Final Report: Assessment of the Joint Base Pearl Harbor-Hickam and Aliamanu Military Reservation Public Water Systems

U.S. Environmental Protection Agency
Region 9

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Acronyms and Abbreviations

2,2MEE	2-(2-methoxyethoxy)ethanol or diethylene glycol methyl ether
ACO	Administrative Consent Order
AL	Action Level
AMR	Aliamanu Military Reservation
AS	Air Sparging
BCEE	bis(2chloroethyl)ether
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes
CFR	Code of Federal Regulations
COA	Course of Action
DBAA	Dibromoacetic Acid
DEHP	Bis(2-ethylhexyl)phthalate or BEHP
DI	Deionized
DLA	United States Defense Logistics Agency
DOC	Demonstration of Capability
DOH	Hawai‘i Department of Health
DRO	Diesel Range Organics or TPH-d
EAL	Environmental Action Level
EDB	Ethylene Dibromide or 1,2-dibromoethane
ECD	Electron Capture Detector
EDWM	Extended Drinking Water Monitoring
EPA	United States Environmental Protection Agency
EPDS	Entry Point to the Distribution System
FID	Flame Ionization Detection
GAC	Granular Activated Carbon
GC	Gas Chromatography
GRO	Gasoline Range Organics or TPH-g
HAA5	Haloacetic Acid
HAR	Hawai’i Administrative Rules
HCl	Hydrochloric Acid
HDPE	high-density polyethylene
HRS	Hawai’i Revised Statutes
ID	Identification
IDWST	Interagency Drinking Water System Team
IUPAC	International Union of Pure and Applied Chemistry
ISP	Incident-Specific Parameter
JBPHH	Joint Base Pearl Harbor–Hickam
JP-5	Jet Propellant-5
LOE	Lines of Evidence
LTM	Long-Term Monitoring
m/z	Mass-to-Charge
MCL	Maximum Contaminant Level
MDL	Method Detection Limit
MG	Million Gallons
mg/L	Milligrams per Liter
MRM	Multiple Reaction Monitoring
MS	Mass Spectrometry

NaOCl	Sodium Hypochlorite
NEIC	EPA National Enforcement Investigations Center
ND	Non-detect
ng/L	Nanograms per Liter
NELAP	National Environmental Laboratory Accreditation Program
NPDES	National Pollutant Discharge Elimination System
NPDWR	National Primary Drinking Water Regulations
ORO	Oil Range Organics or TPH-o
OSC	On-Scene Coordinator
OTP	o-terphenyl
PAHs	Polycyclic Aromatic Hydrocarbons
PEX	Polyethylene
PIANO	Paraffins, Isoparaffins, Aromatics, Naphthenes, Olefins
PID	Photoionization Detector
PN	Public Notice
POAM	Plan of Action and Milestones
PVC	Polyvinyl Chloride
PWS	Public Water System
QA	Quality Assurance
QC	Quality Control
RAR	Removal-Action Report
RCRA	Resource Conservation and Recovery Act
RHSRMP	Red Hill Shaft Recovery and Monitoring Plan
RI	Remedial Investigation
RL	Reporting Limit or MRL
RPZ	Reduced Pressure Zone
SAP	Sampling and Analysis Plan
SDWA	Safe Drinking Water Act
SIM	Single Ion Monitoring
SOP	Standard Operating Procedure
SOW	Statement of Work
SPE	Solid-Phase Extraction
SVE	Soil Vapor Extraction
SVOCs	Semivolatile Organic Compounds
SOCs	Synthetic Organic Contaminants
TIC	Tentatively Identified Compound
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
TTHM	Total trihalomethanes
UCM	Unresolved Complex Mixture
UDF	Unidirectional Flushing
U.S.C.	United States Code
µg/L	Micrograms per Liter
UWA	Unsafe Water Advisory
VOCs	Volatile Organic Compounds
WQAT	Water Quality Action Team

Executive Summary

In November 2021, a fuel release from the Red Hill Bulk Fuel Storage Facility ("Red Hill") contaminated the Red Hill Shaft, a drinking water well that serves the Joint Base Pearl Harbor-Hickam (JBPHH) and the Aliamanu Military Reservation (AMR) public water systems (PWSs). Hundreds of families living on the JBPHH and the AMR reported petroleum odors coming from residential tap water supplied by the PWSs. Approximately 93,000 drinking water consumers were impacted by the contaminated drinking water, many of whom relocated to temporary housing during the drinking water crisis.

In response to this fuel release, an Interagency Drinking Water System Team (IDWST) was established with representatives from the United States Environmental Protection Agency (EPA), the United States Navy (Navy), the United States Army (Army) and the Hawai'i Department of Health (DOH). Water quality targets were also established based on applicable drinking water standards under the Safe Drinking Water Act (SDWA) and the environmental action levels developed by DOH. The primary focus of the IDWST was to restore safe drinking water to the affected water consumers in the PWS service areas to the established water quality target levels. As documented in this report, the IDWST worked extensively to restore the PWSs through isolation, flushing and sampling, and in March 2022, DOH amended their Unsafe Water Advisory (UWA) to allow for unrestricted drinking water use throughout the JBPHH and the AMR PWS service areas.

Between March 2022 and April 2025, EPA worked with the Navy and DOH to thoroughly assess and monitor water quality within the JBPHH and the AMR PWSs. In June 2023, EPA signed an Administrative Consent Order (ACO) under Section 1431 of the SDWA with the Navy and the United States Defense Logistics Agency (DLA) to improve both the infrastructure and operations at the PWSs, and to oversee the safe defueling and closure of Red Hill.

This report describes the actions taken in response to the fuel release and explains the evidence showing that jet fuel is no longer present in the PWSs. The response, monitoring, and investigations led by EPA at the JBPHH and AMR PWSs were conducted under Section 1431(a) of the SDWA, 42 U.S.C. § 300i(a), which grant the EPA emergency authority to protect public health when a contaminant in a PWS or underground source poses an imminent and substantial endangerment. All information reviewed by EPA is publicly available. This report includes references and links that were active when this report was written.

Based on the review of the extensive spill response and recovery efforts documented herein, EPA concludes there is no evidence of residual fuel, or other fuel-related contaminants, remaining in the JBPHH or AMR PWSs following the November 2021 fuel release from Red Hill. DOH also confirms that the PWSs meet all federal and state drinking water standards and have met those standards since the UWA was amended in March 2022. Consequently, EPA supports the PWSs' return to routine compliance monitoring under DOH oversight as the authorized primacy agency for the National Primary Drinking Water Regulations in the state, pursuant to SDWA Section 1413.

EPA continues to work with the Navy, the Army, and DOH to improve infrastructure and operations at the JBPHH and the AMR PWSs under the 2023 ACO. Improvements made during the response and recovery phases, along with planned upgrades, will strengthen and ensure the long-term reliability of the JBPHH and the AMR PWSs.

1.0 Introduction

The Safe Drinking Water Act[1] (SDWA) authorizes the Administrator of the United States Environmental Protection Agency (EPA) to promulgate National Primary Drinking Water Regulations (NPDWR)[2], including maximum contaminant levels (MCLs) and treatment techniques that apply to public water systems (PWSs). The NPDWR protect public health by limiting the concentrations of contaminants in drinking water to the extent feasible. The SDWA also allows EPA to authorize states, territories, and tribes primary enforcement authority, known as "primacy," enabling them to run their own drinking water programs as long as their standards are at least as strict as the federal ones. The Hawai'i Department of Health (DOH) is the authorized primacy agency for PWSs in Hawai'i, and EPA oversees DOH in the implementation of their drinking water program.

In November 2021, a fuel release from the Red Hill Bulk Fuel Storage Facility ("Red Hill") contaminated the Red Hill Shaft, a drinking water well that serves the Joint Base Pearl Harbor-Hickam (JBPHH)[3] and the Aliamanu Military Reservation (AMR)[4] PWSs. The PWSs were impacted when contaminated water entered the JBPHH drinking water distribution system. The impact to the PWSs and their distribution system is herein referred to as the 2021 Red Hill jet fuel release incident ("incident"). Following the incident, on November 29, 2021, DOH issued an Unsafe Water Advisory (UWA)[5] for the JBPHH and the AMR PWSs. Following decontamination activities and water quality monitoring that demonstrated drinking water was meeting the established water quality standards, the UWA was amended to allow for unrestricted use on March 18, 2022[6].

After the UWA was amended in March 2022, the United States Navy (Navy) and the United States Army (Army) undertook an intensive monitoring and infrastructure improvement effort under the 2023 Administrative Consent Order (ACO)[7]. The Navy conducted three years of sampling under Long-Term Monitoring (LTM) program from March 2022-March 2024 and the Extended Drinking

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[1] United States Code (U.S.C.), Title 42, Chapter 6A, Subchapter 12, Safety of Public Water Systems: https://uscode.house.gov/view.xhtml?req=granuleid%3AUSC-prelim-title42-chapter6A-subchapter12&saved=%7CZ3JhbnVsZWlkOlVTQy1wcmVsaW0tdGl0bGU0Mi1zZWN0aW9uMzAwZg%3D%3D%7C%7C%7C0%7Cfalse%7Cprelim&edition=prelim.

[2] National Primary Drinking Water Regulations are codified in the Code of Federal Regulations, 40 CFR 141: https://www.ecfr.gov/current/title-40/chapter-I/subchapter-D/part-141.

[3] JBPHH PWS identification number: #HI0000360

[4] AMR PWS identification number: #HI0000337

[5] DOH – Hawai'i Department of Health advises Navy water system consumers not to drink, consume tap water, November 29, 2021: https://health.hawaii.gov/news/files/2021/11/21-165-DOH-advises-Navy-water-system-consumers-not-to-drink-consume-tap-water.pdf.

[6] DOH - DOH declares four Navy drinking water distribution system zones safe, March 18, 2022: https://health.hawaii.gov/news/files/2022/03/22-033-DOH-declares-four-Navy-drinking-water-distribution-system-zones-safe.pdf.

[7] EPA, Navy, and DLA – 2023 Consent Order for Defueling, Closure, and JBPHH Drinking Water System (Docket No. RCRA 7003-R9-2023-001, PWS-AO-2023-001), June 2, 2023: https://www.epa.gov/system/files/documents/2023-06/2023-red-hill-aoc-for-defueling-closure-dw-protection-2023-06-02.pdf.

Water Monitoring (EDWM) program from April 2024-April 2025. Once the Navy finalized the LTM Plan to the satisfaction of regulators, the UWA was ultimately lifted on October 26, 2022[8].

The purpose of this report is to document EPA's assessment of the condition of the JBPHH and the AMR PWSs, with respect to the incident, as demonstrated by multiple lines of evidence. The sources of data evaluated include, but not limited to, water quality analyses compared against Incident-Specific Parameters (ISPs)[9], remedial actions, EPA and DOH inspections and investigations, and Navy documentation and analyses. In this report, EPA is verifying the effectiveness of the various response actions through the three years of robust water quality monitoring completed, and the ongoing management and system improvements directed by the 2023 ACO.

2.0 Assessing Presence of Fuel Contamination

This report dedicates a significant amount of discussion to the interpretation of Total Petroleum Hydrocarbon (TPH) data generated from EPA analytical methods. Interpreting TPH data involves an understanding of the nature of organic compounds (i.e., carbon-based compounds), as well as the uncertainty and limitations that are inherent when using the available analytical methods for TPH analysis.

All organisms are made of organic compounds. The term "hydrocarbon" refers to a broad-ranging subset of organic compounds comprised of only hydrogen and carbon. During the natural, geological process of crude oil formation, organic compounds become complex mixtures of simpler, often more toxic hydrocarbons such as alkanes (e.g., hexane) and aromatic compounds (e.g., benzene). Through industrial processes, crude oil is refined to remove impurities, separated into hydrocarbon fractions and concentrated to produce petroleum fuels, as well as food-grade petroleum jelly and mineral oils.

One of the principal limitations of the available methods for TPH analysis, as discussed in Section 2.3, is that the TPH methods cannot distinguish petroleum hydrocarbons from other organic compounds (i.e., biogenic carbon) that may be non-toxic. The following subsections provide a scientific overview of fuel mixtures, analyses for the detection of fuel compounds and the limitations of these analyses to support the discussion of EPA's investigation in Sections 3.0-8.0 of this report.

2.1 Jet Fuel Overview

The Red Hill Shaft was impacted by a release of Jet Propellant-5 (JP-5), a "mid-range" distillate of refined crude oil, similar in composition to kerosene. JP-5 is less dense than water, and when

[8] DOH - Lifting of Hawaii Department of Health Public Health Advisory No. 21-165 Related to the Joint Base Pearl Harbor-Hickam Public Water System (PWS NO. HI0000360) and Aliamanu Military Reservation Public Water System (PWS NO. HI0000337), October 26, 2022: https://health.hawaii.gov/about/files/2022/11/22-101-LG_DOHAdvisoryLiftMemo-signed-1.pdf.

[9] DOH Guidance on the Approach to Amending the Public Health Advisory, February 12, 2022: https://health.hawaii.gov/about/files/2022/02/DOHGuidanceOnApproachToAmendPublicHealthAdvisory.20220212-part-1-signed.pdf. The ISP for Combined Total Petroleum Hydrocarbons (TPH) was updated to 266 µg/L in the June 2022 Drinking Water Long-Term Monitoring Plan: https://health.hawaii.gov/about/files/2022/08/JBPHH-Drinking-Water-LTM-Plan-FINAL-20220823.pdf.

present as a separate phase, it floats on the water table. JP-5, like all petroleum fuels, is a complex mixture of hundreds of individual compounds that vary in their physical and chemical properties and toxicities. Examples of the most toxic constituents of JP-5 include aromatic compounds, such as benzene and naphthalene. Examples of the less toxic constituents of JP-5 include aliphatic compounds, such as decane and nonane. The JP-5 stored at Red Hill also contained the additive 2-(2-methoxyethoxy)ethanol (also known as diethylene glycol methyl ether; 2,2MEE), a deicing agent.

When laboratories measure for the presence of petroleum, it is not feasible to identify and quantify all the individual compounds that may be present. Instead, samples are typically analyzed in two different ways: 1) quantifying the total mass of "petroleum hydrocarbons" present, and 2) identifying the presence and quantifying the concentration of a small subset of individual compounds that are indicative of petroleum. These two approaches will be further discussed in Sections 2.2, 2.3 and 2.4.

2.2 Total Petroleum Hydrocarbon Analysis

EPA Method 8015C[10]/8015D[11] (referred to as 8015) is part of the SW-846 Compendium[12], a suite of analytical methods developed for sampling environmental media, such as soil and groundwater. 8015 is the analytical method commonly used to quantify TPH; however, it also detects non-petroleum organic compounds. There are over a thousand organic compounds that will be detected by 8015 and categorized based on carbon range. 8015 sums the separate "signals" from each individual analyte and provides a bulk measurement (summation) for the total detected compounds within pre-defined ranges commonly associated with petroleum products, which leads to the term Total Petroleum Hydrocarbons. The term "petroleum" may be misleading within the context of 8015 because non-petroleum mixtures such as vegetable oil can be detected and reported.

The ability to measure TPH as a bulk measurement is an important analytical tool for detecting and quantifying petroleum contamination in the environment, such as in oil spill responses, remediation efforts, and industrial wastewater permitting. Petroleum products, such as fuels and lubricants, are complex and highly variable mixtures of hundreds of individual hydrocarbons. The very large number of hydrocarbon compounds potentially present in petroleum products makes it technically infeasible to identify and quantify all of them individually. In addition, specific petroleum constituents (e.g., benzene and naphthalene), that are quantified through EPA Methods 8260D[13] and 8270E[14] (referred to as 8260D and 8270E, respectively) and are indicative of petroleum contamination, may not be present in quantities above the method detection limits. Thus, the bulk TPH measurement can support the identification of the presence of petroleum contamination in

[10] EPA Method 8015C (SW-846) – Nonhalogenated Organics by Gas Chromatography: https://www.epa.gov/hw-sw846/sw-846-test-method-8015c-nonhalogenated-organics-gas-chromatography.
[11] EPA Method 8015D (SW-846) – Nonhalogenated Organics Using GC/FID, 2003: https://www.epa.gov/esam/epa-method-8015d-sw-846-nonhalogenated-organics-using-gcfid.
[12] EPA SW-846 Compendium: https://www.epa.gov/hw-sw846/sw-846-compendium#8000series.
[13] EPA Method 8260D (SW-846) – Volatile Organic Compounds by GC/MS, 2006: https://www.epa.gov/esam/epa-method-8260d-sw-846-volatile-organic-compounds-gas-chromatography-mass-spectrometry-gcms.
[14] EPA Method 8270E – Semivolatile Organic Compounds by GC/MS: https://www.epa.gov/esam/epa-method-8270e-sw-846-semivolatile-organic-compounds-gas-chromatographymass-spectrometry-gc.

the environment when other targeted analyses are limited due to degredation or dilution. In these environmental applications, TPH is usually measured in the parts per million range, equivalent to milligrams per liter (mg/L).

8015 is the typical method for TPH analysis, though 8260D can also be used for detection of lighter, volatile hydrocarbons. There are two validated 8015 methods: 8015C[10] and 8015D[11]. 8015C is the official method that is included in the SW-846 Compendium. 8015D is a revised method that is validated but not officially added to the SW-846 Compendium through the Federal Register process. 8015C and 8015D have minimal differences and will be referred to collectively as 8015 in this report.

Hydrocarbon mixtures can be evaluated using 8015 by analyzing the distinct chromatographic patterns and retention times (i.e., the duration it takes for a compound to reach the detector after injection). The method compares the data to petroleum product standards and quantifies based on the following ranges: gasoline range organics (TPH-g or GRO), diesel range organics (TPH-d or DRO), and oil range organics (TPH-o or ORO). These three ranges are separately reported and manually summed for a Combined TPH concentration. The methodology utilized by the EPA and Navy defines TPH-g as carbon ranges C5-C12 (C6-C10 for EPA analysis), TPH-d as C10-C24, and TPH-o as C24-C40. Kerosene, jet fuel, and diesel fuel are analyzed within the TPH-d range, but individual constituents of those fuels may be detected in the TPH-g and/or TPH-o ranges. While 8015 has the capability to analyze for all three carbon ranges (TPH-g, TPH-d and TPH-o), 8260D may only be used to analyze for TPH-g.

8015 utilizes gas chromatography flame ionization detection (GC/FID) as the analytical instrumentation. An FID is a non-specific detector that will produce a signal for anything that contains carbon and displays these signals in a chromatogram. 8260D utilizes gas chromatography with mass spectrometry (GC/MS) identification. TPH is a multicomponent parameter that would be plotted and quantified using a Total Ion Chromatogram to display the summed intensity of all detected ions, including noise, for the sample using 8260D. TPH analysis, with methods such as 8015 and 8260D, is therefore a bulk measurement and does not contain direct information about specific constituents within the sample. 8015 and 8260D call for laboratories implementing these methods to sum any “signal” for TPH regardless of pattern, even what is considered noise. Section 2.3.2 further discusses and defines “signals” and “noise”.

2.3 Screening for Fuel in Drinking Water

As mentioned in Section 2.2, 8015 is an analytical method that was developed for sampling environmental media and was not originally intended for analyzing drinking water. Nonetheless, this analytical method provides a broad measure of potential petroleum contamination through the TPH measurement and can serve as a valued screening tool during drinking water investigations and emergency response. However, understanding the uncertainty and limitations inherent with 8015 in measuring and interpreting TPH is important, particularly for the low-level concentrations typically seen in drinking water samples in the order of parts per billion, equivalent to micrograms per liter (µg/L). Further information on the uncertainty and limitations with the TPH analytical methods are found in Sections 2.3.1 and 2.3.3.

For the Red Hill incident investigation, 8015 and 8260D were used as screening methods for reporting the aggregate sum of TPH across specific carbon ranges in drinking water samples. The

EPA Region 9 laboratory analyzed split samples using 8015 for TPH-g, TPH-d, and TPH-o. The EPA Region 8 laboratory also used 8015 for TPH-g and TPH-d but did not have the capability at the time to analyze for TPH-o. The Navy laboratory analyzed for TPH-d and TPH-o (collectively referred to as TPH-d/o) using 8015 and for TPH-g using 8260D.

2.3.1 Limitations in TPH Sampling and Analysis

A particular challenge with the 8015 and 8260D analytical methods is that the results for TPH are not compound-specific and do not distinguish fuel source hydrocarbons from those derived from natural biogenic sources (e.g., soil humus, degraded plant matter). Essentially, both fuel-related and non-fuel-related carbon-containing compounds and mixtures can be detected and labeled as TPH, as prescribed by the analytical methods and reported as such by certified laboratories. This lack of specificity can result in misidentifying biogenic hydrocarbons as petroleum contamination. A few non-fuel-related products that would be detected as TPH under these analyses include petroleum jelly, mineral oil, and cleaning solvents. Therefore, the indiscriminate nature of the analyses can result in false detections of fuel source hydrocarbons in samples. Given this, when samples are expected to have relatively low concentrations of fuel source hydrocarbons, within the µg/L range rather than in the mg/L range, non-fuel or naturally occurring (and non-toxic) biogenic substances have a greater potential to be reported as TPH.

When using 8015 and 8260D for TPH analysis, the only way to determine if a specific fuel mixture is present in the sample is by analyzing a known reference standard of that fuel. The standard would yield a signal pattern in the chromatogram, which is then compared by a qualified[15] analyst to any possible pattern found in the sample. This is not an error-free determinate method and relies on the expertise and experience of the qualified analyst. If a pattern matches a known reference standard of a fuel mixture, it is then qualified and communicated in the laboratory's analytical report. The reported TPH concentrations in the laboratory's analytical report may include qualifiers to provide crucial context about the data quality, issues, limitations, or special conditions. The EPA Region 9 laboratory, for example, uses qualifiers to flag an absence of a fuel or hydrocarbon mixture and to flag the presence of gasoline, kerosene or jet fuel, diesel fuel, motor oil, hydraulic fluid, lacquer thinner, mineral spirits, naphtha, stoddard solvent, turpentine, and unknown mixtures. The qualifiers are assigned when data is reviewed and not automatically generated by the instrument.

Although 8015 and 8260D are used to determine potential fuel contamination in water samples, any detections of TPH may need further evaluation and analyses to confirm that they are fuel in origin, particularly in concentrations below the Method Reporting Limit (MRL or RL). Follow-up evaluations include reviewing chromatograms to determine if the contamination exhibits fuel characteristics and whether specific hydrocarbon indicator compounds (e.g., benzene) are present. If the follow-up evaluation indicates the contamination does not have a fuel signature (e.g., falls outside molecular range, absent of an Unresolved Complex Mixture" (UCM), and absent of fuel indicator compounds), the detection will likely be attributed to biogenic interference.

[15] National Environmental Laboratory Accreditation Program (NELAP) accredited laboratories, that are routinely inspected for accreditation, are required to show an initial and ongoing Demonstration of Capability (DOC) for analysts to be considered qualified to complete a specific analysis, including but not limited to chromatogram interpretation and integration. Each laboratory has an SOP for DOC requirements.

Due to these limitations, reported TPH results alone should not be used as definitive evidence of fuel in the drinking water for this investigation. All TPH results in the Red Hill investigation have been interpreted with other lines of evidence in this report to determine potential impacts from the incident.

2.3.2 Chromatogram Analysis

A chromatogram is a graphical representation of the detector response (signal) as a function of time. Chromatograms are used to identify and quantify the components of mixtures that have been separated by a chromatographic technique, such as gas chromatography (GC). The International Union of Pure and Applied Chemistry (IUPAC) definition of a signal is the "representation of a quantity within an analytical instrument"[16]. As such, the signal in a chromatogram is represented by the peaks in the signal axis (y-axis), and the height or area of the peak is proportional to the concentration of different compounds in the sample. The position of the signal or peak along the time axis (x-axis) is used by analysts to identify individual compounds, since different components elute at different times. Generally, for a sample of a pure substance, a chromatogram would yield a single peak, whereas for samples of mixtures, multiple peaks would be present in the chromatogram. Known mixtures, such as fuel, also have a unique "fingerprint", or pattern of peaks, in the chromatogram. The laboratory also uses chromatograms to develop calibration curves to calculate the concentrations of the compounds of interest. See Figure 1 for an example of a chromatogram for a blank sample and for a typical sample in this incident investigation.

When reviewing chromatograms, qualified analysts must also visually inspect the chromatograms to distinguish between analyte (substance of interest) and noise. The IUPAC definition of noise is "the random fluctuations occurring in a signal that are inherent in the combination of instrument and method"[17]. The practical definition of noise is a signal that does not contain relevant information for the analysis. Thus, for the Red Hill incident investigation, qualified analysts reviewed the chromatograms to identify a potential fuel pattern (i.e., hydrocarbon pattern of interest) signal with the remaining signals considered to be noise. The results of this review are included in the laboratory analytical reports, in which laboratory data qualifiers (i.e., flags) are assigned to the calculated concentrations of TPH to define the presence or absence of the fuel type.

The upper image in Figure 1 shows a chromatogram of a blank with a few peaks that amount to an area with a calculated concentration below the Method Detection Limit (MDL), yielding a non-detect (ND) value. Below the blank in Figure 1 is a chromatogram of a sample with an area that calculated to a concentration above the MDL and received an F1 flag. The assigned F1 flag states that this is not a hydrocarbon pattern. This shows that an increase in noise caused an increase in area, and therefore, an increase in calculated concentration.

