inflow and outflow be measured?
Response (September 6, 2024): Section 14.6.1.1 has been revised to state that any perched water will be cased off with conductor casing. This will eliminate any chance of potential PFAS from an upper perched zone contaminating the basal aquifer. (The perched groundwater in-flow criterion was removed.)		
Comment Resolved (September 12, 2024).		
31	Worksheet #14, Section 14.6.1.4, Page 80	If contaminated soil is encountered, samples must be collected and analyzed for petroleum constituents and PFAS compounds per the HDOH HEER Office TGM and the 2024 HDOH PFAS Guidance. Ensure that the following are also included for analysis: 2-2-methoxyethoxyethanol (EPA method 8270), 2-2-butoxyethoxyethanol (EPA method SW8015C), High resolution GC/FID fingerprint with n-alkanes and isoprenoids (EPA method 8015M), and SVOCs (EPA Method 8270E). In addition to SVOC priority pollutant data, ensure non-target analysis is performed (surfactants, polars, etc.).
Response (September 6, 2024): This investigation is only analyzing for PFAS using EPA Method 1633. There is a Site Assessment that will investigate the (b) (3) area for petroleum hydrocarbons. In the event that petroleum hydrocarbon-impacted soil (i.e., detected via visual staining, odor, or through PID readings) is encountered, the location will be noted and communicated to the Site Assessment investigation team. Section 14.6.1.4 was updated and the second bullet point now reads, "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. In addition, the Site Assessment investigation team will be notified to determine the appropriate course of action regarding sampling for petroleum hydrocarbon constituents."		

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Backcheck Comment (September 11, 2024): Comment partially resolved. Wherever PFAS sampling and analysis occur due to the encounter of contaminated soil during drilling activities, the HEER Office requests that TOPs and TOF analyses are also conducted in order to calculate Total PFAS Risk per our PFAS Guidance. Also, what is the Site Assessment investigation team's protocol in the case that petroleum contamination is discovered during drilling activities? As a reminder, potential new releases must be reported in accordance with HEER Office release reporting requirements outlined online at https://health.hawaii.gov/heer/reporting/how-to-report-a-release-spill/. The HDOH Underground Storage Tank Section (https://health.hawaii.gov/ust/) and Safe Drinking Water Branch (https://health.hawaii.gov/sdwb/) should also be notified according to their respective regulations. To proceed with initial groundwater sampling to begin in September 2024, please 1) state that HEER Office PFAS sampling and analysis requirements will be followed and include a reference to those requirements, as appropriate, and 2) provide details on the Site Assessment investigation team's protocol.		
Response to 1 (October 2024): See response to comment 3. The Navy will not conduct TOPs and TOF analysis as part of the current investigation as there are no standard EPA Methods for TOPs or TOF, and as a result, there are no laboratories that are DoD ELAP-accredited for these analyses. Response to 2 and 3: In the case that petroleum-impacted material is encountered during the PFAS well drilling activities, the Navy RPM for the site assessment program will be provided with the location of the petroleum-impacted material and the evidence of the release that will also be provided to the HEER office (https://health.hawaii.gov/heer/reporting/how-to-report-a-release-spill/), the HDOH Underground Storage Tank Section (https://health.hawaii.gov/ust/), and the Safe Drinking Water Branch (https://health.hawaii.gov/sdwb/), in accordance with their respective regulations. Any notifications will be done by Navy organization overseeing the site assessment. Please see the site assessment work plan for more details on that program's procedures, as the site assessment work plan is currently being finalized with input from the Regulatory Agencies. Response to 4: The Navy requests to proceed with groundwater sampling in September 2024 under the conditions stated above.		
Updated Response (February 2026): Refer to comment #4 regarding the use of TOPs and TOF for the purpose of calculating Total PFAS risks following HDOH guidance. To clarify text in the September 6, 2024, response: "Upon discovery of oily staining or sheen/observation of mobile fuel product, the Navy RPM or representative 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." During expedited well installation and sampling in Area A (December 2024 through July 2025) petroleum was encountered. Based on the results of petroleum constituents and free product observed in borings associated with drilling PFMW01A and PFMW01B at Area A, the Navy has included a petroleum investigation in the current work plan based on the observance of a comingled plume of petroleum product and PFAS constituents in Area A. The petroleum investigation at the former OWDF is being investigated separately. The Navy will evaluate petroleum-impacted soil, sediment, or groundwater observed within the Facility boundary, but outside of the comingled PFAS/petroleum plume under a separate task order, because of the limitations of CERCLA in accordance with CERCLA's petroleum exclusion clause.		
32	Worksheet #15, Page 89	DOH does not agree in that analytes without currently available screening values will not be further evaluated. Revise to state that all PFAS compounds, plus TOPs and TOF should be analyzed during all future events to continue gathering data for future use.
Response (October 2024): Refer to response to comments #4, #7, #10, and #16 regarding DOH PFAS guidance. This sentence was revised to state: "These analytes will not be *definitively* evaluated, and the uncertainty associated with PFAS without screening criteria will be discussed in the risk assessment sections of the RI report."		
Updated Response (February 2026): Refer to responses to comments #1, #4, #7, #10, and #16 regarding DOH PFAS guidance. The October 2024 response text was revised to state in Worksheet #15 "PFAS without currently available screening values will be used to update the CSM. These analytes will not be quantitatively evaluated, and the 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 with DoD policy and in accordance with the ASD Memorandum, *Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program* (ASD 2025), as updated at the time of reporting."		
33	Worksheet #15, Page 89	The 1994 FFA states that state standards must be taken into account at the RI phase and should be addressed as early as possible within the CERCLA process. DOH does not accept state standards beginning with the feasibility study phase as adequate data would not have been gathered in order to determine potential alternatives. Thus, revise to state that state standards will be used during this RI phase.
Response (October 2024): The Navy agrees that State laws and promulgated regulations that are potential Applicable and Relevant and Appropriate Requirements (ARARs) should be identified and discussed amongst the Parties throughout the RI/FS process. However, the FFA defines ARARs as "Federal and State applicable or relevant and appropriate requirements, standards, criteria, or limitations selected pursuant to section 121 of CERCLA." FFA § 4.1(b). Section 121 of CERCLA sets		

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forth requirements for "Cleanup standards" used to "select appropriate remedial actions" CERCLA § 121(a), 42 U.S.C. §9621(a). In contrast to cleanup level, project screening levels (PSLs) listed in Worksheet #15 are screening levels for use during the RI risk assessment, not cleanup standards. The ARARs discussed in the 1994 FFA are part of the FS decision-making process used to select a remedial action that can "attain a degree of cleanup" that is "relevant and appropriate under the circumstances" CERCLA § 121(d), 42 U.S.C. §9621(d). Cleanup standards are set during the feasibility study phase in choosing a remedial action, not at the screening phase of the remedial investigation. Section 7.6(a) of the FFA states "DOH shall identify potential State ARARs as required by CERCLA § 121(d)(2)(A)(ii), 42 U.S.C. § 9621(d)(2)(A)(ii)." As described above, these sections of CERCLA pertain to cleanup standards, not screening levels. Worksheet #15 identifies "Project Action Levels," i.e., screening levels, which are not "regulatory cleanup standards." The RI does not screen based on promulgated cleanup requirements, but instead must use risk-based calculations as described in the Risk Assessment Guidance for Superfund (https://www.epa.gov/risk/risk-assessment-guidance-superfund-rags-part). In addition, Section 7.6(b) of the FFA states that "Prior to the issuance of a draft primary or secondary document for which ARAR determinations are appropriate, the Project Managers shall meet to identify and propose all potential pertinent ARARs, including any permitting requirements that may be a source of ARARs. At that time and within the time period described in NCP § 300.515(h)(2)…" ARARs used to develop cleanup standards are requirements that are evaluated during the FS stage, as confirmed in the referenced section of the NCP, which states that the federal "lead agency shall request potential ARARs from the support agency no later than the time that the site characterization data are available" from the remedial investigation NCP § 300.515(h)(2). The federal agency then requests potential ARARs: "After the initial screening of alternatives has been completed but prior to initiation of the comparative analysis conducted during the detailed analysis phase of the FS" 40 CFR § 300.515(h)(2). The NCP states that "Applicable requirements means those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws." 40 CFR § 300.5. Thus, Section 7.7(b) of the FFA states that "any State guidance that is not promulgated (as defined by the "NCP") shall constitute a "to-be-considered" item (as that phrase is used in the NCP)." The NCP confirms that the "term promulgated means that the standards are of general applicability and are legally enforceable," unlike the screening levels in Worksheet #15 NCP § 300.400(g)(4). NCP § 300.400(g)(3) describes the identification of ARARs and TBCs: "In addition to applicable or relevant and appropriate requirements, the lead and support agencies may, as appropriate, identify other advisories, criteria, or guidance to be considered for a particular release. The "to be considered" (TBC) category consists of advisories, criteria, or guidance that were developed by EPA, other federal agencies, or states that may be useful in developing CERCLA remedies," which occurs during the FS phase. The Navy will continue to consider and evaluate potential ARARs and TBCs identified by DOH and others but will not be revising the PSLs in Worksheet #15 at this time, consistent with DoD Policy.		
34	Worksheet #16, Page 97	Revise to include submittal of a Draft Final RI workplan for DOH and EPA review before proceeding to the Final version of the document. Further, ensure a regulatory review period of 60 days is granted to both EPA and DOH.
Response (October 2024): Worksheet #16 has been revised to include a Draft Final RI WP and regulatory review periods of 60 days.		
Updated Response (February 2026): Based on discussions and agreements reached during Scoping Meeting No. 5, the regulatory agencies may choose to accept the Revised Draft Work Plan in lieu of a Draft Final Work Plan, if all material comments have been addressed with no additional changes to the work plan requiring a Draft Final Work Plan. In that case, the Navy will move directly to a Final Work Plan to begin field work in a timely manner. Worksheet #9 of the Revised Draft Work Plan (February 2026) includes summaries of all associated scoping meetings conducted prior to its publication.		
35	Worksheet #16, Page 97	DOH requests that laboratory reports be submitted to both EPA and DOH as soon as they are received. Further, ensure that raw data from laboratory analysis of samples is included (i.e., EDD files, chromatograms in ASCII files and text files, etc.).
Response (October 2024): Comment acknowledged. The Navy will provide updates of validated data to the regulators during sampling. Regular data dumps of raw data and EDDs will not be provided as soon as they are available from the laboratory. Specific requests for raw data will be considered and the Navy will continue to work closely with regulators on sharing data during the course of sampling; however, the project will follow the WP and assess the data quality, present the entirety of the data set, and evaluate the data in the RI report. This is consistent with CERCLA investigations conducted at JBPHH.		
36	Worksheet #21, Page 115	Revise to include both the DOH PFAS Guidance and DOH HEER Office TGM as sampling references.
Response (October 2024): Refer to response to comments #4, #7, #10, and #16 regarding DOH PFAS guidance.		

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37	Worksheet #23, Page 119	Revise to include TOPs and TOF as methods for analysis of samples. Further, provide information for the laboratory (name, address, and point of contact) that will be used to analyze obtained samples.
Response (October 2024): Refer to response to comments #4, #7, #10, and #16 regarding DOH PFAS guidance. Worksheet #23 has been updated to include the laboratory's name and contact information.		
Updated Response (February 2026): See updated response to comments #1 and #4.		
38	Figure 7, Page 165	Include On-Site Construction Workers as potential human receptors for Area B.
Response (October 2024): Figure 7 has been revised to Figure 30 and has been updated to include on-site construction workers as potential human receptors.		
39	Figure 8, Page 167	What was the standard or guidance used to make the "Insignificant" determination for multiple pathways of the conceptual site model? DOH considers a pathway as Incomplete, Potentially Complete, or Complete, thus revise all "Insignificant" determinations to "Potentially Complete" until data collected through the RI can provide information as to a more appropriate determination.
Response (October 2024): An exposure pathway is considered insignificant because of the relatively short timeframes of exposure, low exposure frequency, dilution/attenuation from the source, the potential magnitude of exposure from a pathway is low, the exposure resulting from the pathway is much less than that from another pathway involving the same medium at the same exposure point, and the probability of the exposure occurring is very low and the risks associated with the occurrence are not high.		
Updated Response (February 2026): The Navy agrees with DOH's interpretation and has revised all references from "Insignificant" exposure routes to "Potentially Complete but limited compared to other pathways" exposure routes. The Revised Draft Work Plan Figure 8 is now Figure 31.		

Appendix H.1.2:
DOH Letter

Subject: Backcheck to Response to Comments on Draft Remedial Investigation Work Plan, Per- and Polyfluoroalkyl Substances Release, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Oahu, HI, Pearl Harbor HI FISC Site 30;
Received September 6, 2024
September 12, 2024

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In reply, please refer to:
File:
211694 AH

September 12, 2024

Ms. Jocelyn Tamashiro
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Facility/Site: Red Hill Bulk Fuel Storage Facility

Subject: Backcheck to Response to Comments on Draft Remedial Investigation Work Plan, Per- and Polyfluoroalkyl Substances Release, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Oahu, HI, Pearl Harbor HI FISC Site 30; received September 6, 2024

Dear Ms. Tamashiro:

The Hawaii Department of Health (HDOH) Hazard Evaluation and Emergency Response (HEER) Office has reviewed the response to comments (RTCs) for the Red Hill Bulk Fuel Storage Facility site and has determined that Comments 6, 25, 26, 27, 28, 29, and 30 have been resolved with no further comments at this time. The following are backcheck comments for Comments 3, 22, and 31:

HEER Office Comment 3:

<u>HEER Office (August 12, 2024):</u> HDOH requests that initial sampling of groundwater adhere to the minimum requirements, as agreed upon by the Navy, the EPA, and HDOH during meetings that occurred on July 3, 9, 12, and 17, 2024. Revise all areas of the report detailing groundwater sampling activities to reflect the following requirements:

a. Wells to be sampled include RHMW-2254, RHP01, RHP02, RHP03, RHP-06, RHP-07, RHP 08, RHMW-06, RHMW-17, RHMW-17S, RHMW-17D, RHP04A, RHP04B, RHP04C, RHP-05, OWDPMW01, RHMW-18, RHMW-20, RHMW-07, RHMW-08, RHMW-21, RHMW-04, RHP 08B, RHP-08C, RHMW01R, RHMW-02, RHMW-03, RHMW-05, OWDFMW03A, OWDFMW03B, OWDFMW08A, and OWDFMW08B.

b. Sampling of the above groundwater monitoring wells will begin in September and will occur quarterly for at least one year, after which wells to be sampled, and frequency and duration of sampling will be re-evaluated by the Navy, the EPA, and HDOH.

c. Laboratory analysis of samples obtained from the above groundwater monitoring wells will be EPA method 1633 for 40 PFAS compounds.

Navy Response (September 6, 2024): a. The Navy agrees with the list of wells to be sampled. However, as discussed in the August 27 Scoping Meeting #3, it was agreed that wells OWDFMW01 and OWDFMW04A will be sampled, well OWDFMW05A will be sampled in place of RHP08C, and well OWDFMW02A will be sampled for one round.

b. The Navy agrees that groundwater sampling will begin in September 2024 and will occur quarterly for at least one year.

c. The Navy agrees that the groundwater samples will be analyzed by EPA method 1633 for 40 PFAS compounds.

HEER Office Backcheck (September 11, 2024): Comment partially resolved. Please revise response b. to "The Navy agrees that groundwater sampling will begin in September 2024 and will occur quarterly for at least one year, *after which wells to be sampled, and frequency and duration of sampling will be re-evaluated by the Navy, the EPA, and HDOH."*

The HEER Office also wants to clarify the fact that discussions between the Navy, EPA, and HDOH regarding initial groundwater sampling began before the 2024 HDOH HEER Office PFAS Guidance was finalized in July 2024. In an effort to expedite initial groundwater sampling and remain consistent with previous discussions, the HEER Office agreed solely to analysis via EPA method 1633 for these four events. However, all other samples outside of the initial groundwater sampling must be analyzed for Total Oxidizable Precursors (TOPs) and Total Organic Fluorine (TOF) in addition to EPA method 1633 in order to assess for Total PFAS Risk per our PFAS guidance. This request for TOPs and TOF in addition to EPA method 1633 and the use of our PFAS guidance is reflected throughout the remainder of the HEER Office comments on the Draft Remedial Investigation (RI) Work Plan (WP) (Comments 4, 9, 10, 16, 20, 32, 36, and 37).

To proceed with initial groundwater sampling to begin in September 2024, please state the above revised response.

HEER Office Comment 22:

HEER Office (August 12, 2024): Worksheet #12 (PDF pg. 65) lists relative percent differences (RPDs) of ≤50% for water and ≤100% for soil and sediment under measurement performance criteria, with Section 10.6.1.2 of the HDOH HEER Office TGM as a source for those criteria, which is an incorrect reference. Section 10.6.1 of the HDOH HEER Office TGM discusses field replicates, or duplicates, which states that a field replicate precision of approximately 10-35% is generally established as a data quality objective (DQO) for discrete, or grab, sampling. For DU-MIS methodology, a relative standard deviation (RSD) of <35% is the recommended DQO. Thus, the proposed RPDs must be revised to reflect a maximum RPD of 35% for water, and for soil and sediment, two sets of DUMIS replicates must be collected to establish an RSD of <35%.

Navy Response (September 6, 2024): Comment Acknowledged. The Navy recognizes the importance of collecting representative samples and implements sampling protocols and best practices when conducting environmental sampling to minimize sampling error. The MPCs in the WP are reflective of those typically used for soil and water for PFAS (and other analytes) field duplicate evaluation for investigations conducted by the Navy under the CLEAN program at Joint Base Pearl Harbor-Hickam. In

addition, the field duplicate RPD MPCs in the WP are consistent with Navy SOPs for non-PFAS chemicals.

HEER Office Backcheck (September 11, 2024): Comment not resolved. For groundwater, if duplicates obtained result in an RPD above 35%, then the HEER Office requests 1) additional sampling of that well and 2) a discussion of the steps taken to limit errors during sample processing and analysis included in monitoring reports and/or RI reports. For soil and sediment, the HEER Office reiterates its request for DU-MIS methodology which requires triplicates that would produce RSDs. An RSD between 35% and 50% indicates moderate data precision, an RSD between 50% and 100% indicates poor data precision, and an RSD above 100% indicates very poor data precision. If soil and/or sediment triplicates result in an RSD above 35%, then the HEER Office requests that recommendations per Section 4, Appendix L, Section L.3.3, Table L-1 (https://health.hawaii.gov/heer/tgm/section-04/#table-l-1) be followed and included as a discussion in the RI reports.

Further, please provide a copy of the guidance or policy that the Navy's CLEAN Program uses regarding field duplicate evaluation for investigations of PFAS in soil and water.

To proceed with initial groundwater sampling to begin in September 2024, please state that the Navy will adhere to the requests listed above for groundwater sample duplicates with an RPD above 35%. The soil and sediment RSD portion of the comment and the copy of Navy guidance may be addressed in the RTCs for the entire Draft RI WP.

HEER Office Comment 31:

HEER Office (August 12, 2024): Worksheet #14, Section 14.6.1.4 (PDF pg. 80): If contaminated soil is encountered, samples must be collected and analyzed for petroleum constituents and PFAS compounds per the HDOH HEER Office TGM and the 2024 HDOH PFAS Guidance. Ensure that the following are also included for analysis: 2-2-methoxyethoxyethanol (EPA method 8270), 2-2-butoxyethoxyethanol (EPA method SW8015C), High resolution GC/FID fingerprint with n-alkanes and isoprenoids (EPA method 8015M), and SVOCs (EPA Method 8270E). In addition to SVOC priority pollutant data, ensure non-target analysis is performed (surfactants, polars, etc.).

Navy Response (September 6, 2024): This investigation is only analyzing for PFAS using EPA Method 1633. There is a Site Assessment that will investigate the (b) (3) area for petroleum hydrocarbons. In the event that petroleum hydrocarbon-impacted soil (i.e., detected via visual staining, odor, or through PID readings) is encountered, the location will be noted and communicated to the Site Assessment investigation team. Section 14.6.1.4 was updated and the second bullet point now reads, "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. In addition, the Site Assessment investigation team will be notified to determine the appropriate course of action regarding sampling for petroleum hydrocarbon constituents."

HEER Office Backcheck (September 11, 2024): Comment partially resolved. Wherever PFAS sampling and analysis occur due to the encounter of contaminated soil during drilling activities, the HEER Office requests that TOPs and TOF analyses are also conducted in order to calculate Total PFAS Risk per our PFAS Guidance.

Also, what is the Site Assessment investigation team's protocol in the case that petroleum contamination is discovered during drilling activities?

As a reminder, potential new releases must be reported in accordance with HEER Office release reporting requirements outlined online at https://health.hawaii.gov/heer/reporting/how-to-report-a-release-spill/. The HDOH Underground Storage Tank Section (https://health.hawaii.gov/ust/) and Safe Drinking Water Branch (https://health.hawaii.gov/sdwb/) should also be notified according to their respective regulations.

To proceed with initial groundwater sampling to begin in September 2024, please 1) state that HEER Office PFAS sampling and analysis requirements will be followed and include a reference to those requirements, as appropriate, and 2) provide details on the Site Assessment investigation team's protocol.

If you have any questions or should you need a hardcopy of this letter, please contact me at 808-586-4249 or by email at allison.hutto@doh.hawaii.gov.

Sincerely,

Allison Hutto

Allison Hutto
Remedial Project Manager
Hazard Evaluation and Emergency Response Office
Hawaii Department of Health

cc: Mr. Chris Lichens, EPA, via email.

Appendix H.1.3:
DOH Letter

Subject: Second Backcheck to Response to Comments on Draft Remedial Investigation Work Plan, Per- and Polyfluoroalkyl Substances Release, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Oahu, HI, Pearl Harbor HI FISC Site 30;
Received September 23, 2024
September 26, 2024

JOSH GREEN, M.D.
GOVERNOR OF HAWAI'I
KE KIA'ĀINA O KA MOKU'ĀINA 'O HAWAI'I

KENNETH S. FINK, MD, MGA, MPH
DIRECTOR OF HEALTH
KA LUNA HO'OKELE

STATE OF HAWAII
DEPARTMENT OF HEALTH
KA 'OIHANA OLAKINO
P. O. BOX 3378
HONOLULU, HI 96801-3378

In reply, please refer to:
File:
211856 AH

September 26, 2024

Ms. Jocelyn Tamashiro
Environmental Remediation Manager
Environmental Restoration, Department of the Navy
Naval Facilities Engineering Command, Hawaii
400 Marshall Road, Building X-11
Pearl Harbor, Hawaii 96860
Sent via e-mail to: jocelyn.tamashiro.civ@us.navy.mil

Facility/Site: Red Hill Bulk Fuel Storage Facility

Subject: Second backcheck to Response to Comments on Draft Remedial Investigation Work Plan, Per- and Polyfluoroalkyl Substances Release, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Oahu, HI, Pearl Harbor HI FISC Site 30; received September 23, 2024

Dear Ms. Tamashiro:

The Hawaii Department of Health (HDOH) Hazard Evaluation and Emergency Response (HEER) Office has reviewed the response to comments for the Red Hill Bulk Fuel Storage Facility (RHBFSF), and the responses are noted.

The HEER Office notes that the Navy will not adhere to the assessment of Total Oxidizable Precursors (TOPs) or Total Organic Fluorine (TOF) per our 2024 PFAS Guidance, or decrease their relative percent difference (RPD) for duplicate groundwater samples to 35% and resample if an RPD is exceeded per our 2017 HDOH HEER Office *Technical Guidance Manual* (TGM). It is our understanding that the Navy is proceeding with interim groundwater monitoring regardless, with the first event scheduled for September 26, 2024.

To provide clarification, there is no standard method for TOPs as TOPs is a sampling procedure, not an analytical method. To obtain TOPs data, a sample is first processed for TOPs, then analyzed via EPA Method 1633. The May 2024 DoD Memorandum on PFAS precludes the use of *methods* other than EPA Method 1633 to assess for PFAS, not the use of processing procedures, and states that other PFAS can be added "as necessary". The HEER Office considers using pre- and post-TOPs data as necessary in order to adequately assess for Total PFAS Risk at the RHBFSF. As for TOF, this data are required to identify PFAS-related compounds in groundwater that are not reported by the standard laboratory methods. Of particular concern is the presence of "ultrashort" PFAS compounds likely to be present in AFFF-impacted

groundwater. HDOH groundwater sample data from other AFFF-impacted sites indicate that these compounds can dominate the mixture of PFAS likely to be present at such sites.

In addition, the HEER Office understands that exceeding RPDs for duplicate samples with low concentrations is not uncommon. However, we maintain that an RPD between 50% and 100% indicates poor data precision. The HEER Office will review the referenced 2015 Department of Navy *Data Validation Procedures*.

The HEER Office is done commenting on the priority comments required to initiate interim groundwater sampling. However, throughout the investigative process, we will continue to request that the Navy adhere to our guidance, which should have been considered in developing the work plan, in order to adequately assess for Total PFAS Risk.

If you have any questions or should you need a hardcopy of this letter, please contact me at 808-586-4249 or by email at allison.hutto@doh.hawaii.gov.

Sincerely,

Allison Hutto

Allison Hutto
Remedial Project Manager
Hazard Evaluation and Emergency Response Office
Hawaii Department of Health

Cc: Mr. Chris Lichens, US EPA, via email.

Appendix H.1.4:
Navy Responses to DOH Comments
March 2026

JOSH GREEN, M.D.
GOVERNOR OF HAWAI'I
KE KIA'ĀINA O KA MOKU'ĀINA 'O HAWAI'I

KENNETH S. FINK, MD, MGA, MPH
DIRECTOR OF HEALTH
KA LUNA HO'OKELE

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In reply, please refer to:
File:
232834 JO

March 19, 2026

Ms. Jocelyn Tamashiro
Environmental Restoration Manager
Environmental Restoration Division, Department of the Navy
Naval Facilities Engineering Command, Hawaii
400 Marshall Road, Building X-11
Pearl Harbor, Hawaii 96860
Transmitted via e-mail to: *jocelyn.tamashiro.civ@us.navy.mil*

Facility/Site: Red Hill Bulk Fuel Storage Facility (iHEER Site 3365)

Subject: HDOH Comments on *Revised Draft Remedial Investigation Work Plan, Per- and Polyfluoroalkyl Substances Release, Red Hill Bulk Fuel Storage Facility*; Dated February 2026

Dear Ms. Tamashiro:

The Hawaii Department of Health (HDOH) Hazard Evaluation and Emergency Response (HEER) Office has reviewed the Revised Draft Remedial Investigation Work Plan (RI WP) and has the following comments pertaining to the investigation of Area B. Additional comments on the remainder of RI WP are forthcoming.

1. Please conduct multi-incremental sampling (MIS) for soil sampling in accordance with the HDOH Technical Guidance Manual (TGM). HDOH does not consider discrete soil sampling adequate for final decision-making purposes but considers use of discrete samples sufficient for determination of contaminant presence/ absence. For example, if concentrations of chemicals of potential concern (COPCs) were detected in discrete samples, even if below the Environmental Action Levels (EALs), then additional sampling to adequately characterize the nature and extent utilizing MIS must be conducted. This should include the collection of triplicate soil samples to test for accuracy, reliability, and reproducibility of the results and calculation of the relative standard deviation.

2. In addition to analysis via U.S. Environmental Protection Agency (EPA) Method 1633, HDOH highly recommends that soil and groundwater samples are processed for Total Oxidizable Precursors (TOPs) and analyzed for Total Organic Fluorine (TOF) to calculate a cumulative Hazard Index for PFAS and determine the Total

PFAS Risk per HDOH HEER Office's updated *Interim Soil and Water Environmental Action Levels (EALs) for Perfluoroalkyl and Polyfluoroalkyl Substances (PFASs)* (https://health.hawaii.gov/heer/files/2025/04/Hawaii-PFAS-Guidance-April-2024-Rev-022125.pdf). Furthermore, please require that the laboratory take an MIS subsample size of 10 grams for soil analysis. Revise all areas of the RI WP that discuss laboratory analysis of soil and groundwater samples to include TOPs and TOF analysis in addition to EPA Method 1633, and a laboratory subsample size of 10 grams.

Should you have any questions, please contact Jennah Oshiro at (808) 586-4249 or via email at jennah.oshiro@doh.hawaii.gov.

Sincerely,

Gracelda Simmons

Gracelda Simmons
Environmental Management Program Manager
Site Discovery, Assessment, and Remediation
Hazard Evaluation and Emergency Response Office
Hawaii Department of Health

Cc: Captain Gregory deWindt, NCTF-RH (via email at gregory.p.dewindt.mil@us.navy.mil)
CDR Benjamin Dunn, NCTF-RH (via email at benjamin.r.dunn1.mil@us.navy.mil)
Joshua Stout, NCTF-RH (via email at joshua.c.stout8.civ@us.navy.mil)
Charlotte Rangel, NAVFAC (via email at charlotte.c.rangel.civ@us.navy.mil)
Niels Heidner, NAVFAC (via email at niels.f.heidner.civ@us.navy.mil)
Tonya Russi, U.S. EPA (via email at russi.tonya@epa.gov)
John Chestnutt, U.S. EPA (via email at chesnutt.john@epa.gov)
Kelly Ann Lee, Hawai'i Department of Health (via email at kellyann.lee@doh.hawaii.gov)

Project Title: Revised Draft Remedial Investigation Work Plan Per- and Polyfluoroalkyl Substances, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Hawaii, February 2026
Reviewer: Gracelda Simmons, State of Hawaii Department of Health
Date: March 19, 2026

Item	Section No.	Comment
1	General	Please conduct multi-incremental sampling (MIS) for soil sampling in accordance with the HDOH Technical Guidance Manual (TGM). HDOH does not consider discrete soil sampling adequate for final decision-making purposes but considers use of discrete samples sufficient for determination of contaminant presence/absence. For example, if concentrations of chemicals of potential concern (COPCs) were detected in discrete samples, even if below the Environmental Action Levels (EALs), then additional sampling to adequately characterize the nature and extent utilizing MIS must be conducted. This should include the collection of triplicate soil samples to test for accuracy, reliability, and reproducibility of the results and calculation of the relative standard deviation.

Response:

The Navy is required to follow DoD requirements when conducting remedial investigations under CERCLA for decision-making, such as risk assessment. This project will therefore be conducted consistent with the DoD Environmental Data Quality Workgroup Memorandum, *"Issues with Applying the Incremental Sampling Methodology (ISM) to PFAS Investigations,"* dated Jan 31, 2025, which recommends against the use of MIS subsampling for PFAS investigations.

As discussed with HDOH during the two-day scoping meeting on September 10-11, 2025, one of the objectives of the Navy's soil investigation is to identify potential sources of PFAS in soil that may adversely impact underlying groundwater. As documented by the USGS (Watson, E., and Sanford, W.E., 2025; https://doi.org/10.5066/P146YNIU), PFAS constituents are more likely to sorb to organic carbon, silts, and clays than to sand, gravel, cobbles, and boulders. As described during the September scoping meeting, the Facility hydrogeology consists of subsurface valley fill material that overlays shallow (perched) groundwater where PFAS has exceeded screening levels. This valley fill material may potentially be a secondary source of PFAS to groundwater, and consists of highly variable (heterogeneous) alluvium, with lenses of silts and clays (fines) intermixed with sand, gravel, cobbles, and boulders (larger clasts).

As described in Section 14.8.1, specific soil intervals from each boring will be continuously sampled, and the fine-grained components (clays, silts and sands) will be composited in the field, and subsampled into the appropriate container, which will be analyzed at the project laboratory in accordance with EPA Method 1633. Exposure concentrations from each composited interval will be calculated using the 95% upper confidence level of the mean from soil borings in the area of concern. Based on the results of these samples, the Navy will evaluate whether additional actions are required to assess potential risks to human health and the environment.

2	General	In addition to analysis via U.S. Environmental Protection Agency (EPA) Method 1633, HDOH highly recommends that soil and groundwater samples are processed for Total Oxidizable Precursors (TOPs) and analyzed for Total Organic Fluorine (TOF) to calculate a cumulative Hazard Index for PFAS and determine the Total PFAS Risk per HDOH HEER Office's updated Interim Soil and Water Environmental Action Levels (EALs) for Perfluoroalkyl and Polyfluoroalkyl Substances (PFASs) (https://health.hawaii.gov/heer/files/2025/04/Hawaii-PFAS-Guidance-April-2024-Rev-022125.pdf). Furthermore, please require that the laboratory take an MIS subsample size of 10 grams for soil analysis. Revise all areas of the RI WP that discuss laboratory analysis of soil and groundwater samples to include TOPs and TOF analysis in addition to EPA Method 1633, and a laboratory subsample size of 10 grams.

Response: The Navy must adhere to DoD policy for conducting PFAS investigations, specifically *Establishing a Consistent Methodology for the Analysis of Per- and Polyfluoroalkyl Substances in Matrices Other than Drinking Wate*r (ASD Memorandum May 2024). In accordance with this policy, the project will use EPA Method 1633, Revision A (December 2024), *Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS*, as the sole method for definitive PFAS decision-making.

Under DoD policy, the TOP Assay/EPA Method 1621 (Adsorbable organic fluorine/AOF) cannot be used for definitive CERCLA decision-making and are therefore not incorporated into this investigation. Accordingly, TOP/TOF analysis will not be used for the purposes of regulatory compliance, risk assessment, or comparison to project screening or action levels, which precludes the evaluation of Total PFAS Risk following HDOH TGM guidance. Potential risks associated with PFAS at the site will be evaluated using the EPA CERCLA human health and ecological risk assessment framework and done in accordance with DoD policy and applicable federal guidance.

Appendix H.1.5:
Navy Responses to DOH Comments
April 2026

JOSH GREEN, M.D.
GOVERNOR OF HAWAI'I
KE KIA'ĀINA O KA MOKU'ĀINA 'O HAWAI'I

KENNETH S. FINK, MD, MGA, MPH
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In reply, please refer to:
File:
233218 JO

April 28, 2026

Ms. Jocelyn Tamashiro
Environmental Restoration Manager
Environmental Restoration Division, Department of the Navy
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400 Marshall Road, Building X-11
Pearl Harbor, Hawaii 96860
Transmitted via e-mail to: *jocelyn.tamashiro.civ@us.navy.mil*

Facility/Site: Red Hill Bulk Fuel Storage Facility (iHEER Site 3365)

Subject: HDOH Second Comments on *Revised Draft Remedial Investigation Work Plan, Per- and Polyfluoroalkyl Substances Release, Red Hill Bulk Fuel Storage Facility*; Dated February 2026

Dear Ms. Tamashiro:

The Hawaii Department of Health (HDOH) Hazard Evaluation and Emergency Response (HEER) Office has reviewed the Revised Draft Remedial Investigation Work Plan (RI WP) and has the following comments.