[16] IUPAC definition of "signal": https://goldbook.iupac.org/terms/view/S05661
[17] IUPAC definition of "noise": https://goldbook.iupac.org/terms/view/N04175

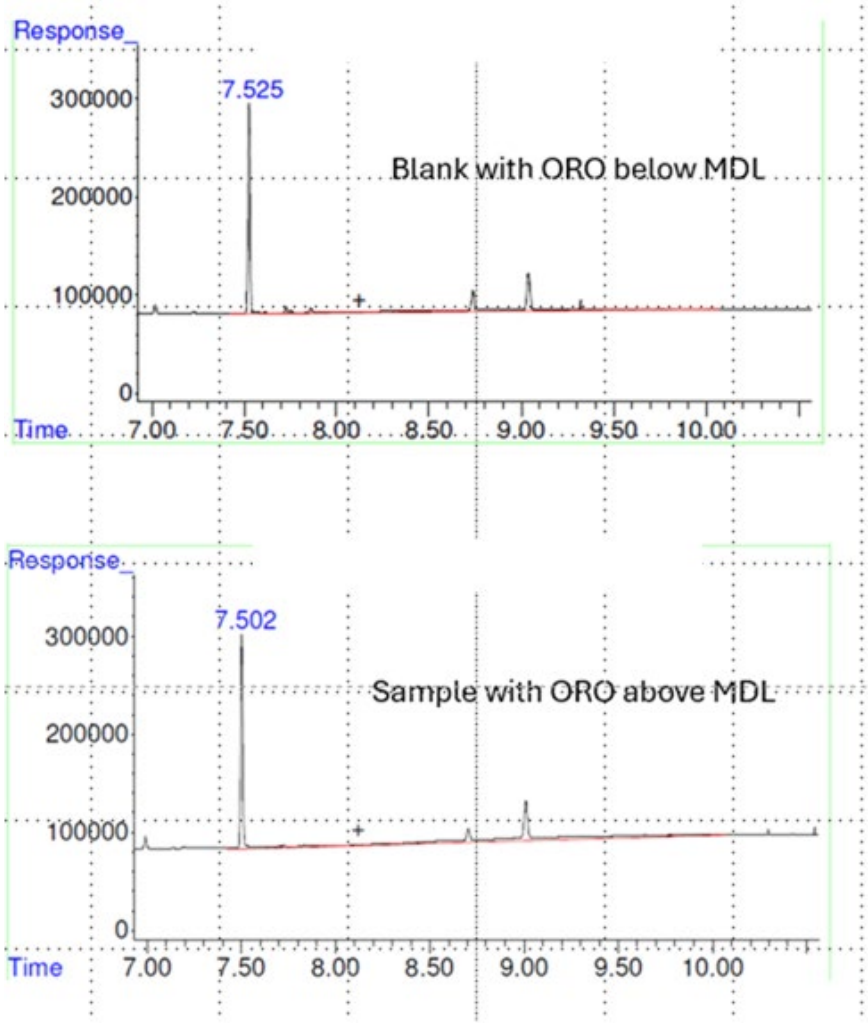

Figure 1. Chromatogram of a blank (top) and a typical sample (bottom). The peak at 7.5 minutes is the surrogate.

All analytical processes, though not all the same, can contribute to noise, and the source of the noise can vary. For example, the detector and the apparatus used for extraction or sample preparation can both contribute to noise. Noise is used for the development of the MDL, which is the lowest concentration of an analyte that can be reported with 99% confidence that the analyte concentration is greater than zero (i.e., a detection). MDL determination is difficult when a pattern is needed for identification. Similarly, noise is also used to develop the laboratory RL, which is the lowest concentration that can be reported with a high level of confidence to be the true concentration. Laboratories target a 99% confidence, but the actual percentage is laboratory specific.

2.3.2.1 TPH Analysis in Chromatograms

As discussed in Section 2.3.2, laboratories can only compare patterns from analyses against known patterns (i.e., standards), and qualified analysts assess the chromatograms for these known and recognizable patterns. All unrecognizable patterns, particularly low “background” level

signals, is considered noise. Fuels will display a consistent, unique pattern on the chromatogram, similar to a fingerprint.

As part of analyzing TPH via 8015 or 8260D, an analyst reviews the chromatogram produced during analysis to assess for a fuel-related pattern, such as JP-5. Chromatograms are compared to that of the JP-5 standard by comparing the time when the pattern is observed, such as from 4.35 to 5.75 minutes. The example chromatograms in Figure 1 and Figure 2 are typical from the analysis performed by EPA during the Red Hill incident investigation. DRO or TPH-d is a label given to any signal that is detected within the same range as diesel fuel on the chromatogram (elution range is approximately 4.40 to 7.60 minutes for the EPA Region 9 method). Figure 2 shows a typical chromatogram of a JP-5 standard compared to a sample that had a concentration of TPH-d below the MDL and reported as ND.

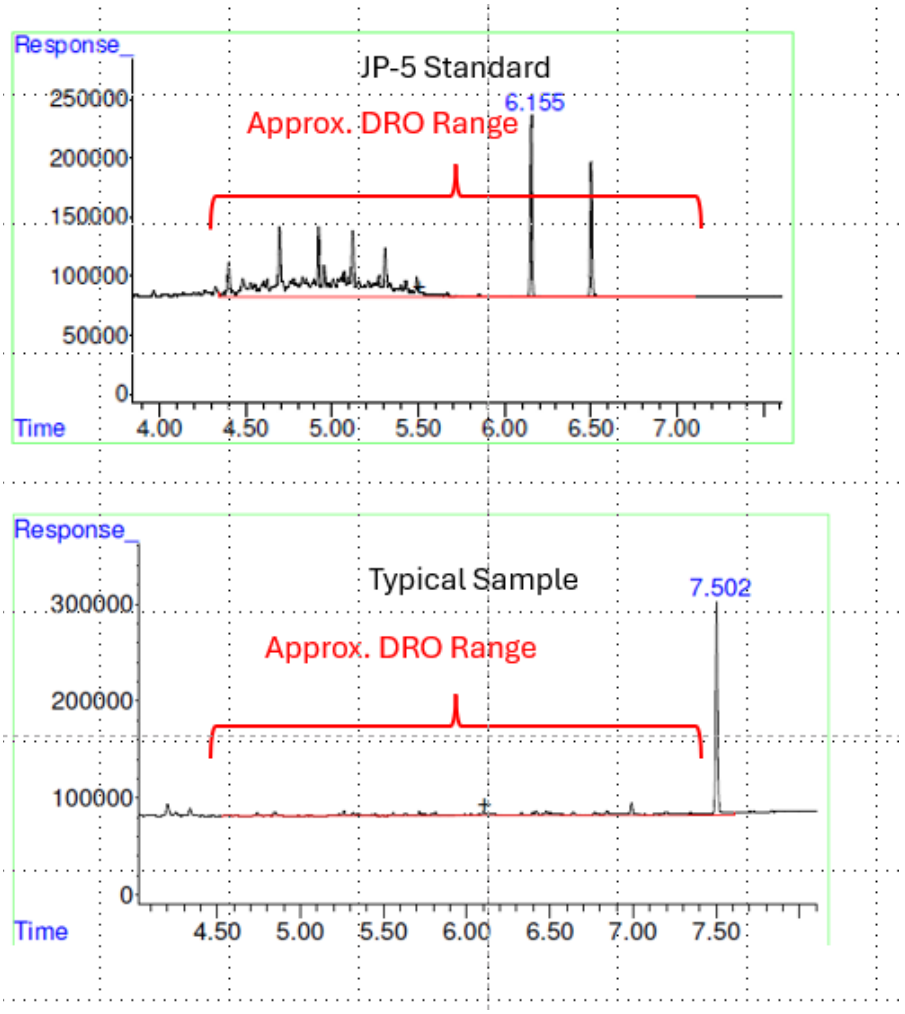

Figure 2. Chromatogram of a JP-5 standard and a typical sample.

2.3.3 Interpreting Analytical Results and Uncertainty

TPH results have a degree of uncertainty because they rely on interpretation of chromatogram patterns, and the reported totals can vary with chosen carbon-range windows. Nonetheless, interpretation is essential when analyzing for TPH with methods such as 8015 because the hydrocarbon pattern is the useable signal. 8015 states that “if this method is used for the analysis

of petroleum hydrocarbons, it is limited to analysts experienced in the interpretation of hydrocarbon data". For the interpretation of results, close attention should be paid to the qualifiers the laboratory uses to communicate the signal (i.e., the noise and patterns the analyst observes in the chromatograms). Furthermore, qualifiers may not provide specifics if there are degraded mixtures and/or unknown mixtures, which would be labeled as an unknown mixture in the analytical report, thus there is added uncertainty related to what that mixture is.

TPH analysis via methods such as 8015 are also susceptible to misinterpretation due to the broad retention time ranges and the associated large area of integration. For instance, see the broad range of TPH-d in Figure 2. Retention time is an important marker for identifying an analyte of interest. Therefore, having a broader range leads to a loss in specificity of identification with a nonspecific detector. This is the case for 8015, since the flame ionization detector used in the method is non-specific. Furthermore, the calibration curves used for calculating concentrations that are created by analyzing standards have the greatest uncertainty at the ends (i.e., high and low).

TPH *can be* a reliable fuel indicator at high concentrations (typically above 300 µg/L), which were only observed in the drinking water shortly after the Red Hill incident. However, at low levels, particularly at levels below the RL, TPH data is less definitive. The lower the concentration, the harder it is to distinguish TPH (i.e., a hydrocarbon pattern) from noise. At these low levels below the RL, given the distribution of peaks (see Figure 2), there is uncertainty in identifying the potential fuel mixture and identification needs to be done via analyst judgement and comparison with a standard. Furthermore, fuel mixtures weather and degrade over time and may differ from analytical standards prepared in the lab, increasing uncertainty in the TPH analysis.

In summary, for TPH analysis via 8015, and other similar methods, there is uncertainty in what is being reported (e.g., signal/noise), in the judgement of the analyst reviewing the chromatograms, and in the condition and certainty of the fuel mixture itself. The overall uncertainty cannot be quantified but the concerns discussed above should be considered when interpreting 8015 analytical data. As such, TPH and data from individual fuel components should be considered together to provide evidence of drinking water fuel contamination. Furthermore, there have been several reports and memos written by the DOH discussing the limitations and uncertainty related to TPH data:

- A memo discussing the composition of what was spilled (https://health.hawaii.gov/about/files/2023/02/Red-Hill-Shaft-DW-System-Contamination-HIDOH-Feb-2-2023-2.pdf), which provided information on fuel indicators in JP-5.
- A memo that summarizes a study investigating the water accommodated fraction of JP-5 (https://health.hawaii.gov/heer/files/2024/04/JP-5-WAF-Study-Report-Newfields-July-2023.pdf), providing information on what fuel indicators would be found in water.
- A report discussing the limitations of Method 8015D in low level TPH-d analyses (https://health.hawaii.gov/news/files/2024/05/JBPHH-HIDOH-DW-Report-20240510.pdf), stating that the method used for TPH-d, and TPH-o is "not able to definitively determine if low-level petroleum hydrocarbons are present or if TPH and TPH-d concentrations are due to the presence of non-petroleum chemicals",
- A memo stating the unreliability of using values below the RL (https://health.hawaii.gov/heer/files/2024/06/Use-of-TPH-Action-Levels-HIDOH-June-2024.pdf).

- Finally, a useful resource for interpreting low level detections and quantification was published by the Department of Defense and posted by DOH (https://health.hawaii.gov/ust/files/2019/12/2019-11-3rd-qtr-gw-monitoring-rept-App-C.3-DODEDQWFactSheet20171113.pdf).

2.4 Targeted Analyses

For the Red Hill incident investigation, targeted methods were used to determine if TPH detections in the drinking water were associated with fuels or other hydrocarbon mixtures. As mentioned in Section 2.3, TPH analysis produces chromatograms that must be interpreted by experienced analysts and flagged accordingly to confirm a presence or absence of fuels. Targeted methods analyze for a specific list of individual compounds, such as naphthalene and toluene, which may also be detected as TPH. The following subsections discuss the fuel indicating compounds and targeted analytical methods used to assess the presence of fuel in drinking water.

2.4.1 Volatile Organic Compounds

Volatile Organic Compounds (VOCs) are carbon-based analytes with high vapor pressures that tend to form gases at relatively low temperatures. VOCs detected in JP-5 include hydrocarbons that are naturally found in petroleum, such as BTEX (benzene, toluene, ethylbenzene, and xylene), 1,2,4-trimethylbenzene, and isopropylbenzene. Other VOCs, including ethylene dibromide (also known as 1,2-dibromoethane or EDB) are not a known constituent of JP-5; however, it is a common additive in aviation gasolines and may provide insight into the presence of potential leaks into the distribution system. Laboratories commonly monitor purgeable VOCs in drinking water samples using validated methods, as discussed in Section 2.4.1.1.

2.4.1.1 EPA Methods 524.2 and 504.1 - VOCs

EPA Method 524.2[18], Revision 4.1 (referred to as 524.2) targets and measures up to 84 VOCs in surface water, groundwater, and drinking water, including 11 constituents of JP-5. EPA regulates[19,20] over 20 individual VOCs setting legally enforceable MCLs in drinking water for chemicals such as benzene and tetrachloroethylene. 524.2 is also an approved analytical method for drinking water compliance monitoring of organic contaminants as specified in the NPDWR[21]. 524.2 employs GC/MS and commonly uses Single Ion Monitoring (SIM) to detect individual analytes. SIM is a highly sensitive MS technique that scans for specified mass-to-charge (m/z) ratios in a set retention time window. After gas chromatography separates a compound, the compound is ionized and fragmented. The MS detector will detect the parent and fragment ions and record them as peaks defined by their m/z ratios and retention times, which are distinctive for

[18] EPA Method 524.2 - Measurement of Purgeable Organic Compounds in Water: https://www.epa.gov/esam/epa-method-5242-measurement-purgeable-organic-compounds-water-capillary-column-gas.
[19] EPA chemical contaminant rule summary for Phase II/V Rules in the Code of Federal Regulations: https://www.epa.gov/dwreginfo/chemical-contaminant-rule-phase-iiv-rules-code-federal-regulations.
[20] EPA Stage 1 and Stage 2 Disinfectants and Disinfection Byproducts Rule summary: https://www.epa.gov/dwreginfo/stage-1-and-stage-2-disinfectants-and-disinfection-byproducts-rules#rule-summary.
[21] The methods required to meet Federal drinking water standards for the sample and analysis of organic chemicals are specific in the Code of Federal Regulations Title 40, § 141.24(e): https://www.ecfr.gov/current/title-40/chapter-I/subchapter-D/part-141/subpart-C/section-141.24.

all individual analytes. Once an analyte is identified, its concentration is measured using an internal standard calibration procedure, typical of most methods unless otherwise noted.

EPA Method 504.1[22] (referred to as 504.1) may be used specifically for detection of three VOCs, including EDB. 504.1 is a highly sensitive groundwater and drinking water method that prescribes microextraction to concentrate and extract analytes of concern prior to injection into a gas chromatography - linear electron capture detector (GC/ECD). ECD uses electron capture ionization to detect trace amounts of an analyte of concern, typically halogenated compounds like EDB. EPA regulates[19] EDB in drinking water with a legally enforceable MCL of 0.05 µg/L. 504.1 is the analytical method approved for drinking water compliance monitoring of EDB as specified in the NPDWR[21] since 504.1 is more sensitive than 524.2, and depending on the analytical instrumentation used, 524.2 does not typically include RLs below 0.05 µg/L. Nonetheless, for drinking water sampling and monitoring outside of regulatory compliance monitoring, 524.2 may be used to analyze for EDB.

The Navy laboratory used 524.2 for general VOC analysis and 504.1 for EDB. The EPA Region 9 laboratory analyzed VOCs, including EDB, via the 524.2 full method list. The EDB RLs are 0.022 µg/L for the Navy's 504.1 method and 0.5 µg/L for EPA's 524.2 method.

2.4.1.2 EPA Method 8260D Modified for Paraffins, Isoparaffins, Aromatics, Naphthenes, and Olefins (PIANO)

The Navy employed a modified 8260D[13] for PIANO analysis (referred to as 8260D PIANO) to identify and quantify 68 VOC analytes previously detected in JP-5 samples collected from the Red Hill Bulk Storage fuel tanks. 8260D PIANO is used to analyze 143 VOCs in total. The samples undergo purge-and-trap extraction prior to injection into the GC/MS and quantified via internal standard calibration curves. 8260D PIANO provides a moderately sensitive method, with RLs ranging from 1-5 µg/L, for the detection of an extensive list of JP-5 constituents, the presence of which would confirm the presence or absence of residual fuel oils in a distribution system. As mentioned in Section 2.3, the Navy utilized 8260D as a method for TPH-g analysis, in addition to PIANO analysis.

2.4.2 Semivolatile Organic Compounds

Semivolatile Organic Compounds (SVOCs) consist of organic compounds with lower volatility and water solubility than VOCs. SVOCs include components of JP-5 and compounds with potential associations with other petroleum products, serving as a key indicator of JP-5 and other fuel oils. For instance, DOH's contract laboratory analyzed a sample of JP-5 fuel and a positive detection[23] of 2,2MEE confirmed the usage of 2,2MEE as a Fuel System Icing Inhibitor additive in JP-5, as described in Section 2.2 of DOH's June 2023 Exposure Assessment[24]. As such, 2,2MEE was selected as a targeted analyte to support any potential impacts to the drinking water from the Red Hill incident.

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[22] EPA Method 504.1 – 1,2-dibromoethane (EDB) and 1,2-dibromo-3-chloropropane (DBCP) in Water: https://www.nemi.gov/methods/method_summary/4825/.

[23] NewFields JP-5 analysis laboratory report: https://health.hawaii.gov/about/files/2023/08/ATT-4-WAF-Lab-Report-Newfields-June-2023.pdf.

[24] DOH – Exposure Assessment: November 2021 Release of JP-5 Jet Fuel into the Joint Base Pearl Harbor Hickam and Connected Drinking Water Systems, updated October 2, 2023: https://health.hawaii.gov/about/files/2023/10/JP-5-Exposure-Assessment-June-2023-updated-Oct-2-2023.pdf.

2.4.2.1 EPA Methods 525.2/525.3 and 8270E - SVOCs

EPA Methods 525.2[25]/525.3[26] (referred to as 525.2/525.3) may be used to measure over 120 SVOCs. EPA regulates[19] over 30 specific synthetic organic contaminants (SOCs), 17 of which are analyzed via 525.2/525.3, setting legally enforceable MCLs and treatment technique requirements in drinking water for these man-made organic chemicals that include SVOCs such as benzo[a]pyrene. 525.2/525.3 are also analytical methods approved for drinking water compliance monitoring of organic contaminants as specified in the NPDWR[21]. 525.3 is a newer revised version of 525.2; however, the two methods are expected to yield similar results above the RLs, with the former method having a higher sensitivity (i.e., lower MDL and RL). 525.3 analyzes an additional 27 analytes when compared to 525.2. In 525.2, samples are concentrated with C-18 solid-phase extraction (SPE) and analytes are subsequently separated and detected via GC/MS with a full-scan mode. 525.3 utilizes polymeric-based SPE and the resulting extract is analyzed with a GC/MS using SIM.

SVOCs can also be analyzed with 8270E[14], which is included under the SW-846 Compendium. 8270E allows the usage of either microextraction or SPE to separate SVOCs from the sample matrix and recommends the extracts to be screened on a GC/FID or gas chromatography – photoionization detector (GC/PID) to limit contamination of the GC/MS. Measurement and detection of SVOC target analytes are conducted using GC/MS with SIM or gas chromatography with tandem mass spectrometry (GC/MS/MS) with multiple reaction monitoring (MRM). 8270E can be used to analyze for 2,2MEE, a fuel system icing inhibitor in jet fuel (as discussed in Section 2.4.2).

The Navy used 525.2 for SVOC analysis and 8270E to analyze for 2,2MEE. The EPA Region 9 subcontract laboratory utilized 525.3 for benzo[a]pyrene (BaP) analysis, 8270E for the full list of SVOCs, and an internal method Standard Operating Procedure (SOP) 3915 for 2,2MEE.

2.4.2.2 Comparing MDLs and RLs for Similar Analytical Methods

The employment of differing extraction techniques and analytical instrumentation for the same analysis can significantly affect method sensitivity. The MDLs and RLs for EPA's 525.3 and 8270E are one to two orders of magnitude lower than the Navy's MDLs and RLs for 525.2 (see Section 5.5.3, Table 17 and Table 18). Due to the consistency and accuracy of 525.2/525.3 for drinking water analysis and inclusion under EPA's approved analytical methods for drinking water compliance monitoring[27], 525.2/525.3 is a reliable and sensitive method that can reliably report concentrations below applicable federal and state drinking water standards.

2.5 Enforceable Standards

The SDWA[1] directs the Administrator of EPA to promulgate NPDWR for contaminants where there is scientific evidence of the potential for adverse health effects from exposure to the contaminant in

[25] EPA Method 525.2 – Determination of Organic Compounds in Drinking Water: https://www.epa.gov/esam/epa-method-5252-determination-organic-compounds-drinking-water-liquid-solid-extraction-and.
[26] EPA Method 525.3 – Analysis of Semivolatiles in Drinking Water: https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100I9ZG.txt. https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=NERL&dirEntryId=252043.
[27] EPA - Analytical Methods Approved for Drinking Water Compliance Monitoring of Organic Contaminants, January 2024: https://www.epa.gov/system/files/documents/2024-02/organic-methods-table.pdf.

drinking water. Some contaminants may not be regulated due to such factors as insufficient scientific data on health effects, analytical method detection challenges, lack of occurrence information, and limited significance as a national concern. As noted throughout Section 2, fuels are mixtures of contaminants with varying toxicity; EPA does not regulate fuels as mixtures but instead regulates the most toxic chemical ingredients through MCLs and requires the use of more precise analytical methods (e.g., EPA methods 524 and 525, among others).

The means for determining violations of the MCLs for the regulated VOCs and SOCs that would be found in fuel are established in the NPDWR[28,29]. The NPDWR requires that sampling points be representative of the water quality from each source after treatment (i.e., representative of water quality throughout the distribution system). Additionally, the NPDWR establishes that violations should be determined based on a running annual average of the results, indicating a persistent issue with water quality (i.e., the system must exceed the MCL for one year, except where results are greater than four times the MCL or may otherwise result in an MCL violation). The NPDWR provides that violation determinations should not be based on a single sample by allowing for confirmation samples and averaging amongst the total number of samples taken. Consequently, individual sample results may exceed an MCL, referred to as an MCL exceedance; however, this may not result in an MCL violation unless it meets the criteria established in the NPDWR.

3.0 Emergency Response

This section outlines key activities during the emergency response to the 2021 Red Hill jet fuel release incident, including water system flushing and sampling. EPA defines the emergency response phase as the period of time during which the PWSs were subject to the UWA. The subsections below detail the flushing and sampling activities, as well as other lines of evidence that supported amending and ultimately lifting the UWA, ending the emergency response phase.

In response to customer complaints in late November 2021, EPA and DOH On-Scene Coordinators (OSCs) deployed to investigate the possible contamination. Under the authority of the Hawai'i Revised Statutes (HRS) Chapter 340E-4[30], on November 29, 2021, DOH issued the UWA for the entire JBPHH PWS and the AMR PWS[31]. In response to the fuel release, the Interagency Drinking Water System Team (IDWST) was established with representation from EPA, the Navy, the Army and DOH. The primary focus of the IDWST was to restore safe drinking water to the affected water consumers in the PWSS service areas.

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[28] MCL violation criteria for SOCs: https://www.ecfr.gov/current/title-40/part-141/section-141.24#p-141.24(h)(11).

[29] MCL violation criteria for VOCs: https://www.ecfr.gov/current/title-40/part-141/section-141.24#p-141.24(f)(15).

[30] Hawai'i Revised Statues Chapter 340E-4, Safe Drinking Water, Imminent Hazards (Volume 6, last modified on 01/05/2026): https://www.capitol.hawaii.gov/hrscurrent/Vol06_Ch0321-0344/HRS0340E/HRS_0340E-0004.htm.

[31] Hawai'i Department of Health advises Navy water system consumers not to drink, consume tap water, November 29, 2021: https://health.hawaii.gov/news/files/2021/11/21-165-DOH-advises-Navy-water-system-consumers-not-to-drink-consume-tap-water.pdf.

The emergency response phase took approximately four months to complete. The IDWST developed a Drinking Water System Recovery Plan[32] ("Recovery Plan") and a sampling and analysis plan titled the Drinking Water Sampling Plan[33] ("SAP"), to establish a stepwise approach to response and recovery of the PWSs. The Recovery Plan and the SAP detailed response activities (including flushing) to remove contaminants from the system, sampling to evaluate the efficacy of the response activities, and long-term monitoring to ensure that water quality continued to meet drinking water standards and the Incident Specific Parameters (ISPs).

ISPs are specialized metrics that are dervied from measurable inputs specific to the incident that aim to capture the severity or impact of a particular incident, such as a unique contamination event or an environmental release. Unlike regulatory thresholds (e.g., MCLs) or general measures of contamination (e.g., environmental action levels (EALs)), ISPs are tailored to the specific context of an incident, setting criteria and data points for the exact contaminants involved and other specific environmental conditions. Typical input values that generate the ISPs include the volume of contaminants released, the toxicity or hazard class of the contaminant, the sensitive receptors affected, and the human health impact. For contamination events in Hawai'i, DOH calculates and sets the ISPs based on environmental and health risks with incident-specific factors.

The Removal Action Reports (RARs) served as the basis for amending the UWA per zone by DOH. These reports were prepared after completing all flushing and remediation activities, confirming that the latest samples were below the ISPs, and thereby meeting IDWST goals and objectives. The RARs compiled flushing and sampling records, lab reports, and evaluations of detections or exceedances of the ISPs. The Navy and Army documented distribution system and water quality conditions to justify the amendments to the UWA through the RARs.

The response phase ended when the UWA was amended by DOH to allow for unrestricted use on March 18, 2022[34]. While the UWA received its final amendment in March 2022, it was not lifted until October 26, 2022. Please note that the subsequent lifting of the UWA in October 2022 was an administrative step by DOH that formalized the end of the advisory for the entire system, long after all zones had already been cleared for unrestricted use of drinking water.

3.1 Emergency Authorities

Chapter 342L-9[35] of the HRS grants the Governor of Hawai'i or the Director of DOH emergency powers to take necessary actions if there is imminent peril to human health and safety or the environment caused by a release from an underground storage tank system. In addition, Chapter 340E-4[30] of the HRS grants the Director of DOH authority to take any actions necessary to protect human health upon learning that a contaminant is present or likely to enter a public water system

[32] IDWST Drinking Water Distribution System Recovery Plan, December 2021: https://health.hawaii.gov/about/files/2021/12/Drinking-Water-Distribution-System-Recovery-Plan.pdf.
[33] JBPHH Flushing and Sampling Plan, December 2021: https://www.cpf.navy.mil/JBPHH-Water-Updates/Flushing-and-Sampling-Plan/.
[34] DOH Declares Four Navy Drinking Water Distribution System Zones Safe, March 18, 2022: https://health.hawaii.gov/news/newsroom/doh-declares-four-navy-drinking-water-distribution-system-zones-safe/.
[35] Hawai'i Revised Statues Chapter 342L-9, Underground Storage Tanks, Emergency Powers (Volume 6, last modified on 01/05/2026): https://www.capitol.hawaii.gov/hrscurrent/Vol06_Ch0321-0344/HRS0342L/HRS_0342L-0009.htm.

or an underground source of drinking water and may present an imminent and substantial danger to the public. Moreover, the Hawai'i Administrative Rules (HAR) Title 11, Chapter 19[36] grants DOH the authority to prescribe appropriate procedures to be undertaken by water suppliers to minimize health risk resulting from any such contamination of drinking water on all emergency circumstances involving drinking water. These state authorities, similar to the federal authority, are not limited to regulated contaminants as unregulated contaminants may meet the definition of presenting an imminent and substantial danger to the public.

SDWA Section 1431[37] grants the EPA Administrator emergency powers to take actions as deemed necessary to protect public health against imminent and substantial endangerment upon receipt of information that a contaminant is present or likely to enter a public water system or underground source of drinking water and appropriate state and local authorities have not acted to abate the threat. This Federal authority is not limited to regulated contaminants, as SDWA[38] defines "contaminant" broadly to include "*any physical, chemical, biological, or radiological substance or matter in water*". While SDWA 1431 was not exercised during the emergency response phase, it was one basis of authority for the 2023 ACO (see Section 4.6.2).

3.2 System Flushing

This subsection describes flushing plans and activities that are only related to the emergency response phase. The primary method for removing contaminants from a drinking water distribution system is to flush the contaminants out. Unidirectional flushing (UDF) is the most effective approach because it prevents contaminants from being pushed into areas that may not have been contaminated, and it prevents contaminated water from circulating back into areas that have already been flushed. However, at the time of the incident, the PWSs did not have an established UDF plan. On December 8, 2021, DOH issued a directive to the Navy to develop a written flushing plan[39]. The Recovery Plan included four stages, two of which are discussed further in Section 3.2: Stage 1: Recover Distribution System and Tanks; and Stage 2: Flushing Points of Service (e.g., buildings, etc.). As discussed in Section 3.3, prior to beginning any flushing, the Waiawa Shaft was sampled to establish baseline water quality and to ensure that the PWSs were not being flushed with contaminated water.

As of the date of this report, the Waiawa Shaft is the sole source of water for the PWSs. The Red Hill Shaft was deactivated on November 28, 2021, due to the incident. The Aiea-Halawa Shaft was taken offline on December 3, 2021, as a precaution due to its close proximity to the incident.

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[36]Hawai'i Administrative Rules – Title 11, Chapter 19 Emergency Plan for Safe Drinking Water: https://health.hawaii.gov/opppd/files/2015/06/11-19.pdf.

[37] Section 1431 of the SDWA, also referred to as 42 U.S.C. § 300(i): https://uscode.house.gov/view.xhtml?req=granuleid%3AUSC-prelim-title42-chapter6A-subchapter12&saved=%7CZ3JhbnVsZWlkOlVTQy1wcmVsaW0tdGl0bGU0Mi1zZWN0aW9uMzAwZg%3D%3D%7C%7C%7C0%7Cfalse%7Cprelim&edition=prelim.

[38] 42 U.S.C. § 300f(6): https://uscode.house.gov/view.xhtml?path=/prelim@title42/chapter6A/subchapter12&edition=prelim.

[39] DOH Directive One (Effective Immediately) – Flushing Requirements, December 8, 2021: https://health.hawaii.gov/about/files/2021/12/DOH-Directive-Flushing.pdf.

According to information available on the Navy's website[40], the Red Hill and Aiea-Halawa Shafts accounted for 15-18% and 2-5% of JBPHH PWS's water capacity, respectively.

3.2.1 Flushing Plan

The IDWST developed flushing plans for the distribution system, homes, and non-residential buildings under the Recovery Plan. While the Navy had not previously developed a UDF plan for the distribution system, the flushing plan that was developed for the distribution system attempted to achieve unidirectional flow based on the operator's best understanding of the system dynamics and the change in flow dynamics due to the new source of water supply, the Waiawa Shaft. The distribution system flushing plan also divided up the system into discrete zones ("flushing zones") that delineated the flow of water from Waiawa Shaft into areas that could be isolated by valves. The IDWST also developed separate flushing plans for homes and non-residential buildings. The Recovery Plan included an enclosure that was titled "UDF Plan"; however, this was specifically developed for remediation of the system during the emergency response and is not considered a traditional UDF[41] designed for long-term use by the PWSs.

All mainline flushing was discharged through a mobile granular activated carbon (GAC) unit, which led the Navy to develop a volumetric exchange concept for each zone since traditional scouring line velocity was not achievable. This volumetric approach was also applied to storage tanks and certain household appurtenances.

The goal of the emergency response UDF Plan was to purge contaminants that originated from the Red Hill Shaft, and their residuals, from the PWSs by pumping water into the PWSs exclusively from the Waiawa Shaft, which was unaffected by the incident due to its distance from Red Hill. Once uncontaminated water from the Waiawa Shaft was flowing into the PWS's distribution system, flushing commenced in the established zone closest to the source, moving downstream of the distribution system by zone. After distribution main flushing was completed in a zone, sampling (as discussed in Section 3.3.2.1) was conducted to verify that contaminants of concern were not present before proceeding with flushing the next zone downstream or before beginning the flushing of residential and non-residential buildings in the current zone.

To achieve adequate flushing of the distribution mains, the Recovery Plan identified the total volume of water that resides within each zone of the distribution system and used that information to establish the target volume of water to flush from each zone. The target volume ranged from 1 to five volumetric turnovers. To achieve adequate flushing from residential and non-residential buildings, the respective plans established flushing targets by a set flushing time, except for toilets which were flushed thrice and not at a set time. As discussed in Section 3.0, the flushing targets and accomplishments for each zone are documented in the RARs for each zone[42].

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[40] Safe Waters, Joint Base Pearl Harbor – Hickam - Well Recovery and Water Resiliency,: https://jbphh-safewaters.org/public/framework/appcontainer.aspx?url=html.aspx&idhtml=10814&title=Well%20Recovery%20and%20Water%20Resiliency&idMenu=103804&ddlDSN=SYSTM&DSN=SYSTM.

[41] The 2023 Administrative Consent Order (ACO; see Section 4.6.2), requires the JBPHH to develop a system UDF plan, separate from the emergency response UDF plan, for EPA approval with specified requirements. EPA approved the JBPHH PWS UDF plan on October 7, 2025.

[42] JBPHH Water System Zone Map, last updated March 14, 2025: https://jbphh-safewaters.org/public/framework/appcontainer.aspx?url=html.aspx&idhtml=10738&title=Water%20System%20Zone%20Map&idMenu=88798&ddlDSN=SYSTM&DSN=SYSTM.

3.2.2 Flushing Activities

Flushing occurred at storage tanks, distribution mains, and buildings. Water was flushed from tanks and distribution mains through fire hydrants. Discharges from hydrants were treated by portable GAC units. Water flushed from building fixtures flowed to the sanitary sewer system for treatment at the wastewater treatment plant.

Based on the pipe diameters of the water mains, the volumetric flushing rate necessary to achieve scouring velocities was not possible due to limitations of the GAC treatment units' volumetric flow capacities. However, the IDWST deemed the flushing as acceptable based on plans to flush the service connections and to conduct rigorous sampling.

3.2.2.1 Storage Tank Flushing

The PWSs have a total of ten drinking water storage tanks: Halawa Tanks S1 and S2; Red Hill Tanks 685 and 316; Camp Smith Tanks 325, 326, and 327; and AMR Tanks North, Middle, and South.

3.2.2.1.1 Tanks S1 and S2

The RAR for Zone F1[43], among other RARs, contains a "S1 and S2 Water Storage Tank Flushing Report Memo", dated February 11, 2022, that states that Tank S1 was "flushed by cycling the water tank for five volumetric flushes", approximately 25-30 million gallons (MG) of water. It should be noted that the Navy reported that the tank was never run dry, but rather was flushed out to approximately 20% capacity, then refilled. This was critical to maintain pressure throughout the PWS, a sanitary necessity. The report also states that Tank S2 was taken out of service and is being scheduled for cleaning and maintenance. A Memorandum for Record, dated February 25, 2022, and included in the RAR, states that Tank S2 "has been secured from the rest of the system since December 22, 2021". EPA interprets this to mean that the tank was at least isolated from the system by valves; however, the Memorandum does not specify the way that Tank S2 was "secured". The Memorandum also states that at the time the tank was secured, a water sample was collected and was "non-detect for TPH". EPA also understands that Tank S2 has been replaced and is back online since January 15, 2026.

3.2.2.1.2 Red Hill Tanks 685 and 316

Flushing activities for the Red Hill Tanks are documented in the RAR for Zone I1[44]. The RAR includes a Memorandum dated February 7, 2022, with the subject "Army Flushing Report for Zone I1" and identifies two, 250,000-gallon (0.25 MG) tanks that are fed by a 30-inch pipe and provide drinking water storage for Red Hill Housing. This is also stated in the February 2022, "Army Flushing Report for Red Hill Housing Area Zone I1" (I1 Flushing Report) within the RAR for Zone I1. The memorandum states that "tank volumes were cycled prior to [pipe] flushing". While the memorandum does not specify how many tank volumes were cycled, the Recovery Plan identifies Zone I1 as being subject to five volumetric turnovers. Flushing logs within the RAR for Zone I1 present two flushing scenarios, "Navy Lines to I1" and "Zone I1 – Red Hill". With the 0.5 MG of total storage, 2.5 MG would be required to achieve five volumetric turnovers within the tanks. While the

[43] IDWST Documentation to Amend Drinking Water Health Advisory in Zone F1 (Removal Action Report), March 2022: https://health.hawaii.gov/about/files/2022/03/jbphh_011280.pdf.
[44] IDWST Documentation to Amend Drinking Water Health Advisory in Zone I1 (Removal Action Report), February 2022 (link on next page): https://health.hawaii.gov/about/files/2022/02/ZoneI1.RemovalActionReport_NoLabReports.20220213-1.pdf.

RAR did not specify the length of the 30-inch line that feeds the Red Hill Tanks, the flushing logs (see Section 2a.4 of the RAR) show that 4.6 MG were flushed through Navy Lines to I1. Multiple online pipe volume calculators confirm that there are slightly over 3,671 gallons in 100-feet of 30-inch pipe (approximately 193,828 gallons per mile). Removing the volume necessary to flush the tanks (2.5 MG) from the 4.6 MG total, calculations show that the remaining 2.1 MG of flushed water would have been sufficient to flush five volumetric turnovers of a 30-inch transmission line that is over 2.1 miles long. The materials available for review do not specify the actual length of the 30-inch transmission line that supplies the Red Hill Tanks, so EPA cannot immediately determine that adequate volumes were delivered to meet the five volumetric turnover targets; however, the efficacy of the flushing activities is ultimately determined by the water quality analyses (discussed in Section 3.3).

3.2.2.1.3 Camp Smith Tanks 325, 326, and 327

Flushing activities for Camp Smith are documented in the RAR for Zone G1[45]. There are three drinking water storage tanks at Camp Smith. The Zone G1 RAR includes a document titled "Joint Base Pearl Harbor Hickam (JBPHH) Potable Water Description", dated February 26, 2022, which identifies the three tanks as two 0.2 MG and one 0.25 MG ("with usable storage capacity of 140,000 gallons"). The total storage capacity for Camp Smith is 0.54 MG. The Recovery Plan identifies Zone G1 as a Phase 3 Zone that should be flushed by 2 volumetric turnovers. The Memorandum for the Record (located in the Zone G1 RAR), dated January 25, 2022, with the subject as "Distribution System Recovery Plan Addendum – Zone G1 Analysis" included the tank storage volumes within the flushing targets for the entire zone, and flushing of the tanks was not specifically discussed. The Memorandum also describes the flow of water to Camp Smith as flowing via a booster to the storage tanks before distribution for use. In essence, the approach to flushing the tanks was to flush the requisite amount of water through the Camp Smith system via the hydrants achieving the target flushing volume for the tanks and the system simultaneously. While this approach achieved greater flow through the tanks, it does present risks of spreading contaminants through the pipes. However, that risk could be more thoroughly assessed via water quality sampling (discussed in Section 3.3 of this report). The Navy set a flush target of 1.24 MG for Camp Smith and achieved flushing of >1.27 MG.

3.2.2.1.4 Aliamanu Military Reserve Tanks North, Middle, and South

Flushing Zone H1 is served by the Middle Tank, Zone H2 is served by the South Tank, and Zone H3 is served by North Tank, and the corresponding flushing reports for each of those tanks are contained within the respective RARs[46-48] for those zones. All three tanks were targeted for five volumetric turnovers in accordance with the Recovery Plan. The flushing targets for Zone H1, H2, and H3 are calculated based on the volume of pipes and the storage tank within each zone.

The Zone H1 RAR[46] does not specify the volume of Middle Tank; however, based on the June 2024 SDWA inspection (see Section 5.3.1), information regarding tank capacity was available to EPA but is not listed in this report due to identification as sensitive information. The flushing summary spreadsheet in the RAR demonstrates that 0.94 MG was flushed from the tank, exceeding the tank volume. While flushing records included in the H1 RAR do not indicate that five volumetric

[45] IDWST Documentation to Amend Drinking Water Health Advisory in Zone G1 (Removal Action Report), February 2022: https://health.hawaii.gov/about/files/2022/03/jbphh_010814.pdf.
[46] IDWST Documentation to Amend Drinking Water Health Advisory in Zone H1 (Removal Action Report), February 2022: https://health.hawaii.gov/about/files/2022/03/jbphh_010780.pdf.

turnovers were achieved, the Navy signed several documents stating that the tanks, including the South and North Tanks, were flushed according to the Recovery Plan.

The Zone H2 RAR[47] did not specify that actual storage capacity of the South Tank; however, based on the June 2024 SDWA inspection, information regarding tank capacity was available to EPA but not listed in this report due to identification as sensitive information. The flushing summary spreadsheet demonstrates that 0.46 MG were flushed from the tank, exceeding the tank volume but below five volumetric turnovers.

The Zone H3 RAR[48] did not specify that actual storage capacity of the North Tank; however, based on the June 2024 SDWA inspection, information regarding tank capacity was available to EPA but not listed in this report due to identification as sensitive information. The flushing summary spreadsheet demonstrates that 0.68 MG were flushed from the tank, exceeding the volume target.

3.2.2.2 Mainline Flushing Operations

Distribution main flushing began on December 20, 2021, and was completed on January 13, 2022. Flushing occurred through fire hydrants, and to reduce potential contaminant exposure from the purged water, it was treated through GAC filters and discharged to the stormwater or sewer system. Table 1, below, presents the distribution system flushing targets and the actual amount of water flushed. The table demonstrates that the flushing targets for each zone were all achieved, sometimes several times over the target. That additional margin of safety was often included to help flush out loops or dead ends that could not be directly addressed due to the lack of unidirectional flushing capabilities. Table 1 does not represent the flushing order for the zones.

Table 1. Flushing activities for each zone.

Flushing Zone	Flushing Target (MG)	Flushing Actual (MG)
A1	1.95	1.969
A2	0.58	1.696
A3	0.19	0.566
B1	0.18	0.332
C1	0.82	2.291
C2	0.50	1.662
C3	0.56	1.699
D1	0.78	0.966
D2	2.67	3.513
D3	1.40	1.789
D4	0.87	0.941
E1	0.24	0.583
F1	1.35	24.6*
F2	1.45	2.916
G1	1.24**	1.275

[47] IDWST Documentation to Amend Drinking Water Health Advisory in Zone H2 (Removal Action Report), March 2022: https://health.hawaii.gov/about/files/2022/03/jbphh_011305.pdf.
[48] IDWST Documentation to Amend Drinking Water Health Advisory in Zone H3 (Removal Action Report), March 2022: https://health.hawaii.gov/about/files/2022/03/jbphh_011308.pdf.

Flushing Zone	Flushing Target (MG)	Flushing Actual (MG)
H1	0.741**	0.987
H2	1.00**	1.06
H3	0.632**	0.638
I1	0.085	0.104

*Water flushed through Halawa Tank S1 was discharged from hydrants in Zone F1 and counted towards the total water turnover within the zone.
**As previously noted in the tank flushing discussion for Camp Smith (Zone G1) and AMR (Zones H1-H3), the total flushing targets include the tank storage capacity.

3.2.2.3 Building Flushing Operations

Once the flushed hydrants had been sampled and the results came back below ISPs, the Recovery Plan directed the initiation of Stage 2: Flushing Points of Service (residential and non-residential). The Navy opened the service connection fixtures in each household to flush water from the mainline into the sanitary sewer. Fixtures included sinks, toilets, exterior hose bibbs, and washing machines, dishwashers and refrigerator drinking taps. Since the effluent was being discharged into the sanitary sewer, DOH approved this as adequate treatment prior to discharge to protect ocean water quality. Flushing adequacy at structures was determined by sampling results.

The IDWST finalized separate flushing plans and SOPs for homes and for non-residential buildings. The Single-Family Home Flushing Plan Checklist and SOPs[49] were finalized in December 2021, and the Non-Residential Facility Flushing Plan Checklist and Standard Operating Procedures[50] was finalized January 2022. The SOPs for both residential and non-residential buildings were similar in that they required flushing all sink fixtures for 15 minutes, flushing all toilets 3 times each, and there were similar instructions for flushing appliances such as water heaters, etc. The RARs include narrative and tables of the residential and non-residential buildings that were flushed. Table 2 summarizes the number of residential and non-residential buildings that were reported as being flushed from each zone. The numbers reported below originate from the tables presented within the zone-specific RARs. A total of 11,195 buildings (9,695 residences and 1,500 non-residential buildings) were flushed.

Table 2. Total number of buildings flushed.

Flushing Zone	Residential	Non-Residential
A1	634	33
A2	410	114
A3	1459	35
B1	227	38
C1	0*	181
C2	30	125
C3	6	144
D1	506	74

[49] IDWST Single Family Home Flushing Plan Checklist and Standard Operating Procedures, December 2021: https://health.hawaii.gov/about/files/2021/12/Home-Flushing-Plan-Checklist-and-Standard-Operating-Procedures-FINAL.pdf.
[50] IDWST Non-Residential Facility Flushing Plan Checklist and Standard Operating Procedures, January 2022: https://health.hawaii.gov/about/files/2022/01/20220104-FINAL-NON-RESIDENTIAL-FLUSHING-SOP.pdf.

Flushing Zone	Residential	Non-Residential
D2	1564	193
D3	912	118
D4	0*	162
E1	88	64
F1	752	93
F2	1435	59
G1	10	40
H1	918	13
H2	230	3
H3	379	4
I1	135**	7**

*There are no such buildings within the zone.
**The reported numbers were gleaned from the narrative portions of the RAR because the photocopy quality of the RAR was illegible.

Some buildings were not flushed. Rationales were included within the flushing summary tables within the RARs, and they were primarily access issues related to maintenance/construction, or the address did not exist.

3.3 Sampling

During the emergency response phase, sampling assessed the effectiveness of the flushing in removing contaminants. Identified as Stage 3 in the Recovery Plan, it provided crucial evidence of water quality conditions with respect to the ISPs. In order to use the results of sampling as a robust line of evidence, the analytes, locations, and quality control (QC) procedures were well established and consistent throughout the assessment. This subsection covers the SAP, sampling activities, and responses to ISP exceedances related to the emergency response phase (November 2021 through March 2022).

3.3.1 Sampling and Analysis Plan

The SAP covered much more than just sampling and served as the blueprint for the entire system recovery. As an evergreen document, subject to revisions as needed, there were changes to the SAP throughout the response and recovery of the PWS; however, this section will only cover the aspects of the SAP that were specific to sampling and analysis during the emergency response phase. The SAP detailed four significant steps that were specific to sampling and analysis: source sampling (Step 0), post-flush distribution main sampling (Step 2), post-flush building sampling (Step 4), and long-term monitoring (LTM) (Step 5). As previously noted, and specified in the SAP, LTM only starts after the UWA is amended for each zone and is considered outside of the emergency response phase, so it is covered in Section 4.0 of this report.

The sampling methods identified in the SAP for the emergency response differed slightly from what was identified for LTM and later in the EDWM program (discussed in Section 5.0). During the emergency response, the SAP utilized comprehensive environmental analytical methods (8015[11] and 8260D[13]) to screen for a wide range of potential fuel-related compounds. Once screening samples showed that no contaminants were above the ISP, confirmation samples were taken from the same sampling locations. Confirmation samples were analyzed via drinking water methods (e.g., 524.2[18] and 525.2[25]/525.3[26]) to check for a specific list of regulated contaminants,

supplemented with the screening method 8015 that was utilized to determine if water quality met the ISP for TPH. When comparing sampling results across all sampling activities, the use of non-drinking water methods 8260D and 8270E may create the appearance of inconsistencies, especially with respect to LTM; however, it should be recognized that, as established in the SAP, the drinking water methods 524.2 and 525.2/525.3 were the methods that the Navy used for evidence that the drinking water met all regulatory standards.

3.3.2 Sampling Activities

Once the Waiawa Shaft source water was determined to be free from contamination, drinking water was sampled from distribution mains and buildings as part of the system-wide assessment. Distribution mains and upstream storage facilities were assessed via samples collected from hydrants once the flushing activities were completed. The residential and non-residential buildings were assessed via samples collected from drinking water fixtures within the buildings (e.g., kitchen sinks), similarly after the building flushing activities were completed. The majority of the sampling activities, both hydrant and building sampling, were conducted by the Navy. For QC, duplicates were collected at 10% of sample sites by the Navy and DOH; EPA conducted sampling oversight. Specifically, DOH collected 15 duplicate distribution samples for TPH from flushing Zone I1, and EPA oversaw the collection of samples to ensure all procedures followed protocol.

3.3.2.1 Distribution Main Sampling

The SAP specifies sampling from "Nodes". Nodes are not defined within the SAP, or other documents reviewed by EPA. The term could mean either the entire flushing zone or flushing units within each zone, as evidenced in the Navy's UDF that depicts multiple flushing hydrants within each zone. For purposes of assessing the sampling completed, EPA interprets the term "Node" to mean the hydrants where flushing occurred within each flushing zone. This is demonstrated in Table 3, which presents the number of hydrants that were sampled in each zone and the total number of ISP exceedances. The exceedances are discussed further in Section 3.3.3.3 of this report.

Table 3. Distribution main sampling summary.

Flushing Zone	Nodes Sampled	ISP Exceedances	Sampling Dates (2022)
A1	6	0	1/11-1/12
A2	10	1 **	1/1-1/13
A3	8	0*	1/8 – 2/4
B1	2	0*	1/8-2/3
C1	6	0*	1/5-2/3
C2	7	2*	1/8-2/3
C3	2	0	1/8-1/16
D1	5	0	1/12
D2	12	7(6**)	1/1-1/14
D3	7	3**	1/15-1/16
D4	2	0	1/8-1/14
E1	4	0	1/8-1/18
F1	7	0	1/13-1/14
F2	15	3**	1/6-2/3
G1	1	0***	1/8

Flushing Zone	Nodes Sampled	ISP Exceedances	Sampling Dates (2022)
H1	3	0	1/11
H2	3	0	1/11-2/4
H3	3	0*	1/12-2/4
I1	1	0***	12/29

*Laboratory reported elevated bis(2chloroethyl)ether (BCEE) in error. Please see discussion in Section 3.3.3.3 for additional information.
** Exceedances for TOC, see discussion in Section 3.3.3.3.
***The RAR did not provide analytical result summary tables so EPA could not verify narrative reporting.

3.3.2.2 Building Sampling

Once a zone had been shown to have water quality meeting the ISPs in the mainlines, residential flushing and subsequent sampling was conducted (see Table 4). After flushing the building, a stagnation period of at least 24 or 72 hours elapsed before sampling occurred, where there was no water usage within or through the building. Samples took place "first draw" after stagnation, where the only water flow within or through the building was for the purpose of collecting the water samples. The SAP specified collecting drinking water samples from 10% of houses/buildings within each flushing zone.

Table 4. Residential and non-residential sampling summary.