General Comments

1. Please conduct multi-incremental (MI) sampling for soil sampling in accordance with the HDOH Technical Guidance Manual (TGM). HDOH does not consider discrete soil sampling adequate for final decision-making purposes but considers use of discrete samples sufficient for determination of contaminant presence/absence. For example, if concentrations of chemicals of potential concern (COPCs) were detected in discrete samples, even if below the Environmental Action Levels (EALs), then additional sampling to adequately characterize the nature and extent utilizing MI sampling must be conducted. This should include the collection of triplicate soil samples to test for accuracy, reliability, and reproducibility of the results and calculation of the relative standard deviation.

2. In addition to analysis via U.S. Environmental Protection Agency (EPA) Method 1633, HDOH highly recommends that soil and groundwater samples are processed for Total Oxidizable Precursors (TOPs) and analyzed for Total Organic Fluorine

(TOF) to calculate a cumulative Hazard Index for PFAS and determine the Total PFAS Risk per HDOH HEER Office's updated *Interim Soil and Water Environmental Action Levels (EALs) for Perfluoroalkyl and Polyfluoroalkyl Substances (PFASs)* (https://health.hawaii.gov/heer/files/2026/02/PFAS-EALs-Update-HIDOH-January-2026.pdf). Furthermore, please require that the laboratory take an MI subsample size of 10 grams for soil analysis. Revise all areas of the RI WP that discuss laboratory analysis of soil and groundwater samples to include TOPs and TOF analysis in addition to EPA Method 1633, and a laboratory subsample size of 10 grams.

Specific Comments

3. Section 10.2.1.2, Page 45 (PDF p. 51), 3rd paragraph, last sentence: It does not appear that the conveyance piping from Building 313 to Adit 6 is shown. Please revise this sentence for accuracy or include piping in Figure 4.

4. Section 10.2.1.3, Page 47 (PDF p. 53): Please discuss the 2021 fuel release in Area B outside of Adit 3.

5. Section 14.4, Page 85 (PDF p. 91), 3rd paragraph, 5th sentence: Please collect the discrete samples for the entire depth interval, not just 3-6 inches. If the sample is only collected from 3-6 inches, then indicate the sampling depth as those 3 to 6 inches, not the entire 1-ft interval.

6. Section 14.7.1, Page 95 (PDF p. 101):

    a. Refer to Comment #1 regarding MI soil sampling.

    b. Recommend including a boring for collection of surface and subsurface soil samples adjacent to the Collection, Holding and Transfer (CHT) tank where contents from the 2021 fuel release were stored and later spilled. It is possible that CHT tank stored PFAS-containing fluids either from the 2021 fuel release product or in the sanitary waste discussed in Section 10.2.8.5.

    c. 1st paragraph, 3rd sentence: Refer to Comment #5.

7. Section 14.7.2, Page 95 (PDF p. 101): HDOH strongly recommends collecting swale surface soil samples as MI samples to increase accuracy and reproducibility in accordance with the HDOH TGM. This includes collection of at least 30 increments per bulk MI sample, collection of quality control/quality assurance triplicate samples for at least 10% of the primary samples, and MI processing by the analytical laboratory. Refer to Comment #1. If no MI samples will be collected, please collect at least 30 discrete surface samples from the swale to account for any spatial heterogeneity of PFAS in the swale.

8. Table 15-5, Pages 125 (PDF pp. 131): Please reference and follow the November 2024 Memorandum for *Comparison of HDOH Total Petroleum Hydrocarbon (TPH) Action Levels to Data for Water Samples* to calculate the total concentration of TPH in water for comparison to the EALs, available at

https://health.hawaii.gov/heer/files/2025/11/25-085-WL-Use-of-THP-EALs-HIDOH-Nov2025.pdf.

9. Worksheet (WS) #16, Page 129 (PDF p. 135): Recommend updating the schedule as appropriate.

10. Section 17.2, Page 131 (PDF p. 137): The collection of discrete samples is acceptable, however, please note that while results can be used for determination of presence/absence, HDOH will not accept use of the analytical results for any final decision-making purposes. Refer to Comment #1.

11. Section 17.2.3, Page 132 (PDF p. 138), 4th paragraph: Collection of groundwater samples from a temporary well is acceptable, however, please ensure that the well is properly developed, purged, and sampled in accordance with Section 6 of the HDOH TGM (e.g., developed after 48 hours of well installation; low-flow purging; and sampling, gauging and sampling no sooner than 72 hour after well development).

12. Section 17.4, Page 135 (PDF p. 141), 4th paragraph: Ensure that the well is properly developed, purged, and sampled in accordance with Section 6 of the HDOH TGM. Refer to Comment #10.

13. WS #20, Pages 151-152 (PDF p. 157-158):

    a. Please indicate how field duplicate soil samples will be collected. Will they be collected from the same borehole or from a nearby boring? If collected from the same boring, these co-located samples would be expected to have similar concentrations and should not be used to measure soil heterogeneity in the area, only within that borehole. Refer to Section 10.6.1.1 of the HDOH TGM for information on discrete sampling replicates.

    b. Page 151, Area A: If the surface soil will be collected using a different manner than the swale surface soil samples, recommend collecting a separate duplicate for the surface soil.

14. Appendix A, Figure 3, PDF p. 227:

    a. Recommend using a different color for the “GAC System Piping” for visibility, as it is currently difficult to see.

    b. Please label the CHT tank that is discussed in Section 10.2.8.5.

15. Appendix A, Figure 4, PDF Page 229: Include a callout for the aqueous film-forming foam (AFFF) conveyance piping from Building 313 to Adit 6 that is mentioned in Section 10.2.1.2.

16. Appendix A, Figure 28, PDF p. 281:

    a. Please provide rational on why direct contact and air transport is “incomplete” for current onsite construction worker, but “potentially complete” for onsite

occupational worker. It seems that onsite construction workers would be potentially exposed to similar levels of AFFF and TPH as onsite occupational workers. Please revise onsite construction worker to "potentially complete" for direct contact and air transport as appropriate.

b. Please provide rationale on why ingestion and dermal contact is "incomplete" for future onsite construction worker, but "potentially complete" for onsite occupational worker. Please revise future onsite construction worker to "potentially complete" for groundwater ingestion and dermal contact as appropriate.

17. Appendix A, Figure 31, PDF p. 287:

    a. Please revise onsite construction worker to "potentially complete" for direct contact and air transport as appropriate. Refer to Comment #16.a.

    b. Please revise future onsite construction worker to "potentially complete" for groundwater ingestion and dermal contact as appropriate. Refer to Comment #16.b.

18. Appendix A, Figure 44, PDF p. 313: Please include the symbol for RHSB-13 in the legend.

19. Appendix C, Attachment I-C-1-1, PDF p. 493-496: Recommend removing the Guam Well Abandonment Procedure.

20. Appendix C, Attachment I-C-2 PDF p. 502, Section 5.1, last sentence: Revise that well development shall not occur until at least 48 hours after the completion of well installation, in accordance with Section 6.6.3.1 of the HDOH TGM.

21. Appendix C, Attachment I-C-3, PDF p. 516, Section 5.3, last sentence: Revise that at least 72 hours should separate well development and well sampling events in accordance with Section 6.6.4.1 of the HDOH TGM.

Should you have any questions, please contact Jennah Oshiro at (808) 586-4249 or via email at jennah.oshiro@doh.hawaii.gov.

Sincerely,

Gracelda Simmons

Gracelda Simmons
Environmental Management Program Manager
Hazard Evaluation and Emergency Response Office
Hawaii Department of Health

Cc: Captain Gregory deWindt, NCTF-RH (via email at gregory.p.dewindt.mil@us.navy.mil)
CDR Benjamin Dunn, NCTF-RH (via email at benjamin.r.dunn1.mil@us.navy.mil)
Joshua Stout, NCTF-RH (via email at joshua.c.stout8.civ@us.navy.mil)
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Niels Heidner, NAVFAC (via email at niels.f.heidner.civ@us.navy.mil)
Tonya Russi, U.S. EPA (via email at russi.tonya@epa.gov)
John Chestnutt, U.S. EPA (via email at chesnutt.john@epa.gov)
Kelly Ann Lee, Hawai'i Department of Health (via email at kellyann.lee@doh.hawaii.gov)

Project Title: Revised Draft Remedial Investigation Work Plan Per- and Polyfluoroalkyl Substances, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Hawaii, February 2026
Reviewer: Gracelda Simmons, State of Hawaii Department of Health
Date: April 28, 2026

Item	Section No.	Comment
1	General	Please conduct multi-incremental sampling (MIS) for soil sampling in accordance with the HDOH Technical Guidance Manual (TGM). HDOH does not consider discrete soil sampling adequate for final decision-making purposes but considers use of discrete samples sufficient for determination of contaminant presence/absence. For example, if concentrations of chemicals of potential concern (COPCs) were detected in discrete samples, even if below the Environmental Action Levels (EALs), then additional sampling to adequately characterize the nature and extent utilizing MIS must be conducted. This should include the collection of triplicate soil samples to test for accuracy, reliability, and reproducibility of the results and calculation of the relative standard deviation.

Response:

The Navy is required to follow DoD requirements when conducting remedial investigations under CERCLA for decision-making, such as risk assessment. This project will therefore be conducted consistent with the DoD Environmental Data Quality Workgroup Memorandum, *"Issues with Applying the Incremental Sampling Methodology (ISM) to PFAS Investigations,"* dated Jan 31, 2025, which recommends against the use of MIS subsampling for PFAS investigations.

As discussed with HDOH during the two-day scoping meeting on September 10-11, 2025, one of the objectives of the Navy's soil investigation is to identify potential sources of PFAS in soil that may adversely impact underlying groundwater. As documented by the USGS (Watson, E., and Sanford, W.E., 2025; https://doi.org/10.5066/P146YNIU), PFAS constituents are more likely to sorb to organic carbon, silts, and clays than to sand, gravel, cobbles, and boulders. As described during the September scoping meeting, the Facility hydrogeology consists of subsurface valley fill material that overlays shallow (perched) groundwater where PFAS has exceeded screening levels. This valley fill material may potentially be a secondary source of PFAS to groundwater, and consists of highly variable (heterogeneous) alluvium, with lenses of silts and clays (fines) intermixed with sand, gravel, cobbles, and boulders (larger clasts).

As described in Section 14.8.1, specific soil intervals from each boring will be continuously sampled, and the fine-grained components (clays, silts and sands) will be composited in the field, and subsampled into the appropriate container, which will be analyzed at the project laboratory in accordance with EPA Method 1633. Exposure concentrations from each composited interval will be calculated using the 95% upper confidence level of the mean from soil borings in the area of concern. Based on the results of these samples, the Navy will evaluate whether additional actions are required to assess potential risks to human health and the environment.

2	General	In addition to analysis via U.S. Environmental Protection Agency (EPA) Method 1633, HDOH highly recommends that soil and groundwater samples are processed for Total Oxidizable Precursors (TOPs) and analyzed for Total Organic Fluorine (TOF) to calculate a cumulative Hazard Index for PFAS and determine the Total PFAS Risk per HDOH HEER Office's updated Interim Soil and Water Environmental Action Levels (EALs) for Perfluoroalkyl and Polyfluoroalkyl Substances (PFASs) (https://health.hawaii.gov/heer/files/2025/04/Hawaii-PFAS-Guidance-April-2024-Rev-022125.pdf). Furthermore, please require that the laboratory take an MIS subsample size of 10 grams for soil analysis. Revise all areas of the RI WP that discuss laboratory analysis of soil and groundwater samples to include TOPs and TOF analysis in addition to EPA Method 1633, and a laboratory subsample size of 10 grams.

Response: The Navy must adhere to DoD policy for conducting PFAS investigations, specifically *Establishing a Consistent Methodology for the Analysis of Per- and Polyfluoroalkyl Substances in Matrices Other than Drinking Wate*r (ASD Memorandum May 2024). In accordance with this policy, the project will use EPA Method 1633, Revision A (December 2024), *Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS*, as the sole method for definitive PFAS decision-making.

Under DoD policy, the TOP Assay/EPA Method 1621 (Adsorbable organic fluorine/AOF) cannot be used for definitive CERCLA decision-making and are therefore not incorporated into this investigation. Accordingly, TOP/TOF analysis will not be used for the purposes of regulatory compliance, risk assessment, or comparison to project screening or action levels, which precludes the evaluation of Total PFAS Risk following HDOH TGM guidance. Potential risks associated with PFAS at the site will be evaluated using the EPA CERCLA human health and ecological risk assessment framework and done in accordance with DoD policy and applicable federal guidance.

3	10.2.1.2 Page 45 (PDF p. 51)	*3rd paragraph, last sentence:* It does not appear that the conveyance piping from Building 313 to (b) (3) is shown. Please revise this sentence for accuracy or include piping in Figure 4.

Response: The conveyance piping from Building 313 to (b) (3) is shown on Figure 2. The text has been revised to reference Figure 2. No change has been made to Figure 4.

4	10.2.1.3 Page 47 (PDF p. 53)	Please discuss the 2021 fuel release in Area B outside of (b) (3).

Response: The 2021 fuel release in Area B outside of (b) (3) was not a known or suspected PFAS release; therefore, it will not be discussed in Section 10.2.1.3. No change was made to the text.

Project Title: Revised Draft Remedial Investigation Work Plan Per- and Polyfluoroalkyl Substances, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Hawaii, February 2026
Reviewer: Gracelda Simmons, State of Hawaii Department of Health
Date: April 28, 2026

Item	Section No.	Comment
5	14.4 Page 55 (PDF p. 91)	Please collect the discrete samples for the entire depth interval, not just 3-6 inches. If the sample is only collected from 3-6 inches, then indicate the sampling depth as those 3 to 6 inches, not the entire 1-ft interval.
Response: The sampling intervals have been revised, such that this comment is no longer relevant. Please see the response to Comment # 1		
6	14.7.1 Page 95 (PDF p. 101)	a. Refer to Comment #1 regarding MI soil sampling. b. Recommend including a boring for collection of surface and subsurface soil samples adjacent to the Collection, Holding and Transfer (CHT) tank where contents from the 2021 fuel release were stored and later spilled. It is possible that CHT tank stored PFAS-containing fluids either from the 2021 fuel release product or in the sanitary waste discussed in Section 10.2.8.5. c. 1st paragraph, 3rd sentence: Refer to Comment #5.
Response: a. Please see the response to Comment #1. b. The Navy has added optional step-out sampling location RHB-BS-S40 near the CHT tank. If either of the nearby borings RHB-BS-S07 or RHB-BS-S21 exceed PFAS PSL(s) in soil or groundwater, this boring will be sampled for soil and groundwater, if encountered. Section 17.4.2 has been revised to describe the sampling design and rationale for RHB-BS-S40, which is shown on Figure 40 and Figure 44.. c. Please see the response to Comment #5.		
7	14.7.2 Page 95 (PDF p. 101)	HDOH strongly recommends collecting swale surface soil samples as MI samples to increase accuracy and reproducibility in accordance with the HDOH TGM. This includes collection of at least 30 increments per bulk MI sample, collection of quality control/quality assurance triplicate samples for at least 10% of the primary samples, and MI processing by the analytical laboratory. Refer to Comment #1. If no MI samples will be collected, please collect at least 30 discrete surface samples from the swale to account for any spatial heterogeneity of PFAS in the swale.
Response: Please see the second portion of the response to Comment #2, which describes DOD and CERCLA policy. The Navy has increased the number of discrete surface soil swale samples to 10, and the number of discrete non-swale surface soil samples to 10, to match the minimum number of samples recommended by the EPA for calculating a 95% upper confidence limit of the mean for the evaluation of risk, under CERCLA. The Navy has revised the text in Section 17.2.2 and Figure 34 to document these increases in swale soil and surface soil sample locations, and these additional samples are also documented in Work Sheet #18.		
8	Table 15-5 Page 125 (PDF p. 131)	Please reference and follow the November 2024 Memorandum for *Comparison of HDOH Total Petroleum Hydrocarbon (TPH) Action Levels to Data for Water Samples* to calculate the total concentration of TPH in water for comparison to the EALs, available at https://health.hawaii.gov/heer/files/2025/11/25-085-WL-Use-of-THP-EALs-HIDOH-Nov2025.pdf.
Response: Navy concurs. The Navy has added a footnote to Table 15-5 that references https://health.hawaii.gov/heer/files/2025/11/25-085-WL-Use-of-THP-EALs-HIDOH-Nov2025.pdf, stating: "[c] The summed total concentrations of GRO, DRO, and RRO in groundwater will be evaluated in accordance with the Hawaii DOH Memorandum *Comparison of HIDOH Total Petroleum Hydrocarbon (TPH) Action Levels to Data for Water Samples* (DOH 2025)."		
9	WS #16 Page 129 (PDF p. 135)	Recommend updating the schedule as appropriate.
Response: The schedule has been updated to best reflect planning at the time of the Final Work Plan.		
10	17.2 Page 131 (PDF p. 137)	The collection of discrete samples is acceptable, however, please note that while results can be used for determination of presence/absence, HDOH will not accept use of the analytical results for any final decision-making purposes. Refer to Comment #1.
Response: Please see the response to Comment #1. CERCLA and the EPA allow for the use of discrete sampling as well as composite sampling to calculate risk to human health and the environment, and those calculated risk values will be used for final decision-making during the RI.		
11	17.2.3 Page 132 (PDF p. 138)	*4th paragraph:* Collection of groundwater samples from a temporary well is acceptable, however, please ensure that the well is properly developed, purged, and sampled in accordance with Section 6 of the HDOH TGM (e.g., developed after 48 hours of well installation; low-flow purging; and sampling, gauging and sampling no sooner than 72 hour after well development).
Response: The Navy will ensure that the well is properly developed, purged, and sampled. Text has been added to Sections 14.6 and 14.8.3 to clarify that the Navy will follow the NAVFAC PAC Project Procedures Manual, which is referenced by and generally aligns with HDOH TGM Section 6.6.8.3..		

Project Title: Revised Draft Remedial Investigation Work Plan Per- and Polyfluoroalkyl Substances, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Hawaii, February 2026
Reviewer: Gracelda Simmons, State of Hawaii Department of Health
Date: April 28, 2026

Item	Section No.	Comment
12	17.4 Page 135 (PDF p. 141)	*4th paragraph:* Ensure that the well is properly developed, purged, and sampled in accordance with Section 6 of the HDOH TGM. Refer to Comment #11.
Response: Please see the response to Comment #11.		
13	WS #20 Pages 151-152 (PDF p. 157-158)	• Please indicate how field duplicate soil samples will be collected. Will they be collected from the same borehole or from a nearby boring? If collected from the same boring, these co-located samples would be expected to have similar concentrations and should not be used to measure soil heterogeneity in the area, only within that borehole. Refer to Section 10.6.1.1 of the HDOH TGM for information on discrete sampling replicates. • *Page 151, Area A:* If the surface soil will be collected using a different manner than the swale surface soil samples, recommend collecting a separate duplicate for the surface soil
Response: Please see the responses in the respective bullets below. • These duplicates will be collected from the same interval of the same borehole (assuming sufficient recovery) and will not be used to evaluate soil heterogeneity of the site. The results will be used to evaluate the heterogeneity of the sampling interval within the borehole. • The Navy concurs. Navy will collect a duplicate to represent the swale surface soil sample, and a duplicate to represent the surface soil samples collected outside of the swale. Table 20 has been revised to include these additional field duplicates.		
14	Appendix A Figure 3 (PDF p. 227)	• Recommend using a different color for the "GAC System Piping" for visibility, as it is currently difficult to see. • Please label the CHT tank that is discussed in Section 10.2.8.5.
Response: Please see the responses in the respective bullets below. • Figure 3 has been revised to make the "GAC System Piping" more visible by adjusting the color and line weight. • Figure 3 has been revised to include a label annotating the location of the CHT tank.		
15	Appendix A Figure 4 (PDF p. 229)	Include a callout for the aqueous film-forming foam (AFFF) conveyance piping from Building 313 to (b) (3) that is mentioned in Section 10.2.1.2.
Response: Please see the response to Comment #3.		
16	Appendix A Figure 28 (PDF p. 281)	• Please provide rational on why direct contact and air transport is "incomplete" for current onsite construction worker, but "potentially complete" for onsite occupational worker. It seems that onsite construction workers would be potentially exposed to similar levels of AFFF and TPH as onsite occupational workers. Please revise onsite construction worker to "potentially complete" for direct contact and air transport as appropriate. • Please provide rationale on why ingestion and dermal contact is "incomplete" for future onsite construction worker, but "potentially complete" for onsite occupational worker. Please revise future onsite construction worker to "potentially complete" for groundwater ingestion and dermal contact as appropriate.
Response: Please see the Navy's responses to Comment #16 in the respective bullets below. • Construction workers may contact soil during intrusive activities (e.g., excavation, trenching), and potential exposure may occur through incidental ingestion, dermal contact, and inhalation of dust generated from surface soil and disturbed subsurface soil. There is no current onsite construction (no soil disturbance) at Area A; therefore, the current pathway is considered incomplete. Since construction activities may potentially take place in the future, the future exposure is considered potentially complete. Those currently working in support of the activities within the tunnel are considered occupational workers due to the lack of soil disturbing activities. Occupational workers are expected to be exposed to soil primarily through incidental ingestion, dermal contact, and inhalation of dust generated from surface soil during routine site activities. • Onsite construction worker exposure to groundwater via dermal contact or incidental ingestion is evaluated based on direct contact during excavation and trenching activities. Because the groundwater is located greater than 10 feet below ground surface the exposure pathway to groundwater is considered incomplete. For the future occupational worker, it is assumed to be potentially complete for direct ingestion and dermal contact if the (b) (3) (b) (3) well (b) (3) is reactivated as a drinking water source. No changes have been made to Figure 28. Text has been added to Section 10.5.3 to clarify the rationale described above.		

Project Title: Revised Draft Remedial Investigation Work Plan Per- and Polyfluoroalkyl Substances, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Hawaii, February 2026
Reviewer: Gracelda Simmons, State of Hawaii Department of Health
Date: April 28, 2026

Item	Section No.	Comment
17	Appendix A Figure 31 (PDF p. 287)	• Please revise onsite construction worker to "potentially complete" for direct contact and air transport as appropriate. Refer to Comment #16.a. • Please revise future onsite construction worker to "potentially complete" for groundwater ingestion and dermal contact as appropriate. Refer to Comment #16.b.
Response: Please see the Navy's responses to Comment #17 in the respective bullets below. • The current construction worker scenario for Area B has been changed to potentially complete based on the current construction work that is underway for the water treatment facility. • See response to comment #16. Text has been added to Section 10.5.3 to clarify the rationale described above.		
18	Appendix A Figure 44 (PDF p. 313)	Please include the symbol for RHSB-13 in the legend.
Response: The Navy has revised the figure to correct the annotation "RHSB-13" to "RHB-BS-S34". No change was made to the legend.		
19	Appendix C Attachment I-C-1-1 (PDF p. 493-496)	Recommend removing the Guam Well Abandonment Procedure.
Response: The Navy concurs. The Guam Well Abandonment Procedure has been removed from the WP.		
20	Appendix C Attachment I-C-2 (PDF p. 502)	*Section 5.1, last sentence:* Revise that well development shall not occur until at least 48 hours after the completion of well installation, in accordance with Section 6.6.3.1 of the HDOH TGM.
Response: Please see the response to comment #11.		
21	Appendix C Attachment I-C-3, (PDF p. 516)	*Section 5.3, last sentence:* Revise that at least 72 hours should separate well development and well sampling events in accordance with Section 6.6.4.1 of the HDOH TGM.
Response: Please see the response to comment #11.		

Appendix H.1.6:
Navy Responses to DOH Comments
August 2026

Project Title: Draft Final Remedial Investigation Work Plan
Per- and Polyfluoroalkyl Substances Release Red Hill Bulk Fuel Storage Facility
JBPHH Oahu HI
Reviewer: Jennah Oshiro, Remedial Project Manager, State of Hawaii Department of Health
Date: August 2026

Item	Section No.	Comment
1	14.7.1.1, 3rd paragraph, 3rd sentence	What is the purpose of these field duplicates? It does not appear that this sampling methodology will test for precision or accuracy. HDOH recommends **not** mixing the primary and duplicate sample containers and instead analyzing these samples separately. Please specify, will the duplicate be collected from the same boring as the primary sample or from a separate boring?
Response: The purpose of the field duplicate sampling is to measure variability and precision associated with the sampling process, including sample heterogeneity, sampling methodology, and analytical procedures. Field duplicate results will be compared to the associated primary sample results to assess both field and laboratory precision relative to the measurement performance criteria specified in Worksheet #12. The sampling methodology does not mix primary and duplicate sample containers; rather, the primary and duplicate samples will be collected in separate containers and analyzed separately. Finally, field duplicates will be collected from the same boring and interval as their primary samples.		
2	14.7.1.1, 3rd paragraph, 3rd sentence	In response to the RTC (above), please note that intra-boring replicates will only measure variability and precision within that borehole. In general, it would be expected that co-located samples will have low variability (Section 10.6.1.1 of the TGM) and will likely not be valuable in measuring variability and precision across a larger area (only within that boring).
Response: Comment acknowledged.		
3	14.7.1.1, 3rd paragraph, 3rd sentence	Section 14.7.1.1 states the following: "Field duplicates will be collected by alternating scoops of mixed material between the primary and duplicate sample containers." This should be reworded to clarify that the primary and duplicate will not be mixed.
Response: The text in Section 14.7.1.1 has been revised for clarity as shown below. "Field duplicates and primary samples will be collected after material from a specific interval is sieved and homogenized to target fine soils most likely to be bound to PFAS. The homogenized soil composite will be split into primary and duplicate sample containers, which will be analyzed independently at the laboratory."		

Appendix H.1.7:
DOH Letter

Subject: Backcheck of the Response to Comments (RTCs)
for the Draft Final Remedial Investigation Work Plan,
Per- and Polyfluoroalkyl Substances Release
Red Hill Bulk Fuel Storage Facility, JBPHH, Oahu, HI;
Received 19 August 2026
August 25, 2026

JOSH GREEN, M.D.
GOVERNOR OF HAWAI'I
KE KIA'ĀINA O KA MOKU'ĀINA 'O HAWAI'I

KENNETH S. FINK, MD, MGA, MPH
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KA LUNA HO'OKELE

STATE OF HAWAII
DEPARTMENT OF HEALTH
KA 'OIHANA OLAKINO
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In reply, please refer to:
File:
235924 JO

August 25, 2026

Ms. Jocelyn Tamashiro
Environmental Restoration Division, Department of the Navy
Naval Facilities Engineering Command, Hawaii
400 Marshall Road, Building X-11
Pearl Harbor, Hawaii 96860
Transmitted via e-mail to: *jocelyn.tamashiro.civ@us.navy.mil*

Facility/Site: Red Hill Bulk Fuel Storage Facility (iHEER Site 3365)

Subject: Backcheck of the Response to Comments (RTCs) for the *Draft Final Remedial Investigation Work Plan, Per- and Polyfluoroalkyl Substances Release Red Hill Bulk Fuel Storage Facility, JBPHH, Oahu, HI*; received 19 August 2026

Dear Ms. Tamashiro:

The Hawaii Department of Health (HDOH) Hazard Evaluation and Emergency Response (HEER) Office has conducted backcheck of the RTCs for the Draft Final Remedial Investigation Work Plan (RI WP). For Item 1, please revise the text to clearly describe how the replicate samples will be collected. The text in Section 14.7.1.1 currently reads, "Field duplicates will be collected by alternating scoops of mixed material between the primary and duplicate sample containers." HDOH finds RTC Items 2 and 3 adequate and has no further comments at this time.

Please make the above requested revision to WP and submit the final RI WP to HDOH for our files. Contact me at (808) 586-4249 or via email at jennah.oshiro@doh.hawaii.gov should you have any questions.

Sincerely,

Jennah Oshiro

Jennah Oshiro
Remedial Project Manager
Site Discovery, Assessment, and Remediation
Hazard Evaluation and Emergency Response Office
Hawaii Department of Health

Appendix H.2:
EPA

Appendix H.2.1:
Navy Responses to EPA Comments
August 07, 2024

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

August 7, 2024

Ms. Jocelyn Tamashiro, L.G.
Environmental Restoration Manager
NAVFAC Hawaii, EV3
400 Marshall Road, Building X-11
Joint Base Pearl Harbor-Hickam, HI 96860

Subject: DRAFT REMEDIAL INVESTIGATION WORK PLAN PER- AND POLYFLUORALKYL SUBSTANCES RELEASE, RED HILL BULK FUEL STORAGE FACILITY, JOINT BASE PEARL HARBOR-HICKMAN, OAHU HI, PEARL HARBOR HI FISC SITE 30, JUNE 2024

Dear Ms. Tamashiro:

Enclosed are the U.S. Environmental Protection Agency's (EPA's) comments regarding the subject document (Draft RI WP). Please prioritize your response to the comments in Enclosure 1 so the Navy can expedite the sampling of the wells agreed upon during the EPA/US Department of the Navy/Hawaii Department of Health teleconference on Friday July 12th. Please see enclosed table summarizing the wells the Navy agreed to sample beginning in September (Enclosure 2).

We understand the Navy would like to finalize the PFAS RI WP without submitting a draft final document. Our acceptance of this process is contingent upon the Navy's responsiveness to our remaining comments. To finalize the PFAS RI WP please also provide formal responses by Friday August 30th.

We are currently scheduled to meet to discuss the PFAS RI WP on August 14th. EPA recommends that we focus on Enclosure 1 during that meeting. Please review the comments and provide questions in advance of that meeting if possible.

If you have any questions regarding this letter, please feel free to call me at (415) 972-3149 or contact me by email at lichens.christopher@epa.gov.

Sincerely,

CHRISTOPHER LICHENS

Digitally signed by CHRISTOPHER LICHENS
Date: 2024.08.07 14:07:25 -07'00'

Chris Lichens
Remedial Project Manager
Superfund and Emergency Management Division
Federal Facilities and Site Cleanup Branch
US EPA, Region IX

Enclosures (3)

cc: Allison Hutto, HDOH

Enclosure 1:
EPA Review of DRAFT REMEDIAL INVESTIGATION WORK PLAN PER- AND POLYFLUORALKYL SUBSTANCES RELEASE, RED HILL BULK FUEL STORAGE FACILITY, JOINT BASE PEARL HARBOR-HICKMAN, OAHU HI, PEARL HARBOR HI FISC SITE 30, JUNE 2024

Priority Comments for Expedited Well Installation

PRIORITY COMMENTS FOR EXPEDITED WELL INSTALLATION

To proceed with sampling of the additional wells the Navy agreed to during the United States Environmental Protection Agency (EPA)/US Department of the Navy (Navy)/Hawaii Department of Health (DOH) teleconference on Friday July 12th, please expedite the Navy's responses to the comments in this enclosure. We understand that the Navy may begin sampling these wells as soon as September.

GENERAL PRIORITY COMMENTS

1. In addition to the subset of wells the Draft RI WP proposes sampling in Areas A and B, Enclosure 2 is a table of the additional wells the Navy agreed to sample quarterly for one year and then re-evaluate. The table lists well names, the status of construction of the wells, and the objectives for sampling. Some of the agreed-upon additional Phase 1 locations are also listed here:

   a. (b) (3) Area: RHP04A, RHP04B, RHP04C, RHP05, RHP08B, RHP08C, OWDFMW01, OWDFMW03A and B, OWDFMW08A and B. These wells need to be sampled for delineation and to evaluate seasonal variability and trends in PFAS concentrations in the vicinity of (b) (3). In addition, only one round of samples has been collected and some of the wells have concentrations that exceeded the Maximum Contaminant Levels (MCLs).

   b. (b) (3) Area: RHMW-01R, RHMW-02, RHMW-03, RHMW-04, RHMW-05, RHMW-07, RHMW-08, RHMW-20, and RHMW-21. These wells need to be sampled for delineation, to evaluate seasonal trends and to understand downgradient transport, due to proximity to (b) (3) and/or uncertainty in the groundwater flow direction.

   Please revise the Draft RI WP to propose these additional Phase 1 locations and include them in Worksheets #17 (Sampling Design and Rationale) and #18 (Locations-Specific Sampling Methods/SOP [Standard Operation Procedures] Requirements Table), so that the objective to delineate the nature and extent of PFAS contamination can be met.

   Additional step-outs may be needed during a Phase 2. As we discussed during the meetings, the other wells that EPA recommended for sampling, but which the Navy did not agree to, are documented in Enclosure 3 of this letter.

Enclosure 1:
EPA Review of DRAFT REMEDIAL INVESTIGATION WORK PLAN PER- AND POLYFLUORALKYL SUBSTANCES RELEASE, RED HILL BULK FUEL STORAGE FACILITY, JOINT BASE PEARL HARBOR-HICKMAN, OAHU HI, PEARL HARBOR HI FISC SITE 30, JUNE 2024

Priority Comments for Expedited Well Installation

2. A laboratory has not been specified to perform sample analyses, so several worksheets are incomplete and cannot be fully evaluated. For example, in Worksheet #15, Reference Limits and Evaluation Tables, laboratory detection limits are listed as "TBD [to be determined]" and therefore can't be compared to project screening levels. Worksheets #24, Analytical Instrument Calibration Table, and #28, Laboratory QC Samples Table, contain requirements of EPA Method 1633, but may not match a laboratory's specific standard operating procedures (SOPs). This is not an exhaustive list of affected worksheets. Please revise the Draft RI WP to include information about the laboratory and include relevant analytical SOPs as an appendix.

3. It is unclear why matrix spike/matrix spike duplicate (MS/MSD) samples are not proposed for collection. Please revise the Draft RI WP to include the collection of MS/MSD samples for soil, sediment, and groundwater.

SPECIFIC PRIORITY COMMENTS

1. **Worksheet #12, Field Quality Control Samples, Page 59 -** The measurement performance criteria (MPC) for field duplicates in waters (relative percent difference [RPD] $\leq$50) and soils (RPD $\leq$100%), are taken from *Department of Defense (DoD) Module 6: Data Validation Guidelines*. However, these limits in the guidelines are used in the context as an example of what *may be considered* a major exceedance. EPA recommends that the RPD criteria be reviewed for adequacy and that rationale for the MPC be provided in the RI Work Plan.

2. **Appendix B, SOP I-C-3, Monitoring Well Sampling, PDF Page 273:** While some of this Standard Operating Procedure (SOP) is applicable to this project, it seems more targeted to sampling wells with fuel-related and/or volatile constituents. Please update this SOP to include site-specific requirements for sampling PFAS contaminants. Similar comments apply to the decontamination SOP I-F and Field QC SOP III-B.