Flushing Zone	10% Target Res & Building	Locations Sampled	# of Exceedances	Exceeded Analytes	Sampling Dates
A1	66	76	3	Combined TPH, TOC	12/30/21-1/27/22
A2	52	57	14	Combined TPH, TOC	1/15/22-2/11/22
A3	149	152	27	TOC	1/31/22-3/5/22
B1	27	33	3	DEHP, TOC	1/27/22-2/21/22
C1	18	19	1	Lead	1/27/22-2/26/22
C2	16	33	3	TOC	1/26/22-2/26/22
C3	15	21	6	TOC	1/26/22-2/26/22
D1	58	58	4	Combined TPH, TOC, DEHP	1/9/22-2/15/22
D2	180	190	28	Methylene chloride, TOC	1/11/22-2/18/22
D3	103	105	3	TOC	1/20/22-1/26/22
D4	15	14	3	TOC	2/2/22-2/2/22
E1	15	23	9	TOC	1/27/22-2/2/22
F1	84	87	12	TOC, Beryllium	1/15/22-2/19/22
F2	150	156	61	Combined TPH, DEHP	1/23/22-2/25/22
G1	6	15	10	TOC	1/23/22-1/25/22

Flushing Zone	10% Target Res & Building	Locations Sampled	# of Exceedances	Exceeded Analytes	Sampling Dates
H1	93	97	19	TOC	1/24/22-2/4/22
H2	23	25	3	TOC	1/27/22-2/3/22
H3	38	38	5	TOC	1/29/22-2/4/22
I1	14	18	8	TOC	1/12/22-1/17/22

3.3.3 Exceedance of ISPs

The SAP identified actions to be taken when ISPs were exceeded within the distribution mains in Steps 2c and 2d (re-flushing the zone and resampling, respectively); however, it defers to the IDWST to establish and implement a Plan of Action and Milestones (POAM) when ISPs were exceeded in buildings. There were multiple exceedances of the Total Organic Carbon (TOC) ISP that were not addressed via Steps 2c and 2d or a POAM, and this is discussed further in the subsections below. Additional details on the results and associated actions taken are also provided in Section 3.3.3.3. Ultimately, all ISP exceedances were addressed, and all sampling locations were below ISPs prior to development and issuance of the RARs.

3.3.3.1 ISP Exceedance in Distribution Mains

There was only one exceedance of the ISP for TPH in the distribution samples that occurred in Zone D2. The exceedance was from a distribution sample that was collected after building sampling had already begun due to concerns about the adequacy of the original distribution sampling strategy for the Zone. In-lieu of following Steps 2c and 2d, as established in the SAP, the IDWST agreed that flushing the specific hydrant and resampling, along with sampling a nearby hydrant, would be appropriate. Both follow-up samples were ND for TPH. This is documented on the March 3, 2022, Zone D2 Exceedance Investigation Summary and Results in Section 2.b.3 of the RAR for Zone D2[51].

3.3.3.2 ISP Exceedances in Buildings

The IDWST developed POAMs for ISP exceedances in buildings. The POAMs were ad-hoc in nature and were not formalized in any documents. For example, the basic approach of the POAM for TPH exceedances was to re-flush the home/building, resample the home/building, and collect bracketing samples from nearby homes/buildings to determine if the exceedance was limited to the specific building/home or if there was an issue within that specific portion of the distribution system. These bracket samples contribute to the additional sample locations above the target detailed in Table 4 in Section 3.3.2.2, above. On the other hand, the POAM for lead ISP exceedances focused on the individual house (i.e., no bracket samples) for re-flushing and resampling, and if necessary, fixture or plumbing replacement.

3.3.3.3 Emergency Response Sampling Summary

Approximately 1680 drinking water samples, not including duplicates or QC samples, were collected at 1323 locations from December 22, 2021, to March 9, 2022, as part of the emergency response actions. This total includes 15 samples collected and analyzed by DOH the week of January 13, 2022. As previously discussed in Section 3.2 and 3.3.2, the drinking water sampling during the emergency response followed the flushing within each zone, typically within a week, and

[51] IDWST - Documentation to Amend Drinking Water Health Advisory in Zone D2 (Removal Action Report), March 2022: https://health.hawaii.gov/about/files/2022/03/jbphh_011433.pdf.

all locations with samples exceeding an ISP were further investigated, resampled, and/or re-flushed (also detailed in Table 5).

In February 2022, DOH established an ISP of 266 µg/L[52] in drinking water for total organics from certain ranges associated with petroleum products and reported as "Combined TPH", which is calculated by summing the concentrations of TPH-g, TPH-d, and TPH-o, as quantified via 8015 or other TPH methods, such as 8260D. Five emergency response samples contained Combined TPH levels above the ISP (Table 6).

Approximately 1662 distinct samples were analyzed for TPH during the emergency response and 63 samples displayed Combined TPH concentrations (Figure 4). Due to the high number non-detects (1599 samples), a scatterplot of detections is provided in Figure 5a. The distribution of only the 53 TPH detections is presented in Figure 5b and demonstrates a downward trend both in detection frequency and mean concentration. The referenced 31 µg/L in Figure 5(a)(b) is the lowest TPH MDL reported for the emergency response and specifically the MDL for TPH-g. The Navy flushed and resampled locations with Combined TPH concentrations detected above the ISP and all resample concentrations were non-detectable (see Figure 3 for examples and related timelines).

Other exceedances include TOC, bis(2-ethylhexyl)phthalate (DEHP), methylene chloride, and beryllium (Table 5). There were 209 exceedances of the TOC ISP of 2,000 µg/L. Per the Navy's Stage 4 Sampling Result Report for Zone D2[53], the Navy stated: *"Total Organic Carbon (TOC) test results report any constituent containing carbon, many of which are naturally occurring and some of which may be man-made. The IDWST selected a TOC project screening level of 2,000 ppb. For each exceedance, the IDWST investigated by reviewing the associated water quality data (e.g., BTEX results, TPH) and determined that all TOC exceedances are not associated with petroleum hydrocarbons. The DOH is reviewing all of the lines of evidence, include the TOC result, and will make a final determination as to whether or not to amend the public health advisory for this zone."* DEHP is used as a plasticizer and, due to its presence in laboratory equipment, is a common laboratory contaminant. An investigation by a Navy contractor into ISP exceedances in both trip blanks and normal samples attributed these exceedances to laboratory contamination, concluding that further action (i.e., flushing and sampling) was not warranted[54]. Methylene chloride exceedances were observed in two samples at a non-residential facility building in Flushing Zone D2[51]. The associated facility was closed for renovations at the time of sampling and follow-up actions included isolation from the distribution system to prevent any potential spread of contamination from the potential source. One beryllium exceedance was observed in a residential sample in Flushing Zone F1. The home was resampled the following day and flushing and

[52] DOH - Recommended Risk-Based Drinking Water Action Levels for Total Petroleum Hydrocarbons (TPH) Associated with Releases of JP-5 Jet Fuel, revised February 12, 2022: https://health.hawaii.gov/heer/files/2022/10/JP-5TapwaterActionLevelsSignedHIDOHApril2022.pdf.
[53] IDWST - Drinking Water Distribution System Recovery Plan: Stage 4 Sampling Results Report for Zone D2, March 13, 2022: https://jbphh-safewaters.org/public/D2_Flushing_Zone_IDWST_Stage_4_Data_Release_13MAR2022.pdf.
[54] IDWST - Documentation to Amend Drinking Water Health Advisory in Zone C3 - Zone C3 (Removal Action Report), March 2022: https://health.hawaii.gov/about/files/2022/03/jbphh_011424.pdf.

resampled a month after the initial sampling with the reported exceedance. All resamples were non-detect for beryllium[55].

Preliminary reports, including publicly distributed fact sheets, included elevated detections of bis(2-chloroethyl)ether (BCEE). The laboratory, the Navy, and EPA, all independently confirmed that the BCEE was reported in error and that BCEE was not detected. This was subsequently verified by follow-up sampling that was Non-Detect for BCEE. There were no ISP exceedances from Zone A3, B1 distribution sampling.

Three indicator compounds (2-methylnaphthalene, fluorene, and benzo(a)anthracene) were detected at trace levels in drinking water samples with associated Combined TPH concentrations. Fluorene and 2-methylnaphthalene are JP-5 constituents and benzo(a)anthracene is commonly associated with petroleum-related products. Fluorene and benzo(a)anthracene were detected at 0.0136 and 0.0123 µg/L, respectively, in one residential sample from Flushing Zone A1 that also reported a Combined TPH concentration of 760 µg/L. 2-methylnaphthalene was detected in one hydrant in Flushing Zone C1 at 0.00915 µg/L, along with 180 µg/L for Combined TPH.

[55] IDWST - Documentation to Amend Drinking Water Health Advisory in Zone F1 (Removal Action Report), March 2022: https://health.hawaii.gov/about/files/2022/03/jbphh_011280.pdf.

Table 5. Summary of sample exceedances and Navy remedial actions taken during emergency response.

Analyte	Incident Specific Parameter (ISP) (µg/L)	# of ISP Exceedances	Highest Exceedance (µg/L)	Follow-up Actions Taken
Beryllium	4	1	5.7	Flushed and resampled. Resample was non-detect.
Bis(2-ethylhexyl)phthalate (DEHP)	6	5	42	Investigation conducted and DEHP results linked to laboratory contamination.
Combined Total Petroleum Hydrocarbons (TPH)	266	5	760	All samples flushed and resampled. Nearby buildings were also sampled. Final resamples were non-detect.
Methylene Chloride	5	2	186	Both exceedances were reported for a facility closed for renovations. Impacted facility was isolated from the distribution system.
Total Organic Carbon (TOC)	2000	209	14,500	All results reviewed and determined as not associated with petroleum hydrocarbons.

Table 6. Five samples taken during the emergency response phase displayed Combined TPH levels above the DOH ISP of 266 µg/L.

Flushing Zone	Location Type	Date Collected	Combined TPH (µg/L)	TPH-g (µg/L)	TPH-d (µg/L)	TPH-o (µg/L)
H2	Distribution (H2-HYD0377A)	12/26/2021	719	ND	99	620
A1	Residential (A1-ROBI1231)	12/30/2021	760	ND	110	650
D1	Residential (D1-EOUT1007)	1/10/2022	505	ND	268	237
A2	Residential (A2-DAUN4913)	1/18/2022	468	ND	259	209
F2	Residential (F2-NOON4018)	1/24/2022	640	ND	180	460

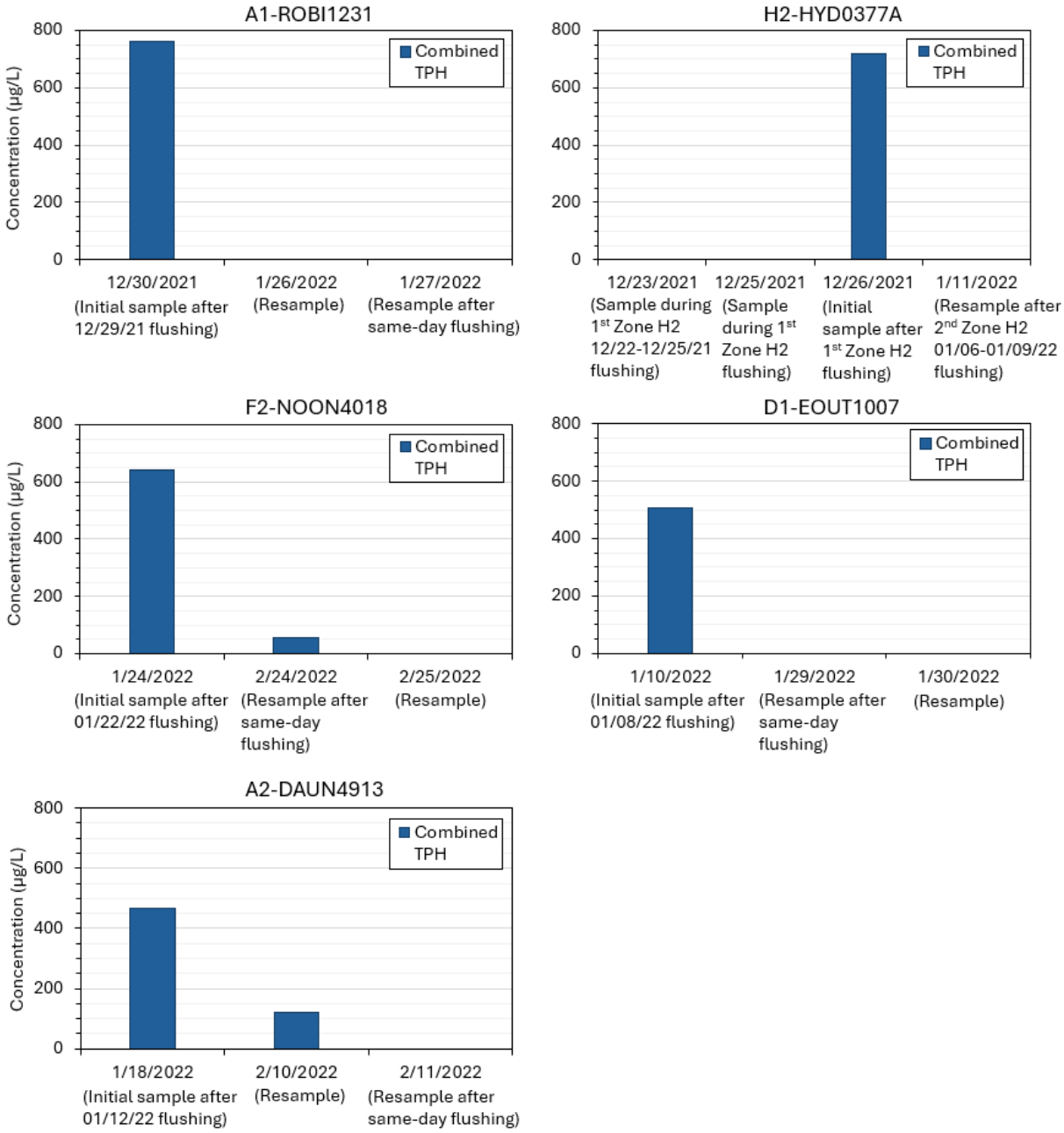


Figure 3. Sample locations with above ISP detections during the emergency response phase and sample results after follow-up actions were taken.

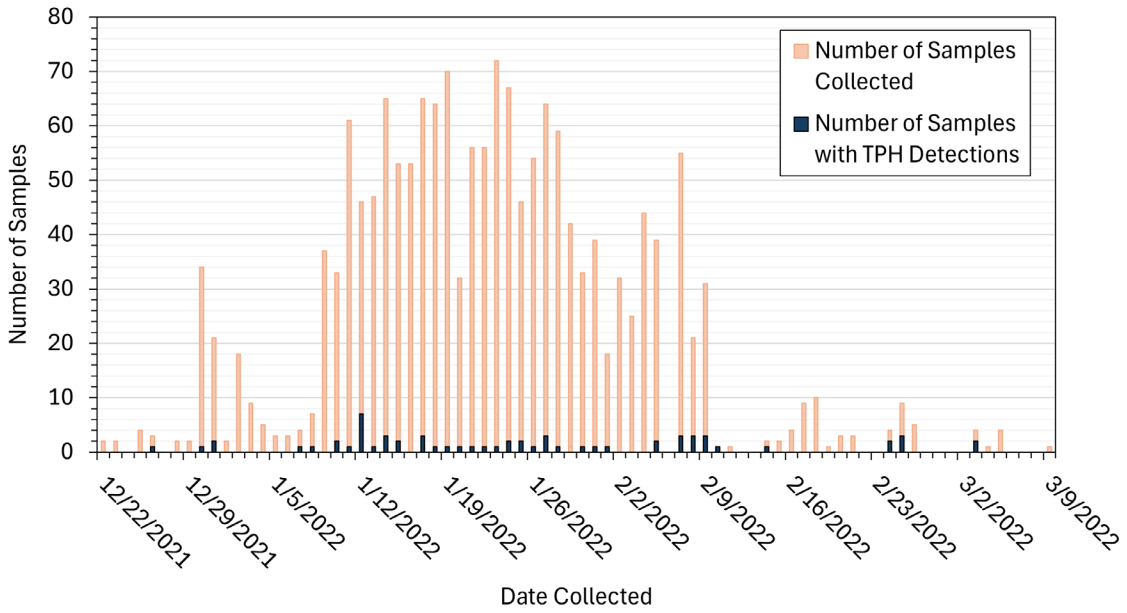
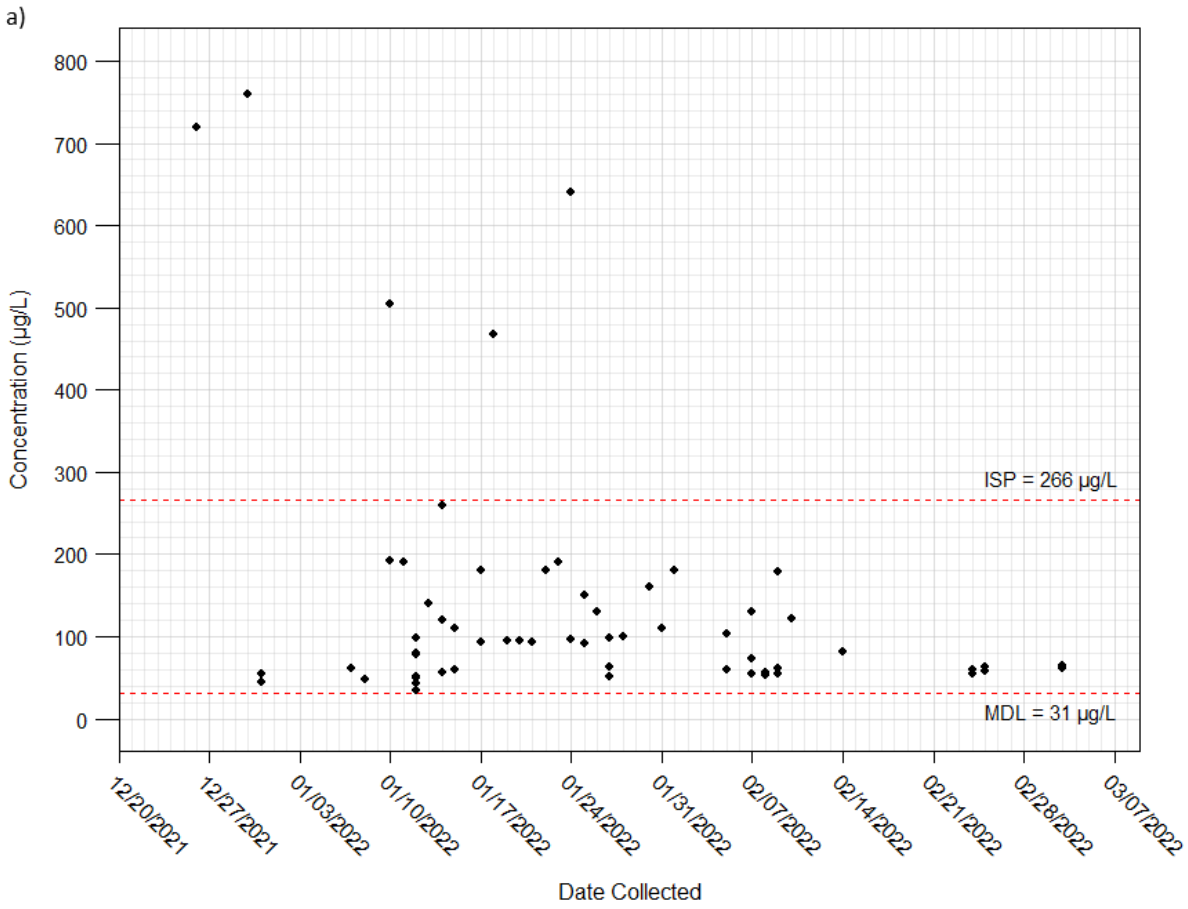


Figure 4. Number of samples with a reported TPH-g, TPH-d, or TPH-o detection compared to the number of samples taken on the same day, typically within the same flushing zone.



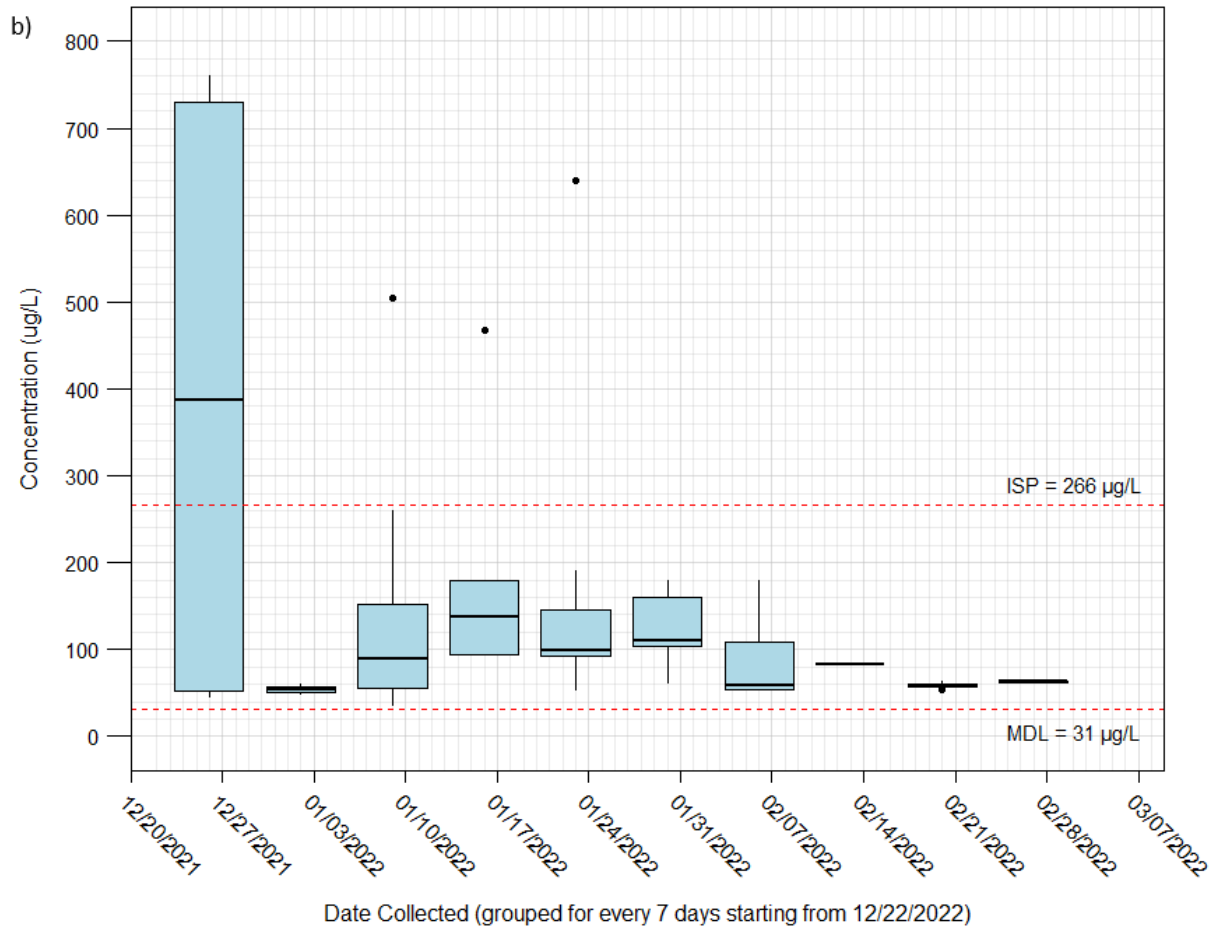


Figure 5. a) Scatterplot of all Combined TPH detections reported during emergency response; b) Box-and-Whisker plot for Combined TPH detections during emergency response.

3.4 Cross-Connection Control Investigation

This subsection covers cross-connection control activities specific to the emergency response phase. Cross-connection control programs are critical for protecting consumers from contaminants at businesses and in some homes. Acknowledging that the Red Hill fuel storage facility is not the only potential source of contamination, system-wide cross-connection control was included as a line of evidence for zone clearance and was discussed in the RARs. The JBPHH drinking water system had over 700 high risk service connections and testable backflow prevention assemblies to guard against backflow of contaminants back into the distribution system.

Examples of high-risk service connections include car washes, laundries, dental offices, hospitals, and industry or auto service stations. These types of customers could have chemicals or biological agents present and thus constitute a risk of contaminant backflow into the potable water system. Backflow can occur whenever the pressure inside of a structure exceeds the pressure in the mainlines. This can occur when the water demand exceeds the supply such as when there is a line break or when firefighters connect to the system to put out a fire.

Testable backflow prevention assemblies consist of dual check valves or reduced pressure zone (RPZ) devices. An RPZ is a type of backflow preventer that offers the highest level of protection against backflow into potable water systems. It is designed to prevent both back-siphonage and back-pressure, ensuring that potentially contaminated water from the building never enters the drinking water supply. These assemblies are required by DOH based upon the risk of each service connection. They require annual testing to assure their proper function. Among the emergency response requirements, DOH required the Navy and Army to conduct a cross-connection control investigation and documented as part of a checklist submitted for each flushing zone[56] to show that the distribution system is protected, resulting in no additional sources of contamination. The Investigation is separate from Cross-Connection and Backflow Control Programs that are implemented by public water systems. Following the end of the emergency response phase, the LTM plan required the Navy to conduct a Cross-Connection Control Survey, and the 2023 ACO SOW Section 6.5.7 requires JBPHH to submit for EPA approval and implement a Cross-Connection and Backflow Control Program.

The RARs required a check of the cross-connection control programs that covered each distribution zone. EPA and DOH reviewed these and cross-referenced the records against satellite/map data and building flushing reports.

3.5 Removal-Action Reports (RARs) – February-March 2022

While DOH was responsible for amending the UWA pursuant to their authority under HRS 340E-4[30], the content of the RARs (previously discussed in Section 3.0) was the responsibility of the Navy and Army. As RARs served as the ultimate basis for amending the UWAs by DOH, EPA assisted DOH to validate the content of the RARs to assure everything required was correct and included. The subsection covers RARs developed as part of the emergency response phase activities.

3.5.1 Amending Health Advisory

DOH established a comprehensive checklist and multi-step process[57] based on the multiple lines of evidence presented by the Navy and Army to amend the drinking water health advisory. This process ensured the integrity of the drinking water. The initial and most critical steps involved isolating the source of contamination and systematically flushing the entire water distribution system. Following the flushing, an extensive water sampling and testing plan was executed. The data from this testing was then rigorously reviewed by DOH and EPA to verify that the water met all federal and state standards as well as the ISPs before the advisory could be amended for any zone and ultimately lifted for the PWS as a whole. A long-term monitoring plan was also established to ensure the continued integrity of the water quality.

The overall process utilized by DOH, with support from EPA, to amend the UWAs is summarized in Figure 6.

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[56] DOH – Navy Water System Health Advisory Amendments (Zone Checklists): https://health.hawaii.gov/about/navy-water-amendments/.

[57] DOH's Guidance on the Approach to Amending the Public Health Advisory, Addendum 1, February 12, 2022: https://health.hawaii.gov/about/files/2022/02/DOHGuidanceOnApproachToAmendPublicHealthAdvisory.20220212-part-1-signed.pdf.

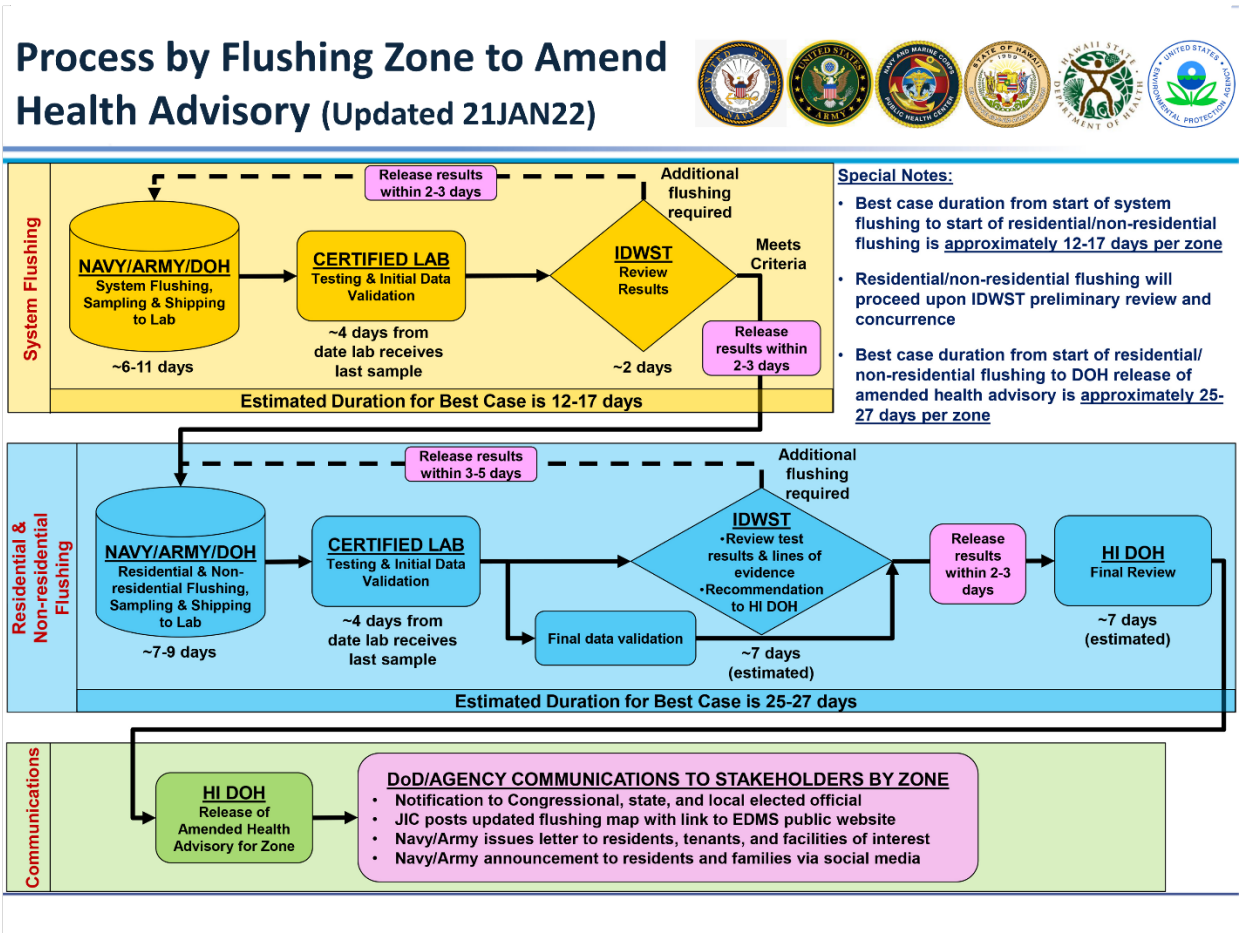

Figure 6. DOH Process Flow to Amend Health Advisory[58].

As previously noted, the UWA for JBPHH and AMR was lifted on October 26, 2022, ending the emergency response phase for the PWSs. Table 7 presents the dates that the UWA was amended for each zone allowing for unrestricted use of drinking water within the specific zone.

Table 7. Dates of UWA Amendment

Flushing Zone	Date of UWA Amendment (2022)
A1	2/23
A2	3/1
A3	3/13
B1	3/3
C1	3/18
C2	3/18
C3	3/18
D1	3/1
D2	3/13
D3	3/18

[58] Navy – Flushing and Sampling Plan, Drinking Water Distribution System Recovery Infograph: https://www.cpf.navy.mil/JBPHH-Water-Updates/Flushing-and-Sampling-Plan/.

Flushing Zone	Date of UWA Amendment (2022)
D4	3/8
E1	3/8
F1	3/11
F2	3/11
G1	3/3
H1	3/3
H2	3/11
H3	3/11
I1	2/14

3.6 Aquifer Recovery

During the emergency response and after it concluded, the Navy, as directed by the IDWST, made efforts to hydraulically contain contamination in the aquifer at Red Hill, in collaboration with DOH and EPA groundwater and remediation experts. On December 24, 2021, the Navy physically disconnected the Red Hill Shaft from the rest of the water system and shut the pump down. In January 2022, the Red Hill Shaft Recovery and Monitoring Plan[59] was established by the Navy, DOH, and EPA. This plan established a target of pumping 5 MG per day from the Red Hill Shaft, with the intention of halting the migration of contaminants away from the source by reversing groundwater flow into the cone of depression created by pumping. The resulting capture zone, created by the draw-down in the vicinity of the Red Hill Shaft, allowed a two-prong approach to removing fuel contamination from the aquifer: drawing floating fuels back into the shaft for skimming and absorbents; and drawing dissolved contamination back to Red Hill Shaft for removal by GAC treatment.

The extent, magnitude, and migration of contamination in the aquifer below Red Hill is evaluated through the sampling of monitoring wells, both pre-existing and those drilled additionally for this effort (currently 46 wells are routinely monitored). The extent of petroleum contamination in the aquifer peaked in 2022 and has been in decline since then. Pumping to protect the aquifer by maintaining hydraulic containment of petroleum continues to this date and the development of a permanent treatment system is underway to once again utilize the Red Hill Shaft as a drinking water source.

3.6.1 Recovering Floating Fuel from Red Hill Shaft

Prior to resuming pumping of Red Hill Shaft, the Navy deployed a skimming pump and absorbent materials to recover floating contamination (e.g., jet fuel) from the water development tunnel. Those activities remain ongoing. Waste generated from these recovery operations is disposed by the Navy at a permitted treatment, storage, or disposal facility. It is worth noting that confirmed free product has not been found during gauging events in Red Hill Shaft since December 15, 2021. While there was also a detection on August 22, 2022, the Navy confirmed there was no presence of observable product and the resulting chromatogram was not similar to middle distillate fuels (e.g., JP-5).

[59] IDWST Red Hill Shaft Recovery and Monitoring Plan (RHSRMP), January 2022: https://health.hawaii.gov/about/files/2022/01/Final-Signed-Red-Hill-Shaft-Recovery-and-Monitoring-Plan-20220126.pdf.

3.6.2 Pumping Red Hill Shaft to GAC Treatment

Red Hill Shaft was re-plumbed to pump 5 million gallons per day (mgd) to a temporary GAC treatment system built in early January 2022. This system consists of parallel pairs of treatment filters in series (lead and lag) that could be rotated for maintenance and allowed for double filtration of the divided flow. Prior to discharging, the treated effluent is regularly tested to inform Navy operations of the effectiveness of the system to maintain water quality below ISPs and EALs for the contaminants of concern.

3.6.3 Discharge of Treated Water to Halawa Stream

Halawa Stream was determined to be the best place to discharge the treated water based on a series of investigations and surveys. IDWST conducted a site investigation of the receiving stream to establish the baseline for any naturally occurring or human-impact to the stream. EPA and Navy conducted the survey of surface water, cracks, and weep holes in Halawa Stream in order to determine whether the jet fuel released to soils via the groundwater drainage and collection system was seeping into the stream. The Navy's contractor used a PID to monitor for VOCs. IDWST observed no significant sheen or VOC measurements during this survey. Once these evaluations were complete, DOH granted a National Pollutant Discharge Elimination System (NPDES) permit[60] to allow for pumping and treating groundwater from Red Hill Shaft and discharge it into South Halawa Stream, which leads to Pearl Harbor and the Pacific Ocean[61].

3.7 Post-Emergency Response Investigation, Verification, and Validation

As the UWA for the various zones of the distribution system were amended and ultimately lifted, a follow-up period of monitoring, investigation and verification began to ensure the water system operated properly and no residual contaminants from the November 2021 release were lingering within the system. The first two years of this monitoring and verification period are referred to as Long-Term Monitoring (LTM)[62]. Following the conclusion of LTM, an additional one-year of monitoring and verification was completed, referred to as Extended Drinking Water Monitoring (EDWM). These two efforts comprise a period of recovery where the emergency response actions and determinations regarding the lifting of the UWA are validated by the monitoring results and additional oversight activities. While these monitoring efforts were ongoing, additional investigations of the drinking water at the PWSs were performed by Navy, Army, DOH and EPA. Additional details on these investigations and two monitoring efforts are described in the sections below.

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[60] DOH Emergency Order, 2022 - Permit Number HI21DG544.

[61] DOH letter to NAVFAC Hawai'i- Notice of General Permit Coverage under the National Pollutant Discharge Elimination System (NPDES) to the GAC Water Treatment Facility File No. HI21DG544, January 27, 2022: https://health.hawaii.gov/about/files/2022/01/20220127.Transmittal.NGPC_.NPDES_.GAC-Water-Treatment-Facility-Honolulu-Island-of-Oahu-Hawaii.21DG544.FNL_.22.pdf.

[62] IDWST – Drinking Water Long-Term Monitoring Plan for JBPHH and AMR, June 2022: https://health.hawaii.gov/about/files/2022/08/JBPHH-Drinking-Water-LTM-Plan-FINAL-20220823.pdf.

4.0 Long-Term Monitoring

LTM was developed as a two-year program to verify determinations made concluding the emergency response phase. While the flushing and sampling completed during the emergency response was rigorous, only a limited number of buildings and residences were sampled during this period. In addition, there may have been potential lingering contamination in the dead-ends or loops within the distribution system due to the system's hydraulics, or within the potable water storage tanks that were not fully drained, though put back into service due to the need for water throughout the PWSs. The LTM program, therefore, aimed at expanding the number of sampling locations for targeted analytes to validate that the conditions of the UWA amendments were met.

4.1 Development of LTM

The Navy and Army's LTM Plan was designed to fulfill the post advisory requirements stated in the SAP and the 19 RARs for each zone established during the response phase. As the amendments of UWAs came to an end, the response phase shifted to a recovery phase, where DOH resumed routine regulatory oversight. For the purposes of the LTM Plan, the JBPHH PWS and AMR PWS were considered to be a single distribution system (PWS) divided into zones. The IDWST developed the LTM Plan as a framework that would continue after the IDWST group disbanded and routine oversight transitioned to DOH.

The SAP introduced a preliminary construct of a long-term approach to assure compliance with all drinking water standards and the absence of residual fuel-related contaminants. The elements of the LTM Plan provided a prescriptive process for the Navy and Army to report, test, and remediate potential detections of residual fuel. The Navy and Army were required to sample the source, the distribution lines, and residences/buildings for an additional 24 months to ensure that the drinking water did not exceed federal or state drinking water standards and the ISPs. The Navy and Army were also required to expeditiously report to DOH a detection or exceedance of federal or state drinking water standards or the ISPs in accordance with the appropriate scenario-based course of action (COA) in the LTM Plan and complete the remedial actions necessary following resampling results.

Initial LTM Plan drafts included all ISPs from the SAP, as well as many regulated contaminants, intending to establish a new baseline. This approach was taken because significant disturbances in the source water and, generally, in the water flows can result in unanticipated changes in water quality. For instance, changes in the water chemical composition, in the direction of water flow, in the velocity of water flow and other factors can disturb accumulated sediments, reduce or build scale or directly impact pH or other parameters causing unforeseen consequences. Therefore, a broader panel of contaminants required by DOH for testing under LTM was appropriate to ensure the protection of public health.

4.2 Final Approval of LTM

Between February 2022 and June 2022, the Navy and Army provided subsequent drafts of the LTM Plan following review and comments from EPA and DOH. Long-term monitoring sampling and testing had begun before the LTM Plan was finalized, and sampling was conducted in accordance with the LTM Plan that was in effect during the time of the sampling. Moreover, the first and second LTM rounds for the zones in scope were completed in accordance with the approved SAP at that time. This contributed to slight differences between what was evaluated when LTM first began and

when LTM concluded. The Final LTM Plan superseded the drinking water LTM sections of the previously approved and signed SAP; however, differences were not required to be reconciled through resampling. All sampling and analysis rounds performed after the Final LTM Plan was signed and adopted were conducted in accordance with the requirements of the Final LTM Plan.

The Navy and Army's Final LTM Plan was approved by DOH on June 16, 2022. A copy of the Final LTM Plan is available on DOH's website[63] and the sample results of LTM are available on the Navy website[64], as well as discussed in the sections below. The LTM program required the Navy to complete monitoring for both regulated and unregulated contaminants in drinking water initially under DOH's SDWA jurisdiction[65,66] and the HAR[36]. EPA incorporated by reference the LTM Plan into the 2023 ACO, making the Final LTM Plan enforceable[67] on June 2, 2023. As of March 2024, the Navy and Army concluded their activities associated with LTM.

4.3 LTM Sampling Summary

The Navy's drinking water sample results for LTM are available on the *Joint Base Pearl Harbor-Hickam Drinking Water Monitoring Dashboard*[68], accessible via the *Safe Waters* website: jbphh-safewaters.org. According to Safe Waters, the Navy collected approximately 9,304 samples, excluding QC samples (e.g., field and trip blanks), from 6,391 locations during LTM from March 11, 2022, to March 29, 2024. The total amount of collected samples includes the 20 residence samples that were collected with a grab sample collected in a series, referred as a split sample in this report, for EPA analysis from February 27, 2024, to March 13, 2024 (further discussed in Section 4.3.2).

During LTM, the Navy reported 34 ISP exceedances (Table 8). All affected locations were investigated and remediated through fixture replacement or flushing (Table 9), and the resamples all reported below ISP levels, mostly with non-detects. During LTM Period 6 (June 2023 through November 2023) and Period 7 (December 2023 through March 2024), there was an increase in the frequency of detections from analyses of water quality via 8015, primarily in the organics range

[63] IDWST - Drinking Water Long-Term Monitoring Plan for JBPHH and AMR, June 2022: https://health.hawaii.gov/about/files/2022/08/JBPHH-Drinking-Water-LTM-Plan-FINAL-20220823.pdf.
[64] Safe Waters - JBPHH: https://jbphh-safewaters.org/.
[65] Revision of Approved State Primacy Program for the State of Hawaii, Federal Register, 90 FR 22090, May 23, 2025: https://www.federalregister.gov/documents/2025/05/23/2025-09277/revision-of-approved-state-primacy-program-for-the-state-of-hawaii.
[66] State primary enforcement responsibility, SDWA, 42 U.S.C. § 300g-2(a)(5)): https://uscode.house.gov/view.xhtml?hl=false&edition=prelim&req=granuleid%3AUSC-prelim-title42-chapter6A-subchapter12-partB&num=0&saved=%7CZ3JhbnVsZWlkOlVTQy1wcmVsaW0tdGl0bGU0Mi1zZWN0aW9uMzAwZg%3D%3D%7C%7C%7C0%7Cfalse%7Cprelim.
[67] EPA issued the 2023 Consent Order under authority vested in the EPA Administrator by Section 1431 of the SDWA, 42 U.S.C. § 300(i), which was delegated to the Regional Administrators and redelegated to EPA's Region 9's Enforcement and Compliance Assurance Division pursuant to Regional Directive R9-9-17: https://uscode.house.gov/view.xhtml?req=granuleid%3AUSC-prelim-title42-chapter6A-subchapter12&saved=%7CZ3JhbnVsZWlkOlVTQy1wcmVsaW0tdGl0bGU0Mi1zZWN0aW9uMzAwZg%3D%3D%7C%7C%7C0%7Cfalse%7Cprelim&edition=prelim. .
[68] Navy – JBPHH Drinking Water Monitoring Dashboard: https://app.powerbi.com/view?r=eyJrIjoiNTIyNDU0OTMtODgwNS00ZjQ4LTg1Y2UtODkxYTgxMjQ5NGZhIiwidCI6ImUyYzE5MDhiLTI2NzItNGE0Ni05M2ZkLTdmMDhkYTExNjZiNSIsImMiOjJ9.

associated with diesel (e.g., TPH-d). All but two of these detections were under the ISP for Combined TPH (266 µg/L); however, the increased frequency of these detections above the MDL and RL, along with increased residential reports of water quality concerns during this period, led to multiple investigations from late 2023 through early 2024.

Table 8. Summary of LTM samples collected and exceedances.

Flushing Zone	# Locations Sampled	% Locations Sampled – Residences and Priority Buildings	% Locations Sampled - Distribution	# of Exceedances	Exceeded Analytes
A1	372	98	2	1	Lead
A2	306	97	3	0	-
A3	838	99	1	5	DEHP; lead
B1	154	99	1	0	-
C1	80	92.5	7.5	0	-
C2	69	90	10	0	-
C3	44	91	9	0	-
D1	331	98	2	3	Lead, Mercury
D2	1070	99	1	7	Lead, Combined TPH
D3	596	99	1	1	Lead
D4	51	96	4	0	-
E1	87	95	5	1	Lead
F1	483	98	2	5	Lead, thallium
F2	878	98	2	8	Lead, TOC
G1	31	97	3	0	-
H1	562	99	1	4	Lead, Combined TPH
H2	135	96	4	0	-
H3	217	99	1	0	-
I1	82	99	1	0	-
J1	2	100	0	0	-
Waiawa Shaft	2	-	-	0	-
Red Hill Shaft	1	-	-	0	-
Total	6391	98	2	34	Lead, DEHP, mercury, thallium, TOC, Combined TPH

Table 9. Summary of Navy exceedances and remedial actions during LTM.

Analyte	Incident Specific Parameter (ISP) (µg/L)	# of ISP Exceedances	Highest Exceedance (µg/L)	Geographical[1] or temporal trend?	Follow-up Actions Taken
Combined Total Petroleum Hydrocarbons (TPH)	266	2[2]	359[2]	No	Resampled and reported ND.
Total Organic Carbon (TOC)	2000	1	130,000	No	Resampled and reported ND.
Bis(2-ethylhexyl)phthalate (DEHP)	6	4	20.3	No[1]	Exceedances reported at same residence. Kitchen sink identified as source of contamination. Fixture replaced and follow-up samples reported ND.
Mercury	2	1	3.9	No	Fixture replaced follow-up samples reported ND.
Thallium	2	1	8.7	No	Affected hydrant was flushed, resampled, and reported below ISP.
Lead	15	26	82.7	No	All affected locations flushed, resampled, or fixtures replaced and resampled. Resamples reported below ISP levels or NDs.

[1] Geographical for this table is defined as a pattern of exceedances within the same flushing zone. Exceedances were reported for DEHP 4 times at the same location and not considered to be a geographical trend since nearby buildings or buildings within the same zone did not report exceedances.

[2] The Navy investigated the high frequency of TPH detections during the latter LTM periods, which is discussed in the below text and referenced in Footnote 69.

Early Navy investigations included additional targeted sampling and analysis from various points throughout the distribution system and at hot water heaters and interior faucets to ensure there was no contamination built-up. From January through February 2024, the Navy also led a series of interagency meetings (referred to as the "SWARM") with subject matter experts to discuss the potential causes of the increased frequency of TPH detections during LTM Periods 6 and 7. EPA and DOH participated in these meetings and provided technical input. Following these SWARM discussions, there was a strong recommendation from the subject matter experts that additional monitoring data was necessary to validate that the JBPHH and AMR PWSs have recovered from the Red Hill incident. In addition, following the SWARM discussions, the Navy published their report titled Summary of Technical Memorandum Regarding Low-Level Hydrocarbon Detections Observed During Long-Term Monitoring (hereafter referred to as "the Tech Memo"), dated April 25,

2024, available on the Navy's website[69]. EPA did not provide input or comment on this Tech Memo report prior to publication. Additional discussion on the Tech Memo is available in Section 6.1.2.1.

As the LTM program was set to sunset at the end of March 2024, EPA supported an extended long-term monitoring program incorporating the lessons learned from LTM. As such, on February 2, 2024, EPA sent a letter[70] to the Navy documenting that EPA determined additional work under the 2023 ACO is necessary to monitor drinking water quality in the PWSs beyond the conclusion of LTM.

4.3.1 LTM TPH Detections

The Navy reported[71] levels above the Combined TPH ISP of 266 µg/L for two LTM samples (Table 9). One sample displayed a 359 µg/L concentration at a residence in Flushing Zone H1, collected February 28, 2024. Another sample displayed a 320.8 µg/L concentration at Hickam Elementary School in Flushing Zone D2, collected on February 26, 2024. The Navy confirmed that both exceedances did not match JP-5 or fuel-related components and conducted a further investigation. Based on the investigation, the Navy determined that a reaction between residual chlorine in the drinking water samples and the o-terphenyl (OTP) surrogate, which is used during 8015 (TPH-d and TPH-o) analysis for QC measures, produces byproducts that are not fuel-related but are detected within the TPH-range of the method.

The Navy collected 9,121 samples, according to Safe Waters, for TPH (TPH-d, TPH-o, and TPH-g) analysis. Of these samples, 2,711 samples reported Combined TPH detections, or 29.7% of the total LTM samples collected. The number of reported TPH detections, primarily TPH-d, were highest during August and September of 2023 and the number of detections decreased toward the end of LTM (Figure 7). A majority (~84%) of these detections were below the RL and the concentrations, therefore, were considered an estimated value. The TPH detections during LTM did not display a geographical pattern and all flushing zones reported a 27% ± 10% frequency (

Figure 8). Due to the relatively high detection rate with no specific geographical or temporal pattern nor observed jet fuel or other fuel-related analyte, the Navy and DOH conducted independent investigations discussed in Sections 4.4 and 4.5. The Navy attributed the drop in TPH detections beginning January 2024 to a decrease in the OTP surrogate added to samples and the reported TPH levels to detection of a byproduct of chlorine residual and OTP, as well as lab-artifacts and contamination (Section 4.4).

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[69] JBPHH - Drinking Water Quality Monitoring – Summary of Technical Memorandum Regarding Low-Level Hydrocarbon Detections Observed During Long-Term Monitoring: https://jbphh-safewaters.org/public/Tech_Memo_JBPHH_LOE's_LTM_TPH_Detects_Redacted_Rev.pdf.

[70] EPA letter to Navy – Additional Work Pursuant to the 2023 Consent Order (Paragraph 8 (b)), February 2, 2024: https://www.epa.gov/system/files/documents/2024-03/red-hill-aoc-8.b-modification-letter-re-ltmp-2024-02-02.pdf.

[71] On Safe Waters, the only Combined TPH exceedance listed is for Hickam Elementary (concentration of 320.8 µg/L; collected on February 26, 2024). Based on the Navy's exported dataset and PDF page 405 of the Navy's April 2024 Tech Memo[76] (discussed in Section 4.4), a sample collected on February 28, 2024 at 4445 Kobashigawa Street displayed Combined TPH levels exceeding the 266 µg/L ISP.