Enclosure 2:
EPA Review of DRAFT REMEDIAL INVESTIGATION WORK PLAN PER- AND POLYFLUORALKYL SUBSTANCES RELEASE, RED HILL BULK FUEL STORAGE FACILITY, JOINT BASE PEARL HARBOR-HICKMAN, OAHU HI, PEARL HARBOR HI FISC SITE 30, JUNE 2024

Table of Wells: Navy/DOH/EPA Agreed to Sample Wells on this Table on July 12,2024

Status	Wells Recommended for PFAS RI Sampling			
	Well ID	Location	Purpose of Monitoring	Justification
All Parties Agree	RHMW-2254	RHS	Evaluate impacts to drinking water source	Historical Detections
All Parties Agree	RHP01	< 500 ft from RHS	Delineation; evaluate seasonal variability and trends in PFAS concentrations in the vicinity of (b) (3) (b) (3)	Some wells near RHS exceeded MCLs. PFAS may have been comingled with JP-5 released in November 2021. Only one round of samples collected.
All Parties Agree	RHP02	< 500 ft from RHS		
All Parties Agree	RHP03	< 500 ft from RHS		
All Parties Agree	RHP-06	< 500 ft from RHS		
All Parties Agree	RHP-07	< 500 ft from RHS		
All Parties Agree	RHP-08	< 500 ft from RHS		
All Parties Agree	RHMW-06	Close proximity to (b) (3)	Delineation	Uncertainty in groundwater flow direction, rate, vadose zone breakthrough
All Parties Agree	RHMW-17, 17S, 17D	Near (b) (3) entrance	Evaluate variability and trends in PFAS concentration Near (b) (3) Release	Release history, residual soil contamination, unknown groundwater arrival times
All Parties Agree	RHP-04A,04B,04C	< 500 ft from RHS		
All Parties Agree	RHP-05	< 500 ft from RHS		
All Parties Agree	OWDFMW01	< 500 ft from RHS		

Enclosure 2:
EPA Review of DRAFT REMEDIAL INVESTIGATION WORK PLAN PER- AND POLYFLUORALKYL SUBSTANCES RELEASE, RED HILL BULK FUEL STORAGE FACILITY, JOINT BASE PEARL HARBOR-HICKMAN, OAHU HI, PEARL HARBOR HI FISC SITE 30, JUNE 2024

Table of Wells: Navy/DOH/EPA Agreed to Sample Wells on this Table on July 12,2024

Status	Wells Recommended for PFAS RI Sampling			
	Well ID	Location	Purpose of Monitoring	Justification
All Parties Agree	RHMW-18	East of (b) (3)	Delineation.	Proximity to (b) (3) release, uncertainty in flow direction
All Parties Agree	RHMW-20	500 ft Downridge of (b) (3)	Evaluate trends	Potential migration pathway , Navy fate and transport
All Parties Agree	RHMW-07	Downridge of (b) (3)	Delineation; evaluate downridge Transport from (b) (3)	Historical detections, uncertainty in GW direction, fate and transport modelling
All Parties Agree	RHMW-08	Downridge of (b) (3)	Delineation; evaluate downridge Transport from (b) (3)	Historical detections, uncertainty in GW direction, fate and transport modelling
All Parties Agree	RHMW-21	East of (b) (3)	Delineation	Proximity to (b) (3) release, uncertainty in flow direction
All Parties Agree	RHMW-04	800 ft NE of (b) (3)	Evaluate seasonal variability and trends in PFAS concentrations Near (b) (3) Release	Release history, residual soil contamination, unknown groundwater arrival times
All Parties Agree	RHP-08B,-08C	< 500 ft from RHS		

Enclosure 2:
EPA Review of DRAFT REMEDIAL INVESTIGATION WORK PLAN PER- AND POLYFLUORALKYL SUBSTANCES RELEASE, RED HILL BULK FUEL STORAGE FACILITY, JOINT BASE PEARL HARBOR-HICKMAN, OAHU HI, PEARL HARBOR HI FISC SITE 30, JUNE 2024

Table of Wells: Navy/DOH/EPA Agreed to Sample Wells on this Table on July 12,2024

Status	Wells Recommended for PFAS RI Sampling			
	Well ID	Location	Purpose of Monitoring	Justification
All Parties Agree	RHMW 01R			
All Parties Agree	RHMW-02	1600 ft SW of (b) (3)	Delineation; evaluate trends	Historical Detections, Uncertainty in GW flow direction
All Parties Agree	RHMW-03	700 ft S of (b) (3)	Delineation; evaluate trends	Historical Detections, Uncertainty in GW flow direction
All Parties Agree	RHMW-05	2600 ft SW of (b) (3)	Delineation	Uncertainty in groundwater flow direction and rate
All Parties Agree	OWDFMW03A and 03B			
All Parties Agree	OWDFMW 08A and 08B			

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To finalize the Remedial Investigation Work Plan Per- and Polyfluoralkyl Substances Release (Draft RI WP), please respond to the comments in this enclosure.

GENERAL COMMENTS

1. The "Site" should be the entire Red Hill Bulk Fuel Storage Facility (Red Hill) and not just Areas A and B. Given the lack of documented information about where Per- and Polyfluoroalkyl Substances (PFAS) was used previously and lack of a full Red Hill PA/SI, there is insufficient information to narrow it to these areas. The Remedial Investigation and sampling should also determine whether any other areas may be potential PFAS sources and nature and extent at Red Hill.

2. All Red Hill operations and activities are not discussed or mapped in the Draft RI WP. Specifically, non-AFFF sources of PFAS at Red Hill don't seem to be fully investigated. For instance, petroleum facilities may use PFAS-containing materials for vapor suppression, so the tank gallery may be a large source of PFAS contamination. Over the years, the Navy constructed and maintained metal in the main tanks, pipelines, surge tanks, rail cars, rail lines, etc. It is unclear where smelting, metal-plating and other activities occurred. Sites like the Oily Waste Disposal Facility (OWDF) may have received and burned PFAS-containing chemicals. Figure 2-7 of the 1992 Red Hill Oily Waste Disposal Pit Remedial Investigation/Feasibility Study Work Plan showed a plumber's shop, switch room, septic tank, crusher pit, and other potential PFAS sources. PFAS-containing surfactants may have been used and stored throughout the facility. Please update the RI WP to identify and investigate all potential sources of PFAS contamination.

3. Please provide full schematics that will identify aqueous film-forming foam (AFFF) storage and transport locations through Red Hill. The Navy should provide descriptions and schematics for legacy AFFF systems, as well as the more recent system.

For instance, the following excerpt describes a more extensive and complex fire suppression system than presented in the report figures. Section 10.2.1.4 of the report states, *"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."*

Figures should be revised to show the entire AFFF fire suppression system including but not limited to sprinkler systems, mixing and release stations, distribution piping, aboveground storage tanks (ASTs), release retention piping, waste piping and tanks, as well as the components and sections of the system through which AFFF concentrate, mixed product and

/or PFAS-containing wastes were held or conveyed during testing or operations. The AFFF system at the surge tanks, fuel oil recovery (FOR) facility, underground pumphouse, Building (Bldg) 1721, Bldg 1613, and the connecting pipelines should also be clearly represented.

4. During a meeting on July 17, the Navy discussed looking at the conceptual site model (CSM) and fate and transport three-dimensionally. This three-dimensional approach seems missing from the Draft RI WP. Please update the Draft RI WP to include discussions of subsurface preferential pathways like conduits, pipelines, and the Harbor Tunnel.

5. Delineation of PFAS contamination should be based on detections. In appendix A, please map all locations where PFAS contaminants were detected in soil and groundwater. Use the locations with detections to identify in Worksheets #11 and #17 where data gaps will be investigated.

6. The proposed groundwater sampling should be more comprehensive.

a. It is unclear why installation of additional monitoring wells (i.e., a cluster) and/or sampling existing Oily Waste Disposal Facility wells are not proposed west-southwest of RHP06 downgradient of the investigation area. The Perfluorooctanesulfonic acid (PFOS) MCL exceedance in RHP06 should be delineated. The proposed well would be outside of the investigation area and Red Hill Facility Boundary; however, monitoring well locations RHP06 and RHP08, among others, are located outside of the depicted Red Hill Facility Boundary. Please revise the Draft RI WP to propose additional monitoring well locations west-southwest of RH06.

b. During the EPA/DOH/Navy teleconference in July, EPA proposed multiple additional wells for sampling. While the Navy did not agree to expedite sampling of the following wells, EPA continues to emphasize their importance:

    i. NMW-32 Area: Due to the location of NMW-32 near a Red Hill tunnel, we cannot dismiss the PFAS detected in NMW-32 in September 2023 as being from a non-PFAS source. There is also uncertainty in the groundwater flow direction, so real-world data are needed to understand these PFAS detections. Wells NMW-25, NMW-32, NMW-33, NMW-37, and NMW-39 need to be sampled for delineation and to evaluate trends.

ii. (b) (3) Area:
   1. OWDFMW04: This well needs to be sampled for delineation and to evaluate seasonal variability and trends in PFAS concentrations in the vicinity of (b) (3) .
   2. NMW-23, NMW27/27A, NWM-29/29A, NMW-30, NMW-35, NMW-36, NMW-38/38A, NMW-41, NMW-43, and SS: These wells need to be sampled due to uncertainty in the groundwater flow direction as some of them are potentially downgradient of (b) (3) based on the Groundwater Flow Model. Also, there are groundwater sources/users to the west and northwest of (b) (3) area.

iii. (b) (3) Area: RHMW-01, RHMW-09, RHMW-12, RHMW-12A, RHMW-18, RHMW-19, Halawa Deep, NMW-22, NMW-28/28A, NMW-31, NMW-40/40A, NMW-42/42A, XE, OO, and KK. These wells need to be sampled for delineation, to evaluate seasonal trends and downgradient transport. Several are near (b) (3) and others are needed because of the uncertainty in the groundwater flow direction.

Please revise the Draft RI WP to propose these additional locations and include them in Worksheets #17 (Sampling Design and Rationale) and #18 (Locations-Specific Sampling Methods/SOP [Standard Operation Procedures] Requirements Table), so that the objective to delineate the nature and extent of PFAS contamination can be met.

7. The proposed borings should be numbered on Figures 10 (Proposed Sampling Locations – Area A) and 11 (Proposed Sampling Locations – Area B) and in Worksheet #18. For example, Figure 10 appears to only show 7 of the 12 proposed surface/subsurface soil boring locations surrounding Bldg 313; however, numbering boring locations would allow for easier analysis and ensure that nothing is overlooked in the field. Please revise Worksheet #18 and Figures 10 and 11 of the Draft RI WP to number the proposed borings.

8. EPA Regional Screening Levels (RSLs) released in November 2023 are cited throughout the Draft RI WP, but newer RSLs were released in May 2024. The 24 August 2023 Office of the Assistant Secretary of Defense (OSD) memorandum states that the Department of Defense (DoD) will no longer issue revisions to incorporate future RSL updates and will instead include these updates on its website (https://www.acq.osd.mil/eie/eer/ecc/pfas/pfas101/rsl.html). There are new, lower RSLs for PFOS and perfluorooctanoic acid (PFOA), based on the May 2024 RSLs, which are included by link on the OSD web page. Please revise the Draft RI WP to incorporate the most recent RSLs.

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9. EPA drinking water maximum contaminant levels (MCLs) for certain PFAS were finalized in June 2024, so screening of existing and newly generated data should include applicable MCLs. Please revise the Draft RI WP to incorporate the PFAS MCLs in data screening, including the rescreening of existing data using the MCLs.

10. In some cases, throughout the Draft RI WP, the RSL that was used for screening purposes was not specified. For example, Worksheet #10, Conceptual Site Model, PDF Page 41, first bullet, states that soil sample results from Area A, Excavation Areas/Former DUs (Decision Units), were "below EPA regional screening levels (RSLs)", but it does not specify which RSLs are meant. Please revise the Draft RI WP to note the specific RSL (i.e., release date, residential or industrial, Target Hazard Quotient (THQ) = 0.1 or 1,.) whenever mentioned in text.

11. There is no human health risk assessment work plan presented in the Draft RI WP; it appears that an ecological risk assessment may or may not be applicable for this site. If risk assessment work plan(s) are anticipated to be produced under separate cover, please revise the Draft RI WP to indicate this in the appropriate worksheet(s) (e.g., Worksheet #10, etc.).

SPECIFIC COMMENTS

1. **Worksheet #3, Distribution List, Page 19, and Worksheet #5, Project Organization Chart, Page 23:** The Distribution List displays Alison Fong's title as Regulatory Project Manager. Please correct her title to reflect that she is, "Assistant Director, RCRA Branch Land, Chemicals & Redevelopment Division".

2. **Worksheet #4, Project Personnel Sign-Off Sheet, Page 21:** Having all personnel working in the field read and sign off on the Draft RI WP will benefit the quality of the work. Shouldn't additional field personnel be required to read and sign?

3. **Worksheet #5, Project Organization Chart, Page 23:** The Project Organization Chart seems to indicate that the lines of authority go from EPA to Hawaii Department of Health (DOH), to several Navy contractors. This is incorrect. Please delete the black line from EPA to DOH. Ensure the Navy project managers communicate with both DOH and EPA. Move the contractors to under the Navy's authority.

4. **Worksheet #6, Communication Pathways, Pages 25 and 26:** Work Plan/Sampling and Analysis Plan **(**WP/SAP) changes prior to field/laboratory work and WP/SAP changes in the field, e.g., field change requests, should be reviewed and approved by EPA, and EPA should be included in communications about WP/SAP changes. Please revise the Draft RI WP to include EPA approval of WP/SAP changes and include EPA in all communications about WP/SAP changes.

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5. **Worksheet #10, Conceptual Site Model, Pages 33 through 52:**
   a. **General:**
      i. Section 10.2 describes site history and environmental information. Section 10.2.8 discussed previous investigations and removal actions. However, there is no discussion of the December 20 and 27 exceedances of PFOS in (b) (3) [redacted] or the September 2023 detections of multiple PFAS contaminants in waste characterization samples from the AFFF retention line. Additional (b) (3) [redacted] soil investigation-derived waste (IDW) results were received in July 2024 that weren't documented in the remedial action completion report or this Draft RI WP. Please document these four sets of data somewhere in Section 10.2.
      ii. Given available information on the amount of AFFF spilled, recovered, excavated, and disposed of the Draft RI WP should include an estimate of the net mass of PFAS released to the environment during the November 2022 release at (b) (3).

   b. **Section 10.2.1, Site Description(s) and History, Page 33:** Include all potential PFAS source locations in the investigation. Potential locations include, but aren't limited to:
      i. AFFF storage locations throughout the facility
      ii. Locations of routine or heavy surfactant use
      iii. Location of wastewater storage, seepage, or large releases
      iv. Disposal locations, including where waste was infiltrated, buried, or burned.

   c. **Section 10.2.1.2, (b) (3) and Former Slop Tank, Pages 33 and 34:**
      i. This section describes a historical AFFF system that was plumbed to a 210,000-gallon slop tank outside of (b) (3), however, several details are missing, including the installation date of the AFFF system decommissioned in 2008. Please revise this section of the Draft RI WP to more completely describe the purpose of the AFFF system at (b) (3), period of use, frequency of use, and AFFF formulation it contained. Include discussion of all types of waste that entered the slop tank. Describe the function of the lines connecting the AFFF AST to the slop tank.
      ii. The text describes cutting and plugging piping associated with a slop tank and AFFF AST. Is there documentation that the residual fuel was removed from the piping and the piping was cleaned before plugging?
      iii. Figure 2 indicates wastewater and fluids from the former slop tank (S-355) were discharged to Halawa stream. Please include a discussion in this section of the potential for PFAS to have been discharged directly to Halawa Stream and the resulting contaminant exposure pathways.

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d. **Section 10.2.1.3, Red Hill Fire Suppression System Located at Building 313 and (b) (3), Page 34:** Based on the text, it appears no AFFF system was operated at Red Hill between 2008 and 2018. Please confirm.

e. **Section 10.2.1.4, Site Features, Pages 35 and 36:**
   - **i.** The text indicates post-excavation soil sample results were below EPA RSLs. The text should be revised to indicate the RSLs relate to direct contact with contaminated soil. There should be additional discussion about how the Navy will consider the leaching to groundwater pathway.
   - **ii.** A potential source of PFAS in Area B groundwater is the fuel release in (b) (3) in November 2021. Several lines of evidence support this conclusion including the timing, magnitude, and composition of PFAS detected in (b) (3) (b) (3) after the November 2021 release. Please revise the text to acknowledge this potential source of PFAS in Area B. Include sampling and analyses of soil and perched groundwater for PFAS within the area impacted by the November 2021 JP-5 release. (Comment also applies to Section 10.4.2, Fate and Transport Considerations).
   - **iii.** The first sentence of the paragraph after the bullet states, "No known AFFF release occurred in Area B, but sampling showed perfluorooctanesulfonic acid (PFOS) present in Area B groundwater monitoring wells." However, multiple PFAS contaminants were detected in those wells, including but not limited to PFBS, PFBA, PFHpA, PFHxS, PFHxA, PFNA, PFOS, PFOA, PFPeA, PFHpS. PFOS, PFOA, and PFHxS exceeded screening criteria. Please update the text to state, "~~No known AFFF release occurred in Area B, but S~~**a**mpling ~~showed~~ detected **multiple PFAS contaminants** ~~perfluorooctanesulfonic acid (PFOS)~~ present in Area B groundwater monitoring wells. **Three PFAS, perfluorooctanesulfonic acid (PFOS), Perfluorooctanoic acid (PFOA) and Perfluorohexanesulfonic acid (PFHxS) exceeded screening criteria.**"
   - **iv.** When discussing infrastructure, potential release locations, and wells near Area B, please also include discussion of NMW32 and the tunnel and pipelines running from the "wye" to (b) (3), the pipelines and tunnel through (b) (3), and the associated tanks and infrastructure outside (b) (3).

f. **Section 10.2.2, Surrounding Area and Land Use, Page 36, and Appendix A Figures:** The property boundary does not match the Tax Map Key (TMK) boundary. Please update the Red Hill facility boundary in all figures to use the TMK boundary or add text to Section 10.2.2 documenting how the Navy chose to define the smaller Red Hill footprint. In Section 10.2.2 please also discuss the locations of adits and tunnels that are part of the Red Hill Bulk Fuel Storage Facility.

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g. **Section 10.2.4.2, Topography and Surface Water, Page 37 Section 10.4.3 Potential Receptors and Exposure Pathways, Page 51, and Appendix A, Figures 6, 7, and 8:** Several sections in Worksheet 10 describe (b) (3) as "formerly" used for drinking water and as being offline "since the November 2021 fuel release". However, we understand the Navy is completing MILCON projects at Navy's Aiea-Halawa Shaft (NAH) and (b) (3) to install drinking water treatment systems. Therefore, the drinking water pathway should be considered potentially complete for future receptors.

   Navy has informed EPA that the treatment systems will treat the water to remove PFAS contaminants and TPH. Since the RI and risk assessment are not complete, and since PFAS contaminants were detected in both RHS and NAH, the Navy should monitor the treatment system frequently to understand when breakthrough will occur and should coordinate closely with regulators to ensure the treatment system is effective before serving water from NAH or RHS. In particular, the Navy should very closely monitor for and prevent breakthrough of smaller PFAS molecules.

h. **Section 10.2.5, Geology and Soils, Page 37, and Appendix A, Figures 6 and 7:** It would be helpful to update the text in this section and the associated cross sections/geologic renderings in the CSM figures with real-world data collected from the multiple coring and boring logs that the Navy has generated over the past few years.

i. **Section 10.2.8.2, AFFF Release and Response Actions at (b) (3) (November 2022), Pages 41 through 43** (last sentence) **and Appendix A, Figure 4** – The text indicates that 6:2 FTS is shown in Figure 4, but concentrations of that chemical in soil are not shown in Figure 4. Since 6:2 FTS was detected at a higher soil concentration than other PFAS compounds (maximum 150 µg/kg), it would be useful to add it to Figure 4.

j. **Section 10.2.8.3, Sampling and Analysis at (b) (3), Pages 43 through 45** –
   - **i.** The text indicates that EPA Method 1633 does not include analytes such as 6:2 FTS and 8:2 FTS. However, these are in fact Method 1633 analytes. Please delete the statement indicating these analytes are not detected via EPA Method 1633.
   - **ii.** Please revise the second paragraph of the Baseline PFAS Sampling Event subsection on page 45 to clearly state that concentrations of PFOS in RHP01, RHP02, RHP03, RHP06, RHP07, and NMW32 exceeded the EAL and RSL. Add that concentrations of PFOA exceeded the MCL in RHP02 and NMW32 and that the concentration of PFHxS exceeded the MCL in NMW32.

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k. Table 10-1, Results for Soil, Total PFAS Samples Collected in December 2022, Page 44 – November 2023 residential soil RSLs are listed in Table 10-1, but if May 2024 RSLs were listed, the maximum PFOS and PFOA concentrations would substantially exceed them (by 8-fold to 63-fold). EPA recommends that the most current RSLs be incorporated into the work plan.

l. Table 10-2, Statistical Metrics for Comprehensive Set of Groundwater PFAS Samples Validated through December 2023, Page 46:

- **i.** November 2023 tapwater RSLs are listed in Table 10-2, but if May 2024 RSLs were listed, the maximum PFOS and PFOA groundwater concentrations would substantially exceed them. EPA recommends that the most current RSLs be incorporated into the work plan.
- **ii.** The groundwater results presented in Table 10-2 are not comprehensive. These statistics are only from the weekly and monthly sampling conducted after the (b) (3) release. They do not include the RHS PFOS exceedances on Dec. 20 and 27, 2021, or the Sept 2023 one-time Baseline Sampling Event results. Please revise the title to, "Statistical Metrics of Validated Groundwater PFAS Samples Collected from December 2022 through December 2023 to investigate the (b) (3) release." Add a footnote stating that, PFAS samples collected during December 20 and 27, 2021 and September 2023 are not included in the statistical representation.

m. Section 10.2.8.4, Previous Investigations at OWDF, Page 47: The last sentence discusses the lack of records of AFFF use but does not discuss how the waste fluids that were disposed and/or burned in the oily waste pits may be sources of PFAS. It also doesn't discuss the plumbing shop, septic tank, and other historical operations in this area that may have released PFAS into the environment. Please add text specifying that waste disposed or burned at the OWDF, and military operations conducted in this area may have been sources of PFAS contamination.

n. Section 10.4.1, PFAS Release Mechanism, Page 49: Please add a clarifying statement at the beginning of this section. Most of the Navy's focus has been to investigate the release of AFFF at (b) (3). However, the Navy will expand its investigation as it uncovers other Red Hill PFAS sources.

o. Section 10.4.1.1, PFAS and Environmental Media, Page 50:

- **i.** The text states that only 11 PFAS currently have toxicity values for deriving regulatory screening criteria, but that number is 14 as of May 2024.
- **ii.** Although reference dose and other toxicity data currently may only be available for 14 PFAS, the availability of toxicity data should be periodically re-evaluated as new RSLs are published. In addition, it is expected that for

PFAS that do not have sufficient toxicity data to quantify risks, they will be qualitatively assessed. Please update the Draft RI WP to state that the availability of toxicity data will be re-evaluated as new RSLs are published, and PFAS that do not have sufficient toxicity data to quantify risk will be qualitatively assessed.

p. Section 10.4.2.1, Aqueous Film-Forming Foam and Per-and Polyfluoroalkyl Substances, Pages 50 and 51:

- **i.** The fluorocarbon tail is described as oleophobic, when in fact it is oleophilic. This should be corrected.
- **ii.** Based on the following excerpt from the report the locations of all former wastewater outfalls along Halawa Stream should be identified and the associated discharge areas characterized and potentially sampled: "*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* (b) (3) *release*."
- **iii.** The last paragraph of Section 10.4.2.1 indicates, and EPA concurs, leaching-to-groundwater is one of the principal PFAS transport pathways of concern. Screening soil data for this pathway is important for identifying sources of groundwater contamination and should be incorporated into the DQOs of the investigation. Navy should delineate to detection limits and then consider using EPA soil SSLs and/or HDOH soil EALs to understand risk and fate and transport.

q. Section 10.4.3, Potential Receptors and Exposure Pathways, Pages 51 and Page 52, and Appendix A, Figure 8 - Human Health Exposure Pathway Evaluation, and Appendix A, Figure 9 Ecological Conceptual Site Model/Exposure Pathway Evaluation:

- **i.** Although Hunters are identified as potential receptors at the site (Figure 8), and game animals (such as pigs) are potential receptors for PFAS incidental ingestion and food web transfer (Figure 9), Hunter biouptake of PFAS is considered "Insignificant." This claim needs further justification, e.g., what is the reasonable maximum exposure (RME) of Hunters to PFAS based on their game consumption rates?
- **ii.** The second paragraph on PDF Page 58 (document Page 52) states that dermal exposure to groundwater is considered an insignificant pathway. However, the basal groundwater beneath the site is a drinking water source that could be used in the future. Please revise this section and the conceptual site model figure (Appendix A, Figure 8, Human Health Exposure Pathway Evaluation,

PDF Page 167) to include dermal exposure to groundwater, as well as ingestion, for hypothetical future residents.

iii. The third paragraph of document page 52 discussed perched water. While perched water isn't used for drinking water and direct exposure to in situ perched water isn't likely, isn't there potential for perched water to discharge to the stream and cause direct exposure, ingestion, and/or ecological risk? Please update the Draft RI WP CSMs with this potential exposure pathway.

iv. The text of the last paragraph on Page 52 indicates: "*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.*" However, based on historical operations, there is potential PFAS were a component of the wastes discharged to Halawa Stream. Please update the text and Figure 9 to identify this exposure pathway as complete.

6. **Worksheet #11, Project Quality Objectives/Systematic Planning Process Statements, Pages 53 through 58:**

   a. **Section 11.1, Step 1 - State the Problem**: Between the second and third sentence, please add, "*...former 200-gallon AFFF AST*. **Throughout the history of Red Hill, there may have been additional sources of PFAS contamination associated with the construction, operation, maintenance, and/or disposal practices at the facility.** *Soil and groundwater samples...*"

   b. **Section 11.2, Step 2 – Identify Study Goals:**
      i. PSQ#1, 2 and 3 also apply to Area B.
      ii. Please add a principal study question, "Have there been impacts to Halawa Stream surface water and sediments from Red Hill PFAS releases?" Update the remaining sections of WS #11 to address this new PSQ.
      iii. PSQ#2 should also consider whether soil contamination represents a leaching risk and whether groundwater impacts as a result of previous releases have peaked.
      iv. Please add a caveat at the end of this section that, as the Navy identifies additional Red Hill sources of PFAS, the principal study questions and other project quality objectives will be updated in QAPP addenda.

   c. **Section 11.3, Step 3 – Identify the Information Inputs to the Decision, :** The 2023 RSLs are cited; however, the most recent RSLs (May 2024) should be cited. Please revise the Draft RI WP to cite the most recent RSLs.

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d. **Section 11.5, Step 5 – Develop the Analytical Approach:** Please update this step to indicate that, in addition to no exceedances of PSLs, groundwater concentrations must show a stable or declining trend.

e. **Section 11.7, Step 7 – Optimize the Design:** During a series of meetings in July 2024, the Navy met with regulators to discuss additional requirements for groundwater sampling. Please incorporate the additional well locations and the objectives for those locations into the sampling design **(see enclosed table).**

   Please also include sampling of all available OWDF well clusters and the RHS pre-chlorination point. After updating the DQOs and PSQs, please consider revising the locations of the Navy's proposed new wells to locations that will better meet project objectives.

7. **Worksheet #13, Secondary Data Criteria and Limitations Table, Pages 61 and 62:** Include the remedial action completion report, "Red Hill Bulk Fuel Storage Facility, (b) (3) AFFF Release Report," dated November 2023.

8. **Worksheet #14, Summary of Project Tasks, Pages 70 through 79:**

   a. **Section 14.5.6.2, Well Construction, Page 71:** If the sand pack is completed above the water table, the bentonite pellets may not sufficiently hydrate. Recommend adding PFAS-free potable water to hydrate the seal, preferably after each foot of bentonite pellets have been placed, until the entire seal has been placed and hydrated.

   b. **Section 14.5.8, Well Development, Page 72:** This section acknowledges that groundwater is impacted by well development (i.e., groundwater is oxygenated, affecting dissolved oxygen [DO] and oxidation-reduction potential [ORP]), but does not specify how long an interval should be allowed between well development and groundwater sampling to allow the groundwater in the borehole, sand pack, and vicinity of the borehole to equilibrate with aquifer conditions. If sampling occurs prematurely, the samples may not be representative. At least 7 to 14 days, depending on the lithology, should elapse between well development and sampling in order to allow time for equilibration with the aquifer. Please revise the text to specify the interval between well development and sampling.

   c. **Section 14.11, Investigation-Derived Waste Management and Disposal, Pages 78 and 79:** Section 14.11 states that if liquid IDW contains PFAS concentrations exceeding the EPA lifetime health advisory level, treatment will be required, but this criterion has been rescinded. EPA MCLs for six PFAS were finalized in June 2024, and these values should be used for screening IDW. Please revise Section 14.11 to specify comparison of IDW analyses results to the MCLs.

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9. **Worksheet #17, Sampling Design and Rationale, Pages 93 through 100:**
    a. **Section 17.1 Sampling Design Overview** – The text describes four discrete sampling depths for subsurface soils: 2-3′ bgs, 5-6′ bgs, 11-12′ bgs, and 17-18′ bgs. These four subsurface soil sampling depths are repeated many times throughout Worksheet 17 (e.g., Sections 17.2.1 and 17.2.2). The rationale for these specific depths should be given in the Work Plan. It is not clear how these subsurface soil depths correspond to how human exposure to PFAS in subsurface soil will be evaluated (e.g., for construction workers). These depths also appear to be inconsistent with Section 11.3 (Identify the Information Inputs to the Decision), which states: "*[Primary decision inputs will include the following:] 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*." How will soil PFAS concentrations from 0.5–18′ bgs be evaluated for primary decision making when there will not be any samples corresponding to that full depth interval?

    b. **Section 17.2 Surface and Subsurface Soil Sampling, Page 93:** Given potential PFAS associations with petroleum contamination and the tendency to collect at fluid interfaces, soil intervals exhibiting petroleum contamination should also be targeted for PFAS analyses. In the field, if field observations identify these intervals, the field team should target them for sampling.

    c. **Section 17.2.1, Area A, Page 94:** Sidewall multi-incremental confirmation samples were required in the SAP but were not collected from DU3 before the apron was capped. This remains a data gap and should be addressed in the Work Plan. Please also include additional samples to step out from existing release areas in (b) (3), and more adequately cover the sample areas.

10. **Worksheet #18, Locations-Specific Sampling Methods/SOP Requirements Table, Pages 101 and 102:**

    a. **Page 101:** The number of samples specified for 2-2.5 feet (ft) below ground surface (bgs) at Apron Area Outside (b) (3) and Corner Apron is listed as two; however, three sampling locations are listed and the number of primary samples will be three. Please revise Worksheet #18 to list the correct number of samples for each location.

    b. **Page 101:** The number of samples at Down-Sloping Areas North of (b) (3) are inconsistent with Worksheet #17. For example, Worksheet #18 lists 2 sampling locations; however, Section 17.2.1.5 (Surface and Subsurface Soil Sampling at the Down-Sloping Areas North of (b) (3)) states 7 borings will be completed and "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." Please revise Worksheet #18 to list the correct number of samples at the Down-Sloping Areas North of (b) (3).

c. **Page 101:** The number of samples at Surge Rock Drainage Area are inconsistent with Worksheet #17. For example, Section 17.2.1.6 (Surface Soil Sampling at the Surge Rock Drainage Area) states, "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;" however, there are only two intervals (2-2.5 and 4-5 ft bgs) listed and just 2 samples from the 2-2.5 ft bgs interval listed in Worksheet #18. Please revise Worksheet #18 to list the correct number of samples at the Surge Rock Drainage Area.

d. **Page 102:** The number of samples at Downslope of Road are inconsistent with Worksheet #17. For example, Section 17.2.1.10 (Sediment and Surface Soil Sampling at the Downslope of Road) states, "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." However, only one location is listed on the Worksheet. Please revise Worksheet #18 to resolve the discrepancy.

11. **Worksheet #19, Field Sampling Requirements Table, Page 105:** EPA Method 1633 Sections 8.2.3 and 8.3.2 require that samples be protected from light, but this is not specified in the preservation requirements in Worksheet #19. Please revise Worksheet #19 to specify that samples must be protected from light.

12. **Worksheet #21, Project Sampling SOP References Table, Pages 109 and 110:** The SOPs listed in Worksheet #21 that are not included in Appendix B should be included for reference. Specifically, all SOPs with reference number "N/A" and SOPs I-A-5, I-C-1, I-C-2, and I-E, are not included in the appendix. Additionally, two SOPs are included in Appendix B (I-B-2 and I-H) that are not included on Worksheet #21, although 1-H is mentioned in Worksheet #14. Please revise the Draft RI WP to include all relevant field SOPs in Appendix B and Worksheet #21 and delete any that are not applicable.

13. **Worksheet #22, Field Equipment Calibration, Maintenance, Testing, and Inspection, Pages 111 and 112:** Some equipment specified for use in the Draft WP/SAP are not included in Worksheet #22. For example, a gyroscopic alignment instrument or accelerometer is discussed in Section 14.5.3 and a pressure transducer is discussed in 14.5.4.3. Additionally, an extensive list of potentially necessary video logging equipment is listed in Section 14.5.2. Please revise Worksheet #22 to include all necessary field equipment.

14. **Worksheet #27, Sample Custody Requirements, Section 27.3, Handling, Shipping, and Custody, Page 125:** Section 27.3 states that sample storage and disposal will be managed per Section 5.8 of *Department of Defense (DoD) and Department of Energy (DOE)*

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Consolidated Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.4 (DoD and DOE 2021), but QSM Version 6.0 (2023) is cited elsewhere in the document. Please revise Section 27.3 to cite QSM Version 6.0.

15. **Worksheet #37, Usability Assessment, Page 143:** In Worksheet #37, completeness is defined as the percentage of acceptable sample results compared to the total number of sample results; however, completeness should be calculated relative to the total number of planned results, to account for results that were not able to be obtained (e.g., sample breakage, inability to collect a sample, etc.). Please revise the RI WP to indicate completeness will be calculated based on the number of planned results.

16. **Appendix A, Figures:** Previous comments included suggested revisions to several figures. Additional comments are provided below:

    a. **Figure 6, Pictorial Conceptual Site Model – Area A, PDF Page 163:** The figure shows the perched groundwater as a layer on the model; however, the symbol used for the layer is omitted from the figure legend. The legend should define the layer used to illustrate the perched groundwater. Please revise Figure 6 legend to include and define the symbol (layer) used to illustrate the perched groundwater at Area A.

    b. **Figure 7, Pictorial Conceptual Site Model – Area B, PDF Page 165:**
        i. The figure shows the conceptual site model for Area B; however, perched groundwater is omitted. For example, Section 10.2.6 (Groundwater Hydrogeology) states perched groundwater is present west of Area B. Additionally, Figure 6 (Pictorial Conceptual Site Model – Area A) illustrates the perched groundwater at Area A. Figure 7 should depict the perched groundwater present near Area B. If possible, the location-specific depiction should be generated based on core hole and boring data collected at this site. Please revise Figure 7 to depict the perched groundwater near Area B.
        ii. Please include the locations of the temporary RHS drinking water treatment system and the more permanent RHS drinking water treatment system that should be installed in approximately 5 years.
        iii. Please include a label for Halawa Stream and describe its significance in exposure pathways and contaminant transport.

    c. **Figure 8, Human Health Exposure Pathway Evaluation, PDF Page 167, and Figure 9, Ecological Conceptual Site Model/Exposure Pathway Evaluation, PDF Page 169**: Evaluation of the CSMs is limited because Figures 8 and 9 identify the only release mechanism as AFFF from the Red Hill Fire Suppression System, likely only at (b) (3), and only the recent release. As the Navy identifies additional Red Hill AFFF sources, the CSM should be updated in QAPP addenda.

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d. Figure 10, Proposed Sampling Locations – Area A, PDF Page 171:

- **i.** The figure shows four surface soil/subsurface soil sample locations around the former aqueous film-forming foam (AFFF) aboveground storage tank (AST) and three locations down-slope; however, Section 17.2.1.5 states, "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." Please revise the figure to resolve the discrepancy.
- **ii.** The figure shows seven subsurface soil sample locations around Bldg 313; however, Section 17.2.1.7 (Surface and Subsurface Soil Sampling at Bldg. 313 Pump House, Piping Area, and Former Slop Tank) states, "Twelve borings are proposed to be positioned around and outside of the concrete footprint of Bldg. 313." Please revise the figure to resolve the discrepancy.

e. Figure 10, Proposed Sampling Locations – Area A, PDF Page 171: The figure shows one surface soil and one sediment sample location, respectively, southwest of Bldg. 313; however, Section 17.2.1.10 states, "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." Please revise the figure to resolve the discrepancy.

f. Figure 11, Proposed Sampling Locations – Area B, PDF Page 173:

- **i.** (b) (3) and the area of known and suspected petroleum impacts associated with the November 2021 JP-5 release should be presented in Figure 11.
- **ii.** The Navy's proposed monitoring well clusters don't seem targeted to delineate the contamination identified during the September 2023 Baseline Sampling Event, or to further investigate risk of PFAS contamination at RHS. Please consider adding additional OWDF monitoring wells, including OWDF04/04A and OWDF01/01A, to the sampling design. Consider placing new wells west of RHP 06 and south of OWDF 04 and OWDF 01. Include NMW32.

17. Appendix B, SOP I-A-6, Section 3.1.2, CERCLA Hazardous Substances, PDF Page 182:

a. Please consider changing the word "waste" in the last sentence of the first paragraph to "substances" or list the name of the table, "Table 302.4—List of Hazardous Substances and Reportable Quantities".

b. This section discusses CERCLA hazardous substances but doesn't address PFAS. PFOS and PFOA were designated as CERCLA Hazardous substances on July 8, 2024

(https://www.federalregister.gov/d/2024-08547). Please update this section with information about PFOS and PFOA and reference EPA's Interim Guidance on the Destruction and Disposal of Perfluoroalkyl and Polyfluoroalkyl Substances and Materials Containing Perfluoroalkyl and Polyfluoroalkyl Substances—Version 2 (2024).

18. **Appendix D, Analytical Data Package Requirements, PDF Pages 399 through 402** - Appendix D details the requirements of a "full" deliverable. For data packages requiring full validation, EPA recommends that standard traceability, standard preparation logs, and certificates of analysis be included.

19. **Appendix G, References, PDF Page 419:** Please add the following references:
    - **a.** Glüge J, Scheringer M, Cousins IT, DeWitt JC, Goldenman G, Herzke D, Lohmann R, Ng CA, Trier X, Wang Z. 2020. An overview of the uses of per- and polyfluoroalkyl substances (PFAS). The Royal Society of Chemistry (RSC), Environmental Science Processes and Impacts. 22: 2345-2373.
    - **b.** Barfoot K, McGrath A, Richards S, Shanoff T, Stonebridge J. 2022. PFAS and the Mining Industry: Understanding the Challenges. Proceedings of Mine Water Solutions. http://www.mineconferences.com/bluepixeldesign/wp-content/uploads/2022/07/47.-Krista-Barfoot-PFAS-and-the-Mining-Industry-Understanding-the-Challenges-Final.pdf
    - **c.** Gaines LGT. Historical and current usage of per- and polyfluoroalkyl substances (PFAS): a literature review. Am J Ind Med. 2022;1-26. doi:10.1002/ajim.23362
    - **d.** State Water Resources Control Board. 2021. Water Code Sections 13267 and 13383 Order for the Determination of the Presence of Per- and Polyfluoroalkyl Substances at Bulk Fuel Storage Terminals and Refineries. Order WQ 2021-0006-DWQ. March 12. https://www.waterboards.ca.gov/pfas/docs/order_wq2021-0006-dwq_pfas.pdf
    - **e.** EPA. 2024. Designation of Perfluorooctanoic Acid (PFOA) and Perfluorooctanesulfonic Acid (PFOS) as CERCLA Hazardous Substances. Document Number: 2024-08547. Federal Register, Vol. 89, No. 90. RIN 2050–AH09. May 8. https://www.federalregister.gov/documents/2024/05/08/2024-08547.
    - **f.** EPA. 2024. Interim Guidance on the Destruction and Disposal of Perfluoroalkyl and Polyfluoroalkyl Substances and Materials Containing Perfluoroalkyl and Polyfluoroalkyl Substances—Version 2. April 8. https://www.epa.gov/system/files/documents/2024-04/2024-interim-guidance-on-pfas-destruction-and-disposal.pdf.

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g. Navy. 2023. Red Hill Bulk Fuel Storage Facility, (b) (3) AFFF Release Report. November. (RACR)

h. Navy. 2023. Per- and Polyfluoroalkyl Substances Delineation Baseline Groundwater Wells Investigation Report, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, O‘ahu, HI. November 27.

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Date: August 2024

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General Comments		
1	General	The "Site" should be the entire Red Hill Bulk Fuel Storage Facility (Red Hill) and not just Areas A and B. Given the lack of documented information about where Per- and Polyfluoroalkyl Substances (PFAS) was used previously and lack of a full Red Hill PA/SI, there is insufficient information to narrow it to these areas. The Remedial Investigation and sampling should also determine whether any other areas may be potential PFAS sources and nature and extent at Red Hill.
Response (October 2024): This RI is focusing on areas of known or potentially undocumented AFFF release areas that currently consist of Area A and Area B. The entire Red Hill Bulk Fuel Storage Facility (RHBFSF) was evaluated for potential PFAS sources as part of the Preliminary Assessment (PA) for PFAS at Joint Base Pearl Harbor-Hickam (JBPHH) National Priority List (NPL) Sites (DON 2023), and no potential sources of PFAS other than the AFFF storage tanks and November 2022 AFFF release were identified. If other potential sources are identified during sampling, they will be investigated in subsequent phases of the RI.		
Updated Response (February 2026): During the four expedited quarterly groundwater monitoring events (September 2024 through September 2025), groundwater from monitoring wells throughout the Red Hill Facility were analyzed for PFAS by EPA Method 1633. The results identified PFAS above the PSLs in Area A and in Area B, only. In addition, Area B now extends to the westernmost point of the Facility. These results are the basis for limiting Area A and Area B as potential PFAS source areas within the Facility for this RI. Section 10.4 of the Revised Draft Work Plan (February 2026) presents the results from the expedited quarterly groundwater monitoring events.		
2	General	All Red Hill operations and activities are not discussed or mapped in the Draft RI WP. Specifically, non-AFFF sources of PFAS at Red Hill don't seem to be fully investigated. For instance, petroleum facilities may use PFAS-containing materials for vapor suppression, so the tank gallery may be a large source of PFAS contamination. Over the years, the Navy constructed and maintained metal in the main tanks, pipelines, surge tanks, rail cars, rail lines, etc. It is unclear where smelting, metal-plating and other activities occurred. Sites like the Oily Waste Disposal Facility (OWDF) may have received and burned PFAS-containing chemicals. Figure 2-7 of the 1992 Red Hill Oily Waste Disposal Pit Remedial Investigation/Feasibility Study Work Plan showed a plumber's shop, switch room, septic tank, crusher pit, and other potential PFAS sources. PFAS-containing surfactants may have been used and stored throughout the facility. Please update the RI WP to identify and investigate all potential sources of PFAS contamination.
Response (October 2024): Historical record reviews (including documents, photos, and interviews) have been conducted for the Red Hill Former Oily Waste Disposal Facility (OWDF) on several occasions, which are summarized in the Site Characterization, Phase I – Red Hill Oily Waste Disposal Pit Remedial Investigation/Feasibility Study (RI/FS) (DON 1992) and the Site Assessment Work Plan Red Hill Oily Waste Disposal Facility (SA WP) (DON 2021). The historical documents and information indicate that the material disposed of at the OWDF disposal pits consisted of tank bottom sludges and drippings from fuel line valves and fittings, i.e., fuel-related materials stored inside the tanks. For this purpose, a piping system conveyed material from inside the bottoms of the tanks to the OWDF stilling basin. The Navy is not aware of any records or suggestions that other material was piped to or otherwise deposited into the stilling basin, which was designed to allow the tank bottom sludge liquids to infiltrate and evaporate. There is no reason to suspect that PFAS was contained within those fuels or tank bottom fuel sludges. EPA is correct that the 1992 RI/FS WP noted that "A 1943 plot plan of the lower portion of the fuel depot (Figure 2-17) shows the existence of a machine shop, machine shop warehouse, and service station all of which were located near the steel fabrication shop, to the northeast of the old pit." However, the report went on to state that "No evidence had been found at the time of preparation of this WP to suggest that the rock crusher, service station, steel fabrication shop, or machine shop were related to the waste disposal activities at the site." Therefore, there is no reason to suspect that anything other than the well-documented tank bottom sludges and fuel-related material from inside the tanks were disposed of at the OWDF, and such fuel-related material is not expected to contain AFFF or PFAS. Additionally, the PA for PFAS at JBPHH NPL Sites (DON 2023) evaluated the RHBFSF and did not identify any potential sources of PFAS within the Former OWDF.		
3	General	Please provide full schematics that will identify aqueous film-forming foam (AFFF) storage and transport locations through Red Hill. The Navy should provide descriptions and schematics for legacy AFFF systems, as well as the more recent system. For instance, the following excerpt describes a more extensive and complex fire suppression system than presented in the report figures. Section 10.2.1.4 of the report states, *"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.*"

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		Figures should be revised to show the entire AFFF fire suppression system including but not limited to sprinkler systems, mixing and release stations, distribution piping, aboveground storage tanks (ASTs), release retention piping, waste piping and tanks, as well as the components and sections of the system through which AFFF concentrate, mixed product and/or PFAS-containing wastes were held or conveyed during testing or operations. The AFFF system at the surge tanks, fuel oil recovery (FOR) facility, underground pumphouse, Building (Bldg.) 1721, Bldg. 1613, and the connecting pipelines should also be clearly represented.
Response (October 2024): Figure 1: Red Hill Collection Tanks and Figure 1: Red Hill Overview are provided in *Attachment A: Selected Figures from Final Evaluation Report, Aqueous Film-Forming Foam, Product Supply Containment System, Joint Base Pearl Harbor, Hickam, Oahu, Hawaii, October 2023*. In addition, text has been added to Section 10.2.1.3 (previously Section 10.2.1.4) to provide more details regarding the current system.		
Updated Response (February 2026): The text previously added to Section 10.2.1.3 (now Section 10.2.1.2) was revised for clarity.		
4	General	During a meeting on July 17, the Navy discussed looking at the conceptual site model (CSM) and fate and transport three-dimensionally. This three-dimensional approach seems missing from the Draft RI WP. Please update the Draft RI WP to include discussions of subsurface preferential pathways like conduits, pipelines, and the Harbor Tunnel.
Response (October 2024): Figure 6 and Figure 7 have been revised to include the AFFF system piping as well as the water development tunnel as potential preferential migration pathways. The following sentence has been added to WP Section 10.4.2.2: “The AFFF piping system is shown on Figure 6 and the water development tunnel is shown on Figure 7.”		
Updated Response (February 2026): Figures 6 and 7 referenced in the previous response are now Figures 27 and 30. Site-specific PFAS fate and transport considerations are now presented in Section 10.5.2.2. The sentence that was previously added to former Section 10.4.2.2 was removed when the current Section 10.5.2.2 was updated based on the expedited sampling results.		
5	General	Delineation of PFAS contamination should be based on detections. In appendix A, please map all locations where PFAS contaminants were detected in soil and groundwater. Use the locations with detections to identify in Worksheets #11 and #17 where data gaps will be investigated.
Response (October 2024): The current DoD policy is to only use PFAS analytes that have screening criteria derived from final, peer-reviewed toxicity values; therefore, for consistency, the figures should focus on locations with PFAS that have established screening criteria.		
Updated Response (February 2026): CERCLA guidance requires delineation of COPCs to their PSLs (defining the boundaries of the COPC impacts with potential for adverse effects prior to conducting screening or baseline risk assessment for decision-making), not to the detection limit of the method of analysis. However, Figures 13 through 26 provide mapped locations and concentration values where PFAS COPCs were detected in investigation samples, to provide evidence whether “delineation” to the PSLs have been achieved.		
6	General	The proposed groundwater sampling should be more comprehensive. a. It is unclear why installation of additional monitoring wells (i.e., a cluster) and/or sampling existing Oily Waste Disposal Facility wells are not proposed west-southwest of RHP06 downgradient of the investigation area. The Perfluorooctanesulfonic acid (PFOS) MCL exceedance in RHP06 should be delineated. The proposed well would be outside of the investigation area and Red Hill Facility Boundary; however, monitoring well locations RHP06 and RHP08, among others, are located outside of the depicted Red Hill Facility Boundary. Please revise the Draft RI WP to propose additional monitoring well locations west-southwest of RHP06. b. During the EPA/DOH/Navy teleconference in July, EPA proposed multiple additional wells for sampling. While the Navy did not agree to expedite sampling of the following wells, EPA continues to emphasize their importance: i. NMW-32 Area: Due to the location of NMW-32 near a Red Hill tunnel, we cannot dismiss the PFAS detected in NMW-32 in September 2023 as being from a non-PFAS source. There is also uncertainty in the groundwater flow direction, so real-world data are needed to understand these PFAS detections. Wells NMW-25, NMW-32, NMW-33, NMW-37, and NMW-39 need to be sampled for delineation and to evaluate trends. ii. (b) (3) Area: 1. OWDFMW04: This well needs to be sampled for delineation and to evaluate seasonal variability and trends in PFAS concentrations in the vicinity of (b) (3) . 2. NMW-23, NMW27/27A, NWM-29/29A, NMW-30, NMW-35, NMW-36, NMW-38/38A, NMW-41, NMW-43, and SS: These wells need to be sampled due to uncertainty in the groundwater flow

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		direction as some of them are potentially downgradient of (b) (3) based on the Groundwater Flow Model. Also, there are groundwater sources/users to the west and northwest of (b) (3) area. iii. (b) (3) Area: RHMW-01, RHMW-09, RHMW-12, RHMW-12A, RHMW-18, RHMW-19, Halawa Deep, NMW-22, NMW-28/28A, NMW-31, NMW-40/40A, NMW-42/42A, XE, OO, and KK. These wells need to be sampled for delineation, to evaluate seasonal trends and downgradient transport. Several are near (b) (3) and others are needed because of the uncertainty in the groundwater flow direction. Please revise the Draft RI WP to propose these additional locations and include them in Worksheets #17 (Sampling Design and Rationale) and #18 (Locations-Specific Sampling Methods/SOP [Standard Operation Procedures] Requirements Table), so that the objective to delineate the nature and extent of PFAS contamination can be met.

Response (October 2024):

a. The Navy and regulatory agencies have agreed to 1 year of quarterly groundwater monitoring before making decisions that would include PFAS sampling of environmental media beyond the current boundaries of the RI. In addition, soil and sediment samples will be collected and analyzed from on-site locations to identify potential source areas from the Facility and the results will be used to determine whether additional offsite sampling of environmental media is warranted.

b. i. The current investigation is focused on the Facility. If the current investigation does not delineate the PFAS extent, then other wells will be considered for sampling outside of these boundaries. Well NMW32 will not be included at this time, because it is located offsite and results from the September 2023 sampling event show PFAS at concentrations that exceed any wells sampled within the Facility, which suggests a different source. Note that well NMW33 does not monitor the basal aquifer, and construction of wells NMW37 and NMW39 has not been started.

b. ii. 1. Well OWDFMW04A will be sampled as agreed upon during Scoping Meeting #3.

b. ii. 2. The current phase of the investigation is focused on the Facility. If the current phase of the investigation does not delineate the extent of PFAS, then other wells will be considered for sampling outside of the RI boundaries. Construction has not yet begun on the following wells: NMW23, NMW27A, NMW29/NMW29A, NMW35, NMW36, NMW38/NMW38A, NMW41, NMW43, and SS. Once these wells are completed, the Navy will evaluate whether these wells should be sampled under follow-on phases to this remedial investigation, based on the existing data at that time. Construction of well NMW27 is currently in progress; once completed, the Navy will evaluate as to whether this well should be sampled under follow-on phases of this remedial investigation. Of the wells listed above, only NMW30 is completed.

b. iii. The current investigation is focused on the Facility. If the current investigation does not delineate the PFAS extent, then other wells will be considered for sampling outside of the RI boundaries. Construction has not yet begun on the following wells: NMW22, NMW28/NMW28A, NMW31, NMW40/NMW40A, NMW42/NMW42A, XE, OO, and KK. Well RHMW01 (1-inch casing and screen, fully submerged screen) has been replaced by Well RHMW01R (2-inch casing and screen, screened across the water table), which is located within 10 feet of the original RHMW01. Well RHMW01R is proposed for sampling. Well RHMW18 is proposed for sampling. Wells RHMW09, RHMW12, RHMW12A, RHMW19, and Halawa Deep Monitoring Well 2253-03, are not currently proposed for sampling under this investigation. If the current investigation does not delineate the PFAS extent, then other wells will be considered for sampling.

Updated Response (February 2026):

a. The sampling and analysis strategy described in Worksheet #17 of the Revised Draft Work Plan (February 2026) was discussed and EPA provided their general agreement during scoping meeting No. 5. All scoping meetings that were conducted to support this RI work plan are summarized in Worksheet #9 of the Revised Draft Work Plan (February 2026). Results from the expedited quarterly groundwater monitoring events (September 2024 to September 2025) show a PFAS concentration gradient which ranges from concentration maxima for PFOS and PFOA along the northern Facility boundary at RHP01, RHP02, and RHP03 (PFOS ranged from 8.5 ng/L to 16 ng/L; PFOA ranged from 3.6 ng/L to 5.6 ng/L), to concentration minima for PFOS and PFOA along the southern Facility boundary at RHP06 (PFOS ranged from 4.2 ng/L to 4.6 ng/L; PFOA ranged from 3.8 ng/L to 4.5 ng/L). The PSLs for PFOS and PFOA are both 4 ng/L, which corresponds to the EPA maximum contaminant level (MCL). The Navy priority at this phase of the remedial investigation, as presented in Section 17.5 of the Revised Draft Work Plan (February 2026), is to define the extent of the PFAS in the basal aquifer along the northern and eastern edges of the monitoring well network in Area B, where additional groundwater results are expected to provide important additions to the fate and transport conceptual site model and risk evaluation. If appropriate, the Navy will conduct an additional phase of remedial investigation site characterization based on the results of the sampling and analysis program described in the Revised Draft Work Plan (February 2026).

b. i. See updated response to comment #6a.

b. ii. 1. Well OWDFMW04A was sampled as part of the expedited quarterly sampling. Refer to Section 10.4 for results.

b. ii. 2. See the updated response to comment #6a.

b. iii. See the updated response to comment #6a.

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7	General	The proposed borings should be numbered on Figures 10 (Proposed Sampling Locations – Area A) and 11 (Proposed Sampling Locations – Area B) and in Worksheet #18. For example, Figure 10 appears to only show 7 of the 12 proposed surface/subsurface soil boring locations surrounding Bldg. 313; however, numbering boring locations would allow for easier analysis and ensure that nothing is overlooked in the field. Please revise Worksheet #18 and Figures 10 and 11 of the Draft RI WP to number the proposed borings.
Response (October 2024): Figures 10 and 11 and Worksheet #18 have been revised to include boring location IDs.		
Updated Response (February 2026): Proposed sampling locations are now labeled and presented in Figures 33 through 44 of the Revised Draft Work Plan (February 2026).		
8	General	EPA Regional Screening Levels (RSLs) released in November 2023 are cited throughout the Draft RI WP, but newer RSLs were released in May 2024. The 24 August 2023 Office of the Assistant Secretary of Defense (OSD) memorandum states that the Department of Defense (DoD) will no longer issue revisions to incorporate future RSL updates and will instead include these updates on its website (https://www.acq.osd.mil/eie/eer/ecc/pfas/pfas101/rsl.html). There are new, lower RSLs for PFOS and perfluorooctanoic acid (PFOA), based on the May 2024 RSLs, which are included by link on the OSD web page. Please revise the Draft RI WP to incorporate the most recent RSLs.
Response (October 2024): Comment acknowledged. The link on the OSD web page is based on the United States Environmental Protection Agency's (EPA) November 2023 RSL update. The Navy will follow OSD policy and update the proposed screening criteria accordingly.		
Updated Response (February 2026): Consistent with OSD policy, the project screening levels will be based on the most current DoD-approved screening criteria at the time of evaluation. The project uses DoD-approved EPA RSLs and Navy-approved ecological screening values as the PFAS screening values. The RI project screening levels are listed in Worksheet #15 of the Revised Work Plan (February 2026) and are based on the January 2025 OSD memorandum, *Investigating Per- and Polyfluoroalkyl Substances within the DoD Cleanup Program*, which incorporates the November 2024 EPA residential soil and tap water EPA RSLs (TR = 1×10^{-6} and THQ = 0.1). When a PFAS has an established maximum contaminant level (MCL), the MCL is incorporated into the screening process. When analytical limitations prevent reliable comparison to low-level EPA RSLs (e.g., those for PFOS and PFOA), or when an MCL is lower than the corresponding RSL, the MCL is applied as the groundwater PSL. The risk assessment will adhere to the established CERCLA risk assessment process and will use the most current and DoD-approved toxicity/screening values at the time of evaluation. Refer to Worksheet #15 for selection of PSLs in soil and groundwater matrices.		
9	General	EPA drinking water maximum contaminant levels (MCLs) for certain PFAS were finalized in June 2024, so screening of existing and newly generated data should include applicable MCLs. Please revise the Draft RI WP to incorporate the PFAS MCLs in data screening, including the rescreening of existing data using the MCLs.
Response (October 2024): In accordance with recent DoD policy, screening levels identified in Worksheet #15 for human health are strictly from EPA Regional Screening Levels (November 2023) for the residential exposure scenario for soil and tap water. For ecological risk screening in Worksheet #15, the DoD policy is to use the ecological screening values in the Navy Emerging Chemicals Workgroup Issue Pape. MCLs are requirements for drinking water systems and are to-be-considered (TBC) criteria for groundwater, which will be addressed in the feasibility study if the RI determines that PFAS pose an unacceptable risk to human health or the environment.		
Updated Response (February 2026): See the updated response to general comment #8.		
10	General	In some cases, throughout the Draft RI WP, the RSL that was used for screening purposes was not specified. For example, Worksheet #10, Conceptual Site Model, PDF Page 41, first bullet, states that soil sample results from Area A, Excavation Areas/Former DUs (Decision Units), were "below EPA regional screening levels (RSLs)", but it does not specify which RSLs are meant. Please revise the Draft RI WP to note the specific RSL (i.e., release date, residential or industrial, Target Hazard Quotient (THQ) = 0.1 or 1) whenever mentioned in text.
Response (October 2024): The citation for each referenced RSL in the document has been updated to clarify which RSL is being evaluated, as requested, including release date, residential or industrial land use, THQ = 0.1 or 1, and 1E-06 cancer risk.		
Updated Response (February 2026): Existing PFAS sampling results from emergency response activities associated with the November 2022 AFFF (b) (3) release and expedited sampling activities (September 2024 through September 2025) are compared to the screening levels presented in the January 2025 OSD memorandum provided at https://www.acq.osd.mil/eie/eer/ecc/pfas/pfas101/rsl.html at the time of the Revised Draft Work Plan (February 2026) publication. See the updated response to general comment #8.		

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11	General	There is no human health risk assessment work plan presented in the Draft RI WP; it appears that an ecological risk assessment may or may not be applicable for this site. If risk assessment work plan(s) are anticipated to be produced under separate cover, please revise the Draft RI WP to indicate this in the appropriate worksheet(s) (e.g., Worksheet #10, etc.).
Response (October 2024): There is no current plan to develop a risk assessment work plan for the Site.		
Specific Comments		
1	Worksheet #3, Distribution List and Worksheet #5, Project Organization Chart, Pages 19 and 23	The Distribution List displays Alison Fong's title as Regulatory Project Manager. Please correct her title to reflect that she is, "Assistant Director, RCRA Branch Land, Chemicals & Redevelopment Division".
Response (October 2024): Worksheet #3 has been revised as suggested.		
Updated Response (February 2026): Alison Fong has been replaced by Matt Cohen. Worksheet #3 has been revised accordingly.		
2	Worksheet #4, Project Personnel Sign-Off Sheet, Page 21	Having all personnel working in the field read and sign off on the Draft RI WP will benefit the quality of the work. Shouldn't additional field personnel be required to read and sign?
Response (October 2024): Comment acknowledged. All field personnel are required to read the WP prior to the start of field work. However, they are not required to sign the WP.		
3	Worksheet #5, Project Organization Chart, Page 23	The Project Organization Chart seems to indicate that the lines of authority go from EPA to Hawaii Department of Health (DOH), to several Navy contractors. This is incorrect. Please delete the black line from EPA to DOH. Ensure the Navy project managers communicate with both DOH and EPA. Move the contractors to under the Navy's authority.
Response (October 2024): Worksheet #5 has been revised as suggested.		
4	Worksheet #6, Communication Pathways, Page 25 and 26	Work Plan/Sampling and Analysis Plan (WP/SAP) changes prior to field/laboratory work and WP/SAP changes in the field, e.g., field change requests, should be reviewed and approved by EPA, and EPA should be included in communications about WP/SAP changes. Please revise the Draft RI WP to include EPA approval of WP/SAP changes and include EPA in all communications about WP/SAP changes.
Response (October 2024): Substantial changes to the WP/SAP, prior to field or laboratory work, will be communicated to EPA for approval. However, to avoid delays, minor changes will not be communicated for approval. The Navy requests that EPA identifies the type of change requests it wants to review.		
Updated Response (February 2026): Worksheet #6 specifies under "Regulatory Agency Interface" that the Navy RPM will be notifying EPA and DOH when significant changes or corrective actions occur.		
5a	Worksheet #10, Conceptual Site Model, Page 33 through 52	**General:** i. Section 10.2 describes site history and environmental information. Section 10.2.8 discussed previous investigations and removal actions. However, there is no discussion of the December 20 and 27 exceedances of PFOS in (b) (3) or the September 2023 detections of multiple PFAS contaminants in waste characterization samples from the AFFF retention line. Additional (b) (3) soil investigation-derived waste (IDW) results were received in July 2024 that weren't documented in the remedial action completion report or this Draft RI WP. Please document these four sets of data somewhere in Section 10.2. ii. Given available information on the amount of AFFF spilled, recovered, excavated, and disposed of the Draft RI WP should include an estimate of the net mass of PFAS released to the environment during the November 2022 release at (b) (3).
Response (October 2024): i. Section 10.2.8 was revised to discuss the PFAS results from December 20 and 27, 2021, in the (b) (3). Additionally, the section mentions the IDW samples and analysis results from the removal action following the (b) (3) AFFF release. The AFFF retention line was not sampled for PFAS after the 2021 release, and the characterization of IDW is not known to include PFAS analysis. ii. There is insufficient information to provide EPA with the net mass of PFAS released. The (b) (3) *AFFF Release Report,* prepared by the Commander Navy Region Hawaii, states that approximately 1,100 gallons of Ansulite AFC-3NS 3% AFFF concentrate was released in November 2022. The major PFAS compounds found in the Ansulite AFFF produced between		

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1986 and 2010 are 6:2 fluorotelomer thioamido sulfonate (6:2 FtTAoS, concentration ranging from 6 to 18 g/L) and 8:2 fluorotelomer thioamido sulfonate (8:2 FtTAoS, concentration ranging from 1 to 3 g/L) (Houtz et al. 2013; Backe et al. 2013). However, EPA Method 1633 does not include the quantification of 6:2 FtTAoS and 8:2 FtTAoS. Given that these are the major PFAS compounds found in Ansulite AFFF, there is insufficient information to provide the net mass of PFAS released to the environment due to the AFFF release in November 2022. In addition, the removal action report (*Red Hill Bulk Fuel Storage Facility* (b) (3) *AFFF Release Report*, November 2022) also describes use of absorbent towels to remove AFFF concentrate that cannot be reliably quantified.		
Updated Response (February 2026): i. The results from PFAS samples collected from the Red Hil Shaft in December 2021 are not included in the Revised Draft Work Plan (February 2026). The December 2021 sampling for PFAS in the (b) (3) occurred during emergency response sampling activities that were focused on petroleum cleanup and were not conducted in accordance with PFAS sampling guidance. PFAS results from the expedited quarterly monitoring events (September 2024 through September 2025) from the (b) (3) at RHM (b) (3) were collected in accordance with PFAS sampling guidance and are presented in Worksheet #10, Section 10.4.		
5b	Worksheet #10, Conceptual Site Model, Pages 33 through 52	**Section 10.2.1, Site Description(s) and History, Page 33:** Include all potential PFAS source locations in the investigation. Potential locations include but aren't limited to: i. AFFF storage locations throughout the facility ii. Locations of routine or heavy surfactant use iii. Location of wastewater storage, seepage, or large releases iv. Disposal locations, including where waste was infiltrated, buried, or burned.
Response (October 2024): Potential PFAS sources were evaluated in the PA for JBPHH NPL Sites (DON 2023), which has been summarized in WP Section 10.2.8.2. Bldg. 313 and the AFFF system located near (b) (3) were the only potential PFAS release locations identified. If other potential sources are identified during sampling, they will be investigated in subsequent phases of the RI.		
5c	Worksheet #10, Conceptual Site Model, Pages 33 through 52	**Section 10.2.1.2, (b) (3) and Former Slop Tank, Pages 33 and 34:** i. This section describes a historical AFFF system that was plumbed to a 210,000-gallon slop tank outside of (b) (3), however, several details are missing, including the installation date of the AFFF system decommissioned in 2008. Please revise this section of the Draft RI WP to more completely describe the purpose of the AFFF system at (b) (3), period of use, frequency of use, and AFFF formulation it contained. Include discussion of all types of waste that entered the slop tank. Describe the function of the lines connecting the AFFF AST to the slop tank. ii. The text describes cutting and plugging piping associated with a slop tank and AFFF AST. Is there documentation that the residual fuel was removed from the piping and the piping was cleaned before plugging? iii. Figure 2 indicates wastewater and fluids from the former slop tank (S-355) were discharged to Halawa stream. Please include a discussion in this section of the potential for PFAS to have been discharged directly to Halawa Stream and the resulting contaminant exposure pathways.
Response (October 2024): i. The first paragraph of WP Section 10.2.1.2 has been revised to address details requested in this comment, including the following: • The installation date of the original AFFF system for the slop tank area: Installed in July 1962. • The purpose of the former AFFF system for the slop tank area: fire suppression for fires external to the slop tank. • The period of use: between 1962 and 1968. • The frequency of use: not documented. • The AFFF formulation it contained: not documented. • All types of waste that entered the slop tank: oily waste and water from tank cleaning. • Function of the line connecting the AFFF AST to the slop tank: transfer AFFF to suppress potential fires external to the slop tank. ii. The WP was revised to include supporting documentation and information about the cutting and plugging of the piping associated with the slop tank and slop tank demolition. This activity is not related to this PFAS investigation and will be documented in more detail in the Red Hill Bulk Fuel Storage Facility Site Assessment Work Plan. iii. Halawa Stream is not included in the current investigation. If surface soil sampling results indicate PFAS impact, then the stream may be investigated during a subsequent RI phase.		