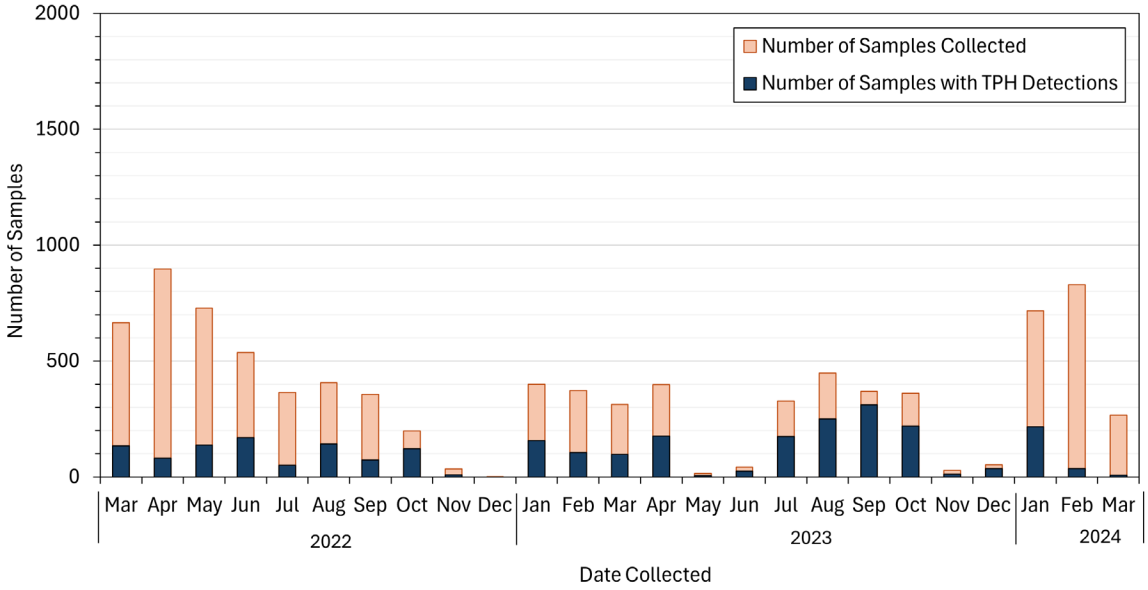

Figure 7. Number of samples with a reported TPH detection during LTM compared to the number of samples taken.

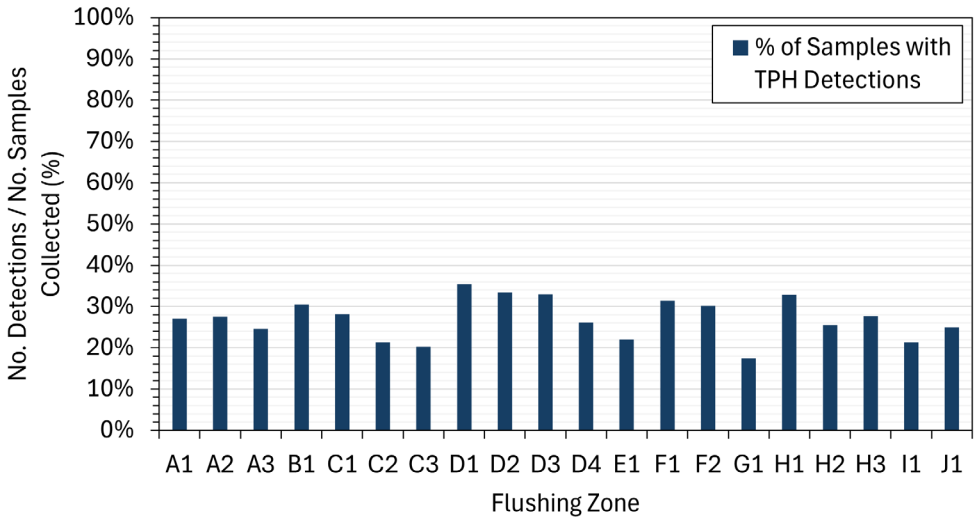

Figure 8. Percentage of TPH detections reported compared to total number of samples collected during LTM for each Flushing Zone.

The SW-846 Compendium (as discussed in Section 2.3) includes general techniques for preservation and sampling that apply to all methods, including 8015. Chapter four of the SW-846 Compendium, Table 4-1[72] includes wording that aqueous samples with residual chlorine present should be pre-preserved with sodium thiosulfate. Sodium thiosulfate neutralizes residual chlorine,

[72] EPA – SW-846 Compendium, Chapter 4 – Table 4-1 on page 10: https://www.epa.gov/sites/default/files/2019-06/documents/chapter_four_update_vi_12-11-2018.pdf.

also known as a chlorine quencher. Navy-collected LTM samples for 8015 (TPH-d/o) were only preserved with hydrochloric acid (HCl), and not the method recommended sodium thiosulfate.

Fuel indicator compounds that were detected during LTM are listed in Table 10. All potential fuel indicators were at low-level concentrations and below all applicable MCLs or ISPs. BaP was detected at a higher frequency (3%) compared to the other fuel indicators. The Navy detected BaP in EDWM samples at a similar frequency and a resulting Navy investigation determined that the BaP detections were not related to JP-5 and likely due to low-level laboratory contamination (further discussed in Section 5.5.3). It is uncertain if this conclusion only relates to EDWM samples, or if it applies to LTM BaP detections, as well. The levels and frequency of detection for the fuel-related indicators during LTM did not match the high level of TPH detections and what would be expected for a true JP-5 or fuel-related detection.

Table 10. LTM fuel indicator detections.

Fuel Indicators	# Detections	# Collected Samples	Range (µg/L)
1-Methylnaphthalene	1	9093	0.33
2-Methylnaphthalene	1	9093	0.25
Naphthalene	4	9093	0.49-1.2
Benzo[a]pyrene (BaP)	237	9093	0.01-0.13
Benzene	1	9085	0.5
Ethylbenzene	4	9085	0.27-0.32
Toluene	2	9085	0.29-0.46

4.3.2 LTM Split Samples

From February 27, 2024, through March 13, 2024, EPA conducted independent laboratory analysis of 20 LTM split samples collected at residences with drinking water complaints. Split sampling is a technique where samples are divided up and sent to separate laboratories for analysis. In the context of the LTM and EDWM programs, "split" samples are samples collected sequentially from the same source of water (e.g., residential tap, hydrant). While this technique is technically referred to as collecting duplicate samples, the term "split" sampling has been applied from early on in the Red Hill incident investigation and will continue to be used in this report. The results from the separate Navy and EPA laboratories were then used to compare and evaluate the validity of the data. Slight differences in concentrations that may occur due to sampling in series are discussed in Section 6.1.1.2.

The split samples were collected by the Navy and sent to the EPA Region 8 certified laboratory in Lakewood, Colorado for TPH analysis, the BSK Laboratories for SVOC and haloacetic acid (HAA5) analysis, and the EPA Region 9 certified laboratory in Corvallis, Oregon for all other LTM analyses. The EPA split samples contained detections for barium, chromium, copper, lead, selenium, total trihalomethanes (TTHM), TPH-d, and naphthalene below the ISPs and MCLs and two detections above the ISP and MCL for bis(2-ethylhexyl)phthalate (BEHP or DEHP). DEHP, a plasticizer used in polyvinyl chloride (PVC) products (e.g., lab equipment tubes), was falsely detected in samples due to lab contamination and was not detected in Navy equivalent split samples. The results of these split sample analyses are summarized in Table 11.

Comparing EPA and Navy's results for equivalent samples collected, there were minor discrepancies in number of detections for arsenic, chromium, dibromoacetic acid (DBAA), lead, selenium, DEHP, thallium, TPH-d, and naphthalene (Table 11). EPA reported detections for DEHP,

while the Navy reported NDs, due to lab contamination. EPA's detections of DBAA (1 sample at 0.69 µg/L) and naphthalene (4 samples ranging 0.0023-0.0025 µg/L) were below the Navy's MDLs for both analytes. The slight variations between the number of detections and concentrations for metals analyzed under EPA Method 200.8 (referred as 200.8), which the EPA Region 9 laboratory explained were typical of independent laboratories with differing RLs and accuracy and precision, particularly for low-level detections near the RL. For example, the MDL and RL for chromium are 0.5 µg/L and 1.0 µg/L for EPA and 0.5 µg/L and 2.0 µg/L for the Navy, respectively. EPA's chromium detections were 1.5-2 µg/L, below the Navy's RL, and the Navy's detections were 0.53-0.9 µg/L. Despite these differences, the Navy's concentrations for split samples were all below MCLs and ISPs.

The EPA Region 8 laboratory did not have the capability for TPH-o analysis and only analyzed EPA split samples for TPH-d and TPH-g. TPH-g was ND in all 20 samples for both EPA and Navy. The 12 EPA splits displayed TPH-d levels ranging from 20.5 to 28.8 µg/L, and the Navy reported > MDL levels for two of the 12 splits. Split sample F1-TW-0009214-23335-N-S, collected on February 28, 2024, reported 23.1 µg/L for TPH-d and 53.3 µg/L for TPH-d in the Navy's equivalent sample. Split sample D3-TW-0009455-23342-N, collected on March 1, 2024, displayed a concentration of 25.6 µg/L for TPH-d and 51.6 µg/L in the Navy's sample. For reference, EPA Region 8's MDL and RL for TPH-d are 11 µg/L and 20 µg/L, respectively, while the Navy's MDL and RL are 50 µg/L and 73 µg/L, respectively. The EPA Region 8 laboratory analysts did not flag a JP-5 or other known fuel chromatographic patterns but did observe the same pattern that the Navy attributed to residual chlorine and o-terphenyl surrogate interaction in the 2024 Tech Memo (refer to Section 4.4).

Table 11. EPA and Navy LTM comparison summary table for only samples that were collected with a split.

					EPA		*Navy*	
Analytical Method	**Analyte**	**MCL (µg/L)[1]**	**ISP (µg/L)[2]**	**# Samples Analyzed**	**# Detects**	**Highest Detection (µg/L)**	**# Detects**	**Highest Detection (µg/L)**
Metals EPA and Navy: EPA Methods 200.8 and 245.1 (Hg)	Antimony	6	6	20	0	-	0	-
	Arsenic	10	10	20	0	-	5	0.8
	Barium	2000	220	20	20	2.2	20	13.2
	Beryllium	4	0.66	20	0	-	0	-
	Cadmium	5	3	20	0	-	0	-
	Chromium	100	11	20	20	2	10	0.9
	Copper	1300[3]	2.9	20	20	52	20	55.5
	Lead	15[3]	-	20	1	1.7	10	0.68
	Mercury	2	0.025	20	0	-	0	-
	Selenium	50	5	20	0	-	15	1.4
	Thallium	2	2	20	0	-	1	0.058
Volatile Organic Compounds (VOCs) EPA: EPA Methods 524.2, 8021/8015D, 552.3 (HAA5), 8270E (DEHP)	1,1,1-Trichloroethane	200	11	17	0	-	0	-
	1,1,2-Trichloroethane	5	5	17	0	-	0	-
	1,1-Dichloroethylene	7	7	17	0	-	0	-
	1,2,4-Trichlorobenzene	70	70	17	0	-	0	-
	1,2-Dichlorobenzene (o-dichlorobenzene)	600	10	17	0	-	0	-
	1,2-Dichloroethane (EDC)	5	5	17	0	-	0	-
	1,2-Dichloropropane (DCP)	5	5	17	0	-	0	-
	1,4-Dichlorobenzene (p-dichlorobenzene)	75	5	17	0	-	0	-

[1] EPA MCLs are the maximum permissible levels of a contaminant in water provided by a PWS. MCLs are legally enforceable under the SDWA: https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations.

[2] ISPs were set by DOH for the 2021 Red Hill jet fuel release based on environmental and health risk with incident-specific factors. The DOH ISP at the time of LTM was 266 µg/L for Combined TPH (sum of TPH-g, TPH-d, and TPH-o).

[3] Lead and copper do not have set MCLs. Action levels are a measure of the effectiveness of corrosion control treatment by a public water system. The 15 µg/L AL listed for lead was effective during the time of LTM and was lowered to 10 µg/L at the federal level effective November 1, 2027. Additional action must be undertaken by the water system if more than 10% of tap water samples exceed the action level (40 CFR § 141.80(c)). Hawai‘i is implementing the federal Lead and Copper Rule and does not have a separate MCL or AL. For more information on the Lead and Copper Rule: https://www.epa.gov/sites/default/files/2019-10/documents/lcr101_factsheet_10.9.19.final_.2.pdf.

					EPA		*Navy*	
Analytical Method	**Analyte**	**MCL (µg/L)[1]**	**ISP (µg/L)[2]**	**# Samples Analyzed**	**# Detects**	**Highest Detection (µg/L)**	**# Detects**	**Highest Detection (µg/L)**
Navy: EPA Method 524.2	Benzene	5	5	20	0	-	0	-
	Bis(2-ethylhexyl)phthalate (DEHP)	6	3	20	5	14	0	-
	Carbon tetrachloride (CTC)	5	5	17	0	-	0	-
	Chlorobenzene	100	25	17	0	-	0	-
	cis-1,2-Dichloroethylene	70	70	17	0	-	0	-
	Dichloromethane (methylene chloride)	5	5	17	0	-	0	-
	Ethyl Benzene	700	700	20	0	-	0	-
	Styrene	100	10	17	0	-	0	-
	Tetrachloroethene (PCE)	5	5	17	0	-	0	-
	Toluene	1000	1000	20	0	-	0	-
	Total Haloacetic Acids (HAA5)	60	60	20	0	-	0	-
	Total Trihalomethanes (TTHM)	80	-	17	2	2.1	7	2.52
	Total Xylenes (sum of o-, m-, and p-xylene)	10000	10000	20	0	-	0	-
	trans-1,2-Dichloroethylene	100	100	17	0	-	0	-
	Trichloroethene (TCE)	5	5	17	0	-	0	-
	Vinyl chloride	2	2	17	0	-	0	-
Total Petroleum Hydrocarbons (TPH) EPA: EPA Method 8021/8015D Navy: EPA Methods 8260D (TPH-g), 8015D (TPH-d)	TPH - Diesel Range Organics (TPH-d/DRO)	-	266[2]	20	12	28.8	2	51.6
	TPH - Gasoline Range Organics (TPH-g/GRO)	-		20	0	-	0	-
Semivolatile Organic	Naphthalene	-	12	20	4	0.0025	0	-
	1-Methylnaphthalene	-	2.1	20	0	-	0	-
	2-Methylnaphthalene	-	4.7	20	0	-	0	-

					EPA		*Navy*	
Analytical Method	**Analyte**	**MCL (µg/L)[1]**	**ISP (µg/L)[2]**	**# Samples Analyzed**	**# Detects**	**Highest Detection (µg/L)**	**# Detects**	**Highest Detection (µg/L)**
Compounds (SVOCs) EPA: EPA Method 8270E Navy: EPA Method 525.2	Benzo[a]pyrene (BaP)	0.2	0.06	20	0	-	0	-
Total Organic Carbon (TOC) EPA: EPA Method 415.3 Navy: SM 5310	Total Organic Carbon (TOC)	-	2000	20	0	-	0	-

4.4 Navy Investigations

As discussed in Section 4.3, in early 2024, the Navy initiated an investigation of the increasing trends in both the frequency and concentration of TPH detections measured in LTM samples from late 2023 and early 2024. This also corresponded to a period when residents on the JBPHH distribution system continued to report water quality concerns (see Sections 4.6.4 and 4.6.6 for discussion on EPA's drinking water complaints investigations).

To better discern the source and magnitude of sampling and analytical artifacts and errors identified during LTM, EPA requested that the Navy evaluate each factor potentially contributing to the error, separately. Instead, Navy made multiple changes simultaneously to the sampling and analytical protocols, confounding the error analysis, and potentially obscuring the contributions of individual factors to the total analytical error.

Following this investigation, the Navy issued their Tech Memo[76] in April 2024, developed and published independently by the Navy. The Tech Memo concluded that increased detections of TPH observed during LTM were the result of sampling and analytical artifacts and method limitations. The Navy also concluded that the increased detections of TPH during LTM were unrelated to the release of JP-5 or any other fuel-related product into the JBPHH and the AMR PWSs.

EPA considered several of the Navy's conclusions presented in the Tech Memo inadequately supported. However, EPA did concur with the Navy's proposed changes to the sampling and analytical protocols. EPA indicated an additional year of extended monitoring following the conclusion of LTM, with the recommended changes to sampling and analytical SOPs implemented, would be necessary before the agency could fully evaluate the Navy's conclusions. EPA's review of the Tech Memo is included in Section 6.1.2.1 of this report.

An additional outcome of the Navy's investigation during LTM was the formation of the Navy's Water Quality Action Team (WQAT). The WQAT was created to quickly respond to residents' drinking water complaints, including tap water sampling. According to the Navy's Safe Waters website "Contact Us" tab[77], the WQAT continues to operate from 6:00 AM to 9:00 PM seven days a week.

4.5 DOH Investigations

4.5.1 Drinking Water Complaints Received by DOH

For context of drinking water concerns received by DOH alongside Sections 4.4, 4.6.4, and 4.6.6, DOH received 1 complaint between January to October 2023 and 37 complaints confirmed through

[76] Navy, April 25, 2024: Low-Level Hydrocarbon Detections Result of Test Method Interferences in Total Petroleum Hydrocarbon (TPH) Analysis of Chlorinated Drinking Water: https://www.navyclosuretaskforce.navy.mil/Portals/101/Tech%20Memo_JBPHH%20LOEs%20LTM%20TPH%20Detects_Redacted.pdf.

[77] Navy – Safe Waters Drinking Water Quality Concerns: https://jbphh-safewaters.org/public/framework/appcontainer.aspx?url=html.aspx&idhtml=10835&title=Contact%20Us&idMenu=101362&ddlDSN=SYSTM&DSN=SYSTM.

follow-up from October 2023 to March 2024. After confirming complaints, DOH referred complaints to Navy and EPA for follow-up and provided oversight during sampling.

4.5.2 Forensic Analysis Report

In response to the increased detections of organics via 8015 observed during LTM, DOH requested NewFields Environmental Forensics Practice, LLC to perform a forensic chemistry analysis on 15 samples as part of an independent investigation. The samples were collected by DOH from 12 residences, the Waiawa Shaft, the Navy Aiea-Halawa Shaft, and the Red Hill Shaft in February 2024. The selection of residential sample locations was based on the five residences sampled during the October 2023 premise plumbing Drinking Water Complaints Investigation, as described in Section 4.6.3, as well as seven locations that reported elevated detections of organics via 8015 during LTM Period 5 and 6. The 15 samples reported low-level organics via 8015 below or slightly above the laboratory RL. The resulting *Joint Base Pearl Harbor-Hickam Drinking Water Characterization* ("Forensic Analysis Report")[78] was released in May 2024.

The Forensic Analysis Report concluded that petroleum hydrocarbons were not detected in the 15 analyzed samples. In agreement with the conclusions of the Navy's Tech Memo, the report attributed the increase detection of organics via 8015 during LTM to non-petroleum hydrocarbons including brominated organic compounds, halogenated alcohol compounds, and other tentatively identified compounds (TICs) and the limitations of the laboratory methods.

Following the discovery of the TICs, DOH initiated a follow-up study in 2024 to investigate the origin of these brominated organic, halogenated alcohol, and other unknown compounds. Several chemicals with profiles matching the TICs were found to be related to leaching of synthetic pipe materials suggesting that the TICs may be typical degradation products from polyethylene pipes exposed to chlorinated water. The primary goal of the study is to determine whether petroleum hydrocarbons promote or accelerate the leaching and/or chemical reaction with plastic pipe (i.e., high-density polyethylene, known as HDPE, and cross-linked polyethylene, also known as PEX) exposed to chlorine. As of the date of this report, the study has ended, and the final report is still pending to be published.

4.6 EPA Investigations and Enforcement During LTM

After the incident and throughout the duration of the long-term and extended drinking water monitoring programs, EPA conducted several investigations and inspections of the PWSs and associated complaints from residents specifically within the JBPHH distribution system. EPA SDWA compliance evaluation inspections are conducted under SDWA Section 1445, 42 U.S.C. § 300j-4[79]. Findings from these investigations have been used to draft the requirements of and assess compliance with EPA's 2023 ACO with the Navy and the United States Defense Logistics Agency (DLA).

[78] NewFields Environmental Forensic Practice, LLC – JBPHH Drinking Water Characterization: https://health.hawaii.gov/news/files/2024/05/JBPHH-HIDOH-DW-Report-20240510.pdf.
[79] SDWA Section 1445, 42 U.S.C. § 300j-4: https://uscode.house.gov/view.xhtml?req=(title:42%20section:300j-4%20edition:prelim).

4.6.1 April 2022 NEIC Public Water System Inspections of JBPHH and AMR

During the week of April 4, 2022, the EPA's National Enforcement Investigations Center (NEIC) conducted public water system inspections at the JBPHH[80] and the AMR[81], completing final inspection reports on May 27, 2022. The JBPHH inspection identified many critical drinking water programs that were not established, including lack of a:

- Preventative maintenance program;
- SOPs for operator duties;
- Operator safety and training program;
- Valve exercising program;
- Flushing plan;
- Cross-connection control program;
- Leak detection plan; and
- Sufficient number of certified operators.

The JBPHH system did not have adequate maintenance, with evidence of rust and sanitary defects at many infrastructure assets such as the storage tanks, pumps, and piping. The chemicals used for drinking water treatment were also inappropriately stored. Additionally, JBPHH's Risk and Resilience Assessment and Emergency Response Plan did not include all the information required by SDWA Section 1433.

Regarding public notification, EPA determined that JBPHH did not issue a Tier 1 Public Notice (PN)[82] within 24 hours of learning of the JP-5 fuel contamination of the Red Hill Shaft. EPA also noted that the customer complaint process was flawed, as JBPHH staff were not notified of water quality issues to address.

The reports found that both the Navy and Army failed to adequately operate and maintain their PWSs serving the JBPHH and the AMR, respectively. In response, the Navy and Army submitted documentation of corrective actions addressing EPA concerns, including photographic documentation and plans for implementation of structural controls to prevent animals from nesting inside the JBPHH's finished water storage tanks and to remove excessive vegetation from around the tanks. The findings from the 2022 inspection provided the basis for the requirements to improve drinking water system operations and maintenance in the 2023 ACO. The findings have been or are in the process of being addressed through the requirements of the 2023 ACO.

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[80] NEIC JBPHH Inspection Report, May 27, 2022: https://www.epa.gov/system/files/documents/2022-08/NEICVP1463E01%20Joint%20Base%20Pearl%20Harbor%20Hickam%20Public%20Water%20System_Redacted.pdf.

[81] NEIC AMR Inspection Report, May 27, 2022: https://www.epa.gov/system/files/documents/2022-08/neicvp1463E02-sdwa-aliamanu-military-reservation-public-water-system-redacted.pdf

[82] JBPHH Administrative Notification: https://jbphh-safewaters.org/public/ADMINISTRATIVE%20NOTICE%20(N00)_revised_13%20May.pdf.

4.6.2 2023 Consent Order

On June 2, 2023, EPA finalized and signed the 2023 ACO[83] with the Navy and DLA that required steps to properly operate and maintain the JBPHH PWS to protect the health and safety of its consumers, as well as to ensure the safe defueling and closure of the Red Hill Bulk Storage Facility. In order to protect drinking water consumers served by the JBPHH PWS, the 2023 ACO includes requirements that address source water protection, drinking water quality monitoring (including long-term monitoring and additional sampling), tank inspection, cleaning and sampling, general operation and maintenance, public notice, and emergency response planning.

4.6.3 October 2023 Complaints Investigation Report

Starting in late 2023, EPA, DOH, and Navy received an increased number of complaints being reported by residents served by the PWSs. On October 19, 2023, EPA conducted a complaints investigation and published its findings on December 18, 2023[84]. The report presents the EPA's findings from the investigation into five complaints received by EPA and the subsequent follow-up from the Navy. The report also articulated areas of concern and recommendations for how Navy can improve their complaint response process.

4.6.4 October 2023 Drinking Water Complaints Investigation

EPA initiated the October 2023 investigation into drinking water complaints after an influx of resident complaints were sent to EPA in early October 2023. EPA successfully reached five of six residents who provided contact information for follow-up. The investigation collected information about historical and current concerns with water quality and its alleged impact on health, and the Navy's response to drinking water concerns filed by the resident. Through EPA coordination with DOH, Navy representatives collected drinking water samples at four of the homes visited.

The investigation identified that while Navy representatives were typically prompt and respectful, the representatives did not clearly communicate with residents, and delivery of any sampling results were difficult to access. The nature of the residents' complaints varied, but some common themes included allegedly observing an oily sheen in the water and rashes and/or skin irritation as a symptom. Three of the four samples Navy collected as a result of the investigation detected TPH-d, and all three results were only estimates as they were barely above the Navy laboratory MDL and all below the laboratory RL.

This investigation recommended improvements to Navy's complaint process, such as having clear communications with residents, sharing any sampling results as soon as possible and distributing a pamphlet with helpful information, and that alternative water should be considered for residents with drinking water concerns that warrant sampling or further investigation.

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[83] EPA, Navy, and DLA – 2023 Consent Order for Defueling, Closure, and JBPHH Drinking Water System (Docket No. RCRA 7003-R9-2023-001, PWS-AO-2023-001), June 2, 2023: https://www.epa.gov/system/files/documents/2023-06/2023-red-hill-aoc-for-defueling-closure-dw-protection-2023-06-02.pdf.

[84] EPA letter to Navy – EPA Investigation Report on October 2023 Drinking Water Complaints, December 20, 2023: https://www.epa.gov/system/files/documents/2023-12/r9-epa-red-hill-investigation-rpt-2023-10-drinking-water-complaints-2023-12-20.pdf.

The report called for Navy to further investigate premise plumbing and water heaters for potential causes to reported symptoms. In addition, the report recommended an investigation into the root cause of the trace presence of TPH and claims of oily sheens.

Navy implemented all recommendations to the complaint response process. Residents reported receiving alternative water, a pamphlet, and quicker delivery of sampling results. Navy also retained a community liaison that accompanied sampling teams during responses to drinking water concerns to ensure clear communication with residents on sampling activities and answer any questions.