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Updated Response (February 2026): iii. If the PFAS investigation within the boundaries of Area A indicates a potentially complete transport pathway of PFAS between Area A and South Halawa Stream, this pathway will be investigated in a subsequent phase of the RI. See Sections 17.2 and 17.3 of the Revised Draft Work Plan (February 2026).		
5d	Worksheet #10, Conceptual Site Model, Pages 33 through 52	**Section 10.2.1.3, Red Hill Fire Suppression System Located at Building 313 and (b) (3), Page 34:** Based on the text, it appears no AFFF system was operated at Red Hill between 2008 and 2018. Please confirm.
Response (October 2024): Based on available information, no AFFF system operated at the RHBFSF between 2008 and 2018.		
5e	Worksheet #10, Conceptual Site Model, Pages 33 through 52	**Section 10.2.1.4, Site Features, Pages 35 and 36:** i. The text indicates post-excavation soil sample results were below EPA RSLs. The text should be revised to indicate the RSLs relate to direct contact with contaminated soil. There should be additional discussion about how the Navy will consider the leaching to groundwater pathway. ii. A potential source of PFAS in Area B groundwater is the fuel release in (b) (3) in November 2021. Several lines of evidence support this conclusion including the timing, magnitude, and composition of PFAS detected in (b) (3) after the November 2021 release. Please revise the text to acknowledge this potential source of PFAS in Area B. Include sampling and analyses of soil and perched groundwater for PFAS within the area impacted by the November 2021 JP-5 release. (Comment also applies to Section 10.4.2, Fate and Transport Considerations). iii. The first sentence of the paragraph after the bullet states, "No known AFFF release occurred in Area B, but sampling showed perfluorooctanesulfonic acid (PFOS) present in Area B groundwater monitoring wells." However, multiple PFAS contaminants were detected in those wells, including but not limited to PFBS, PFBA, PFHpA, PFHxS, PFHxA, PFNA, PFOS, PFOA, PFPeA, PFHpS. PFOS, PFOA, and PFHxS exceeded screening criteria. Please update the text to state, "Sampling detected multiple PFAS contaminants present in Area B groundwater monitoring wells. Three PFAS, perfluorooctanesulfonic acid (PFOS), Perfluorooctanoic acid (PFOA) and Perfluorohexanesulfonic acid (PFHxS) exceeded screening criteria." iv. When discussing infrastructure, potential release locations, and wells near Area B, please also include discussion of NMW32 and the tunnel and pipelines running from the "wye" to (b) (3), the pipelines and tunnel through (b) (3), and the associated tanks and infrastructure outside (b) (3).
Response (October 2024): i. The text has been revised to specify EPA residential soil and tap water RSLs (THQ=0.1 and TR=1E-06), November 2023, as applicable. The leaching to groundwater pathway is discussed in WP Section 10.4.2.2. ii. WP Section 10.2.8.3 Fuel Release Response Actions at (b) (3) (December 2021) has been added to include results of PFAS detections from Well RHMW2254-01, including that eleven PFAS were detected and PFOS was detected at levels exceeding the November 2023 EPA residential tap water RSL (4 ng/L for THQ = 0.1 and TR = 1E-06) at 6.73 ng/L and 4.35 ng/L, respectively. iii. The first sentence of the paragraph after the bullet has been revised as suggested. iv. A paragraph has been added to WP Section 10.2.1.4 (second to last paragraph of the section) which describes Wells NMW25 and NMW32, including: • The maximum PFAS results observed at well NMW32 for PFOA, PFHxS, and PFPeS. • The distance and bearing of each well from the Facility boundary. • The distance between the Pearl Harbor Tunnel and Well NMW32. • The absence of PFAS sources in the Pearl Harbor Tunnel. • The likelihood that the Facility is not the source for PFAS detected at Well NMW32 is high because Well NMW32 has higher concentrations of PFOA, PFHxS, and PFPeS than observed in groundwater results from any Facility wells to date.		
Updated Response (February 2026): i. Refer to the updated response to general comment #8. ii. Refer to the updated response to comment #5a. iii. Text describing the results of the September 2023 Baseline Groundwater Sampling Event is currently located in Section 10.2.8.4. The text addressing this comment is located on Page 55, second paragraph under the subtitle September 2023 PFAS Baseline Groundwater Sampling Event: *"Ten out of 40 PFAS were detected above the analytical limit of quantitation (LOQ) in the samples collected."*		

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iv. This paragraph was removed from Revised Draft Work Plan (February 2026). See Response to comment 5.e.ii.		
5f	Worksheet #10, Conceptual Site Model, Pages 33 through 52	**Section 10.2.2, Surrounding Area and Land Use, Page 36, and Appendix A Figures:** The property boundary does not match the Tax Map Key (TMK) boundary. Please update the Red Hill facility boundary in all figures to use the TMK boundary or add text to Section 10.2.2 documenting how the Navy chose to define the smaller Red Hill footprint. In Section 10.2.2 please also discuss the locations of adits and tunnels that are part of the Red Hill Bulk Fuel Storage Facility.
Response (October 2024): During the August 14 scoping meeting, the Navy presented boundaries to the Red Hill Bulk Fuel Storage Facility (RHBFSF) to the stakeholders, which included portions of the Federal property that have been granted to the State of Hawaii via easement(s) in 1972. That boundary extends the previous Facility boundary to the west along South Halawa Stream and north along (b) (3) toward Moanalua Freeway. All figures are updated to reflect the boundaries presented in the August 14 scoping meeting. The following text was added to Section 10.2.2: [redacted] (b) (3) [redacted]		
5g	Worksheet #10, Conceptual Site Model, Pages 33 through 52	**Section 10.2.4.2, Topography and Surface Water, Page 37 Section 10.4.3 Potential Receptors and Exposure Pathways, Page 51, and Appendix A, Figures 6, 7, and 8:** Several sections in Worksheet 10 describe (b) (3) as "formerly" used for drinking water and as being offline "since the November 2021 fuel release". However, we understand the Navy is completing MILCON projects at Navy's Aiea-Halawa Shaft (NAH) and (b) (3) to install drinking water treatment systems. Therefore, the drinking water pathway should be considered potentially complete for future receptors. Navy has informed EPA that the treatment systems will treat the water to remove PFAS contaminants and TPH. Since the RI and risk assessment are not complete, and since PFAS contaminants were detected in both (b) (3) and NAH, the Navy should monitor the treatment system frequently to understand when breakthrough will occur and should coordinate closely with regulators to ensure the treatment system is effective before serving water from NAH or (b) (3). In particular, the Navy should very closely monitor for and prevent breakthrough of smaller PFAS molecules.
Response (October 2024): The CSM has been revised for exposure to groundwater, as suggested, to potentially complete. The Navy will coordinate with the regulators on the scope of any required monitoring of the treatment system when it is online. This treatment system is not associated with the Red Hill PFAS RI.		
5h	Worksheet #10, Conceptual Site Model, Pages 33 through 52	**Section 10.2.5, Geology and Soils, Page 37, and Appendix A, Figures 6 and 7:** It would be helpful to update the text in this section and the associated cross sections/geologic renderings in the CSM figures with real-world data collected from the multiple coring and boring logs that the Navy has generated over the past few years.
Response (October 2024): The Navy is actively collecting lithologic data as it expands its monitoring well network. The Navy is in the process of updating their cross sections/geologic renderings of the area under a different contract. These updated cross sections can be provided once finalized at a later date.		
Updated Response (February 2026): The updated cross sections are presented in Figures 6, 7a, 7b, and 7c.		
5i	Worksheet #10, Conceptual Site Model, Pages 33 through 52	**Section 10.2.8.2, AFFF Release and Response Actions at (b) (3) (November 2022), Pages 41 through 43 (last sentence) and Appendix A, Figure 4:** The text indicates that 6:2 FTS is shown in Figure 4, but concentrations of that chemical in soil are not shown in Figure 4. Since 6:2 FTS was detected at a higher soil concentration than other PFAS compounds (maximum 150 µg/kg), it would be useful to add it to Figure 4.
Response (October 2024): Figure 4 has been updated to include results for 6:2 FTS detections in soil.		
Updated Response (February 2026): Figure 4 has been replaced with Figure 13, which presents PFAS exceedances in soil; however, because there is no PSL for 6:2 FTS, 6:2 FTS detections are not presented. All 6:2 FTS results from analytical samples are presented in Appendix B: Analytical Data Tables.		
5j	Worksheet #10, Conceptual Site Model, Pages 33 through 52	**Section 10.2.8.3, Sampling and Analysis at (b) (3), Pages 43 through 45:** i. The text indicates that EPA Method 1633 does not include analytes such as 6:2 FTS and 8:2 FTS. However, these are in fact Method 1633 analytes. Please delete the statement indicating these analytes are not detected via EPA Method 1633.

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		ii. Please revise the second paragraph of the Baseline PFAS Sampling Event subsection on page 45 to clearly state that concentrations of PFOS in RHP01, RHP02, RHP03, RHP06, RHP07, and NMW32 exceeded the EAL and RSL. Add that concentrations of PFOA exceeded the MCL in RHP02 and NMW32 and that the concentration of PFHxS exceeded the MCL in NMW32.
Response (October 2024): i. The referenced text in what is now Section 10.2.8.5 has been deleted "(e.g., 6:2 FTS, 8:2 FTS)." ii. Comment Acknowledged. The MCLs will not be discussed in this section as an exceedance in groundwater. The text was revised to state "Ten out of 40 PFAS analytes were detected above the analytical limit of quantitation (LOQ) in the samples collected. Analytical results from five wells (RHP01, RHP02, RPH03, RHP07, and NMW32) showed concentrations of PFOS above the DOH EAL and tap water EPA RSL (THQ of =0.1 and TR of= 1E-06) of 4.0 ng/L. PFOS concentrations ranged from 9.0 ng/L to 16.0 ng/L."		
Updated Response (February 2026): ii. The revised text is now in Section 10.2.8.4.		
5k	Worksheet #10, Conceptual Site Model, Pages 33 through 52	**Table 10-1, Results for Soil, Total PFAS Samples Collected in December 2022, Page 44:** November 2023 residential soil RSLs are listed in Table 10-1, but if May 2024 RSLs were listed, the maximum PFOS and PFOA concentrations would substantially exceed them (by 8-fold to 63-fold). EPA recommends that the most current RSLs be incorporated into the work plan.
Response (October 2024): Soil and groundwater screening levels are identified and in accordance with the Assistant Secretary of Defense Memorandum, "*Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program*" and subsequent online updates. The current DoD policy on the web update includes only the November 2023 RSL Tables.		
Updated Response (February 2026): Refer to updated response to general comment #8.		
5l	Worksheet #10, Conceptual Site Model, Pages 33 through 52	**Table 10-2, Statistical Metrics for Comprehensive Set of Groundwater PFAS Samples Validated through December 2023, Page 46:** i. November 2023 tap water RSLs are listed in Table 10-2, but if May 2024 RSLs were listed, the maximum PFOS and PFOA groundwater concentrations would substantially exceed them. EPA recommends that the most current RSLs be incorporated into the work plan. ii. The groundwater results presented in Table 10-2 are not comprehensive. These statistics are only from the weekly and monthly sampling conducted after the (b) (3) release. They do not include the (b) (3) PFOS exceedances on Dec. 20 and 27, 2021, or the Sept 2023 one-time Baseline Sampling Event results. Please revise the title to, "Statistical Metrics of Validated Groundwater PFAS Samples Collected from December 2022 through December 2023 to investigate the (b) (3) release." Add a footnote stating that, PFAS samples collected during December 20 and 27, 2021 and September 2023 are not included in the statistical representation.
Response (October 2024): i. PFAS investigations conducted under the Navy's Environmental Restoration program are required to follow current DoD policy. In accordance with current DoD policy, the November 2023 RSLs will be used. If the DoD policy is updated, the RSLs will be revised accordingly. ii. The title of Table 10-2 has been revised to "Statistical Metrics for November 2022 Release Response Groundwater Sampling and Analysis." A footnote was not added to the table because the revised title no longer indicates a comprehensive data set. The table header was revised to clarify collect dates from December 2022 through December 2023. An additional Table 10-3 has been included to present the September 2023 baseline sampling results.		
Updated response (February 2026): i. Refer to updated response to general comment #8. ii. Table 10-2 is now Table B-2, and the title has been revised to "November 2022 Release Response Detected Groundwater PFAS results." The table has been revised to include groundwater screening levels identified in the 2025 OSD memorandum, and the table summarizes 241 groundwater samples collected and reported from December 2022 through the end of December 2023. The September 2023 baseline sampling results are now presented in Table B-3.		
5m	Worksheet #10, Conceptual Site Model, Pages 33 through 52	**Section 10.2.8.4, Previous Investigations at OWDF, Page 47:** The last sentence discusses the lack of records of AFFF use but does not discuss how the waste fluids that were disposed and/or burned in the oily waste pits may be sources of PFAS. It also doesn't discuss the plumbing shop, septic tank, and other historical operations in this area that may have released PFAS into the environment. Please add text specifying that waste disposed or burned at the OWDF, and military operations conducted in this area may have been sources of PFAS contamination.

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Response (October 2024): As discussed in the response to Enclosure 3, General Comment 2, the only materials known to have been disposed of at OWDF were tank bottom sludges and associated fuel-related material. While there was one documented attempt to burn the oily waste in the disposal pit, the records indicate that it was unsuccessful and was not repeated (DON 1992; Jensen, November 1989). There was no indication that AFFF or PFAS-containing material were used during the attempt to burn the oily waste, and the available information suggests that a complete burn, rather than fire suppression, was attempted. Also as discussed in the response to Enclosure 3, General Comment 2, the records indicate that other operations did not contribute to the oily waste disposal at OWDF.		
5n	Worksheet #10, Conceptual Site Model, Pages 33 through 52	**Section 10.4.1, PFAS Release Mechanism, Page 49:** Please add a clarifying statement at the beginning of this section. Most of the Navy's focus has been to investigate the release of AFFF at (b) (3). However, the Navy will expand its investigation as it uncovers other Red Hill PFAS sources.
Response (October 2024): Comment acknowledged. The Navy recognizes that there is a potential for undocumented releases which is why the investigation area has been expanded. This investigation is focusing on areas of known PFAS detections. No revisions to this text were made, as this section is intended only to state what is known. If new information comes to light, this section will be revised accordingly.		
Updated response (February 2026): In the Revised Draft Work Plan (February 2026), the response refers to Section 10.5.1, PFAS Release Mechanism. The text was revised based on the results of expedited sampling events (September 2024 through September 2025): *"The potential release mechanisms for most PFAS at the Site are associated with AFFF, which include incidental leaks, accidental spills, and releases that may have occurred during equipment maintenance and testing, and training. A significant AFFF spill occurred on November 29, 2022, at Area A, 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 modern formulation AFFF liquid concentrate, which occurred at the (b) (3) tunnel at the Facility as described in Section 10.2.8.* *There is no known source for PFAS at Area B, nor are there any known releases of AFFF. However, several PFAS were consistently detected above the DoD-approved screening levels (ASD 2025) during expedited groundwater monitoring events between September 2024 and September 2025. (Section 10.4). Perched groundwater from groundwater monitoring wells at Area B that exceed DoD-approved screening levels (ASD 2025) are local to the Facility; however, the source of the PFOS and PFOA in basal groundwater wells is currently unknown."* The Revised Draft Work Plan (February 2026) sampling strategy focuses on identifying currently unknown sources of PFAS, as described in Worksheet #17.		
5o	Worksheet #10, Conceptual Site Model, Pages 33 through 52	**Section 10.4.1.1, PFAS and Environmental Media, Page 50:** i. The text states that only 11 PFAS currently have toxicity values for deriving regulatory screening criteria, but that number is 14 as of May 2024. ii. Although reference dose and other toxicity data currently may only be available for 14 PFAS, the availability of toxicity data should be periodically re-evaluated as new RSLs are published. In addition, it is expected that for PFAS that do not have sufficient toxicity data to quantify risks, they will be qualitatively assessed. Please update the Draft RI WP to state that the availability of toxicity data will be re-evaluated as new RSLs are published, and PFAS that do not have sufficient toxicity data to quantify risk will be qualitatively assessed.
Response (October 2024): i. Section 10.4.1.1 was revised to cite the OSD Memorandum and the website that is used to update it, which describes the peer-reviewed toxicity values that are currently approved for use within the DoD. The sentence now reads: "However, only 10 PFAS currently have peer-reviewed toxicity values that are approved for use in deriving screening criteria (DoD 2023c; 2024c). These PFAS include hexafluoropropylene oxide dimer acid, PFBS, PFBA, PFHxS, PFHxA, perfluorononanoic acid, PFOS, PFOA, Bis(trifluoromethylsulfonyl) amine, and perfluoropropanoic acid. Toxicity data will be re-evaluated as new RSLs are published, and appropriate peer-reviewed toxicity values will be used as the DoD policy is updated (DoD 2023; 2024). PFAS that do not have sufficient toxicity data will be qualitatively assessed." ii. Comment acknowledged: The Navy will continue to update screening levels and toxicity values as applicable. Section 10.4.1.1 has been updated as stated above.		
Updated Response (February 2026): i. Refer to the updated response to general comment #8. ii. Discussion of updated screening levels and toxicity values are now included in Worksheet #15, and Section 10.4.1.1 has been deleted. Refer to the updated response to general comment #8.		

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5p	Worksheet #10, Conceptual Site Model, Pages 33 through 52	**Section 10.4.2.1, Aqueous Film-Forming Foam and Per-and Polyfluoroalkyl Substances, Pages 50 and 51:** i. The fluorocarbon tail is described as oleophobic, when in fact it is oleophilic. This should be corrected. ii. Based on the following excerpt from the report the locations of all former wastewater outfalls along Halawa Stream should be identified and the associated discharge areas characterized and potentially sampled: "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 (b) (3) release." iii. The last paragraph of Section 10.4.2.1 indicates, and EPA concurs, leaching-to-groundwater is one of the principal PFAS transport pathways of concern. Screening soil data for this pathway is important for identifying sources of groundwater contamination and should be incorporated into the DQOs of the investigation. Navy should delineate to detection limits and then consider using EPA soil SSLs and/or DOH soil EALs to understand risk and fate and transport.

Response (October 2024):

i. PFAS "tails" are described as being oleophobic. No change has been made to Section 10.4.2.1.

The perfluoroalkyl-chain is considered to be hydrophobic and oleophobic. Please see the reference from CLU-IN below:

PFAS applications have made use of their unique surfactant properties. Their alkyl tails make these substances both hydrophobic (water-repelling) and oleophobic/lipophobic (oil/fat-repelling) (https://clu-in.org/contaminantfocus/default.focus/sec/Per-_and_Polyfluoroalkyl_Substances_(PFAS)/cat/Overview/).

ii. The text was revised in Section 10.2.1.2 to indicate that wastewater from the slop tank was not impacted by effluent from the AFFF system. The AFFF system piping was external to the slop tank as an external fire suppression system. AFFF effluent never entered the slop tank. Therefore, effluent from the slop tank entering Halawa Stream did not contain AFFF. Likewise, other wastewater outfalls into Halawa stream are not associated with any known AFFF releases.

iii. The text has been revised to describe complexities of the PFAS-partitioning model and heterogeneity of the Red Hill hydrogeology, making leaching assessment a site-specific data evaluation where PFAS is found in the near subsurface soil. The Navy intends to do a phased-evaluation of the potential for PFAS in surface and near surface soil to infiltrate (leach) to the basal drinking water aquifer. In areas identified as potential PFAS source areas where perched groundwater is present above the basal aquifer, perched water wells will be installed first. This will include the following:

- Collecting and analyzing discrete subsurface soil samples by EPA Method 1633 at intervals throughout the unconsolidated alluvium to assess the downward migration of PFAS.
- Collecting and analyzing groundwater samples by EPA Method 1633 in the perched aquifer once the perched groundwater monitoring well is installed and developed.
- The Navy will utilize these data to evaluate site-specific leaching in the alluvial vadose zone and perched groundwater, comparing PFAS constituents and concentrations to assess fate and transport.

Second, the basal groundwater monitoring well will be installed adjacent to the perched groundwater monitoring well, through the saprolite and bedrock to the bedrock basal aquifer:

- Basal groundwater samples will be collected and analyzed by EPA Method 1633 once the basal groundwater monitoring well is installed and developed.
- The Navy will utilize these data to evaluate site-specific leaching in the saprolite/bedrock vadose zone and basal groundwater, comparing PFAS constituents and concentrations to assess fate and transport through the vadose zone and into the basal groundwater aquifer.

Updated Response (February 2026):

i. The previous Section 10.4.2.1 is now Section 10.5.2.1.

5q	Worksheet #10, Conceptual Site Model, Pages 33 through 52	**Section 10.4.3, Potential Receptors and Exposure Pathways, Pages 51 and Page 52, and Appendix A, Figure 8 – Human Health Exposure Pathway Evaluation, and Appendix A, Figure 9 Ecological Conceptual Site Model/Exposure Pathway Evaluation:** i. Although Hunters are identified as potential receptors at the site (Figure 8), and game animals (such as pigs) are potential receptors for PFAS incidental ingestion and food web transfer (Figure 9), Hunter biouptake of PFAS is considered "Insignificant." This claim needs further justification, e.g., what is the reasonable maximum exposure (RME) of Hunters to PFAS based on their game consumption rates? ii. The second paragraph on PDF Page 58 (document Page 52) states that dermal exposure to groundwater is considered an insignificant pathway. However, the basal groundwater beneath the site is a drinking water source that could be used in the future. Please revise this section and the conceptual site model figure (Appendix A, Figure 8, Human Health Exposure Pathway

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		Evaluation, PDF Page 167) to include dermal exposure to groundwater, as well as ingestion, for hypothetical future residents. iii. The third paragraph of document page 52 discussed perched water. While perched water isn't used for drinking water and direct exposure to in situ perched water isn't likely, isn't there potential for perched water to discharge to the stream and cause direct exposure, ingestion, and/or ecological risk? Please update the Draft RI WP CSMs with this potential exposure pathway. iv. The text of the last paragraph on Page 52 indicates: "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." However, based on historical operations, there is potential PFAS were a component of the wastes discharged to Halawa Stream. Please update the text and Figure 9 to identify this exposure pathway as complete.
Response (October 2024): i. The reason behind the exposure being insignificant includes the fact that the home range of feral pigs is approximately 6 square miles, so area use time will be short and the potential for harm on the site is negligible. ii. The CSM has been revised to include both the dermal exposure and ingestion of groundwater for hypothetical future residents. iii. Groundwater seeps to the stream are not known in the area; furthermore, the majority of the canal is concrete lined. Direct exposure or incidental ingestion to perched groundwater seeping into surface water in Halawa stream is considered insignificant or incomplete. iv. Comment acknowledged. The project will follow the work plan and use the PQOs to determine if additional sampling and analysis is required to characterize the nature and extent of PFAS impacts surrounding (b) (3). Data collected during the RI will be used to update the CSM accordingly.		
Updated Response (February 2026): i. The exposure pathway for hunters/trespassers was updated to "potentially complete exposure pathway but exposure pathway is considered limited (no quantitative evaluation)." iii. As discussed and with EPA's agreement during Scoping Meeting No. 5 (September 10–11, 2025), South Halawa Stream will be evaluated as a potentially complete exposure pathway. The potential for the perched groundwater to discharge to South Halawa Stream is currently not well understood and are not evaluated in this WP. Pathways are potentially complete but will only be evaluated if PFAS is detected in soil in the drainage ditches. If PFAS are found in the site soils, then an evaluation will be made to determine if off-site sampling in South Halawa Stream is necessary. This change is reflected in Section 10.5.3 and in Figures 28, 29, 31, and 32. All scoping meetings that were conducted to support this RI work plan are summarized in Worksheet #9 of the Revised Draft Work Plan (February 2026).		
6a	Worksheet #11, Project Quality Objectives/Systematic Planning Process Statements, Pages 53 through 58	**Section 11.1, Step 1 – State the Problem:** Between the second and third sentence, please add, "…*former 200-gallon AFFF AST*. Throughout the history of Red Hill, there may have been additional sources of PFAS contamination associated with the construction, operation, maintenance, and/or disposal practices at the facility. *Soil and groundwater samples…*"
Response (October 2024): Revised as suggested.		
Updated Response (February 2026): Section 11.1, Step 1 – State the Problem, now references Section 10.2.1.2, which details documented uses of AFFF at the facility. The Navy recognizes that there is a potential for undocumented releases; however, this investigation is focusing on areas of known PFAS detections, and this section is intended only to state what is known. If new information comes to light, this section will be revised accordingly.		
6b	Worksheet #11, Project Quality Objectives/Systematic Planning Process Statements, Pages 53 through 58	**Section 11.2, Step 2 – Identify Study Goals:** i. PSQ#1, 2 and 3 also apply to Area B. ii. Please add a principal study question, "Have there been impacts to Halawa Stream surface water and sediments from Red Hill PFAS releases?" Update the remaining sections of Worksheet #11 to address this new PSQ. iii. PSQ#2 should also consider whether soil contamination represents a leaching risk and whether groundwater impacts as a result of previous releases have peaked. iv. Please add a caveat at the end of this section that, as the Navy identifies additional Red Hill sources of PFAS, the principal study questions and other project quality objectives will be updated in QAPP addenda.
Response (October 2024): i. The PSQs apply to both Area A and Area B; however, the swale drainage sediment only applies to Area A. No changes have been made.		

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ii. As a follow-up to comment 5.p.ii, if the results of soil sampling at Area A indicate PFAS contamination in surface soil that may have been transported to Halawa Stream via runoff, the stream will be investigated during the next phase of the RI. iii. Leaching risks will be evaluated during the human health and ecological risk assessments which are addressed under PSQ #3. Groundwater impacts will be evaluated during groundwater monitoring and development of the RI report. No changes have been made to PSQ #2. iv. The following text has been added to the end of Section 11.2: "If additional sources of PFAS are identified at the Site, then the PSQs will be updated accordingly."		
Updated Response (February 2026): i. As discussed with EPA's during Scoping Meeting No. 5 (September 10–11, 2025), the PSQs have been revised. And the revised PSQs are presented in this WP. All scoping meetings that were conducted to support this RI work plan are summarized in Worksheet #9 of the Revised Draft Work Plan (February 2026). ii. This PSQ was not added to Worksheet #11. As discussed with EPA during Scoping Meeting No. 5 (September 10-11, 2025), the EPA agreed that the PSQ would not to be added to the work plan. iv. The text in current Section 11.2.1 has been revised as follows: "PSQs will be reviewed and may be updated if warranted during RI data collection and analyses."		
6c	Worksheet #11, Project Quality Objectives/Systematic Planning Process Statements, Pages 53 through 58	**Section 11.3, Step 3 – Identify the Information Inputs to the Decision:** The 2023 RSLs are cited; however, the most recent RSLs (May 2024) should be cited. Please revise the Draft RI WP to cite the most recent RSLs.
Response (October 2024): Comment Acknowledged. Soil and groundwater screening levels are identified and in accordance with the Assistant Secretary of Defense Memorandum, "*Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program*" and subsequent online updates. Currently, the DoD policy includes only the November 2023 RSL Tables.		
Updated Response (February 2026): Refer to the updated response to general comment #8.		
6d	Worksheet #11, Project Quality Objectives/Systematic Planning Process Statements, Pages 53 through 58	**Section 11.5, Step 5 – Develop the Analytical Approach:** Please update this step to indicate that, in addition to no exceedances of PSLs, groundwater concentrations must show a stable or declining trend.
Response (October 2024): The second bullet under PSQ #2 has been revised to the following: "If the extent of PFAS data is horizontally and vertically delineated to the PSLs (taking into consideration groundwater concentration trends), then additional sampling is not required. Proceed to PSQ #3."		
Updated Response (February 2026): As a result of decisions made during Scoping Meeting No. 5 (September 10-11, 2025), current Section 11.4.4, Step 5 – Develop the Analytical Approach, was revised, and PSQ #2 was updated to state: "Are COPCs in each media of concern defined to less than PSLs?" Under this PSQ, impacts to environmental media are determined based on the horizontal and vertical definition of COPCs relative to the PSLs. Evaluation of concentration trends is addressed in current Section 11.5.2, Managing Decision Error, which includes the approach to: "Incorporate statistical analyses and evaluation of trends to support PFAS source designation and refine the CSM." Trend evaluation is an additional consideration to reduce uncertainty and decision errors, inform source interpretation, and refine the understanding of the site CSM, rather than a decision rule to define the potential impacts of site COPCs or determining the need for additional evaluation. All scoping meetings that were conducted to support this RI work plan are summarized in Worksheet #9 of the Revised Draft Work Plan (February 2026).		
6e	Worksheet #11, Project Quality Objectives/Systematic Planning Process Statements, Pages 53 through 58	**Section 11.7, Step 7 – Optimize the Design:** During a series of meetings in July 2024, the Navy met with regulators to discuss additional requirements for groundwater sampling. Please incorporate the additional well locations and the objectives for those locations into the sampling design (see enclosed table). Please also include sampling of all available OWDF well clusters and the (b) (3) pre-chlorination point. After updating the DQOs and PSQs, please consider revising the locations of the Navy's proposed new wells to locations that will better meet project objectives.
Response (October 2024): Regarding the following request, "Please also include sampling of all available OWDF well clusters," the current agreement between the Navy, EPA, and DOH is to sample five OWDF well clusters in the vicinity of the (b) (3), namely OWDF clusters 1, 3, 4, 5, and 8 (note: OWDF cluster well 2A will be sampled for one round and then re-evaluated). Step-out sampling at other wells maybe be considered after the four rounds of quarterly monitoring are		

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completed and evaluated based on the results of the initial agreed-upon sampling. Finally, the (b) (3) is sampled pre-chlorination for PFAS, as part of the drinking water program.		
Updated Response (February 2026): Comment acknowledged, but no changes were required or made to Section 11.7 to address the comment. The comment presents EPA requests associated with the expedited quarterly groundwater monitoring events which were conducted between September 2024 and September 2025. The Navy, EPA, and DOH negotiated which wells would be sampled in scoping meetings conducted in July 2024, August 2024, and January 2025. These meetings are summarized in Worksheet #9 of the Revised Draft Work Plan (February 2026). The results of the expedited quarterly groundwater monitoring events are summarized in Worksheet #10, Section 10.4, and the updated sampling plan is detailed in Worksheet #17 of the Revised Draft Work Plan (February 2026).		
7	Worksheet #13, Secondary Data Criteria and Limitations Table, Pages 61 and 62	Include the remedial action completion report, "Red Hill Bulk Fuel Storage Facility, (b) (3) AFFF Release Report," dated November 2023.
Response (October 2024): The remedial action completion report (Red Hill Bulk Fuel Storage Facility, (b) (3) AFFF Release Report, dated November 2023) has been included in Worksheet #13.		
8a	Worksheet #14, Summary of Project Tasks, Pages 70 through 79	**Section 14.5.6.2, Well Construction, Page 71:** If the sand pack is completed above the water table, the bentonite pellets may not sufficiently hydrate. Recommend adding PFAS-free potable water to hydrate the seal, preferably after each foot of bentonite pellets have been placed, until the entire seal has been placed and hydrated.
Response (October 2024): Section 14.5.6.2 has been updated to state that bentonite seals placed above the water table will be hydrated with PFAS-free water after each foot of bentonite pellets has been placed.		
Updated Response (February 2026): The previous Section 14.5.6.2 is now Section 14.6.7.2.		
8b	Worksheet #14, Summary of Project Tasks, Pages 70 through 79	**Section 14.5.8, Well Development, Page 72:** This section acknowledges that groundwater is impacted by well development (i.e., groundwater is oxygenated, affecting dissolved oxygen [DO] and oxidation-reduction potential [ORP]), but does not specify how long an interval should be allowed between well development and groundwater sampling to allow the groundwater in the borehole, sand pack, and vicinity of the borehole to equilibrate with aquifer conditions. If sampling occurs prematurely, the samples may not be representative. At least 7 to 14 days, depending on the lithology, should elapse between well development and sampling in order to allow time for equilibration with the aquifer. Please revise the text to specify the interval between well development and sampling.
Response (October 2024): Section 14.5.8 has been revised to specify that a minimum of 14 days is required between well development and sampling.		
Updated Response (February 2026): The previous Section 14.5.8 is now Section 14.6.9.		
8c	Worksheet #14, Summary of Project Tasks, Pages 70 through 79	**Section 14.11, Investigation-Derived Waste Management and Disposal, Pages 78 and 79:** Section 14.11 states that if liquid IDW contains PFAS concentrations exceeding the EPA lifetime health advisory level, treatment will be required, but this criterion has been rescinded. EPA MCLs for six PFAS were finalized in June 2024, and these values should be used for screening IDW. Please revise Section 14.11 to specify comparison of IDW analyses results to the MCLs.
Response (October 2024): Comment acknowledged. PFAS-impacted IDW will be disposed of offsite at RCRA-C permitted landfill and will be solidified in accordance with Navy guidance and in accordance with landfill requirements. MCLs will not be used to screen IDW for disposal.		
Updated Response (February 2026): Section 14.11, Investigation-Derived Waste Management and Disposal, in the Revised Draft Work Plan (February 2026) has been revised to allow flexibility in accordance with regulatory requirements and Navy guidance as described in the 4th paragraph of the section: *"IDW will be disposed of within a reasonable time after completing the field activities. In April 2023, EPA designated PFOA and PFOS as CERCLA hazardous substances (40 Code of Federal Regulations Part 302). The disposal options for IDW will be in accordance with the ASD Memorandum Guidance on Destruction or Disposal of Materials Containing Per- and Polyfluoroalkyl Substances in the United States (DoD 2023c) and the EPA's Interim Guidance on the Destruction and Disposal of Perfluoroalkyl and Polyfluoroalkyl Substances and Materials Containing Perfluoroalkyl and Polyfluoroalkyl Substances—Version 2 (EPA 2024a). "*		

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9a	Worksheet #17, Sampling Design and Rationale, Pages 93 through 100	**Section 17.1 Sampling Design Overview:** The text describes four discrete sampling depths for subsurface soils: 2-3′ bgs, 5-6′ bgs, 11-12′ bgs, and 17-18′ bgs. These four subsurface soil sampling depths are repeated many times throughout Worksheet 17 (e.g., Sections 17.2.1 and 17.2.2). The rationale for these specific depths should be given in the Work Plan. It is not clear how these subsurface soil depths correspond to how human exposure to PFAS in subsurface soil will be evaluated (e.g., for construction workers). These depths also appear to be inconsistent with Section 11.3 (Identify the Information Inputs to the Decision), which states: "[Primary decision inputs will include the following:] 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." How will soil PFAS concentrations from 0.5–18′ bgs be evaluated for primary decision making when there will not be any samples corresponding to that full depth interval?
Response (October 2024): Text has been added to Section 17.1, second bullet for clarification. The HHRA will consider surface soil (0 to 0.5 ft soil interval) exposure to residents (hypothetical), occupational workers, construction workers, and trespassers/hunters and subsurface soil exposure to future residents and construction workers. The assumption is that the subsurface soil (2 to 12 ft interval) may be excavated and brought to the surface where the future residents can potentially be exposed. The construction worker can be exposed in a similar manner or if they work in a trench dug by the excavator. As a rule of thumb for exposure to subsurface soil, it is generally assumed that the depth of excavation will be in the 10 to12 foot range which covers normal depths for the installation of water lines, sewer lines, and other underground utilities. The exposure point concentration for an exposure unit to be used in the HHRA for surface will be the 95% UCL and for subsurface soils based would be the 95% UCL of the results from the samples collected (0–0.5 feet below ground surface (ft bgs), 2-3 ft bgs, 5-6 ft bgs, 11-12 ft bgs, respectively) from within that exposure unit. The additional sample results from 17 to18 ft bgs will be used to evaluate the depth of infiltration of any PFAS constituents, if PFAS is observed.		
Updated Response (February 2026): Worksheet #17 was significantly revised based on the results of the expedited quarterly sampling. Rationale for specific sampling depths is provided in Sections 17.2 and 17.3 for Area A and Sections 17.4 through 17.6 for Area B.		
9b	Worksheet #17, Sampling Design and Rationale, Pages 93 through 100	**Section 17.2 Surface and Subsurface Soil Sampling, Page 93:** Given potential PFAS associations with petroleum contamination and the tendency to collect at fluid interfaces, soil intervals exhibiting petroleum contamination should also be targeted for PFAS analyses. In the field, if field observations identify these intervals, the field team should target them for sampling.
Response (October 2024): Text has been revised to clarify these points. Please see Sections 14.6.3 and 14.6.4 that describe soil and groundwater sampling procedures if petroleum hydrocarbon contamination is observed during drilling.		
Updated Response (February 2026): The previous Sections 14.6.3 and 14.6.4 are now Sections 14.5.3 and 14.5.4.		
9c	Worksheet #17, Sampling Design and Rationale, Pages 93 through 100	**Section 17.2.1, Area A, Page 94:** Sidewall multi-incremental confirmation samples were required in the SAP but were not collected from DU3 before the apron was capped. This remains a data gap and should be addressed in the Work Plan. Please also include additional samples to step out from existing release areas in (b) (3) (b) (3) and more adequately cover the sample areas.
Response (October 2024): DU3 is located in the external entrance corridor to (b) (3) and was the surface migration pathway for AFFF from the release inside the (b) (3) tunnel, to the drainage swales north of DU3, which were excavated and sampled as DU1 and DU2. The external entrance corridor to (b) (3) (location of DU2 excavation) was excavated into the basalt lava Red Hill ridge when the (b) (3) portal was constructed in the early 1940s. During the November 2022 emergency removal action, the entire entrance corridor was excavated to remove any observation of AFFF concentrate and the excavated material consisted of bedrock basalt. The sidewalls of this excavation also consisted of basalt bedrock, which cannot be sampled and analyzed for PFAS due to the nature of the rock matrix. These issues were discussed with the on-site DOH representative, Dr. Roger Brewer. Finally, the geometry of the entrance corridor would require that any step-out borings be completed in the steeply sloping elevated hillside, which also consists of basalt volcanic strata, would require 10 to 20 feet of bedrock drilling before the lower elevation of the DU sidewalls were encountered, and similar sampling rock matrix issues would exist. For these reasons, the Navy proposes no step-out borings to assess DU3 at this time.		