4.6.5 February 2024 Complaints Investigation Report

In February 2024, EPA was notified of 28 complaints with actionable contact information from residents served by the PWSs. EPA conducted an investigation on February 14-16, 2024, by interviewing 13 residents and published the findings and recommendations on March 21, 2024[85].

4.6.6 February 2024 Drinking Water Complaints Investigation

The 2024 complaint investigation was triggered after EPA received numerous drinking water complaints with actionable contact information earlier in the year. Of these complaints received, 13 residents served by JBPHH or AMR volunteered to be interviewed by EPA. Some interviews were conducted over the phone due to scheduling conflicts, illness or a preference for a phone call.

The investigation identified that the Navy had implemented EPA's recommendations from the October 2023 complaint investigation report, including providing alternative water to residents with drinking water concerns. Several residents expressed dissatisfaction with the quality and/or amount of alternative water that was supplied. Most residents discussed their lack of trust or confidence in the Navy's actions, and also a fear of reprisal if vocal about drinking water concerns.

Residents' allegations regarding drinking water quality and resulting symptoms varied, with some commonalities including: all reporting skin irritation at some point since the Red Hill incident, some reported gastrointestinal issues when drinking the water, and some observed a sheen in the water. Only approximately half of the residents had reported concerns to Navy for follow-up sampling. Of the available sampling results on Navy's Safe Waters website, one home had a TPH-d detection, which was just above the MDL and below the RL.

This second complaints investigation recommended including sheen analysis as part of the Navy's rapid response protocol in response to a drinking water complaint. In addition, the report recommends an outreach plan to alleviate resident concerns about reprisal and developing a SOP for managing alternative water.

EPA has received and reviewed a SOP that states that one gallon of water per day for five days will be provided upon request. However, there is no criteria for when an alternative water distribution center should be established. EPA is not aware of any specific sheen analysis as part of Navy's drinking water concern response process, if a sheen was observed. EPA has not seen any public correspondence to address concerns of reprisal for filing drinking water concerns.

[85] EPA - Drinking Water Complaints Investigation #2 – JBPHH and AMR, finalized on March 21, 2024: https://www.epa.gov/system/files/documents/2024-03/jbphh-drinking-water-complaint-investigation-report-march-2024.pdf.

4.6.6.1 EPA Attempt to Replicate Chlorine Interaction on Surrogate Recovery

The EPA Region 9 laboratory investigated the potential interaction between OTP (a surrogate used in the Navy's TPH-d analysis) and chlorine in drinking water samples. This was done in part to investigate the claim made by the Navy in the Tech Memo that chlorine was causing "ghost peaks" observed in TPH-d chromatograms which would contribute to total peak area thus, increasing the calculated concentration of TPH-d. Samples were dechlorinated with sodium thiosulfate (a reducing agent) to neutralize the chlorine and prevent potential interactions, but the question remained as to what extent could chlorine cause ghost peaks or increase the calculated concentration of TPH-d.

Composite samples were created from the JBPHH PWS drinking water and spiked with either 0.25 mL or 1.5 mL of 5% sodium hypochlorite (NaOCl), to determine if chlorine was interacting with OTP. A control group was created using deionized (DI) water, along with another group of chlorinated samples (spiked with 0.25 mL of 5% NaOCl) that was subsequently dechlorinated with sodium thiosulfate. Table 12 shows the different treatments that were used. All sample type groups contained samples with a total volume of 1 liter before extraction.

Table 12. Sample type and total number of treatments in each group, preservative, and surrogate added before extraction.

n	Sample Type	Preservative	Surrogate
5	DI Water Control	None	Chlorooctadecane + OTP
5	+0.25 mL 5% NaOCl	80 mg Sodium Thiosulfate	Chlorooctadecane + OTP
5	+0.25 mL 5% NaOCl	None	Chlorooctadecane + OTP
5	+1.5 mL 5% NaOCl	None	Chlorooctadecane + OTP
1	Method Blank	None	Hexacosane
1	Blank Spike with JP-5	None	Hexacosane
1	Blank Spike with JP-5 +0.25 mL 5% NaOCl	None	Chlorooctadecane + OTP
1	Blank Spike with JP-5	80 mg Sodium Thiosulfate	Chlorooctadecane + OTP

There was no statistically significant difference in mean OTP recovery between spiked samples (+0.25 mL of 5% NaOCl) that remained chlorinated and spiked samples that were dechlorinated with 80 mg of sodium thiosulfate 95% CI ($p = 0.098$). There also was no statistical difference between the dechlorinated samples and the treatment with 1.5 mL of 5% NaOCl added at the 95% CI ($p = 0.056$). There were no TPH-d/JP-5 detections apart from the heavily chlorinated samples (spiked with 1.5 mL of 5% NaOCl) which is attributed to SPE media breakdown.

Qualitatively there appeared to be more noise in the chlorinated samples, but this did not have a significant impact on TPH-d area or OTP recovery (Figure 9), except for the samples spiked with 1.5 mL of 5% NaOCl, which was attributed to SPE breakdown.

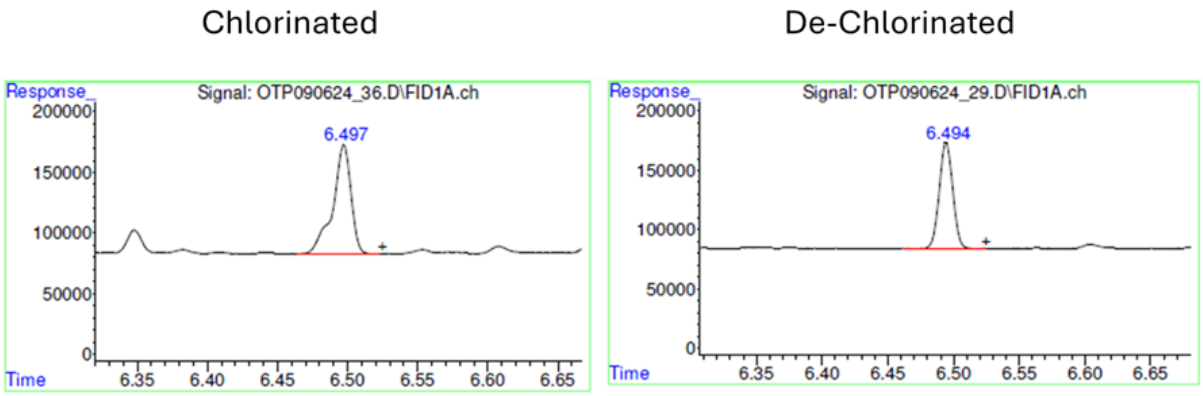

Figure 9. Chromatograms showing the effect of chlorine on the o-terphenyl (OTP) peak shape for samples that were spiked with 0.25 mL of 5% NaOCl.

5.0 Extended Drinking Water Monitoring

EDWM was developed to incorporate lessons learned from LTM and to demonstrate that the PWSs had recovered from the impacts of the Red Hill incident. EDWM expanded the focus beyond JP-5 to include additional fuel-related analytes and ensure that appropriate corrective actions were taken. It should also be noted that the EDWM Plan required the Navy to thoroughly investigate all TPH detections (i.e., any result greater than the MDL), rather than only detections above the ISP. Sampling for EDWM began in April 2024 and concluded in April 2025. Per the EDWM Plan, EDWM sampling was intended to conclude at the end of March 2025, but due to rescheduling insistences, the last EDWM samples collected for Navy analysis occurred in April 2025. The Navy collected EPA's last split samples on March 31, 2025.

5.1 Development of EDWM

As discussed in Section 4.3, the SWARM team meetings concluded with a recommendation for additional monitoring data from the PWSs to validate that the systems had recovered from the Red Hill incident. In addition, on February 2, 2024, EPA sent a letter[70] to the Navy stating that, pursuant to the 2023 ACO, the Statement of Work (SOW) needed to be modified to continue monitoring the PWSs after the expiration of LTM.

On February 16, 2024, in a meeting with EPA and DOH, Navy proposed an EDWM Plan that would continue Navy sampling and testing of the JBPHH PWS and the AMR PWS in all zones for an additional 12 months starting in April 2024. Similar to LTM, for the purposes of the EDWM Plan, the JBPHH PWS and the AMR PWS would be considered a single distribution system (PWS) divided into zones. The EDWM program would also include additional fuel analytes not included in LTM, provide perspective on the analytical methods used during LTM, aid in determining the potential root cause of the increased TPH detections during LTM Periods 6 and 7, and include an enhanced Navy response to water quality complaints. Furthermore, in the EDWM program, the Navy committed to testing residences that were not tested during LTM, including Manana Housing. By the end of EDWM, the goal was to have 100 percent of the residences served by the PWS tested at least once during the Navy's three years of monitoring following the final amendment to the UWA.

5.2 Final Approval of EDWM

The Navy provided draft EDWM Plans following extensive review and comments from EPA and DOH from March through October 2024. EPA approved the Navy's November 1, 2024 submittal of the EDWM Plan as additional work[86] under EPA's 2023 ACO[87]. The Navy began sampling under the EDWM program in April 2024, prior to the final approval of the EDWM Plan by EPA and DOH. As such, the list of analytes and associated sampling frequencies changed throughout EDWM as new drafts of the plan were reviewed and modified.

The final approval of the EDWM Plan was delayed significantly until November 2024 due to disagreements between EPA and the Navy on the enforceability of the EDWM Plan and the scope of analytes that would be tested under this extended monitoring program. The back-and-forth between EPA and Navy is documented through several letters dated February 2, 2024[88], March 6, 2024[89], April 5, 2024[90], July 15, 2024[91] and August 13, 2024[92].

EPA believed that including a broader scope of analytes in EDWM would be appropriate to determine the potential root-cause of the increased detections of organics via 8015 during Periods 6 and 7 of LTM (previously noted in Section 4.3) and to validate that the drinking water systems did not have any residual impact from the Red Hill incident. In particular, a broader scope of fuel-related analytes would capture the varying effects from weathering on fuels. EPA also held the position that Navy not solely focus on JP-5 but consider all fuel products stored at Red Hill as potential contaminants to the water system from other historical releases. To better understand the source and origin of TPH detections, EPA requested the Navy to perform qualitative forensic analyses on all residential tap samples in EDWM with TPH detections above the MDL, including 8260D PIANO (see Section 2.4.1.2) and 8270E for polycyclic aromatic hydrocarbons (PAHs) and alkylated PAHs.

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[86] Additional work is pursuant to the Paragraph 8(b) of the 2023 ACO (pg. 21): https://www.epa.gov/system/files/documents/2023-06/2023-red-hill-aoc-for-defueling-closure-dw-protection-2023-06-02.pdf.

[87] EPA Letter to Navy – Conditional Approval of Extended Drinking Water Monitoring for JBPHH Drinking Water System, November 1, 2024: https://www.epa.gov/system/files/documents/2024-11/epa-letter-conditional-approval-extended-dw-monitoring-jbphh-water-system.pdf

[88] EPA letter to Navy – Additional Work Pursuant to the 2023 Consent Order (Paragraph 8(b)), February 2, 2024: https://www.epa.gov/system/files/documents/2024-02/r9-epa-2-2-24-letter-to-navy-re-red-hill-ltmp.pdf.

[89] EPA letter to Navy – Additional Work Pursuant to the 2023 Consent Order (Paragraph 8(b)), March 6, 2024: https://www.epa.gov/system/files/documents/2024-03/red-hill-aoc-8.b-modification-letter-re-ltmp-2024-03-06.pdf.

[90] EPA letter to Navy – Additional Work Pursuant to the 2023 Consent Order (Paragraph 8(b)), April 5, 2024: https://www.epa.gov/system/files/documents/2025-12/epa-letter-red-hill-edwm-plan-extension-approval-2024-04-05.pdf.

[91] EPA letter to Navy – Additional Work for Drinking Water Monitoring Pursuant to 2023 Administrative Consent Order (Paragraph 8(b)), July 15, 2024: https://www.epa.gov/system/files/documents/2024-08/epa-letter-additional-work-red-hill-dw-monitoring-pursuant-to-2023-aco-2024-07-15.pdf.

[92] EPA letter to Navy – Extended Drinking Water Monitoring Plan (EDWM) – Additional Work Pursuant to the 2023 Administrative Consent Order (Paragraph 8(b)), August 13, 2024: https://www.epa.gov/system/files/documents/2024-08/epa-letter-request-for-edwm-as-additional-work-2024-08-08.pdf.

In June 2024, EPA and the Navy came to an agreement to include an additional eight key fuel indicator analytes that are primary components of JP-5 and an additional 12 petroleum-associated analytes that are found in other fuels, oils, and lubricants, all of which were incorporated into the sampling protocol beginning in July 2024, after one quarter of the EDWM sampling had already been completed. The eight key fuel indicators are n-butylbenzene, sec-butylbenzene, tert-butylbenzene, isopropylbenzene, n-propylbenzene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, and 2,2MEE. The 12 petroleum-associated analytes are acenaphthylene, anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[g,h,i]perylene, chrysene, dibenz[a,h]anthracene, fluorene, indeno[1,2,3-cd]pyrene, phenanthrene, pyrene, and ethylene dibromide (EDB).

In October 2024, EPA and Navy agreed to compartmentalize the EDWM program into two documents, an enforceable[93] Final EDWM Plan to be approved by EPA and a non-enforceable supplementary document to the EDWM plan that the Navy stated they would voluntarily implement. The non-enforceable Supplement A document included a process for completing qualitative forensic analysis of TPH and fuel indicator detections (referred to as "Tier 2"), sampling operating procedures, and a risk evaluation protocol for assessing detections of analytes with no drinking water or other health-based standard. Analyses conducted under Tier 2 include 8260D PIANO (143 VOCs), 8270E (79 PAHs/alkylated PAHs), and 8015D (39 targeted saturated hydrocarbons). Though not required, the Navy performed Tier 2 analysis for eight out of 13 Combined TPH detections above the MDL throughout the EDWM program (see Section 5.5 for additional details).

The following are the eight overarching analyte classifications and analytes analyzed under EDWM:

- VOCs: Chosen as target analytes under EDWM because they include highly toxic constituents of JP-5 and serve as key indicators for the presence or absence of the jet fuel. EDB was targeted under EDWM due to its association with aviation gas historically stored at Red Hill. TTHMs were monitored during EDWM to evaluate whether an observed increase in TTHMs, which is regularly monitored in drinking water systems and therefore has historical baseline data, correspond to the presence of TPH or elevated levels of organic matter.
- SVOCs: Targeted under EDWM because they include components of middle and heavy distillate petroleum fuels and lubricants that would be considered key indicators. 2,2MEE is a Fuel System Icing Inhibitor additive in JP-5 that can indicate the presence of jet fuel in drinking water.
- TPH: EDWM monitored drinking water for the presence or absence of complex hydrocarbon mixtures (e.g., TPH-d, TPH-o, and TPH-g) that are potentially related to the fuel releases that impacted Red Hill.
- Total alkalinity: Monitored under EDWM to provide insight on pH buffering, corrosion control, and scaling in the distribution system.
- TOC: Serves as an indicator of water quality and as a surrogate measurement for disinfection byproduct precursors.
- Anions: Monitored during EDWM to support evaluation of general water quality.

[93] Enforceable under the 2023 ACO and pursuant to SDWA Section 1431, 42 U.S.C § 300i: https://uscode.house.gov/view.xhtml?req=granuleid%3AUSC-prelim-title42-chapter6A-subchapter12&saved=%7CZ3JhbnVsZWlkOlVTQy1wcmVsaW0tdGl0bGU0Mi1zZWN0aW9uMzAwZg%3D%3D%7C%7C%7C0%7Cfalse%7Cprelim&edition=prelim.

- Cations: Monitored to evaluate water quality, water chemistry, and pipe conditions, informing decisions regarding maintenance and flushing of pipes.
- Metals: Copper and lead are regularly tested by PWSs at representative sampling sites throughout a distribution system. Mercury is regularly tested as part of compliance monitoring sampling at entry points to the distribution system.

EPA conditionally approved Navy's Final EDWM Plan, as documented in a letter sent on November 1, 2024[94]. Navy's Final EDWM Plan[95] and EDWM Supplement A[96] document are available on the Navy's website.

5.3 EPA Investigations, Audits, and Enforcement during EDWM

As previously mentioned in Section 4.6, EPA conducted several inspections and investigations of the PWSs as a result of the spill and subsequent public complaints. The inspections focused on key infrastructure, operating procedures and planning, sampling, and response practices of the Navy. EPA inspections and investigations did not reveal any residual fuel in the PWSs.

5.3.1 June 2024 Public Water System Inspections of JBPHH and AMR

During the week of June 3, 2024, EPA conducted public water system inspections under Section 1445 of the SDWA, 42 U.S.C. 300j-4[97] at the PWSs to determine compliance with the SDWA and JBPHH's progress under the 2023 ACO. During the inspections, EPA observed deficiencies with the management, operations, and maintenance, such as storage capacity issues and reliance on only one source water supply.

5.3.1.1 Sampling

The inspection included an extensive sampling component – EPA collected drinking water samples at 13 different locations at JBPHH and AMR, including sampling of the active and inactive groundwater sources. Navy collected split samples at every location EPA collected samples except for one home due to a leaking sink.

EPA samples detected TPH-d in six of the 13 samples collected, while Navy had non-detects for all TPH samples. None of EPA's TPH-d detections appeared to have a JP-5 signature. All 13 samples were non-detect for VOCs and two SVOCs (benzo[a]pyrene and 1-methylnaphthalene). There were low-level detections, close to the MDL, for 2-methylnaphthalene in one sample and naphthalene in

[94] EPA letter to Navy – Conditional Approval of Extended Drinking Water Monitoring for Joint Base Pearl Harbor-Hickam Drinking Water System, November 1, 2024, https://www.epa.gov/system/files/documents/2024-11/epa-letter-conditional-approval-extended-dw-monitoring-jbphh-water-system.pdf.
[95] Navy and Army - Extended Drinking Water Monitoring Plan for JBPHH and AMR, October 23, 2024: https://jbphh-safewaters.org/public/JBPHH_EDWM_Plan_23Oct24.pdf.
[96] Navy and Army – EDWM Supplement A Tier 2 Analysis of Total Petroleum Hydrocarbons (TPH) and Fuel Indicator Compounds, October 2024: https://jbphh-safewaters.org/public/EDWM_Supplement_A_Oct_2024_Redacted.pdf.
[97] 42 U.S.C. § 300j-4: https://uscode.house.gov/view.xhtml?req=(title:42%20section:300j-4%20edition:prelim).

three samples, including one duplicate. Out of these samples containing low-level SVOCs, there was one sample containing a low-level concentration of TPH-d. All of EPA's TPH-d detections had qualifiers for the results, including, but not limited to:

- C1: The reported concentration for this analyte is below the quantitation limit; and
- J: The reported result for this analyte should be considered an estimated value (i.e., the result is between the MDL and the RL).

All EPA sampling results may be found in the 2024 JBPHH inspection report[98] and 2024 AMR inspection report[99].

5.3.1.2 Findings

EPA's inspection observed shortcomings with the PWSs' resilience that were directly attributable to the ongoing recovery efforts from the Red Hill incident. The PWSs were found to be reliant on one source to provide water to approximately 100,000 consumers with insufficient back-up water supply in the event of an emergency because the PWSs' two other sources (Red Hill and Aiea-Halawa Shafts) were temporarily offline due to contamination concerns. The PWSs had a low total storage capacity and only had enough storage to provide water for a few hours in an emergency due to the replacement project of the PWSs' redundant large capacity storage tank. Moreover, the infrastructure assets had sanitary defects, with the storage tanks in particular lacking in sufficient maintenance such as the failure to comprehensively inspect and clean multiple tanks for a prolonged period of time. Lastly, the PWSs' Risk and Resilience Assessment did not contain all the required information.

The inspection identified that the operator work schedule and system records did not meet the 2023 ACO requirements. As a result, the Navy set out to improve JBPHH's resilience. This included working with DOH to identify the necessary steps to re-activate the Aiea-Halawa Shaft and the Red Hill Shaft to have additional sources available. The Navy is aware of the storage tank concerns and are in the process of replacing storage tanks but will not be able to fully address tank maintenance and system storage capacity concerns for multiple years due to the replacement/construction process. Findings from the 2024 inspection have been responded to by the Navy and addressed or corrective actions have been identified and folded into the 2023 ACO as requirements.

5.3.2 September 2024 Field Sampling Audit of JBPHH

During the week of September 9, 2024, EPA performed a field audit of every Navy drinking water sampling team in the field during the period of the audit to ensure adherence with the SOPs of the EDWM Supplement A document and to observe the collection of split samples that would be analyzed at EPA Region 9 Laboratory. All five sampling teams were audited at a total of 11 locations, including residences/priority buildings, fire hydrants, and the Waiawa Shaft, to account for the different SOPs followed and the varying parameters sampled at each location type. EPA

[98] EPA - SDWA June 3-7, 2024 Inspection Report for JBPHH, redacted version finalized on September 19, 2024: https://www.epa.gov/system/files/documents/2024-10/sdwa-jbphh-inspection-report-complete-redacted-2024-09-19.pdf.

[99] EPA - SDWA June 3-7, 2024 Inspection Report for AMR, redacted version finalized on September 19, 2024: epa.gov/system/files/documents/2024-10/sdwa-inspection-report-aliamanu-military-reservation-pws-complete-redacted-2024-09-19.pdf.

provided a Field Audit Report[100] to the Navy with observations and recommendations to be appropriately addressed and the Navy implemented modifications into the applicable SOPs.

5.4 EDWM Sampling Summary

The Navy's drinking water sample results for EDWM are available on the Joint Base Pearl Harbor-Hickam Drinking Water Monitoring Dashboard[101], accessible via the Safe Waters[102] website. The Navy collected approximately 9,107 samples from 3,810 locations during EDWM from April 4, 2024, to April 4, 2025. According to the EDWM Plan, the monitoring concluded on March 31, 2025. Due to schedule conflicts, the last Navy samples were taken on April 4, 2025.

Considering the lessons learned from LTM, EPA committed to performing independent split sample analysis on a selection of drinking water samples collected by the Navy under the EDWM program. Similar to the LTM split samples, the Navy collected split samples for EPA analysis in a series due to variances in laboratory required bottleware and preservation (discussed in Section 4.3.2). Split samples collected by the Navy were sent to EPA Region 9's certified laboratory in Corvallis, Oregon for independent analysis. EPA began laboratory analysis of EDWM split samples on April 22, 2024, and concluded on March 31, 2025. Analytical challenges were experienced with 8015 for the analysis of TPH-d in samples analyzed before September 30, 2024, as discussed further in Section 5.5.4.2. For a list of the analytes and results of EPA's EDWM split sample results, refer to Section 5.5 in this report.

MCLs[103], established under the NPDWR, are the highest level of a contaminant allowed in drinking water and are the enforceable standards for all public water systems. ISPs are set by DOH for specific contamination events and are calculated based on environmental and health risk with incident-specific factors. In the case of the Red Hill incident, the ISP for TPH reflects the composition and toxicity of JP-5 and its constituents. The purpose of ISPs is to set parameters for analytes related to the contamination event that do not have an MCL or to set parameters that are at least the set MCL, if not more stringent. ISPs were used for monitoring purposes during the emergency response and LTM periods (December 2021-March 2024). After LTM ended, ISPs were no longer used by DOH or the Navy for monitoring purposes. Instead, MCLs were the sole standards to assess water quality. In June 2024, DOH revised the EAL for Combined TPH from 266 µg/L to 91 µg/L. However, the EDWM plan required the Navy to investigate and remediate all TPH detections above the MDL.

Under the Final EDWM Plan[95], there were four COA scenarios that required Navy follow-up action: COA 1 to respond to MCL exceedances at fire hydrants, COA 2 for MCL exceedances and residences and priority buildings, COA 3 for TPH detections above the MDL or detections of JP-5 indicator compounds and petroleum indicators above the RL, and COA 4 for detections of other

[100] EPA – Field Sampling Audit of Red Hill JBPHH (Redacted), October 21, 2024: https://www.epa.gov/system/files/documents/2024-11/field-sampling-audit-of-red-hill-joint-base-pearl-harbor-hickam-honolulu-hi-redacted-2024-11-27.pdf.
[101] JBPHH Drinking Water Monitoring Dashboard: https://app.powerbi.com/view?r=eyJrIjoiNTIyNDU0OTMtODgwNS00ZjQ4LTg1Y2UtODkxYTgxMjQ5NGZhIiwidCI6ImUyYzE5MDhiLTI2NzItNGE0Ni05M2ZkLTdmMDhkYTExNjZiNSIsImMiOjJ9.
[102] JBPHH– Safe Waters: https://www.jbphh-safewaters.org
[103] EPA NPDWR Primary Standards and Treatment Techniques: https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations.

analytes that do not have an MCL. TPH does not have an MCL; however, the Navy was required under the enforceable Final EDWM Plan to conduct further investigations under COA 3, due to the non-specific nature of the TPH analytical method, as discussed previously.

The Navy reported an exceedance of regulatory drinking water standards for only one analyte, lead, during EDWM (Table 13). Lead currently has an Action Level (AL) of 15 µg/L that requires actions be taken by the PWS to mitigate lead levels in drinking water if more than 10% of sample sites report concentrations above the AL. All analytes detected during EDWM are further discussed and compared between EPA and Navy's data in Section 5.5 for VOCs, SVOCs, TPH, TOC, 2,2MEE, Anions, Cations and Silica, and Metals. During EDWM, the Navy used sample bottles for 8015 (TPH-d/o) that contained sodium thiosulfate as a chlorine quencher, for all Navy samples. The Navy also used sample bottles for 8260 (TPH-g) that contained ascorbic acid to quench samples in the field for Navy analysis. EPA provided sample bottles containing sodium thiosulfate for split sample collection for TPH-d, TPH-o, and TPH-g analysis. The low-level TPH-like detections observed during LTM were not observed after quenching was implemented during EDWM.