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10a	Worksheet #18, Locations-Specific Sampling Methods/SOP Requirements Table, Pages 101 and 102	**Page 101:** The number of samples specified for 2-2.5 feet (ft) below ground surface (bgs) at Apron Area Outside (b) (3) and Corner Apron is listed as two; however, three sampling locations are listed and the number of primary samples will be three. Please revise Worksheet #18 to list the correct number of samples for each location.
Response (October 2024): The 2- to 2.5-foot interval sample count at the Apron Area Outside (b) (3) and Corner Apron has been revised to three in Worksheet #18.		
Updated Response (February 2026): Comment #10a and the October 2024 response no longer represent the sampling strategy presented in the Revised Draft Work Plan (February 2026). The sampling strategy in the Revised Draft Work Plan (February 2026) was discussed and agreed upon during scoping meeting No. 5, which is summarized in Worksheet #9. The rationale for the revised sampling strategy is based on the results of the expedited sampling activities that were conducted between September 2024 and September 2025. These results are summarized in Worksheet #10, Section 10.4. Worksheets #17 and #18 in the Revised Draft Work Plan (February 2026) have been revised based on the results of the expedited field work.		
10b	Worksheet #18, Locations-Specific Sampling Methods/SOP Requirements Table, Pages 101 and 102	**Page 101:** The number of samples at Down-Sloping Areas North of (b) (3) are inconsistent with Worksheet #17. For example, Worksheet #18 lists 2 sampling locations; however, Section 17.2.1.5 (Surface and Subsurface Soil Sampling at the Down-Sloping Areas North of (b) (3)) states 7 borings will be completed and "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." Please revise Worksheet #18 to list the correct number of samples at the Down-Sloping Areas North of (b) (3).
Response (October 2024): Worksheet #18 has been revised to include all 7 borings at the down-sloping areas north of (b) (3). The sample count for subsurface samples reflect the expected depth to refusal as requested by the Navy RPM.		
Updated Response (February 2026): See updated response to comment #10a.		
10c	Worksheet #18, Locations-Specific Sampling Methods/SOP Requirements Table, Pages 101 and 102	**Page 101:** The number of samples at Surge Rock Drainage Area are inconsistent with Worksheet #17. For example, Section 17.2.1.6 (Surface Soil Sampling at the Surge Rock Drainage Area) states, "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;" however, there are only two intervals (2-2.5 and 4-5 ft bgs) listed and just 2 samples from the 2-2.5 ft bgs interval listed in Worksheet #18. Please revise Worksheet #18 to list the correct number of samples at the Surge Rock Drainage Area.
Response (October 2024): The intervals included in Worksheet #18 are based on the expected depth to refusal. If refusal does not occur at the expected depth, then sampling will continue until refusal or 18 feet bgs. The sample count for the 2–2.5 feet bgs interval has been updated to six.		
Updated Response (February 2026): See updated response to comment #10a.		
10d	Worksheet #18, Locations-Specific Sampling Methods/SOP Requirements Table, Pages 101 and 102	**Page 102:** The number of samples at Downslope of Road are inconsistent with Worksheet #17. For example, Section 17.2.1.10 (Sediment and Surface Soil Sampling at the Downslope of Road) states, "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." However, only one location is listed on the Worksheet. Please revise Worksheet #18 to resolve the discrepancy.
Response (October 2024): Worksheet #18 has been revised to align with the number of samples and locations listed in Worksheet #17.		
Updated Response (February 2026): See updated response to comment #10a.		
11	Worksheet #19, Field Sampling Requirements Table, Page 105	EPA Method 1633 Sections 8.2.3 and 8.3.2 require that samples be protected from light, but this is not specified in the preservation requirements in Worksheet #19. Please revise Worksheet #19 to specify that samples must be protected from light.
Response (October 2024): The preservation requirements in Worksheet #19 have been updated to include "protected from light."		

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12	Worksheet #21, Project Sampling SOP References Table, Pages 109 and 110	The SOPs listed in Worksheet #21 that are not included in Appendix B should be included for reference. Specifically, all SOPs with reference number "N/A" and SOPs I-A-5, I-C-1, I-C-2, and I-E, are not included in the appendix. Additionally, two SOPs are included in Appendix B (I-B-2 and I-H) that are not included on Worksheet #21, although 1-H is mentioned in Worksheet #14. Please revise the Draft RI WP to include all relevant field SOPs in Appendix B and Worksheet #21 and delete any that are not applicable.
Response (October 2024): Worksheet #21 and Appendix B have been updated to include all relevant SOPs.		
Updated Response (February 2026): The previous Appendix B is now Appendix C.		
13	Worksheet #22, Field Equipment Calibration, Maintenance, Testing, and Inspection, Pages 111 and 112	Some equipment specified for use in the Draft WP/SAP are not included in Worksheet #22. For example, a gyroscopic alignment instrument or accelerometer is discussed in Section 14.5.3 and a pressure transducer is discussed in 14.5.4.3. Additionally, an extensive list of potentially necessary video logging equipment is listed in Section 14.5.2. Please revise Worksheet #22 to include all necessary field equipment.
Response (October 2024): Worksheet #22 has been revised to include all necessary field equipment.		
14	Worksheet #27, Sample Custody Requirements, Section 27.3, Handling, Shipping, and Custody, Page 125	Section 27.3 states that sample storage and disposal will be managed per Section 5.8 of *Department of Defense (DoD) and Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories,* Version 5.4 (DoD and DOE 2021), but QSM Version 6.0 (2023) is cited elsewhere in the document. Please revise Section 27.3 to cite QSM Version 6.0.
Response (October 2024): Section 27.3 has been revised to cite QSM Version 6.0.		
15	Worksheet #37, Usability Assessment, Page 143	In Worksheet #37, completeness is defined as the percentage of acceptable sample results compared to the total number of sample results; however, completeness should be calculated relative to the total number of planned results, to account for results that were not able to be obtained (e.g., sample breakage, inability to collect a sample, etc.). Please revise the RI WP to indicate completeness will be calculated based on the number of planned results.
Response (October 2024): Comment acknowledged. No change to the WP. The difference between intended and actual sample results is considered to be a WP deviation. Deviations to the WP will be discussed in the RI report, including broken samples, planned samples uncollected, and unplanned samples collected. Data quality and usability of the sampled and analyzed results will be discussed in the RI report.		
16a	Appendix A, Figures	**Figure 6, Pictorial Conceptual Site Model – Area A, PDF Page 163:** The figure shows the perched groundwater as a layer on the model; however, the symbol used for the layer is omitted from the figure legend. The legend should define the layer used to illustrate the perched groundwater. Please revise Figure 6 legend to include and define the symbol (layer) used to illustrate the perched groundwater at Area A.
Response (October 2024): The "Perched Groundwater" symbol has been revised to a dotted blue line with a hollow potentiometric triangle to differentiate between the solid potentiometric triangle used to indicate the "Basal Groundwater" potentiometric surface.		
Updated Response (February 2026): The previous Figure 6 is now Figure 27.		
16b	Appendix A, Figures	**Figure 7, Pictorial Conceptual Site Model – Area B, PDF Page 165:** i. The figure shows the conceptual site model for Area B; however, perched groundwater is omitted. For example, Section 10.2.6 (Groundwater Hydrogeology) states perched groundwater is present west of Area B. Additionally, Figure 6 (Pictorial Conceptual Site Model – Area A) illustrates the perched groundwater at Area A. Figure 7 should depict the perched groundwater present near Area B. If possible, the location-specific depiction should be generated based on core hole and boring data collected at this site. Please revise Figure 7 to depict the perched groundwater near Area B. ii. Please include the locations of the temporary (b) (3) drinking water treatment system and the more permanent (b) (3) drinking water treatment system that should be installed in approximately 5 years. iii. Please include a label for Halawa Stream and describe its significance in exposure pathways and contaminant transport.

Project Title: Draft Remedial Investigation Work Plan Per- and Polyfluoroalkyl Substance Release at Building 313 Red Hill Bulk Fuel Storage Facility
Joint Base Pearl Harbor-Hickam Oahu HI
Reviewer: Chris Lichens, EPA
Date: August 2024

Item	Section No.	Comment
Response (October 2024): i. "Perched Groundwater" was added to Figure 7 based on the perched water, similar to how it is depicted on Figure 6. The location was selected based on the perched groundwater encountered at the OWDF. ii. The drinking water treatment system is not part of determining nature and extent for this RI and will not be added to Figure 7 at this time. iii. Halawa Stream has been added to Figure 7. In addition, text has been added to the last paragraph of Section 10.4.2.3 to describe the significance in exposure pathways and contaminant transport of PFAS in South Halawa stream.		
Updated Response (February 2026): The previous Figure 7 is now Figure 30. The previous Section 10.4.2.3 is now Section 10.5.3.		
16c	Appendix A, Figures	**Figure 8, Human Health Exposure Pathway Evaluation, PDF Page 167, and Figure 9, Ecological Conceptual Site Model/Exposure Pathway Evaluation, PDF Page 169:** Evaluation of the CSMs is limited because Figures 8 and 9 identify the only release mechanism as AFFF from the Red Hill Fire Suppression System, likely only at (b) (3), and only the recent release. As the Navy identifies additional Red Hill AFFF sources, the CSM should be updated in QAPP addenda.
Response (October 2024): Comment acknowledged. If additional AFFF sources at the RHBFSF are identified, the CSMs will be updated.		
Updated Response (February 2026): The previous Figure 8 is now Figure 28 (Area A) and Figure 31 (Area B).		
16d	Appendix A, Figures	**Figure 10, Proposed Sampling Locations – Area A, PDF Page 171:** i. The figure shows four surface soil/subsurface soil sample locations around the former aqueous film-forming foam (AFFF) aboveground storage tank (AST) and three locations down-slope; however, Section 17.2.1.5 states, "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." Please revise the figure to resolve the discrepancy. ii. The figure shows seven subsurface soil sample locations around Bldg. 313; however, Section 17.2.1.7 (Surface and Subsurface Soil Sampling at Bldg. 313 Pump House, Piping Area, and Former Slop Tank) states, "Twelve borings are proposed to be positioned around and outside of the concrete footprint of Bldg. 313." Please revise the figure to resolve the discrepancy.
Response (October 2024): Figure 10 has been revised to match the tables in Worksheet #18 and the text in Worksheet #17.		
Updated Response (February 2026): See updated response to comment #10a. Updated proposed sampling locations in the Revised Draft Work Plan (February 2026) are presented on Figures 33 through 44.		
16e	Appendix A, Figures	**Figure 10, Proposed Sampling Locations – Area A, PDF Page 171:** The figure shows one surface soil and one sediment sample location, respectively, southwest of Bldg. 313; however, Section 17.2.1.10 states, "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." Please revise the figure to resolve the discrepancy.
Response (October 2024): Figure 10 has been revised to match the tables in Worksheet #18 and the text in Worksheet #17.		
Updated Response (February 2026): See updated response to comment #16d.		
16f	Appendix A, Figures	**Figure 11, Proposed Sampling Locations – Area B, PDF Page 173:** i. (b) (3) and the area of known and suspected petroleum impacts associated with the November 2021 JP-5 release should be presented in Figure 11. ii. The Navy's proposed monitoring well clusters don't seem targeted to delineate the contamination identified during the September 2023 Baseline Sampling Event, or to further investigate risk of PFAS contamination at (b) (3). Please consider adding additional OWDF monitoring wells, including OWDF04/04A and OWDF01/01A, to the sampling design. Consider placing new wells west of RHP 06 and south of OWDF 04 and OWDF 01. Include NMW32.
Response (October 2024): i. Figure 11 has not been revised. The November 20, 2021, (b) (3) JP-5 Release consisted of petroleum fuel, not AFFF nor other material expected to contain PFAS. ii. At this time, the investigation is limited to Area A and Area B. The Navy and regulatory agencies have agreed to conduct 1 year of quarterly sampling at 33 monitoring wells on-site to verify results of earlier sampling events that includes Wells OWDFMW01 and OWDFMW04A. In addition, soil sampling and analysis is proposed in the RI WP to characterize PFAS at		

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Joint Base Pearl Harbor-Hickam Oahu HI
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Date: August 2024

Item	Section No.	Comment
Area A and Area B. If, after sampling, PFAS is not delineated in Area A or Area B, additional sampling locations and/or monitoring well installations will be considered. Well NMW32 will not be included at this time, because it is located offsite and results from the September 2023 sampling event show PFAS constituents at concentrations that exceed any wells sampled within the Facility, which seems to indicate a different source.		
Updated Response (February 2026): See updated response to comment 16d and general comment #6a.		
17	Appendix B, SOP I-A-6, Section 3.1.2, CERCLA Hazardous Substances, Page 182	a. Please consider changing the word “waste” in the last sentence of the first paragraph to “substances” or list the name of the table, “Table 302.4—List of Hazardous Substances and Reportable Quantities”. b. This section discusses CERCLA hazardous substances but doesn’t address PFAS. PFOS and PFOA were designated as CERCLA Hazardous substances on July 8, 2024 (https://www.federalregister.gov/d/2024-08547). Please update this section with information about PFOS and PFOA and reference EPA’s Interim Guidance on the Destruction and Disposal of Perfluoroalkyl and Polyfluoroalkyl Substances and Materials Containing Perfluoroalkyl and Polyfluoroalkyl Substances—Version 2 (2024).
Response (October 2024): a. Comment acknowledged. The SOPs provided in Appendix B are published material that cannot be revised. b. As mentioned above, the SOPs in Appendix B cannot be revised. However, Section 14.11 has been revised to state that PFOS and PFOA are CERCLA-regulated substances and reference the EPA guidance as suggested.		
Updated Response (February 2026): The previous Appendix B is now Appendix C.		
18	Appendix D, Analytical Data Package Requirements, Pages 399 through 402	Appendix D details the requirements of a “full” deliverable. For data packages requiring full validation, EPA recommends that standard traceability, standard preparation logs, and certificates of analysis be included.
Response (October 2024): The following text was added to Item 14: Standard preparation logs and standard traceability.” The lab deliverables will include a signed cover letter certifying the data package test results meet all the requirements of NELAC and DoD QSM.		
19	Appendix G, References, Page 419	Please add the following references: a. Glüge J, Scheringer M, Cousins IT, DeWitt JC, Goldenman G, Herzke D, Lohmann R, Ng CA, Trier X, Wang Z. 2020. An overview of the uses of per- and polyfluoroalkyl substances (PFAS). The Royal Society of Chemistry (RSC), Environmental Science Processes and Impacts. 22: 2345-2373. b. Barfoot K, McGrath A, Richards S, Shanoff T, Stonebridge J. 2022. PFAS and the Mining Industry: Understanding the Challenges. Proceedings of Mine Water Solutions. http://www.mineconferences.com/bluepixeldesign/wp-content/uploads/2022/07/47.-Krista-Barfoot-PFAS-and-the-Mining-Industry-Understanding-the-Challenges-Final.pdf c. Gaines LGT. Historical and current usage of per- and polyfluoroalkyl substances (PFAS): a literature review. Am J Ind Med. 2022;1-26. doi:10.1002/ajim.23362 d. State Water Resources Control Board. 2021. Water Code Sections 13267 and 13383 Order for the Determination of the Presence of Per- and Polyfluoroalkyl Substances at Bulk Fuel Storage Terminals and Refineries. Order WQ 2021-0006-DWQ. March 12. https://www.waterboards.ca.gov/pfas/docs/order_wq2021-0006-dwq_pfas.pdf e. EPA. 2024. Designation of Perfluorooctanoic Acid (PFOA) and Perfluorooctanesulfonic Acid (PFOS) as CERCLA Hazardous Substances. Document Number: 2024-08547. Federal Register, Vol. 89, No. 90. RIN 2050–AH09. May 8. https://www.federalregister.gov/documents/2024/05/08/2024-08547. f. EPA. 2024. Interim Guidance on the Destruction and Disposal of Perfluoroalkyl and Polyfluoroalkyl Substances and Materials Containing Perfluoroalkyl and Polyfluoroalkyl Substances—Version 2. April 8. https://www.epa.gov/system/files/documents/2024-04/2024-interim-guidance-on-pfas-destruction-and-disposal.pdf. g. Navy. 2023. Red Hill Bulk Fuel Storage Facility, (b) (3) AFFF Release Report. November. (RACR) h. Navy. 2023. Per- and Polyfluoroalkyl Substances Delineation Baseline Groundwater Wells Investigation Report, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, O‘ahu, HI. November 27.

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Date: August 2024

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Response (October 2024):

a-c: AFFF as the source of PFAS is the focus of this RI WP; therefore, other sources of PFAS have not been included and these citations are not applicable.

d: Citation is not applicable since it is a California State Water Resources Control Board directive.

e: The current CLEAN Program report style for federal regulations is to only include an in-text citation. An in-text citation has been included in Section 10.4.2.1, Paragraph 3.

f: Citation reference added in Section 14.11.

g: Citation reference added in Section 10.2.8.4.

h: A more current version of this document has already been included as a reference in Section 10.2.8.3. The citation is as follows: “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.”

Updated Response (February 2026): The references section in the Revised Draft Work Plan (February 2026) is located after Worksheet #37 and is not designated as Appendix G.

e. This reference is now cited in Section 14.11.

References identified in comment #19 as g. and h. are not cited in the Revised Draft Work Plan (February 2026).

Appendix H.2.2:
Navy Responses to EPA Priority Comments
September 16, 2024

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

September 16, 2024

Ms. Jocelyn Tamashiro, L.G.
Environmental Restoration Manager
NAVFAC Hawaii, EV3
400 Marshall Road, Building X-11
Joint Base Pearl Harbor-Hickam, HI 96860

Subject: RESPONSE TO EPA PRIORITY COMMENTS REGARDING DRAFT REMEDIAL INVESTIGATION WORK PLAN PER- AND POLYFLUORALKYL SUBSTANCES RELEASE, RED HILL BULK FUEL STORAGE FACILITY, JOINT BASE PEARL HARBOR-HICKMAN, OAHU HI, PEARL HARBOR HI FISC SITE 30, JUNE 2024

Dear Ms. Tamashiro:

The U.S. Environmental Protection Agency (EPA) received the subject response to priority comments Friday September 6, 2024. The priority comments were identified in our August 7, 2024, letter and considered by EPA to be the most immediate with respect to new monitoring well construction and quarterly sampling. Follow up scoping sessions including EPA, Navy, and Hawaii Department of Health personnel were held August 14th and 27th, 2024. The initial scope of Remedial Investigation field work, including monitoring well locations and sampling frequency, was determined during the August 27th meeting.

Based on the responses to priority comments and agreement reached during the August 27th meeting, EPA concurs that monitoring well construction and sampling should begin. However, full work plan approval is contingent on resolution of all comments in the August 7, 2024, letter.

Although EPA agrees groundwater sampling can begin, some of the Navy's responses were incomplete. Please also note that EPA's acceptance of the data will require the Navy to provide the following additional information:

- Laboratory Standard Operating Procedures or portions that discuss:
    - Sample dilution procedures,
    - Protocols for handling high turbidity samples,
    - Technical definitions of "limit of quantitation", "limit of detection", and "detection limit".
- An operations and maintenance plan for the wells or a summary of how the condition of each monitoring well will be documented in the field.
- A description of how duplicate precision will be used to evaluate the impact of uncertainty on decisions for the RI Report.
- Detailed protocols for collecting field blanks, equipment blanks, and rinsate blanks.

Additionally, expectations set forth in the scoping meeting are not fully captured by the response to General Priority Comment 1:

- Please ensure that the preliminary groundwater sampling events include all wells depicted in the updated Figure 1a that was provided with the RTCs, and update the document text globally to include all wells. The revised draft text for Section 14.7.3 is missing many of the agreed-upon wells, including RHMW wells 01R, 02, 03, 04, 05, 06, 07, 08, 17D, 18, 20, and 21; RHP wells 04a-c, 05, and 08b.
- After a year of quarterly sampling, the data will be evaluated to determine future sampling locations and frequency.
- To evaluate risk, PFAS results will be evaluated comprehensively along with co-occurring contaminants, not as individual, maximum concentrations of PFAS at each well.

If you have any questions regarding this letter, please feel free to call me at (415) 972-3149 or contact me by email at lichens.christopher@epa.gov.

Sincerely,

Chris Lichens
Remedial Project Manager
Superfund and Emergency Management Division
Federal Facilities and Site Cleanup Branch
US EPA, Region IX

cc**:** Allison Hutto, Hawaii Department of Health

Draft Remedial Investigation Work Plan – Priority RTCs, including Follow-up Comments
Per- and Polyfluoroalkyl Substance Release at Building 313 Red Hill Bulk Fuel Storage Facility
JOINT BASE PEARL HARBOR-HICKAM OAHU HI
Reviewer: Chris Lichens, EPA
Date: September 16, 2024

Comment #	Reviewer	Section	Page	Comment	Response
Priority Comments for Expedited Well Installation (August 7, 2024)					
General Priority Comments					
1	EPA	General	—	In addition to the subset of wells the Draft RI WP proposes sampling in Areas A and B, Enclosure 2 is a table of the additional wells the Navy agreed to sample quarterly for one year and then re-evaluate. The table lists well names, the status of construction of the wells, and the objectives for sampling. Some of the agreed-upon additional Phase 1 locations are also listed here: a. (b) (3) Area: RHP04A, RHP04B, RHP04C, RHP05, RHP08B, RHP08C, OWDFMW01, OWDFMW03A and B, OWDFMW08A and B. These wells need to be sampled for delineation and to evaluate seasonal variability and trends in PFAS concentrations in the vicinity of (b) (3). In addition, only one round of samples has been collected and some of the wells have concentrations that exceeded the Maximum Contaminant Levels (MCLs). b. (b) (3) Area: RHMW-01R, RHMW-02, RHMW-03, RHMW-04, RHMW-05, RHMW-07, RHMW-08, RHMW-20, and RHMW-21. These wells need to be sampled for delineation, to evaluate seasonal trends and to understand downgradient transport, due to proximity to (b) (3) and/or uncertainty in the groundwater flow direction. Please revise the Draft RI WP to propose these additional Phase 1 locations and include them in Worksheets #17 (Sampling Design and Rationale) and #18 (Locations-Specific Sampling Methods/SOP [Standard Operation Procedures] Requirements Table), so that the objective to delineate the nature and extent of PFAS contamination can be met. Additional step-outs may be needed during a Phase 2. As we discussed during the meetings, the other wells that EPA recommended for sampling, but which the Navy did not agree to, are documented in Enclosure 3 of this letter.	Comment acknowledged. The Navy agrees with the list of wells in Enclosure 2. However, as discussed in the August 27 Scoping Meeting #3, it was agreed that wells OWDFMW01 and OWDFMW04A will be sampled, well OWDFMW05A will be sampled in place of well RHP08C, and well OWDFMW02A will be sampled for one round. The Revised Draft RI WP has been updated to include the additional groundwater sampling locations.

Comment #	Reviewer	Section	Page	Comment	Response
2	EPA	General	—	A laboratory has not been specified to perform sample analyses, so several worksheets are incomplete and cannot be fully evaluated. For example, in Worksheet #15, Reference Limits and Evaluation Tables, laboratory detection limits are listed as “TBD [to be determined]” and therefore can’t be compared to project screening levels. Worksheets #24, Analytical Instrument Calibration Table, and #28, Laboratory QC Samples Table, contain requirements of EPA Method 1633, but may not match a laboratory’s specific standard operating procedures (SOPs). This is not an exhaustive list of affected worksheets. Please revise the Draft RI WP to include information about the laboratory and include relevant analytical SOPs as an appendix.	The laboratory subcontractor has been procured and specific information about the laboratory has been updated. The WP updates include the laboratory-specific limits in Worksheet #15, #24, and #28. The laboratory SOP information will be listed in the WP's worksheets. The analytical laboratory's SOPs will not be included in the appendix as the SOPs are considered business confidential information. A copy of the laboratory's SOP could be provided for review if requested.
3	EPA	General	—	It is unclear why matrix spike/matrix spike duplicate (MS/MSD) samples are not proposed for collection. Please revise the Draft RI WP to include the collection of MS/MSD samples for soil, sediment, and groundwater.	Although EPA Method 1633 does not require matrix spike/matrix spike duplicates (MS/MSDs) to evaluate matrix interference, and the DOD QSM 6.0 does not require MS/MSDs, the Navy will collect MS/MSDs for soil, sediment, and groundwater samples and analyze them using EPA Method 1633 to be consistent with the Navy Comprehensive Long-Term Environmental Action Navy (CLEAN) program.
Specific Priority Comments					
1	EPA	Worksheet #12, Field Quality Control Samples	Page 59	The measurement performance criteria (MPC) for field duplicates in waters (relative percent difference [RPD] <50) and soils (RPD <100%), are taken from Department of Defense (DoD) Module 6: Data Validation Guidelines. However, these limits in the guidelines are used in the context as an example of what may be considered a major exceedance. EPA recommends that the RPD criteria be reviewed for adequacy and that rationale for the MPC be provided in the RI Work Plan.	Comment Acknowledged. The Navy recognizes the importance of collecting representative samples and implements sampling protocols and best practices when conducting environmental sampling to minimize sampling error. The MPCs in the WP are reflective of those typically used for soil and water for PFAS (and other analytes) field duplicate evaluation for investigations conducted by the Navy under the CLEAN program at Joint Base Pearl Harbor-Hickam. In addition, the field duplicate RPD MPCs in the WP are consistent with Navy SOPs for non-PFAS chemicals.
2	EPA	Appendix B, SOP I-C-3, Monitoring Well Sampling	Page 273	While some of this Standard Operating Procedure (SOP) is applicable to this project, it seems more targeted to sampling wells with fuel-related and/or volatile constituents. Please update this SOP to include site-specific requirements for sampling PFAS contaminants. Similar comments apply to the decontamination SOP I-F and Field QC SOP III-B.	The project sampling SOPs specific to PFAS will be included in Appendix B. These include best practices and PFAS sampling guidance from the Michigan Department of Environmental Quality (MDEQ): General PFAS Sampling Guidance, Groundwater PFAS Sampling, Soil PFAS Sampling, and Sediment PFAS Sampling. Other general PFAS sampling and supplemental guidance materials are listed in Worksheet #21. The MDEQ documents provide guidance on decontamination procedures and field QC samples.

Draft Remedial Investigation Work Plan – Priority RTCs, including Follow-up Comments
Per- and Polyfluoroalkyl Substance Release at Building 313 Red Hill Bulk Fuel Storage Facility
JOINT BASE PEARL HARBOR-HICKAM OAHU HI
Reviewer: Chris Lichens, EPA
Date: September 16, 2024

Comment #	Reviewer	Section	Page	Comment	Response
Follow-on Comments (September 16, 2024)					
1	EPA	General	—	Laboratory Standard Operating Procedures or portions that discuss: • Sample dilution procedures. • Protocols for handling high turbidity samples. • Technical definitions of “limit of quantitation”, “limit of detection”, and “detection limit”.	1) Sample dilution procedures are provided in the attached SOP: SOP HPL 1633, Section 15.4. Alternatives to dilution procedures include subsampling and reanalysis of high concentration samples found in the attached SOP: SOP PRE 1633, Appendix B. 2) Protocols for handling high turbidity samples are provided in the attached SOP: SOP PRE 1633, Appendixes C and D. 3) The LOQ, LOD, and DL are defined by DoD QSM and the laboratories following the DoD QSM are required to have procedures for determining and verifying the LOQ, LOD, and DL as defined by the QSM Module 4. The technical definition provided by DoD QSM: Limit of Quantitation: The smallest concentration that produces a quantitative result with known and recorded precision and bias. The LOQ shall be set at or above the concentration of the lowest non-zero initial calibration standard and within the calibration range. Limit of Detection: The lowest concentration empirically determined to consistently provide a response meeting identification and minimum signal requirements for a specific analyte-matrix/method combination. This is an estimation of the smallest concentration of an analyte that shall be present in order to be detected with a result at or above the DL with 99% confidence (false negative, Type II, error of 1%). The LOD is the lowest concentration for reliably reporting a non-detect of an analyte. Detection Limit: The smallest analyte concentration that can be demonstrated to be different from zero or a blank concentration with 99% confidence. At the DL, the false positive rate (Type I error) is 1%. A DL may be used as the lowest concentration for reliably reporting a detection of a specific analyte in a specific matrix with a specific method with 99% confidence.
2	EPA	General	—	An operations and maintenance plan for the wells or a summary of how the condition of each monitoring well will be documented in the field.	The well condition will be documented in the monitoring well installation logs that will be provided as an attachment to the RI report. Well conditions assessed during subsequent field work will be documented in the field logbooks and/or purge logs completed during groundwater sampling and included in an appendix to the RI report.
3	EPA	General	—	A description of how duplicate precision will be used to evaluate the impact of uncertainty on decisions for the RI Report.	The precision and other data quality indicators will be evaluated during the reporting phase, as detailed in Worksheet #37. Data will be validated according to relevant established procedures. Results and data quality will be assessed using various indicators from QA/QC samples and parameters. Precision determination and usability will be part of the data assessment process, with RPDs for field duplicate samples evaluated in the context of specific acceptance criteria. The data usability assessment will identify potential uncertainties and discuss their impact on decision making.
4	EPA	General	—	Detailed protocols for collecting field blanks, equipment blanks, and rinsate blanks.	The SOP for collecting field QC samples is provided in Appendix B (NAVFAC Pacific Environmental Restoration Program Procedure III-B and the MDEQ General PFAS Sampling Guidance).

Comment #	Reviewer	Section	Page	Comment	Response
5	EPA	General Priority Comment #1	—	Please ensure that the preliminary groundwater sampling events include all wells depicted in the updated Figure 1a that was provided with the RTCs, and update the document text globally to include all wells. The revised draft text for Section 14.7.3 is missing many of the agreed-upon wells, including RHMW wells 01R, 02, 03, 04, 05, 06, 07, 08, 17D, 18, 20, and 21; RHP wells 04a-c, 05, and 08b.	The preliminary groundwater sampling events (i.e., four quarters of expedited groundwater sampling) have been added as Section 14.7.3.1, and include the wells indicated on the revised figure while the originally scoped two rounds of post-monitoring well installation groundwater sampling has been revised to Section 14.7.3.2.
6	EPA	General Priority Comment #1	—	After a year of quarterly sampling, the data will be evaluated to determine future sampling locations and frequency.	The Navy agrees that groundwater sampling will begin in September 2024 and will occur quarterly for at least one year, after which wells to be sampled, and frequency and duration of the sampling program will be re-evaluated by the Navy, EPA, and HDOH. This has been added to the end of WP Section 17.5.
7	EPA	General Priority Comment #1	—	To evaluate risk, PFAS results will be evaluated comprehensively along with co-occurring contaminants, not as individual, maximum concentrations of PFAS at each well.	This PFAS RI report will evaluate a comprehensive PFAS-related risk. Once the PFAS RI, as well as the Site Assessment for petroleum, is completed, the data will be evaluated to determine where there is comingling. Once those areas are identified, then a combined path forward (risk assessment, FS, etc.) will be planned.

Appendix H.2.3:
EPA Letter

Subject: Response to EPA Priority Comments Regarding Draft Remedial Investigation Work Plan, Per- and Polyfluoroalkyl Substances Release, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Oahu, HI, Pearl Harbor HI FISC Site 30; June 2024

REGION 9
SAN FRANCISCO, CA 94105

March 18, 2026

VIA ELECTRONIC MAIL ONLY

Jocelyn Tamashiro
Environmental Restoration Manager
NAVFAC Hawaii, EV3
400 Marshall Road, Building X-11
Joint Base Pearl Harbor-Hickam, Hawai'i 96860

Subject: U.S. Environmental Protection Agency Conditional Approval of the *Revised Daft Remedial Investigation Work Plan Per- and Polyfluoroalkyl Substances, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Hawaii*, February 2026

Dear Ms. Tamashiro:

Thank you for submitting the *Revised Daft Remedial Investigation Work Plan Per- and Polyfluoroalkyl Substances, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Hawaii.* We appreciate the accelerated timeline of the investigation of polyfluoroalkyl substances (PFAS) contamination at the Oily Waste Disposal Facility (OWDF) and beneath Adit 3. The PFAS Remedial Investigation (RI) is essential to developing a comprehensive understanding of the nature and extent of PFAS and comingled petroleum hydrocarbons in soil and groundwater at the Red Hill facility. Our comments on the work plan are provided below. In an effort to expedite the investigation in the vicinity of the proposed Red Hill Shaft (RHS) water treatment plant, we are granting conditional approval of several aspects of the Area B investigation. Final approval of the comprehensive RI work plan, including Area B, and the proposed groundwater monitoring program requires further discussion.

Comments

1. EPA approves the number, depths and locations of soil borings and temporary wells proposed for the OWDF and Adit 3 portion of Area B as shown in Figures 39, 40 and 41.

2. To support PFAS delineation at Area B, EPA recommends conducting Total Oxidizable Precursor (TOP) assays and Total Organic Fluorine (TOF) analyses on groundwater samples. These lines of evidence will be interpreted qualitatively to characterize potential source(s), relative strength, extent, and the presence of precursor compounds. TOP results can also help differentiate and apportion contributions from multiple PFAS sources within a commingled plume. We also

recommend applying these methods to perched-water samples at the Oily Waste Disposal Facility to evaluate whether shallow contamination is connected to the basal aquifer.

3. **Section 14.5.2 Scenario 2: No Petroleum Impacts Observed, PID Reading Between 10 ppmv and 50 ppmv.** The highest levels of both PFAS and total petroleum hydrocarbon (TPH) detected in groundwater at the OWDF were detected at OWDF-03B and OWDF-05B, where a maximum PID reading of 9.8 parts per million by volume (ppmv) was recorded during drilling. This indicates a potential correlation and co-occurrence of TPH and PFAS. EPA recommends targeting collection of soil samples at depth intervals with PID reading from 10-50 ppmv for PFAS analysis.

4. **14.7.1 Surface Soil and Subsurface Soil Sampling -** Sample depths discussed in paragraph 1 should be relative to the bottom elevations of backfilled excavations (i.e. samples should not be collected from recently placed fill).

EPA requests that Navy notify regulatory agencies if changes in scope occur that may impact data quality, or the ability to meet the data quality objectives. Modifications to the scope must be agreed upon in writing by EPA and the Navy.

If Navy disagrees with EPA comments, please schedule a meeting to ensure the investigation schedule remains on track. If you have any questions regarding this letter, please contact Tonya Russi at russi.tonya@epa.gov or (415) 972-3706.

Sincerely,

TONYA RUSSI Digitally signed by TONYA RUSSI Date: 2026.03.18 12:55:13 -07'00'

Tonya Russi
Red Hill Project Coordinator
U.S. Environmental Protection Agency, Region 9

JOHN CHESNUTT Digitally signed by JOHN CHESNUTT Date: 2026.03.18 12:51:50 -07'00'

John Chesnutt
Manager, Superfund Pacific Islands Section
U.S. Environmental Protection Agency, Region 9

cc: (email only)
Captain Gregory deWindt, NCTF-RH
CDR Benjamin Dunn, NCTF-RH
Joshua Stout, NCTF-RH
Charlotte Rangel, NAVFAC
Niels Heidner, NAVFAC
Kelly Ann Lee, Hawai'i Department of Health
Gracelda Simmons, Hawai'i Department of Health

Project Title: Revised Draft Remedial Investigation Work Plan Per- and Polyfluoroalkyl Substances, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Hawaii, February 2026
Reviewer: Tonya Russi, John Chesnutt, U.S. EPA
Date: March 18, 2026

Item	Section No.	Comment
1	General	EPA approves the number, depths and locations of soil borings and temporary wells proposed for the OWDF and (b) (3) portion of Area B as shown in Figures 39, 40 and 41.
Response: Comment acknowledged.		
2	General	To support PFAS delineation at Area B, EPA recommends conducting Total Oxidizable Precursor (TOP) assays and Total Organic Fluorine (TOF) analyses on groundwater samples. These lines of evidence will be interpreted qualitatively to characterize potential source(s), relative strength, extent, and the presence of precursor compounds. TOP results can also help differentiate and apportion contributions from multiple PFAS sources within a commingled plume. We also recommend applying these methods to perched-water samples at the Oily Waste Disposal Facility to evaluate whether shallow contamination is connected to the basal aquifer.
Response: As described in the responses to comments in Appendix G of the Revised Draft RI Work Plan (February 2026), the Navy is required to follow DoD policy for conducting PFAS investigations, specifically DoD policy *Establishing a Consistent Methodology for the Analysis of Per- and Polyfluoroalkyl Substances in Matrices Other than Drinking Wate*r (ASD Memorandum May 2024). In accordance with this policy, the project will use EPA Method 1633, Revision A (December 2024), *Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS*, as the sole method for definitive PFAS decision-making. Current DoD policies do not allow use of TOP and TOF screening tools for fingerprinting PFAS types because these methods are not certified under the Environmental Laboratory Accreditation Program (ELAP) and may be unreliable. EPA Method 1633 provides an ELAP certified and comprehensive suite of target analytes, including terminal and precursor compounds and known transformation products associated with AFFF formulations. The method is sufficient to support the RI objectives of evaluation of the nature and extent of contamination, investigation of potential source areas, and assessment of groundwater vertical connectivity. Accordingly, supplemental PFAS screening analyses, including TOP or TOF, are not proposed as part of the RI Work Plan. The Navy will continue to evaluate site data, work with EPA on interpretation of results, and present the findings of the RI in the RI report, at which time the need for additional sampling and analysis can be evaluated.		
3	Section 14.5.2	**Section 14.5.2 Scenario 2: No Petroleum Impacts Observed, PID Reading Between 10 ppmv and 50 ppmv.** The highest levels of both PFAS and total petroleum hydrocarbon (TPH) detected in groundwater at the OWDF were detected at OWDF-03B and OWDF-05B, where a maximum PID reading of 9.8 parts per million by volume (ppmv) was recorded during drilling. This indicates a potential correlation and co-occurrence of TPH and PFAS. EPA recommends targeting collection of soil samples at depth intervals with PID reading from 10-50 ppmv for PFAS analysis.
Response: The Navy agrees that there may be a correlation between TPH and PFAS, based on the limited samples collected to date at the Facility. No change was made to Section 14.5.2; however, the following text has been added to the subsections of WS 17: • For Area A, Section 17.2.3, "If evidence of PHCs is observed in fine grained soil, including PID readings above 10 ppmv, petroleum-related staining, or LNAPL, a soil sample will be collected for both PHCs and PFAS analysis." • For Area B, Section 17.4 "Potential PHCs COPCs are being evaluated under different programs at Area B, however, if evidence of PHCs is observed in soil cores with fine grained material, including PID readings greater than 10 ppmv, petroleum-related staining, or LNAPL, a soil sample will be collected for PFAS analysis."		
4	Section 14.7.1	**14.7.1 Surface Soil and Subsurface Soil Sampling** - Sample depths discussed in paragraph 1 should be relative to the bottom elevations of backfilled excavations (i.e. samples should not be collected from recently placed fill).
Response: The Navy concurs. Section 14.8.1 (formerly Section 14.7.1) has been revised to state "Composited analytical soil samples will not include manmade fill from recent excavations or road construction material.".		

Appendix H.2.4:
Navy Responses to EPA Comments
May 05, 2026

REGION 9
SAN FRANCISCO, CA 94105

May 05, 2026

VIA ELECTRONIC MAIL ONLY

Jocelyn Tamashiro
Environmental Restoration Manager
NAVFAC Hawaii, EV3
400 Marshall Road, Building X-11
Joint Base Pearl Harbor-Hickam, Hawai'i 96860

Subject: U.S. Environmental Protection Agency Comments on the *Revised Draft Remedial Investigation Work Plan Per- and Polyfluoroalkyl Substances, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Hawaii*, February 2026

Dear Ms. Tamashiro:

Thank you for submitting the *Revised Draft Remedial Investigation Work Plan Per- and Polyfluoroalkyl Substances, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Hawaii.* The Remedial Investigation (RI) is essential to developing a comprehensive understanding of the nature and extent of per- and polyfluoroalkyl substances (PFAS) and comingled petroleum hydrocarbons in soil and groundwater at the Red Hill Bulk Fuel Storage Facility (RHBFSF). The Work Plan focuses on two areas: Area A, including Building 313 and the Adit 6 entrance, and Area B, including the westernmost portion of the Red Hill facility around Adit 3 and the Oily Waste Disposal Facility (OWDF). EPA is committed to working with the Navy to expedite the sampling efforts in Area B. Please find attached EPA's comments on the RI Work Plan. We look forward to the Navy's revisions and commencement of field work.

If you have any questions regarding this letter, please contact Tonya Russi at russi.tonya@epa.gov or (415) 972-3706.

Sincerely,

JOHN CHESNUTT Digitally signed by JOHN CHESNUTT Date: 2026.05.05 08:39:32 -07'00'

John Chesnutt
Manager, Superfund Pacific Islands Section
U.S. Environmental Protection Agency, Region 9

TONYA RUSSI Digitally signed by TONYA RUSSI Date: 2026.05.05 07:35:29 -07'00'

Tonya Russi
Red Hill Coordinator
U.S. Environmental Protection Agency, Region 9

Attachment: 1. EPA Comments on Revised Draft Remedial Investigation Work Plan Per- and Polyfluoroalkyl Substances

cc: (email only)
CAPT Gregory deWindt, NCTF-RH
CDR Benjamin Dunn, NCTF-RH
Joshua Stout, NCTF-RH
Charlotte Rangel, NAVFAC
Niels Heidner, NAVFAC
Gracelda Simmons, Hawaii Department of Health
Jennah Oshiro, Hawaii Department of Health
Kelly Ann Lee, Hawaii Department of Health

Attachment 1 – EPA Comments on Revised Draft Remedial Investigation Work Plan Per- and Polyfluoroalkyl Substances

Comments:

1. EPA understands the proposed data collection effort described in this work plan is the first phase of the investigation of PFAS impacts at the Red Hill Facility. EPA appreciates Navy's commitment to fully investigate the PFAS impacts at Red Hill in this and future phases. Accordingly, we have limited our comments to matters most relevant to this initial phase of investigation.

2. Construction projects around the facility are ongoing. Active construction may limit access to potential areas of concern. Please provide all known construction and grading timelines in identified areas of concern. Please describe how you will alert EPA/Hawaii Department of Health in advance of any planned or changed construction that could affect PFAS investigation/cleanup activities (i.e. written notification to EPA project manager, etc.)

3. If additional sampling methods or protocols are implemented, please submit a quality assurance project plan addendum, minimally including project quality objectives, reference limits, sampling design/rationale, and field and laboratory quality control processes.

4. **Page 23 (PDF page 29), Worksheet #6, Communication Pathways:** For Regulatory Agency Interface procedures, please update the language as follows: *The Navy RPM will forward all project documentation. The Navy will ensure EPA Region 9 and DOH are notified of major changes or corrective actions. While input on corrective actions will be sought beforehand whenever possible, notification will occur within 24 hours of implementation.*

5. **Page 43 (PDF page 49), Worksheet #10, 10.1 Overview (objectives of the RI):**
    a. The work plan states, "Characterize the nature and extent of PFAS in Area B…" Please update to "…characterize the nature, extent, and sources of PFAS in soil and groundwater in Area B…"
    b. For the objectives of the RI, please add Area B remedial investigation will include developing a hydrogeologic and contaminant conceptual site model (CSM) for the perched aquifers in the vicinity of the former OWDF facility and beneath Adit 3.

6. **Page 69 (PDF page 75), Worksheet #11, 11.1.2 Step 1 – State the Problem, Area B:** The work plan presents the following conclusion: "*Initial assessments of the monitoring data indicated that PFAS detected in NMW32 probably does not originate from the Facility (DON 2023o)*." The cited reference does not provide this global conclusion. Rather, it states the PFAS found in NMW-32 was not related to aqueous film forming foam (AFFF) product released in November 2022. However, the PFAS detected on the former OWDF represents a different and unknown source. Please remove this statement and reevaluate the connection with NMW-32 following delineation of OWDF impacts.

7. **Page 70 and 71 (PDF page 76), Worksheet #11, 11.3 Step 3 – Identify the Information Inputs to the Decision:** The seventh bullet indicates that the: **"***Results from DoD-approved methods to*

assess the potential for COPCs to migrate from soil and perched water measured in the valley fill sediments to the underlying basal groundwater that is a drinking water resource." Please identify project screening levels (PSL) for specific PFAS protective of the leaching-to-groundwater pathway and provide a description of the method for EPA review.

8. **Page 103 (PDF page 109), Worksheet #14, 14.13.1 Data Management Tasks:** Please provide field notes/data sheets to regulators. This should include all information necessary to understand the results (example: water quality collected via a flow-through cell). EPA requests this information be uploaded to the Navy's Environmental Data Management System or other equivalent database accessible to regulators.

9. **Page 138 (PDF page 144) 17.6, Worksheet #17, 17.6 Area B Groundwater Sampling Design and Locations:** EPA recommends installing pressure transducers in Area A and Area B perched wells and temporary wells in Adit 3 to collect continuous groundwater elevation measurements. This information will be important for identifying sources of perched aquifer recharge, temporal response to precipitation events, saturated thickness of the perched zone and the direction and rate of groundwater flow.

<u>Expectations for Future Submittals</u>

10. As part of future phases, when updating the CSM, evaluating fate and transport, and choosing sample locations, please consider pipelines, utility conduits, and other infrastructure that may cause preferential pathways for contaminant migration.

11. EPA acknowledges there is a Department of Defense (DoD) Office of the Secretary of Defense memorandum that stipulates which screening levels the Navy will use. EPA recommends that DoD use the updated regional screening level that reflects the latest science. Rescreening may be needed as new scientific information emerges.

12. Releases to the environment have occurred from the collection, holding and transfer tank (CHT) and holding tank-leach tank (HT/LT) and are currently being investigated for petroleum impacts. These release locations also represent possible PFAS release locations. Future project phases may require PFAS soil and groundwater sampling at CHT and HT/LT locations.

13. PFAS was detected in the perched aquifer beneath Adit 3 (OWDF-08B). EPA expects that future phases of the project will include sampling in Adit 3 to improve our understanding of the distribution of PFAS contamination in the perched aquifer.

14. **Page 63 (PDF page 69), Worksheet #10, 10.4.3.2 Area B:** The report states; *"PFOA is defined in the basal aquifer below the PSL to the west and south of Area B; however, it is not fully defined to the east, or to the north along the Facility boundary toward the Halawa Industrial Park (Figure 17)."* As presented in Figure 20, perfluorooctanoic acid results from OWDFMW-04A, RHP-05 and RHP-06 exceed the PSL in the basal aquifer, suggesting that in future phases of the project, further definition will be necessary to the south and west of the OWDF. The results of the initial phase of soil and groundwater investigation and an updated hydrogeologic CSM should be used to optimize the locations of these basal wells.

15. **Page 77 (PDF page 83), Worksheet #12, Field Quality Control Samples:** From previous Navy responses, EPA understands that the high relative percent difference (RPD) shown for field duplicates are standard for Navy sites on Joint Base Pearl Harbor Hickam (JBPHH). However, the limits in DoD Module 6: Data Validation Guidelines are used as an example of what may be considered a major exceedance. Results with high RPDs may require additional sampling.

16. **Page 96 (PDF page 102), Worksheet #14, 14.7.3 Groundwater Sampling:** EPA requests four quarters of groundwater sampling after all monitoring wells are installed. EPA requests a meeting to discuss groundwater monitoring frequency and the included wells.

17. **PDF page 321, Table B-4, Summary of Area A Perched Groundwater Quarterly Expedited Sampling Analytical Data:** EPA notes PFAS data collected between December 2022-December 2023 at Red Hill monitoring wells after the November 2022 release outside Adit 6 is missing from the analytical data summary. EPA requests this data be reviewed and considered for both the CSM development and the evaluation of impact on basal groundwater quality.

18. At minimum, the CSM in the final report should include the following:
    a. Characterization of seasonal variability in perched aquifer conditions including saturated thicknesses, flow directions and flow rates.
    b. An evaluation of basal groundwater flow direction in the vicinity of the OWDF.
    c. Identification of sources of water recharging the perched aquifers.
    d. Identification of areas where perched aquifers are recharging the basal aquifer.
    e. An estimate of the net mass of PFAS contamination released to the environment in November 2022 that was not recovered through removal activities.
    f. An evaluation of PFAS weathering, transformation, and mobility in the environment.
    g. An evaluation of PFAS mass loading rates to the basal aquifer resulting from individual (impacted) perched aquifers and to the basal aquifer in the vicinity of Adit 6.
    h. An evaluation of the concentration and mass flux of individual PFAS and total PFAS migrating onto Red Hill, and the mass of individual and total PFAS migrating off the facility.
    i. An evaluation of the relationship between PFAS contamination detected at the former OWDF and Red Hill Facility and PFAS contamination detected in offsite wells including NMW-24, 25 and 32.

19. In the final report please include:
    a. A description of the geostatistical methods used to support the development of all plume maps.
    b. A description of previous soil excavations, site grading, and other work that may have affected contaminant occurrence and distribution at or adjacent to the OWDF.
    c. Details about the 2025 removal of the AFFF Retention Tank and ongoing trenching, excavation, and grading near Area B, including locations where soil movement activity occurred.
    d. Cross-section and plan-view figures of soil excavations and site grading.
    e. Figures identifying the footprint of the proposed permanent water treatment facility relative to features on the OWDF such as the former AFFF storage tank, the temporary GAC treatment system infrastructure, existing wells, and soil borings and temporary well

locations.

f. Description of the water releases from Tank 316 in May 2025 and Tank 685 in September 2025, focusing on their impact on potential contaminant transport.
g. A figure showing proposed sampling locations in proximity to the Tank 685 washout area.
h. Discussion of any impact the erosion control project may have on the sampling schedule.

Project Title: Revised Draft RI Work Plan Per- and Polyfluoroalkyl Substances, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Hawaii, February 2026
Reviewer: EPA John Chesnutt Tonya Russi
Date: May 2026

Item	Section No.	Comment
1	General	EPA understands the proposed data collection effort described in this work plan is the first phase of the investigation of PFAS impacts at the Red Hill Facility. EPA appreciates Navy's commitment to fully investigate the PFAS impacts at Red Hill in this and future phases. Accordingly, we have limited our comments to matters most relevant to this initial phase of investigation.
Response: Comment acknowledged.		
2	General	Construction projects around the facility are ongoing. Active construction may limit access to potential areas of concern. Please provide all known construction and grading timelines in identified areas of concern. Please describe how you will alert EPA/Hawaii Department of Health in advance of any planned or changed construction that could affect PFAS investigation/cleanup activities (i.e. written notification to EPA project manager, etc.)
Response: Comment acknowledged but no change was made to the document. The Navy RPM has and will continue to work closely with all other neighboring operations at the Facility. Construction and grading timelines for other projects are not the responsibility of the Navy PFAS RI team and may change from day to day, therefore, we are unable to provide comprehensive schedules to the regulatory agencies. However, if there are any significant impacts to the RI field schedule or potential impacts to sampling activities, the Navy will notify the EPA and DOH via email from the Navy RPM to the EPA and DOH RPMs.		
3	General	If additional sampling methods or protocols are implemented, please submit a quality assurance project plan addendum, minimally including project quality objectives, reference limits, sampling design/rationale, and field and laboratory quality control processes.
Response: The Navy concurs. A quality assurance project plan addendum will be submitted if additional sampling methods or protocols are implemented due to a change in project quality objectives.		
4	Worksheet #6, pg 23 (PDF pg 29)	For Regulatory Agency Interface procedures, please update the language as follows: The Navy RPM will forward all project documentation. The Navy will ensure EPA Region 9 and DOH are notified of major changes or corrective actions. While input on corrective actions will be sought beforehand whenever possible, notification will occur within 24 hours of implementation.
Response: The Navy has revised the subject text for clarity: "The Navy RPM will forward all project documentation to the regulatory agencies. The Navy will ensure EPA Region 9 and DOH are notified of major changes. While input on corrective actions will be sought beforehand whenever practical, notification will occur within 24 hours of implementation."		
5	Worksheet #10, 10.1 pg 43 (PDF pg 49)	a. The work plan states, "Characterize the nature and extent of PFAS in Area B…" Please update to "…characterize the nature, extent, and sources of PFAS in soil and groundwater in Area B…" b. For the objectives of the RI, please add "Area B remedial investigation will include developing a hydrogeologic and contaminant conceptual site model (CSM) for the perched aquifers in the vicinity of the former OWDF facility and beneath (b) (3)"
Response: The Navy has revised the subject text for clarity: a. Based upon a comprehensive review, the Navy has not identified a historical source of PFAS in Area B. However, one objective of the RI is to define potential source area(s) in Area B, which includes environmental media currently impacted by PFAS at concentrations that exceed project screening levels (PSLs). Therefore, the text has been revised as follows: "Characterize the nature and extent of PFAS at concentrations exceeding project screening levels (PSLs), including potential source area(s) of PFAS in soil and groundwater in Area B." b. Sampling beneath (b) (3) will not occur during this phase of the RI due to conflicts with site closure construction projects in the area; however, the hydrogeologic and contaminant CSM will include the perched groundwater in the vicinity of the former OWDF facility and in the vicinity of (b) (3). The following text has been added: "Develop a hydrogeologic and contaminant conceptual site model (CSM) for the perched groundwater in the vicinity of the former OWDF facility and in the vicinity of (b) (3)."		

Project Title: Revised Draft RI Work Plan Per- and Polyfluoroalkyl Substances, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Hawaii, February 2026
Reviewer: EPA John Chesnutt Tonya Russi
Date: May 2026

Item	Section No.	Comment
6	Worksheet #11, 11.1.2 pg 69 (PDF pg 75)	The workplan presents the following conclusion: "Initial assessments of the monitoring data indicated that PFAS detected in NMW32 probably does not originate from the Facility (DON 2025o)." The cited reference does not provide this global conclusion. Rather, it states PFAS found in NMW-32 was not related to aqueous film forming foam (AFFF) product released in November 2022. However, the PFAS detected at former OWDF represents a different and unknown source. Please remove this statement and reevaluate the connection with NMW-32 following the delineation of OWDF impacts.
Response: The Navy concurs and has removed the sentence in quotes from the work plan for clarity. The Navy will continue to evaluate the potential for onsite and offsite migration of PFAS, and will include NMW32 in that assessment.		
7	Worksheet #11, 11.3 pg. 70 and 71 (PDF pg 76)	The seventh bullet indicates that the: "Results from DoD-approved methods to assess the potential for COPCs to migrate from soil and perched water measured in the valley fill sediments to the underlying basal groundwater that is a drinking water source." Please identify project screening levels (PSLs) for specific PFAS protective of the leaching-to-groundwater pathway and provide a description of the method for EPA review.
Response: Comment acknowledged but no change was made to the document. The Navy has not identified appropriate soil to groundwater screening levels that are compatible with the complex vadose zone PFAS fate and transport conceptual site model at the Facility. EPA soil to groundwater screening levels (Regional Screening Levels (RSLs) - Generic Tables | US EPA) assume concentrations in soil are directly above the drinking water aquifer, while PFAS observed at ground surface at the Facility is 100 to 260 feet above the drinking water aquifer. If necessary, the Navy will discuss potential site-specific leaching evaluation methodologies with the regulatory agencies upon completion of the investigations described in the work plan..		
8	Worksheet #14, 14.13.1 pg 103 (PDF pg 109)	Please provide field notes/data sheets to regulators. This should include all information necessary to understand the results (example: water quality collected via a flow-through cell). EPA requests this information be uploaded to the Navy's Environmental Data Management System or other equivalent database accessible to regulators.
Response: Comment acknowledged but no change was made to the document. The Navy will provide field notes, including the field logbook and field data sheets as an attachment to the RI Report, once they have been reviewed and have been through the project quality control and quality assurance process.		
9	Worksheet #17, 17.6 pg 138 (PDF pg 144)	EPA recommends installing pressure transducers in Area A and Area B perched wells and temporary wells in (b) (3) to collect continuous groundwater elevation measurements. This information will be important for identifying sources of perched aquifer recharge, temporal response to precipitation events, saturated thickness of the perched zone and the direction and rate of groundwater flow.
Response: Comment acknowledged but no change was made to the document. The Navy will evaluate potentially installing pressure transducers in permanent wells in future phases of the investigation.		
Expectations for Future Submittals [a]		
10	Future Submittals [a]	As part of future phases, when updating the CSM, evaluating fate and transport, and choosing sample locations, please consider pipelines, utility conduits, and other infrastructure that may cause preferential pathways for contaminant migration.
Response: Comment acknowledged but no change was made to the document.		
11	Future Submittals [a]	EPA acknowledges there is a Department of Defense (DoD) Office of the Secretary of Defense memorandum that stipulates which screening levels the Navy will use. EPA recommends that DoD use the updated regional screening level that reflects the latest science. Rescreening may be needed as new scientific information emerges.
Response: Comment acknowledged but no change was made to the document.		

Project Title: Revised Draft RI Work Plan Per- and Polyfluoroalkyl Substances, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Hawaii, February 2026
Reviewer: EPA John Chesnutt Tonya Russi
Date: May 2026

Item	Section No.	Comment
12	Future Submittals [a]	Releases to the environment have occurred from the collection, holding and transfer tank (CHT) and holding tank-leach tank (HT/LT) and are currently being investigated for petroleum impacts. These release locations also represent possible PFAS release locations. Future project phases may require PFAS soil and groundwater sampling at CHT and HT/LT locations.
Response: Comment acknowledged but no change was made to the document.		
13	Future Submittals [a]	PFAS was detected in the perched aquifer beneath (b) (3) (OWDF-08B). EPA expects that future phases of the project will include sampling in (b) (3) to improve our understanding of the distribution of PFAS contamination in the perched aquifer.
Response: Comment acknowledged but no change was made to the document.		
14	Future Submittals [a] Worksheet #10, 10.4.3.2, pg 63 (PDF pg 69)	The report states; "PFOA is defined in the basal aquifer below the PSL to the west and south of Area B; however, it is not fully defined to the east, or to the north along the Facility boundary toward the Halawa Industrial Park (Figure 17)." As presented in Figure 20, perfluorooctanoic acid results from OWDFMW04A, RPH05 and RPH06 exceed the PSL in the basal aquifer, suggesting that future phases of the project, further definition will be necessary to the south and west of the OWDF. The results of the initial phases of soil and groundwater investigation and an updated hydrogeologic CSM should be used to optimize the locations of these basal wells.
Response: Comment acknowledged but no change was made to the document. The Navy acknowledges that PFOA exceeds screening criteria at OWDFMW04A during the four expedited quarterly groundwater monitoring events, ranging from 7.5 ng/L to 10 ng/L compared to the PSL of 4 ng/L. OWDFMW04A is in the middle of the Facility, not along the south or west boundaries. However, RPH05 is located south of OWDFMW04A, along the southern boundary and PFOA concentrations ranged from 3.8 ng/L to 4.5 ng/L, very close to the PSL of 4 ng/L. Similarly, RPH06, located southeast of OWDFMW04A, and PFOA concentrations ranged from 3.2 ng/L to 4.4 ng/L, very close to the PSL of 4 ng/L. Therefore, the Navy concludes that PFAS in the basal aquifer to the south and southeast is defined. RHP04A is directly west of OWDFMW04A and PFOA ranged from 1.3 ng/L to 1.6 ng/L, not exceeding the PSL of 4 ng/L. Based on these data, the Navy does not consider further delineation to the south or west necessary and will focus on areas north and west of the RPH02 and RHP01 as described in the work plan. If results from future sampling events indicate that further investigation is needed in these areas, this will be evaluated in future phases of the RI.		
15	Future Submittals [a] Worksheet #12 pg 77 (PDF pg 83)	From previous Navy responses, EPA understands that the high relative percent difference (RPD) shown for field duplicates are standard for Navy sites on Joint Base Pearl Harbor Hickam (JBPHH). However, the limits in DoD Module 6: Data Validation Guidelines are used as an example of what may be considered a major exceedance. Results with high RPDs may require additional sampling.
Response: Comment acknowledged but no change was made to the document.		
16	Future Submittals [a] Worksheet #14, 14.7.3 pg 96 (PDF pg 102)	EPA requests four quarters of groundwater sampling after all monitoring wells are installed. EPA requests a meeting to discuss groundwater monitoring frequency and the included wells.
Response: Comment acknowledged. No changes have been made to the PFAS RI work plan, which plans for two rounds of groundwater samples to be completed after all the wells are installed. These two rounds will be separated by approximately 6 months and will include a consecutive rainy season and dry season. Quarterly samples were collected during the 2025-2026 expedited groundwater monitoring event, weekly sampling was conducted from December 2022 through May 2023, and monthly sampling was conducted from June 2023 through December No seasonal trends were observed and the Navy does not recommend additional quarterly sampling at this time. The Navy will collaborate with the regulatory agencies after the current phase of field work planned in the current work plan is completed to identify and fill data gaps in future phases of the RI.		

Project Title: Revised Draft RI Work Plan Per- and Polyfluoroalkyl Substances, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Hawaii, February 2026
Reviewer: EPA John Chesnutt Tonya Russi
Date: May 2026

Item	Section No.	Comment
17	Future Submittals [a] Table B-4 PDF pg 321	EPA notes PFAS data collected between December 2022-December 2023 at Red Hill monitoring wells after the November 2022 release outside (b) (3) is missing from the analytical data summary. EPA requests this data be reviewed and considered for both the CSM development and the evaluation of impact on basal groundwater quality.
Response: Comment acknowledged but no change was made to the document. The Navy reviewed the groundwater results described in comment #17 and presented results in several emergency response groundwater sampling reports. These data and results are summarized in Section 10.2.8.4 of the revised work plan and in Appendix B, Table B-2, and were used to develop the preliminary CSM and evaluate the potential impact to the basal groundwater quality in the work plan, and the final work plan. Further evaluation and refinement of groundwater conditions, and data interpretation will be conducted during the reporting phase.		
18	Future Submittals [a, b]	At minimum, the CSM in the final report should include the following: a. Characterization of seasonal variability in perched aquifer conditions including saturated thickness, flow directions and flow rates b. An evaluation of basal groundwater flow direction in the vicinity of the OWDF. c. Identification of sources of water recharging the perched aquifers. d. Identification of areas where perched aquifers are recharging the basal aquifer. e. An estimate of the net mass of PFAS contamination released to the environment in November 2022 that was not recovered through removal activities. f. An evaluation of PFAS weathering, transformation, and mobility in the environment. g. An evaluation of PFAS mass loading rates to the basal aquifer resulting from individual (impacted) perched aquifers and to the basal aquifer in the vicinity of (b) (3). h. An evaluation of the concentration and mass flux of individual PFAS and total PFAS migrating onto Red Hill, and the mass of individual and total PFAS migration off the facility. i. An evaluation of the relationship between PFAS contamination detected at the former OWDF and Red Hill Facility and PFAS contamination detected in offsite wells including NMW-24, 25, and 32.
Response: Comment acknowledged but no change was made to the document.		
19	Future Submittals [a, b]	In the final report please include: a. A description of geostatistical methods used to support the development of all plume maps. b. A description of previous soil excavations, site grading, and other work that may have affected contaminated occurrence and distribution at or adjacent to the OWDF. c. Details about the 2025 removal of the AFFF Retention Tank and ongoing trenching, excavation, and grading near Area B, including locations where soil movement activity occurred. d. Cross-section and plan-view figures of soil excavations and site grading. e. Figures identifying the footprint of the proposed permanent water treatment facility relative to features on the OWDF such as the former AFFF storage tank, the temporary GAC treatment system infrastructure, existing wells, and soil borings and temporary well locations. f. Description of the water releases from Tank 316 in May 2025 and Tank 685 in September 2025, focusing on their impact on potential contaminant transport. g. A figure showing proposed sampling locations in proximity to the Tank 685 washout area. h. Discussion of any impact the erosion control project may have on the sampling schedule.
Response: Comment acknowledged but no change was made to the document.		

Project Title: Revised Draft RI Work Plan Per- and Polyfluoroalkyl Substances, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Hawaii, February 2026
Reviewer: EPA John Chesnutt Tonya Russi
Date: May 2026

a. Comment #10 through Comment #19 do not refer to the subject work plan but refer to future documents that will be submitted by the Navy.

b. Comment #18 and Comment #19 do not refer to the subject work plan but refer to the future final remedial investigation report that will be submitted by the Navy.

Appendix H.2.5:
EPA Letter

Subject: U.S. Environmental Protection Agency Approval of the Draft Final Remedial Investigation Work Plan Per- and Polyfluoroalkyl Substances, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Hawaii; July 2026

REGION 9
SAN FRANCISCO, CA 94105

July 31, 2026

VIA ELECTRONIC MAIL ONLY

Jocelyn Tamashiro
Environmental Restoration Manager
NAVFAC Hawaii, EV3
400 Marshall Road, Building X-11
Joint Base Pearl Harbor-Hickam, Hawai'i 96860

Subject: U.S. Environmental Protection Agency Approval of the *Draft Final Remedial Investigation Work Plan Per- and Polyfluoroalkyl Substances, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Hawaii*, July 2026

Dear Ms. Tamashiro:

Thank you for submitting the *Draft Final Remedial Investigation Work Plan Per- and Polyfluoroalkyl Substances, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Hawaii.* The Per- and Polyfluoroalkyl Substances (PFAS) Remedial Investigation (RI) provides the foundation for understanding the nature and extent of PFAS and comingled petroleum hydrocarbons in soil and groundwater at the Red Hill facility. The findings from this remedial investigation will inform subsequent project phases. EPA appreciates the Navy's efforts to accelerate the schedule and remains committed to working together on the site cleanup process.

EPA approves the Navy's Draft Final PFAS RI, with the following conditions. Please provide written acceptance of these conditional comments.

Conditional Comments:

1. Page 135 (PDF page 141), Worksheet #17: We appreciate the effort to develop a comprehensive sampling methodology by collecting and analyzing composite samples. As discussed during a July 22, 2026, meeting, Navy will initially sample soils as proposed; however, in consultation with EPA, procedures will need to be continuously evaluated and modified to ensure representative samples are collected and that they meet project objectives.

Additionally, please incorporate the following:

a. Please target fine grained sediments for analysis and demonstrate the efficacy of the proposed sieve size. The highest PFAS concentrations will accumulate in fine-grained, organic-rich soils where the chemicals bond tightly to the soil matrix and resist migration. The proposed ¼ inch sieve may introduce an overly coarse sediment fraction to the sample, biasing results low.

b. Please evaluate the feasibility of sending all or a subset of the collected soil to the laboratory for compositing to eliminate risk of PFAS adhering to sampling equipment and to reduce the risk of cross-contamination from field gear.

2. Please inform EPA of any significant impacts to the schedule or potential impacts to sampling locations. In the final report, adequately document areas of cut and fill and recent soil disturbance to ensure the appropriate depth intervals have been sampled and the site is properly characterized. The report should include figures identifying excavation locations, depths (with elevations), dates, and the thickness and final elevation of filled areas.

Additional General Comments:

1. Please schedule a meeting with EPA to discuss the PFAS groundwater monitoring program, including installation of pressure transducers in perched aquifer wells.
2. To minimize disruptions to the construction schedule for the (b) (3) water treatment plant, EPA encourages Navy to work expeditiously to develop project screening levels (PSLs) so that any potential removal and/or remedial actions can be scoped and scaled as needed. Please schedule a meeting with EPA to discuss the approach to developing PSLs for the leaching-to-groundwater pathway.
3. Please ensure the conceptual site model and final report incorporate all EPA comments received to date.

If you have any questions regarding this letter, please contact Tonya Russi at russi.tonya@epa.gov or (415) 972-3706.

Sincerely,

TONYA RUSSI Digitally signed by TONYA RUSSI Date: 2026.07.31 14:54:49 -07'00'

Tonya Russi
Red Hill Project Coordinator
U.S. Environmental Protection Agency, Region 9

JOHN CHESNUTT Digitally signed by JOHN CHESNUTT Date: 2026.07.31 15:51:22 -07'00'

John Chesnutt
Manager, Superfund Pacific Islands Section
U.S. Environmental Protection Agency, Region 9

cc: (email only)
CAPT Gregory deWindt, NCTF-RH
CDR Benjamin Dunn, NCTF-RH
Joshua Stout, NCTF-RH

Charlotte Rangel, NAVFAC
Niels Heidner, NAVFAC
Kelly Ann Lee, Hawai'i Department of Health
Gracelda Simmons, Hawai'i Department of Health
Jennah Oshiro, Hawai'i Department of Health

Project Title: Draft Final Remedial Investigation Work Plan Per- and Polyfluoroalkyl Substance Release at Building 313 Red Hill Bulk Fuel Storage Facility
Joint Base Pearl Harbor-Hickam Oahu HI
Reviewer: Tonya Russi, John Chesnutt, EPA
Date: July 31, 2026

Item	Section No.	Comment
Conditional Comments		
1	Page 135 (PDF page 141), Worksheet #17	We appreciate the effort to develop a comprehensive sampling methodology by collecting and analyzing composite samples. As discussed during a July 22, 2026, meeting, Navy will initially sample soils as proposed; however, in consultation with EPA, procedures will need to be continuously evaluated and modified to ensure representative samples are collected and that they meet project objectives. Additionally, please incorporate the following: a. Please target fine grained sediments for analysis and demonstrate the efficacy of the proposed sieve size. The highest PFAS concentrations will accumulate in fine-grained, organic-rich soils where the chemicals bond tightly to the soil matrix and resist migration. The proposed ¼ inch sieve may introduce an overly coarse sediment fraction to the sample, biasing results low. b. Please evaluate the feasibility of sending all or a subset of the collected soil to the laboratory for compositing to eliminate risk of PFAS adhering to sampling equipment and to reduce the risk of cross-contamination from field gear.
Response: a. The Navy and field teams are committed to targeting fine-grained materials. The selected sieve size is intended to exclude larger particles while still allowing inclusion of saprolitic clay material. Based on experience, using a finer sieve would increase the risk of clogging by fat clays (e.g., saprolite), which could significantly slow sampling and increase the potential for cross-contamination. In addition, a finer sieve could bias results low if the screen must be repeatedly cleared or washed, because this process can lead to loss of the clay- and silt-sized fractions most likely to sorb PFAS. The soil sampling field process is as follows: Soil recovered from 1.5-foot split-spoon samplers along the targeted interval will be sieved through a ¼-inch mesh so that only material smaller than ¼ inch is retained for the sample. The resulting composite will be thoroughly mixed to achieve a homogeneous sample. A 4-ounce aliquot will then be placed into a 4-ounce sample jar to represent the composite and submitted to the laboratory for analysis. In accordance with the laboratory's SOP, the lab will subsample 2 grams from the homogenized 4-ounce jar for extraction and analysis. b. It is not feasible to send all collected material to the laboratory.		
2	General	Please inform EPA of any significant impacts to the schedule or potential impacts to sampling locations. In the final report, adequately document areas of cut and fill and recent soil disturbance to ensure the appropriate depth intervals have been sampled and the site is properly characterized. The report should include figures identifying excavation locations, depths (with elevations), dates, and the thickness and final elevation of filled areas.
Response: The Navy will ensure timely communication of any significant schedule changes or potential impacts to sampling locations. In the final report, efforts will be made to thoroughly document the surface areas and total depths of all intrusive activities to support the CSM and ensure accurate site characterization.		
Additional General Comments		
1	General	Please schedule a meeting with EPA to discuss the PFAS groundwater monitoring program, including installation of pressure transducers in perched aquifer wells.
Response: Comment acknowledged.		
2	General	To minimize disruptions to the construction schedule for the Red Hill Shaft water treatment plant, EPA encourages Navy to work expeditiously to develop project screening levels (PSLs) so that any potential removal and/or remedial actions can be scoped and scaled as needed. Please schedule a meeting with EPA to discuss the approach to developing PSLs for the leaching-to-groundwater pathway.
Response: Comment acknowledged.		
3	General	Please ensure the conceptual site model and final report incorporate all EPA comments received to date.
Response: Comment acknowledged.		

Project Title: Draft Final Remedial Investigation Work Plan Per- and Polyfluoroalkyl Substance Release at Building 313 Red Hill Bulk Fuel Storage Facility
Joint Base Pearl Harbor-Hickam Oahu HI
Reviewer: Matt Cohen, EPA
Date: July 1, 2026

Item	Section No.	Comment
1	General	**Additional Documentation:** Photograph the entire soil interval to be sampled (e.g. 0.0-0.5 ft bgs, 0.5-2.0 ft bgs, 2.0-10 ft bgs, etc.). Identify within the photographs, the intervals that are being composited. For the 0.0-0.5 ft bgs it would be the entire interval. For intervals where fines are targeted, identify in the photographs the specific intervals that contributed to a specific composite sample.
Response: The Navy concurs. All split spoon samples collected during continuous sampling of each soil boring will be photographed. The sampled intervals will be identified in the photographs, as well as on the boring logs. In the field, the entirety of each composited interval defined in the work plan will be collected from the split spoon samplers, sieved using a maximum 6.5 mm screen into a PFAS-free container, and mixed thoroughly before being containerized for shipment to the laboratory for analysis. The mass of the sieved composite will be recorded on the sampling form.		
2	General	**Sample and Analyze:** Intervals/layers that exhibit field evidence of contamination such as staining/sheen/discoloration, odors, or elevated PID measurements.
Response: The Navy concurs. Intervals exhibiting field evidence of contamination will be subsampled and analyzed for diesel and residual range organics (Method 8015), gasoline range organics (Method 8015), volatile organic compounds (Method 8260), and polycyclic aromatic hydrocarbons (Method 8270SIM) and PFAS (Method 1633). The PFAS subsample results will be incorporated into the larger interval results using mass-weighted averaging. The sub-sampled intervals will be sieved using a maximum 6.5 mm screen, and the mass of screened materials will be recorded for each subsample interval to allow for mass-weighted averaging of the results.		

Appendix H.3:
U.S. Fish and Wildlife Service

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Pacific Islands Fish and Wildlife Office
300 Ala Moana Boulevard, Room 3-122
Honolulu, Hawai‘i 96850

In Reply Refer To:
01EPIF00-2026-0074690

April 13, 2026

Ms. Jocelyn Tamashiro, L.G.
Environmental Restoration Manager
NAVFAC Hawaii
Environmental Restoration (EV-3)
400 Marshall Road
JBPHH, Hawai‘i 96860

Subject: Review of the Draft Remedial Investigation Work Plan for Per- and Polyfluoroalkyl Substances Release at the Red Hill Bulk Fuel Storage Facility, JBPHH, Oahu, Hawai‘i

Dear Ms. Tamashiro:

The US Fish and Wildlife Service’s Pacific Islands Fish and Wildlife Office (PIFWO) has received and reviewed the document entitled “Remedial Investigation Work Plan; Per- and Polyfluoroalkyl Substances Release; Red Hill Bulk Fuel Storage Facility, JBPHH, Oahu, HI,” which details the work plan for a Remedial Investigation (RI) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), primarily focusing on chemicals of potential concern (COPCs) including per- and polyfluoroalkyl substances (PFAS) and petroleum hydrocarbons. We understand that this document reflects the RI approach that was agreed upon by the Navy, the State of Hawai‘i Department of Health (DOH), and the U.S. Environmental Protection Agency (EPA) in September of 2025. We will therefore limit our comments to a brief discussion of wildlife that may be observed in the area, and remarks on co-occurring PFAS compounds.

Protected Species in the Project Area

Section 10.2.7 of the RI describes the project area as low quality and disturbed habitat characterized by non-native vegetation and introduced species. It additionally references a 1995 biological survey of the area that found no native or sensitive species, and states that “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.” This characterization is largely consistent with PIFWO records, though we note the potential for the Hawaiian hoary bat or Ōpe‘ape‘a (*Lasiurus cinereus semotus)* to forage in

the area, and the possible transit of Hawaiian stilt or Ae‘o (*Himantopus mexicanus knudseni)* and/or Hawaiian seabirds over the area. Please see Appendix A for our recommended avoidance measures.

Co-Occurring PFAS Compounds and PSLs

Project Screening Levels (PSLs) are addressed in Section 15.1.1 and elsewhere in the work plan. We appreciate that the discussion of PSLs recognizes both ecological screening levels and EPA Regional Screening Levels (RSLs) as informative. It is unfortunate, however, that these levels are not applied consistently; several PFAS compounds with established EPA RSLs appear either to lack PSLs or to have been assigned less conservative values. We hope that securing analytical facilities and methods with sufficiently sensitive detection limits will provide the information needed to revisit PSLs as the project advances. We also recommend that interpretation of COPC data from this RI accounts for additive effects among the PFAS compounds known to cooccur at the site. Combinations of PFHxS, PFNA, HFPO-DA, and PFBS warrant close attention, given that the EPA’s enforceable PFAS standards include a Hazard Index Maximum Contaminant Level for this set of compounds.

We are pleased to see the Red Hill site cleanup proceeding. If you have any questions about this review, please contact Fish and Wildlife Biologist Dr. Alicia Hendrix at alicia_hendrix@fws.gov or (808) 347-7524.

Sincerely,

AARON NADIG

Digitally signed by AARON NADIG
Date: 2026.04.13 09:31:27 -10'00'

Deputy Field Supervisor
Pacific Islands Fish and Wildlife Office

Appendix A. Comments and Recommended Avoidance Measures for Protected Species in Work Plan Project Area

PIFWO has reviewed the project area, and identified the following federally listed species:

- Hawaiian hoary bat or Ōpeʻapeʻa (*Lasiurus cinereus semotus)*
- Hawaiian stilt or Aeʻo (*Himantopus mexicanus knudseni*)
- Hawaiian seabirds (*Pterodroma sandwichensis, Puffinus auricularis newelli, Hydrobates castro*)

Ōpeʻapeʻa

Suitable foraging habitat for Ōpeʻapeʻa is present in both Areas A and B. Section 14.2-3 notes that vegetation clearance and tree trimming may occur to support drilling for soil sample collection and well installation. Ōpeʻapeʻa roost in woody vegetation across all islands and will leave their young unattended in trees and shrubs when they forage. If trees or shrubs 15 feet or taller are cleared during the pupping season, June 1 through September 15, there is a risk that young bats could inadvertently be harmed or killed, since they are too young to fly or move away from disturbance.

To avoid and minimize impacts to the endangered Hawaiian hoary bat we recommend you incorporate the following applicable measures into your project description:

- Do not disturb, remove, or trim woody plants greater than 15 feet tall during the bat birthing and pup rearing season (June 1 through September 15).

Aeʻo

Overall, no suitable wetland habitat for aeʻo occurs near RHBFSF. South Halawa stream near Areas A and B is intermittent and generally flows only after storm events; therefore, exposure risk to aeʻo is unlikely.

Hawaiian seabirds

Hawaiian seabirds may traverse the project area at night during the breeding, nesting and fledging seasons (March 1 to December 15). Outdoor lighting could result in seabird disorientation, fallout, and injury or mortality. Seabirds are attracted to lights and after circling the lights they may become exhausted and collide with nearby wires, buildings, or other structures or they may land on the ground. Downed seabirds are subject to increased mortality due to collision with automobiles, starvation, and predation by dogs, cats, and other predators. Young birds (fledglings) traversing the project area between September 15 and December 15, in their first flights from their mountain nests to the sea, are particularly vulnerable to light attraction.

To avoid and minimize potential project impacts to seabirds we recommend you incorporate the following measures into your project description:

- Fully shield all outdoor lights so the bulb can only be seen from below.
- Install automatic motion sensor switches and controls on all outdoor lights or turn off lights when human activity is not occurring in the lighted area.
- Avoid nighttime construction during the seabird fledging period, September 15 through December 15.

Appendix H.3.1:
Navy Responses to U.S. Fish and Wildlife Service Comments
April 13, 2026

Project Title: Revised Draft Remedial Investigation Work Plan Per- and Polyfluoroalkyl Substances, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Hawaii, February 2026
Reviewer: Alicia Hendrix
Date: April 13, 2026

Item	Section No.	Comment
1	General	*Protected Specifies in the Project Area* Section 10.2.7 of the RI describes the project area as low quality and disturbed habitat characterized by non-native vegetation and introduced species. It additionally references a 1995 biological survey of the area that found no native or sensitive species, and states that "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." This characterization is largely consistent with PIFWO records, though we note the potential for the Hawaiian hoary bat or Ōpeʻapeʻa (Lasiurus cinereus semotus) to forage in the area, and the possible transit of Hawaiian stilt or Aeʻo (Himantopus mexicanus knudseni) and/or Hawaiian seabirds over the area. Please see Appendix A for our recommended avoidance measures.

Response: The following text was added to Worksheet #14 Summary of Project Tasks, Section 14.2 Site Surveys and Preparation: "To avoid and minimize potential impacts to sensitive species potentially within the project area, the following measures will be implemented:

- Any trees or woody vegetation 15 feet in height or taller will not be trimmed or cleared during the Hawaiian hoary bat (*Lasiurus cinereus semotus*) pupping season, which occurs from June 1 through September 15 (DON 2024b).
- Outdoor lighting, if used for the project, will comply with the Dark Skies Instruction to minimize potential impacts to potential Hawaiian seabirds traversing the site (DHS and USCG 2020)."

Project Title: Revised Draft Remedial Investigation Work Plan Per- and Polyfluoroalkyl Substances, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Hawaii, February 2026
Reviewer: Alicia Hendrix
Date: April 13, 2026

Item	Section No.	Comment
2	General	*Co-Occurring PFAS Compounds and PSLs* Project Screening Levels (PSLs) are addressed in Section 15.1.1 and elsewhere in the work plan. We appreciate that the discussion of PSLs recognizes both ecological screening levels and EPA Regional Screening Levels (RSLs) as informative. It is unfortunate, however, that these levels are not applied consistently; several PFAS compounds with established EPA RSLs appear either to lack PSLs or to have been assigned less conservative values. We hope that securing analytical facilities and methods with sufficiently sensitive detection limits will provide the information needed to revisit PSLs as the project advances. We also recommend that interpretation of COPC data from this RI accounts for additive effects among the PFAS compounds known to cooccur at the site. Combinations of PFHxS, PFNA, HFPO-DA, and PFBS warrant close attention, given that the EPA's enforceable PFAS standards include a Hazard Index Maximum Contaminant Level for this set of compounds.

Response: The Navy must adhere to DoD-wide policy regarding PFAS PSLs, which incorporate EPA risk-based guidance as described in Section 15.1 and the ASD memorandum *Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program* (DoD 2025). Where EPA residential soil or tap-water RSLs are available, they are used as PSLs unless a more conservative benchmark applies (e.g., an established MCL or a Navy-recommended ecological screening value), in which case the lowest applicable value is selected. PFAS with RSLs not currently approved for use in the DoD Cleanup Program are identified to inform detection-limit capabilities but are not applied as PSLs at this time, as documented in Section 15.1, and the associated table footnotes, consistent with ASD policy. In addition, as noted in Worksheet 15, the Navy agrees that PSLs will be revisited and updated at the time of reporting in accordance with DoD policy.

PFAS will be evaluated using the CERCLA risk assessment framework, applying the most current DoD-approved toxicity values at the time of evaluation. For complete exposure pathways, a cumulative human health risk assessment will be conducted for detected PFAS and other chemicals of potential concern (COPCs), where appropriate, to account for additive effects in a manner consistent with the CERCLA risk assessment process. As required under Navy and EPA guidance, HQs will be added together into the pathway-specific hazard index (HI). If the HI >1, a target-organ evaluation will be performed, recognizing it is not appropriate to sum HQs unless the chemicals that make up the mixture have similar modes of toxicological action or impact the same organ or organ system, such as the nervous system. Consequently, the summing of HQs for a mixture of chemicals that are not expected to include the same type of effects could overestimate the potential hazard.

All samples will be analyzed by DoD ELAP-accredited laboratories using EPA Method 1633. Certain PFAS have EPA-approved analytical methods but have RSL values below the method detection limit (MDL). Where analytical reporting limits exceed available screening criteria, established MCLs or pooled Method 1633 MDLs are applied in accordance with DoD policy. The usability and uncertainty of elevated reporting limits relative to screening levels will be evaluated in the data quality assessment and risk assessment sections of the RI report. PSLs may be revisited as analytical capability, reporting limits, and as EPA and DoD guidance or policy evolve during the project. Consistent with this approach, Worksheet#15 is included to ensure the selected analytical laboratory and method can provide accurate data (i.e., quantitative results with known precision and bias) at or below the PSL.

Appendix H.4:
Aiea Neighborhood Board District 20

AIEA NEIGHBORHOOD BOARD DISTRICT 20

FORMAL TRANSMITTAL LETTER Re: Comments on the Revised Draft PFAS Remedial Investigation Work Plan (February 2026) Date: April 2026

To: Commander, Navy Region Hawaii Environmental Restoration Program Joint Base Pearl Harbor–Hickam, HI

Cc: Hawai‘i Department of Health (DOH) U.S. Environmental Protection Agency (EPA), Region 9 PHHK RAB Co-Chairs

Dear Sir or Madam,

On behalf of the Aiea Neighborhood Board District 20, we respectfully submit the enclosed technical comments and recommendations regarding the Revised Draft Remedial Investigation (RI) Work Plan for PFAS at the Red Hill Bulk Fuel Storage Facility, dated February 2026.

As the community directly adjacent to the Red Hill facility and reliant on the underlying sole-source aquifer, the Aiea Neighborhood Board recognizes the importance of a complete, transparent, and scientifically defensible investigation. The Board appreciates the Navy's continued coordination with local residents, regulatory agencies, and technical stakeholders. After reviewing the Executive Summary and associated RI elements, the Board offers the following overarching observations:

1. The Work Plan establishes a strong technical foundation, including the use of EPA Method 1633, DoD-accredited laboratories, and a multi-media sampling approach.
2. Several elements require clarification or expansion to ensure full delineation of PFAS impacts and to safeguard the aquifer serving Aiea and surrounding communities.
3. Additional monitoring, clearer decision criteria, and strengthened conceptual site modeling are needed to support defensible conclusions in the final RI.

A detailed Comment Matrix is attached, identifying specific technical issues, bases, and recommended revisions. Key themes include:

- Need for a more robust vertical migration model linking perched and basal groundwater.
- Evaluation of preferential pathways (tunnels, utilities, conduits) that may influence PFAS transport.
- Expanded soil and groundwater sampling in Area B and downgradient locations.
- Clarification of Data Quality Objectives (DQOs), reporting limits, and action triggers.
- Strengthened assessment of off-site migration, including additional perched and basal wells.
- Enhanced risk assessment for sensitive populations and ecological receptors.

The Aiea Neighborhood Board submits these comments in the spirit of constructive collaboration and with the shared goal of protecting public health and Hawai‘i's drinking water resources. We respectfully request that the Navy, DOH, and EPA review the attached comments and provide written responses in accordance with standard RI/FS comment-response procedures. The Board also requests that the Navy present an updated Work Plan and response-to-comments summary at a future PHHK RAB meeting.

Thank you for your attention to these comments and for your continued engagement with the Aiea community.

Sincerely, Lawrence Higa, Aiea Neighborhood Board District 20

PFAS RI WORK PLAN — RAB COMMENT MATRIX (DRAFT)

Red Hill Bulk Fuel Storage Facility – February 2026 Revised Draft RI Work Plan Prepared for: PHHK Restoration Advisory Board Prepared by: *Lawrence Higa, Aiea Neighborhood Board District 20,* Date: April 2026

COMMENT MATRIX

Section / Page	Comment	Basis / Technical Rationale	Recommended Revision	Priority
Executive Summary	CSM does not fully describe vertical migration from perched to basal groundwater.	PFAS mobility and the presence of perched water above a sole-source aquifer require explicit modeling of vertical pathways.	Add a vertical migration model linking perched and basal groundwater, including hydraulic gradients and potential preferential pathways.	High
Executive Summary	Preferential pathways (tunnels, utilities, conduits) are mentioned but not evaluated.	Subsurface utilities at Red Hill have historically acted as conduits for contaminant migration.	Add mapping and evaluation of utilities, tunnels, and backfilled trenches as potential PFAS transport pathways.	High
Area A Sampling Plan	Soil boring density may be insufficient to capture heterogeneity near the 2022 release.	PFAS distribution in disturbed fill and excavation backfill is highly variable.	Increase boring density or provide justification for spacing; include vadose-zone transport modeling.	Medium
Area A Groundwater	Reliance on legacy wells may not meet PFAS DQOs due to construction materials.	Teflon/Viton components can bias PFAS results; only RHMW15 is being tested.	Evaluate all existing wells for PFAS-compatible construction materials; replace or exclude wells that do not meet DQOs.	High
Area B Sampling Plan	25 + 13 borings may not adequately characterize 37 acres with multiple features.	Large area with complex hydrogeology and multiple potential migration pathways.	Increase boring density near wells exceeding screening levels and near former OWDF and treatment facilities.	Medium
Area B Groundwater	Only one new basal well is proposed in southeast Area B.	PFAS exceedances in multiple basal wells indicate need for more downgradient coverage.	Add at least one additional basal well downgradient of Area A and one along western boundary.	High
Off-Site Assessment	Only two off-site basal wells are proposed; no perched wells.	Perched groundwater is a key transport mechanism; industrial park stormwater systems may act as conduits.	Add perched and basal wells west/northwest of Area B; evaluate stormwater infrastructure in Halawa Industrial Park.	High
DQOs (Worksheets 34–36)	Reporting limits and decision criteria are not explicitly stated.	Decision-making requires clear thresholds relative to EPA MCLs, HALs, and DOH EALs.	Add reporting limits, comparison tables, and explicit triggers for additional delineation or interim actions.	High
Risk Assessment	Sensitive populations and ecological receptors are not fully defined.	PFAS toxicity varies by receptor; infants and pregnant individuals require explicit evaluation.	Expand receptor list; include future land-use scenarios and ecological pathways.	Medium
Stormwater Pathways	Stormwater transport from Area A swales is acknowledged but not quantified.	Stormwater runoff is a known PFAS migration mechanism.	Add stormwater transport modeling or sampling of swale discharge points.	Medium

Section / Page	Comment	Basis / Technical Rationale	Recommended Revision	Priority
Temporary Wells	Up to 15 temporary perched wells proposed, but criteria for converting to permanent wells are unclear.	Long-term monitoring requires clear criteria for permanent well installation.	Define criteria for converting temporary wells to permanent monitoring wells.	Low
Data Interpretation	No explicit plan for evaluating seasonal variability beyond two events.	Hawaii's wet/dry seasons can significantly affect PFAS concentrations.	Add justification for two events or propose contingency for additional sampling if variability is high.	Low

Appendix H.4.1:
Navy Responses to Aiea Neighborhood Board Comments
April 2026

Project Title: Revised Draft RI Work Plan Per- and Polyfluoroalkyl Substances, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, Hawaii, February 2026
Reviewer: Lawrence Higa, Aiea Neighborhood Board District 20
Date: April 2026

Item	Section No.	Comment
1	Executive Summary	CSM does not fully describe vertical migration from perched to basal groundwater. *Basis / Technical Rationale:* PFAS mobility and the presence of perched water above a sole-source aquifer require explicate modeling of vertical pathways. *Recommended Revision:* Add a vertical migration model linking perched and basal groundwater, including hydraulic gradients and potential preferential pathways. *Priority:* High
Response: In accordance with the CERCLA process, the Navy will develop a comprehensive conceptual site model to evaluate the fate and transport of PFAS, including the potential for vertical migration, as part of the RI. Data gathered during the current phase of field work will be used to develop an increasingly comprehensive CSM.		
2	Executive Summary	Preferential pathways (tunnels, utilities, conduits) are mentioned but not evaluated. *Basis / Technical Rationale:* Subsurface utilities at Red Hill have historically acted as conduits for contaminant migration. *Recommended Revision:* Add mapping and evaluation of utilities, tunnels, and backfilled trenches as potential PFAS transport pathways. *Priority:* High
Response: Preferential pathways were considered during the development of this work plan, which affected the placement of some of the proposed sampling locations. Due to the sensitivity of critical infrastructure, the location of subsurface utilities and tunnels are not permitted to be circulated in the public domain.		
3	Area A Sampling Plan	Soil boring density may be insufficient to capture heterogeneity near the 2022 release. *Basis / Technical Rationale:* PFAS distribution in disturbed fill and excavation backfill is highly variable. *Recommended Revision:* Increase boring density or provide justification for spacing; include vadose-zone transport modeling. *Priority:* Medium
Response: The Navy has reevaluated the density of borings and has determined that the current density is sufficient to complete a risk assessment for this area. As stated in Section 17.2, these borings are intended to identify residual contamination from the 2022 AFFF release. The soil boring density proposed in the Area A sampling plan is designed to identify PFAS distribution in soil, while taking into consideration accessibility, safety, and preferential pathways. The Navy intends to evaluate these PFAS results in soil, then determine whether additional soil sampling may be required to address data gaps, and whether vadose zone modeling is recommended. Groundwater results from weekly, monthly, and quarterly monitoring of basal groundwater monitoring wells in and around Area A do not indicate that PFAS has impacted the basal groundwater beneath Area A.		
4	Area A Groundwater	Reliance on legacy wells may not meet PFAS DQOs due to construction materials. *Basis / Technical Rationale:* Teflon/Viton components can bias PFAS results; only RHMW15 is being tested. *Recommended Revision:* Evaluate all existing wells for PFAS-compatible construction materials; replace or exclude wells that do not meet DQOs. *Priority:* High

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Reviewer: Lawrence Higa, Aiea Neighborhood Board District 20
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Response: The Navy has tested the existing permanent groundwater monitoring wells in the PFAS monitoring well network and found them suitable for the current RI data quality objectives. Prior to testing, the Navy replaced all legacy groundwater sampling pumps that may have contained PFAS-components with PFAS-free sampling pumps and redeveloped all legacy wells that are currently in the PFAS groundwater monitoring network to mitigate potential well-construction-related PFAS false-positives in groundwater samples from these wells. At wells near Area A, PFAS has not been detected above project screening levels or other data quality objectives in the underlying basal groundwater. RHMW15 is a special case; it is a multi-level well that allows groundwater sampling at different depths below the water table with proprietary sampling apparatus that contains components with relatively inert Teflon and/or Viton composition. To date, the Navy has chosen not to sample several multi-level wells for PFAS based on conservative guidance. However, RHMW15 is in a location that represents a potential data gap in the south of Red Hill Facility, and the Navy plans to conduct tests on the RHMW15 sampling apparatus with PFAS-free water to determine whether the results meet data quality objectives. The results of the tests should indicate whether components of the system are leaching PFAS to the PFAS-free water at concentrations greater than project data quality objectives described in Worksheet 15 of the work plan.		
5	Area B Sampling Plan	25 + 14 borings may not adequately characterize 37 acres with multiple features. *Basis / Technical Rationale:* Large area with complex hydrogeology and multiple potential migration pathways. *Recommended Revision:* Increase boring density near wells exceeding screening levels and near former OWDF and treatment facilities. *Priority:* Medium
Response: The soil boring density proposed in the Area B sampling plan is designed to define the extent of PFAS above project screening levels in soil and groundwater. The Navy plans to conduct the RI field work using a CERCLA phased approach, which is a standard process used to identify, assess, and manage contamination risks at a site. It ensures decisions are based on progressively refined data, minimizes uncertainty, and supports regulatory compliance. Using this process, the Navy will evaluate results from the current phase of field work, and if necessary, identify areas where more data is needed to define the extent of PFAS above PSLs, the source of PFAS (if associated with Navy activities), and the risk to human health and the environment.		
6	Area B Groundwater	Only one new basal well is proposed in southeast Area B. *Basis / Technical Rationale:* PFAS exceedances in multiple basal wells indicate need for more downgradient coverage. *Recommended Revision:* Add at least one additional basal well downgradient of Area A and one along western boundary. *Priority:* High

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Response: The concentrations of PFAS measured in groundwater samples collected during expedited quarterly groundwater monitoring conducted between September 2024 and July 2025 at the Red Hill PFAS monitoring well network of 43 wells indicate that PFAS is defined to the project screening levels in the basal aquifer to the south and west at Area B, and are not detected above PSLs in the basal aquifer under or near Area A. To make this clear to the public, the Navy has removed sensitive infrastructure from figures in the version of the work plan that is redacted for public review so that the public can observe the PFAS distribution, including locations of PSL exceedances. In the work plan, Figure 13 through (b) (3) illustrate the lateral and temporal distribution of PFAS in soil and groundwater from samples collected between December 2022 and August 2025. Figure 19 through Figure 22 provide a comprehensive visual summary of the results for all PFAS observed above PSLs in basal groundwater wells from samples collected during the expedited groundwater monitoring events. The upper panel in these figures provides results for Area B and include PFAS exceedances in the basal aquifer. The lower panel in these figures provides the results for Area A and show that no PFAS constituents exceeded PSLs in any basal wells near or in Area A during those sampling events. In these figures: • Grey well icons indicate PFAS constituents were not detected in groundwater samples • Green well icons indicate PFAS constituents were detected, but did not exceed PSLs in groundwater samples • Blue well icons indicate PFAS constituents exceeded PSLs in groundwater samples (b) (3) and (b) (3) provide a visual summary of these results in the basal groundwater at Area B for PFAS risk-drivers, PFOS and PFOA, which are the most commonly observed PFAS constituents exceeding the PSLs in the basal aquifer below the Facility. These figures indicate that PFAS is defined to the PSL to the west, southwest and south at Area B; and not defined to the PSL to the north, northeast, and southeast of Area B. Based on the existing data set, the Navy will not add a basal well downgradient from Area A, nor a basal well at the western perimeter of the Facility in this work plan, as recommended in this comment. As described in the response to Comment #5, the Navy will continue to use the phased approach, evaluate results from the current phase of field work, and if necessary, identify areas where more data is needed to define the extent of PFAS above PSLs, the source of PFAS (if associated with Navy activities), and the risk to human health and the environment.		
7	Off-Site Assessment	Only two off-site basal wells are proposed; no perched wells. *Basis / Technical Rationale:* Perched groundwater is a key transport mechanism; industrial park stormwater systems may act as conduits. *Recommended Revision:* Add perched and basal wells west/northwest of Area B; evaluate stormwater infrastructure in Halawa Industrial Park. *Priority:* High
Response: As described in Section 17.5 of the subject work plan, the Navy does not plan to install permanent perched wells in the Halawa Industrial Park during this phase of the investigation. The stormwater system of the industrial park is not part of the Navy's investigation. To address perched water, which may be impacted by activities from the industrial park, the Navy plans the following actions: If perched water is observed during drilling of the two proposed offsite basal wells in the Halawa Industrial Park, a temporary well will be installed at each location where perched water is observed, and a groundwater grab sample will be collected and analyzed for PFAS, and the temporary well will be removed. Following the validation of PFAS results from the perched groundwater samples, the Navy will collaborate with the regulatory agencies to determine whether additional actions are warranted.		
8	DQOs (Worksheet 34-36)	Reporting limits and decision criteria are not explicitly stated. *Basis / Technical Rationale:* Decision-making requires clear thresholds relative to EPA MCLs, HALs, and DOH EALs. *Recommended Revision:* Add reporting limits, comparison tables, and explicit triggers for additional delineation or interim actions. *Priority:* High
Response: Worksheets 11, 14, and 15 provide the regulatory limits, reporting limits, decision criteria, and decision-making process in accordance with CERCLA guidance.		

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9	Risk Assessment	Sensitive populations and ecological receptors are not fully defined. *Basis / Technical Rationale:* PFAS toxicity varies by receptor; infants and pregnant individuals require explicit evaluation. Recommended Revision: Expand receptor list; include future land-use scenarios and ecological pathways. *Priority:* Medium
Response: Section 10.5 and 10.6 and the cited figures (Figure 27 through Figure 32) of the work plan present the preliminary exposure assessment and environmental media to be addressed in accordance with CERCLA and Navy risk assessment requirements. Based on this guidance, the human receptors to be evaluated will include current and future adult site workers; current and future adult construction workers; current and future adult and child trespasser/hunters; and hypothetical future adult and child residents. The evaluation of the child resident will consider potential exposure of children from 0–6-year-olds. Evaluation of hypothetical residential exposure provides the Navy with a conservative upper bound risk estimate for each area of concern at the Facility. Exposure to surface soil, subsurface soil, and groundwater will be evaluated for each potentially exposed population. Based on current guidance, the risk assessment will use EPA approved toxicity values derived from studies which take into consideration health effects to infants, fetuses, and sensitive populations. These toxicity values undergo independent peer review before they are accepted by EPA for use in CERCLA risk assessments. In accordance with EPA and DoD guidance, the ecological risk assessment will not evaluate future exposure scenarios. Ecological receptors chosen for evaluation will likely be surrogates for local species that are expected to be present at the site and will be selected based on similar body size, feeding habits, diet, year-round residents or nesting species, and home range. These surrogates will be chosen based on EPA-approved life history parameters such as their home range and feeding habits as not all species have documented life history parameters needed to evaluate risk. At the Site, the ecological risk assessment will evaluate the house mouse, the common myna, the northern cardinal, the short-eared owl, and barn owl as the potential ecological receptors based on site habitats. The proposed ecological exposure pathways will be based on observations during site reconnaissance. In addition, ecological receptors will not be considered to be exposed to subsurface soil as it is beyond the normal exposure depth for terrestrial organisms; and will not be considered to be exposed to groundwater because groundwater does not migrate to ground surface at the Facility.		
10	Stormwater Pathways	Stormwater transport form Area A swales is acknowledged but not quantified. *Basis / Technical Rationale:* Stormwater runoff is a known PFAS migration mechanism. *Recommended Revision:* Add stormwater transport modeling or sampling of swale discharge points. *Priority:* Medium
Response: The Navy plans to collect 10 stormwater swale soil samples in the Area A as shown on Figure 34. Following the validation of PFAS results from the stormwater swale soil samples, the Navy will collaborate with the regulatory agencies to determine if additional actions are warranted.		
11	Temporary Wells	Up to 15 temporary perched wells proposed, but criteria for converting to permanent wells are unclear. *Basis / Technical Rationale:* Long-term monitoring requires clear criteria for permanent well installation. *Recommended Revision:* Define criteria for converting temporary wells to permanent monitoring wells. *Priority:* Low
Response: The Navy plans to conduct the RI field work using a CERCLA phased approach, where PFAS in perched groundwater will be defined to PSLs based on the results from groundwater samples collected from temporary wells. After PFAS is defined to the PSLs in perched groundwater based on validated results, the Navy will update the conceptual site model and evaluate data gaps. Once all the temporary well data has been validated, the Navy will collaborate with the regulatory agencies to identify the need and locations of permanent perched groundwater monitoring wells to meet project quality objectives for completion of the RI.		

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12	Data Interception	No explicit plan for evaluation seasonal variability beyond two events. *Basis / Technical Rationale:* Hawaii's wet/dry seasons can significantly affect PFAS concentrations. *Recommended Revision:* Add justification for two events or propose contingency for additional sampling if variability is high. *Priority:* Low

Response: The Navy conducted high frequency PFAS groundwater sampling at wells located in proximity to Area A following the November 2022 AFFF release in (b) (3) for a period of one year (6 months of weekly sampling followed by 6 months of monthly sampling) as described in Section 10.2.8.3 of the subject work plan. In addition, the Navy conducted four rounds of quarterly groundwater monitoring at wells throughout the monitoring well network between September, 2024, and July, 2025, as described in Section 10.4 of the subject work plan. These results did not indicate that a significant change in contaminant concentration variability over the short term (less than bi-annually) are to be expected. As described in the comment, "Hawaii's wet/dry seasons" can potentially result in changes to contaminant concentrations in groundwater, and the two groundwater sampling events proposed in the work plan will be scheduled to be conducted during the wet season and dry season over a period of approximately 6 months, to evaluate that potential variation on PFAS concentrations in groundwater at the Facility and offsite wells in the study area.