Table 13. Navy's sampling summary for EDWM.

Flushing Zone	# Locations Sampled	% Locations Sampled – Residences and Priority Buildings	% Locations Sampled - Distribution	# of Exceedances	Exceeded Analytes
A1	255	98	2	0	-
A2	149	93	7	0	-
A3	537	97	3	0	-
B1	78	97	3	0	-
C1	13	54	46	0	-
C2	31	77	23	0	-
C3	4	50	50	0	-
D1	180[1]	97	3	0	-
D2	547	98	2	1	Lead
D3	379	98	2	0	-
D4	3	33	67	0	-
E1	33	88	12	0	-
F1	265	96	4	0	-
F2	506	96	4	0	-
G1	7	86	14	0	-
H1	345[1]	98	2	0	-
H2	103	97	3	0	-
H3	164	96	4	0	-
I1	60	98	2	0	-
J1	146	97	3	0	-
Waiawa Shaft	2 (pre- and post-treatment)	-	-	0	-

Flushing Zone	# Locations Sampled	% Locations Sampled – Residences and Priority Buildings	% Locations Sampled - Distribution	# of Exceedances	Exceeded Analytes
AMR EPDS and Other Buildings	2	-	-	0	-
Total	3809[1]	96	3	1	Lead

[1] The listed number of locations sampled were acquired from an export of the Navy's validated results but do not match the number listed on the Safe Waters site due to the organization of the website. The number of sample identifications and exceedances are the same.

EPA received approximately 480 split samples, not including QC samples, collected at 332 locations from April 2024-March 2025 for EDWM. EPA's EDWM drinking water sample results are published on the *Red Hill Split Sample Drinking Water Results Application*[104], summarized in Table 14 and analyzed in Section 5.5.

The EPA Region 9 and subcontract laboratories did not have the capabilities to analyze for the following EDWM target analytes: benzo[g,h,i]perylene, dibenz[a,h]anthracene, indeno[1,2,3-cd]pyrene, ortho-phosphate-p, chlorite, bromate, and chlorate. Therefore, EPA did not collect data on these chemicals for drinking water in the JBPHH and AMR PWSs. However, results for these analytes were reported by the Navy for the applicable sample types.

The EPA Region 9 laboratory and contract laboratory began analysis of EDWM samples for the full analyte list comprising methods 524.2 (Section 2.4.1.1) and 525.3 (refer to Section 2.4.2) with samples collected on June 10, 2024 and July 1, 2024. The Navy did not report the analysis for the full analyte list of 524.2 and 525.3, and instead only reported the analysis for the VOCs and SVOCs in the EDWM analyte list. However, Navy's results for the full lists were available for EPA review. The results of the supplemental constituents analyzed by EPA under 524.2 and 525.3 that are not part of the EDWM analyte list are not included in the Section 5.0 discussion; however, they are available on EPA's dashboard.

Table 14. EPA split sample summary for EDWM.

Flushing Zone	Locations Sampled	% Samples - Residential and Non-Residential Buildings	% Samples - Distribution	# of Exceedances	Exceeded Analytes
A1	15	60	40	0	-
A2	26	62	38	0	-
A3	27	70	30	0[1]	-
B1	5	60	40	0	-
C1	8	25	75	0	-

[104] EPA – Red Hill Drinking Water Results for EDWM Split Samples: https://awsedap.epa.gov/public/single/?appid=67ca6d70-bd07-4f7b-8131-fd93ce85dd76&&obj=wXRqPy&theme=horizon&opt=ctxmenu,currsel&theme=horizon&opt=ctxmenu,currsel&identity=preview.

Flushing Zone	Locations Sampled	% Samples - Residential and Non-Residential Buildings	% Samples - Distribution	# of Exceedances	Exceeded Analytes
C2	8	25	75	0	-
C3	2	0	100	0	-
D1	16	63	38	0	-
D2	45	84	16	0[1]	-
D3	33	79	21	0	-
D4	3	33	67	0	-
E1	4	25	75	0	-
F1	21	62	38	0[1]	-
F2	53	72	28	0	-
G1	1	0	100	0	-
H1	28	96	4	0	-
H2	7	71	29	0	-
H3	14	86	14	0	-
I1	6	83	17	0	-
J1	8	63	38	0	-
Waiawa Shaft	2	-	-	0	-
Total	332	70	30	0[1]	-

[1] Though not federally regulated, high TOC levels were detected and confirmed to be associated with the usage of an incorrect preservative and assigned an A1 qualifier (A1: the sample was not properly preserved in the field). Refer to Section 5.5.5 for more information.

5.5 EPA EDWM Split Sample Comparison and Analysis

EPA's drinking water split sample results for EDWM are available on the EPA Red Hill website[105]. The subsections below summarize the comparison of EPA's EDWM split sample results with the Navy's results for each individual parameter. The listed number of samples refers to all analyzed samples from April 2024 to March 2025 for EDWM. Notably, as described in Table 28, Footnote 2, the number of EPA split samples listed for each analyte in Tables 15-28 refers to the number of distinct samples collected. The number of sample results may be a higher number due to duplicates with the same sample identification (ID) that were analyzed, or samples were ran twice with two different methods (e.g. naphthalene was analyzed with both 8270E and 524.2, yielding 876 results for 474 samples). Monitoring frequencies for each analyte can be found in Table 2-2 of the EDWM Plan[95]. For a comparison of only EPA's split samples for EDWM and the associated Navy sample, please refer to Table 28.

[105] EPA Drinking Water System Compliance at Joint Base Pearl Harbor – Hickam: https://www.epa.gov/red-hill/drinking-water-compliance. Direct link to the EPA Red Hill Drinking Water Results dashboard: https://awsedap.epa.gov/public/single/?appid=67ca6d70-bd07-4f7b-8131-fd93ce85dd76&&obj=wXRqPy&theme=horizon&opt=ctxmenu,currsel&theme=horizon&opt=ctxmenu,currsel&identity=preview.

EPA and Navy laboratories use different naming conventions for the same chemical constituents. The EPA Region 9 laboratory reports analytes based on the IUPAC nomenclature, whereas the Navy laboratory uses common names. To facilitate direct comparison with the Navy's sampling data, the common nomenclature will be listed in parentheses in the summary tables and used to directly reference analytes.

5.5.1 Non-Detects (ND)

The MDL is the lowest concentration of an analyte that can be reported with 99% confidence that the analyte concentration is greater than zero (i.e., a detection). A result below the MDL is listed as ND. The laboratory RL is the lowest concentration that can be reported with a high level of confidence to be the true concentration. Any value between the MDL and the laboratory RL is considered an estimated value. The MDL and RL for each analyte differ depending on the utilized laboratory, method, and analytical equipment. MDLs and RLs may also differ slightly in a few samples per batch due to small variances in the analytical equipment (e.g., the MDL and RL for TPH-d based on the MDL study is 90 µg/L and 270 µg/L, respectively, but a sample analyzed for TPH-d may be reported with an MDL of 87 µg/L and RL of 267 µg/L).

5.5.2 Volatile Organic Compounds (VOCs)

For a description of VOCs, refer to Section 2.4.1. Of the 13 EDWM VOC analytes, EPA reported detections of only TTHM, and Navy reported low-level detections for two additional analytes, EDB and toluene (Table 16). The highest Navy detection for EDB was 0.02 µg/L, below the EPA MCL of 0.05 µg/L. The highest Navy detection for toluene was 0.57 µg/L, below the EPA MCL of 1000 µg/L. Of the 13 EDWM VOC analytes, neither EPA nor Navy detected the 10 analytes listed below (Table 15).

Table 15. Summary of EPA and Navy VOC non-detects for EDWM.

Analyte	Total EPA EDWM Samples	Total Navy EDWM Samples	EPA MDL (µg/L)	Navy MDL (µg/L)
1,2,4-Trimethylbenzene[2]	454	6857	0.25	0.26
1,3,5-Trimethylbenzene[2]	454	6857		0.25
Benzene[2]	454	6857		
Butylbenzene (n-butylbenzene)[2]	394	4489		
Ethylbenzene[2]	454	6857		
Isopropylbenzene (cumene)[2]	394	4488		
Propylbenzene (n-propylbenzene)[2]	394	4489		
sec-Butylbenzene[2]	394	4489		
tert-Butylbenzene[2]	394	4489		
Total Xylenes[2]	454	6857		

[2]Primary component and key indicator of JP-5.

As previously noted, TTHMs were the sole VOC analyte detected by EPA during EDWM. TTHMs are the sum of four trihalomethanes (THMs) (chloroform, bromodichloromethane, dibromochloromethane (also known as chlorodibromomethane), and bromoform) that form from a reaction between a drinking water disinfectant such as chlorine and naturally occurring organic or inorganic matter. All PWSs that use chlorination to disinfect drinking water will have measurable

levels of THMs. Detectable concentrations of TTHMs were reported in 174 of 454 (38.3%) EPA split samples and 3324 of 6854 (48.5%) Navy samples. All reported EPA and Navy results were below the EPA MCL of 80 µg/L.

Overall, the VOCs detected in drinking water by EPA and the Navy were below their respective MCLs. However, Section 5.2.3 of the EDWM Plan describes follow-up actions per COA 3 that are to be followed if a JP-5 or petroleum indicator is detected above the RL. Per COA 3[106], the Navy was to notify EPA and DOH within 24 hours of receipt of the lab report for any above RL detections for JP-5 indicators and petroleum indicators. EPA did not receive notice of the Navy's toluene detection of 0.57 µg/L nor of any actions taken as described in COA 3.

Table 16. Summary of EPA and Navy VOC detections for EDWM.

Analyte	MCL (µg/L)	Lab	MDL (µg/L)	RL (µg/L)	# Samples	# Detects	Highest Result (µg/L)
Total Trihalomethanes (TTHM)	80	EPA	0.25	0.5	454	173	38.7
		Navy	0.25	0.5	6854	3324	45.4
1,2-Dibromoethane (EDB)[1]	0.05	EPA	0.25	0.5	394[3]	0	ND
		Navy	0.005	0.022[4]	488	3	0.02
Toluene[2]	1000	EPA	0.25	0.5	454	0	ND
		Navy	0.25	0.5	6857	2	0.57

[1] Potentially associated with non-JP-5 petroleum products.
[2] Primary component and key indicator of JP-5.
[3] EDB samples collected at hydrants were ran twice using Method 524.2, with an MDL of 0.25 µg/L, and Method 524.2 – low level, with an MDL of 0.0025 µg/L. 394 total samples were analyzed by the EPA Region 9 laboratory with a total of 452 sample results reported. 58 hydrants were analyzed for both Method 524.2 and Method 524.2 – low level. No detections were reported for the 452 results.
[4] To analyze for EDB, the Navy used 504.1, which is more sensitive than the EPA's utilized 524.2.

5.5.3 Semivolatile Organic Compounds (SVOCs)

For a description of SVOCs, refer to Section 2.4.2. EPA analyzed BaP with 525.3 and the remaining EDWM SVOCs with 8270E, while Navy used 525.2 for all SVOC analysis. EPA detected only three of the 12 targeted SVOCs in the EDWM split samples (Table 18). The Navy reported low-level detections for two additional SVOC analytes in their samples. Notably, EPA did not report concentrations for the two additional analytes despite employing an order of magnitude lower MDL than the Navy (Table 18). Variances in sensitivities that may occur due to differing methodology is discussed in Section 0. Neither EPA nor Navy detected seven of the 12 targeted SVOC analytes (Table 17). The highest Navy EDWM detection was 0.2 µg/L for phenanthrene, which is not regulated in drinking water under SDWA. The highest Navy EDWM detection for BaP was 0.064 µg/L and there were no exceedances of the EPA MCL of 0.2 µg/L in drinking water (Table 18).

[106] EDWM Plan, Section 5.2 Next Steps After Detection or Exceedance (pg. 20): https://jbphh-safewaters.org/public/JBPHH_EDWM_Plan_23Oct24.pdf.

Table 17. Summary of EPA SVOC non-detect results and Navy comparison for EDWM.

Analyte	Total EPA EDWM Samples	Total Navy EDWM Samples	EPA MDL (µg/L)	Navy MDL (µg/L)
Acenaphthylene[1]	386	4499	0.024	0.25
Anthracene[1]		4497	0.031	
Benzo[b]fluoranthene[1]		4499	0.034	
Benzo[k]fluoranthene[1]		4499	0.026	
Chrysene[1]		4499	0.028	
Fluorene[1]		4499	0.028	
Pyrene[1]		4499	0.024	

[1] Potentially associated with non-JP-5 petroleum products.

EPA reported concentrations for 1-methylnaphthalene, 2-methlynaphthalene, and naphthalene (Table 18). Detectable levels of 1-methylnaphthalene and 2-methylnaphthalene were reported in 0.6% and 1.1% of EPA split samples, respectively, and absent in Navy EDWM samples. Naphthalene was detected in 28 of 474 (5.9%) of EPA split samples and 2 of 6867 (0.03%) Navy EDWM samples. All three analytes are not regulated in drinking water under the SDWA, and since the results were below the RL, EDWM COA 4 did not apply and there was no follow-up action required by the Navy.

Table 18. Summary of EPA and Navy SVOC detections for EDWM.

Analyte	MCL (µg/L)	Lab	MDL (µg/L)	RL (µg/L)	# Samples	# Detects	Highest Result (µg/L)
Benzo[a]pyrene (BaP)[1]	0.2	EPA	0.0062	0.02	473	0	ND
		Navy	0.01	0.02	6867	233	0.064
1-Methylnaphthalene[2]	-	EPA	0.0025 - 0.025	0.01 - 0.1	474	3	0.0041
		Navy	0.25	0.5	6867	0	ND
2-Methylnaphthalene[2]	-	EPA	0.0029 - 0.029	0.01 - 0.1	474	5	0.007
		Navy	0.25	0.5	6867	0	ND
Naphthalene[2]	-	EPA	0.0022 - 0.022	0.01 - 0.1	474[3]	28[3]	1.5
		Navy	0.25	0.5	6867	2	1.3
Phenanthrene[1]	-	EPA	0.0034 - 0.034	0.01 - 0.1	386	0	ND
		Navy	0.25	0.5	4499	3	0.41

[1] Potentially associated with non-JP-5 petroleum products.

[2] Primary component and key indicator of JP-5.

[3] Naphthalene was analyzed using both 8270E and 524.2, as part of the full 524.2 method analyte list. EPA Region 9 laboratory began reporting the full method analyte list for 524.2 starting with samples collected on June 10, 2024, for additional insight on other potentially hydrocarbon associated analytes outside of the EDWM analyte list. A total of 876 results were reported for naphthalene for the entirety of EDWM. The 474 samples listed are the number of samples collected for SVOC 8270E analysis. The 28 detections listed are the number of detections for unique sample IDs. There were 29 total naphthalene detections for 28 unique sample IDs.

Methylnaphthalene and Naphthalene

EPA had 28 detections of naphthalene and the Navy reported only two detections of naphthalene in their samples (Table 18). The higher detection frequency of naphthalene in EPA split samples compared to the Navy's results is attributed to the lower detection limit of the analytical method used by the EPA Region 9 subcontract laboratory. EPA's 8270E MDL for naphthalene was 0.0022 µg/L for April to July 2024 analysis and 0.022 µg/L for July 2024. This decrease in sensitivity was also reflected in the 8270E MDLs for 1-methylnaphthalene and 2-methylnaphthalene (Table 18). Both MDLs display a higher sensitivity than the Navy's 0.25 µg/L MDL. EPA's naphthalene detections ranged from 0.0022 µg/L to 1.5 µg/L and 27 out of the 28 detects were below Navy's MDL. EPA's single detection above Navy's MDL had a concentration of 1.5 µg/L, similar to the Navy's reported result of 1.3 µg/L for the same sample. Per the EDWM Plan COA 3, the Navy was to notify EPA of the sample displaying 1.5 µg/L for naphthalene, a JP-5 indicator. EPA did not receive notice of this sample nor of any actions taken as described under the EDWM Plan COA 3. Concentrations for 1-methylnaphthalene and 2-methylnaphthalene, also analyzed using 8270E, fell below the Navy's respective MDLs, consistent with the non-detects reported by the Navy for these analytes.

Benzo[a]pyrene (BaP)

BaP was detected in 3.4%, or 233 out of 6867, of Navy's EDWM samples. BaP was not detected in any of the 473 EPA split samples analyzed, including three split samples where the Navy reported detections, despite the EPA's laboratory exhibiting lower, more sensitive detection capabilities with an MDL of 0.0062 µg/L, compared to the Navy's MDL of 0.01 µg/L. The Navy detected BaP during EDWM at a higher frequency than other fuel indicators, similar to what was observed during LTM (see Section 4.3.1).

Per the EDWM Plan COA 3, the Navy notified EPA and DOH of applicable BaP detections for Q3 and Q4, conducted Tier 1 analysis of laboratory method blanks to assess correlation with laboratory contamination, conducted an initial assessment to evaluate blank contamination and association with TPH-g, TPH-d, or TPH-o, and notified the resident or building manager for the sampling location. For these Q3 and Q4 BaP detections, the Navy also completed a Tier 2 analysis per the EDWM Supplement A document. The Navy determined that the BaP detections were unrelated to fuel contamination. EPA did not receive notice of any above RL BaP detections for Q1 or Q2, nor of any follow-up actions as described in the EDWM Plan COA 3.

TPH has not been detected in Navy samples with quantifiable BaP concentrations, and there are no observed patterns between the detections and location types, zones, or frequency. The Navy conducted a technical investigation and determined that the detections were likely due to low-level contamination at the laboratory, likely from trace amounts present on laboratory equipment and not related to the Red Hill Incident. The presence of BaP is further discussed in the Navy's Extended Drinking Water Monitoring Plan: Fourth Quarterly Report, to be later uploaded to the Safe Waters site. The Navy will be releasing a technical memorandum detailing the findings of the investigation at a future date.

5.5.4 Total Petroleum Hydrocarbons (TPH)

The Navy utilized 8015D[11] for TPH-d/o analysis and 8260D for TPH-g analysis of Navy samples. The EPA Region 9 laboratory analyzed split samples with 8015C[10]. These methods and an overview of TPH are discussed in Sections 2.2 and 2.0, respectively. 8015C and 8015D have minimal differences and are expected to yield similar results. For the purposes of this report, 8015C and 8015D will be referred to as 8015.

During EDWM, the Navy collected drinking water samples for TPH (TPH-d, TPH-o, and TPH-g) analysis from residences and priority buildings on a daily basis and from hydrants and the Waiawa Shaft on a monthly basis. Per the Navy's 2024 Tech Memo (see Section 4.4), the Navy's partially attributed TPH detections during LTM to residual chlorine interaction with the utilized surrogate, OTP. As such, the Navy began quenching TPH-d and TPH-o samples in the laboratory starting April 4, 2024, and in the field starting May 28, 2024. Due to a delay in bottleware shipments, EPA quenched TPH-d and TPH-o split samples in the laboratory until the Navy received the bottleware in July 2024. EPA TPH split samples were quenched with sodium thiosulfate, as prescribed in Chapter 4[72] of the SW-846 Compendium, beginning July 29, 2024. The EPA Region 9 laboratory used another surrogate for TPH-d and TPH-o analysis, hexacosane, and did not observe any residual chlorine interactions with this specific surrogate in their surrogate interaction investigation (see Section 4.6.6.1).

For EPA EDWM split samples, following an initial detection of organic hydrocarbons through the TPH analysis, chromatographic patterns were further evaluated for the presence of identifiable signatures that correspond to known hydrocarbon or fuel mixtures. Experienced EPA Region 9 laboratory analysts evaluated the patterns of all reported hydrocarbon results against a reference library of defined hydrocarbon mixtures, including jet fuel, and assigned an appropriate qualifier based on the match. If a pattern was identified but did not match a characteristic signature of a known mixture, it was assigned a F13 qualifier. If a pattern was not present, the F1 qualifier was assigned, indicating that the quantified hydrocarbon result cannot be considered a definitive detection of a hydrocarbon mixture (see Section 2.3.2 for examples of F1 associated TPH-d results). EPA has assigned qualifiers to all reported hydrocarbon data, including non-detects, as an integral part of the result that provides critical context regarding the associated mixture. Further details on the interpretation of hydrocarbon data that was reported within the TPH ranges are provided in Section 6.0.

5.5.4.1 TPH-g

The TPH-g range includes relatively short-length hydrocarbons that are flammable and easily evaporate. TPH-g includes compounds such as BTEX, hexane, propene, and alcohols, and can be found in products like gasoline fuel, aerosol sprays, paint thinners, and jet fuel. TPH-g was absent in EPA split samples and detected in 3 of 6,869 (0.04%) of Navy EDWM samples (Table 19). Concentrations ranged from 63.5 to 143 µg/L in Navy samples.

Table 19. Summary of EPA and Navy TPH-g detections for EDWM.

Analyte	MCL[1] (µg/L)	Lab	MDL (µg/L)	RL (µg/L)	# Samples	# Detects	Highest Result (µg/L)
TPH-Gasoline Range Organics (TPH-g/GRO)	-	EPA	25	50	475	0	ND
		Navy	50	80	6869	3[2]	143

[1] There is no individual MCL for TPH-g, but DOH does have an EAL for Combined TPH at 91 µg/L.

[2] Four samples are listed as detections on the Navy's Safe Waters website and in the Navy's Q4/Final Report. One of the displayed results is from a duplicate sample and not included in this table.

Navy followed the EDWM Plan COA 3 as follow-up for its three TPH-g detections. The samples were collected at three different hydrants on May 29, July 16, and October 22, 2024, indicating a potential correlation with sample location type but not sample date. No EPA split samples were

collected on these dates. The samples exhibiting TPH-g impacts were non-detect for TPH-d and TPH-o. In addition, for the TPH-g detection on October 22, 2024, the Navy completed a Tier 2 analysis following the EDWM Supplement A document. The Navy determined the three detections as non-fuel related and attributed the TPH-g detections to the isopropyl alcohol that is used as a disinfectant prior to hydrant sampling. The Navy documented these determinations in technical memos sent to EPA.

5.5.4.2 TPH-d

The TPH-d range includes middle distillate petroleum hydrocarbons and products, such as diesel, kerosene, and jet fuel. Cooking oils (e.g., vegetable and olive oil) will also be identified in this range. These medium-length hydrocarbons are less volatile and flammable than those present in TPH-g. The TPH-d range includes straight-chain alkanes such as hexane, nonane, dodecane, tricosane, and paraffins, and ringed aromatics such as naphthalenes and pyrene. TPH-d was detected in 1 of 260 (0.38%) EPA split samples and 4 of 6,870 (0.06%) Navy samples (Table 20). Concentrations ranged from 62.3 to 145 µg/L in Navy samples and 47 to 87 µg/L in EPA split samples. Three of the four Navy samples with TPH-d detections also reported TPH-o detections and have Combined TPH levels of 1,552, 109, and 390 µg/L. The Navy did not collect split samples for EPA analysis on the days the four Navy samples had TPH-d detections.

The Navy followed the EDWM Plan COA 3 as a follow-up for its four TPH-d detections. In addition, for three of the TPH-d detections on July 11, July 23, and December 24, 2024, the Navy completed a Tier 2 analysis following the EDWM Supplement A document. The Navy confirmed all four detections as non-fuel-related and attributed the concentrations to contamination from a glove, laboratory contamination, or lubricating grease on a sampled hydrant. The Navy documented these determinations in technical memos sent to EPA.

Table 20. Summary of EPA and Navy TPH-d detections for EDWM.

Analyte	MCL[1] (µg/L)	Lab	MDL (µg/L)	RL (µg/L)	# Samples	# Detects	Highest Result (µg/L)
TPH - Diesel Range Organics (TPH-d/DRO)	-	EPA	90	270	260	1	87
		Navy	50	73	6870	4	145

[1] There is no individual MCL for TPH-d, but DOH does have an EAL for Combined TPH at 91 µg/L.

EPA analyzed 480 total samples for TPH-d from April 2024-March 2025, but only 260 samples are included in the final dataset due to extraction and analysis problems that EPA experienced from April through September 2024. Prior to the EDWM program, the Region 9 Laboratory had not yet reconstituted the TPH-d method following the laboratory's relocation from Richmond, California to Corvallis, Oregon in 2024. The problems encountered during the initial months of the EDWM program were with the extraction procedure method development, only affecting TPH-d analysis. The EPA Red Hill team requested a data review by the Region 9 Quality Assurance (QA) Branch due to discrepancies seen between EPA and Navy's TPH-d data. EPA Region 9 QA Branch conducted a data review of 13 batches of data, covering approximately 192 samples collected and analyzed during EDWM from April 24, 2024, to August 5, 2024, which raised attention to quality-control issues for the TPH-d method. The QC issues were resolved by the EPA Region 9 laboratory post October 17, 2024, affecting all TPH-d samples collected before September 30, 2024. Per the EPA Region 9 QA Branch recommendations (detailed in Section 6.1.2.2), TPH-d samples collected before September 30, 2024, or 220 total samples, will not be reported due to QC failures during

method development that were not adequately addressed. All Navy EDWM samples that had a corresponding EPA split sample collected before September 30, 2024, did not have a TPH-d detection. The EPA Region 9 QA Branch reviewed the Navy contract laboratory's QC measures and confirmed validity and quality of the utilized methods and reported results.

Also, as a response to the EPA Region 9 QA Branch recommendation (see Section 6.1.2.2) to review the MDL study due to the QC issues observed with low-level detections, an updated MDL based on method blanks for 8015, affecting both TPH-d and TPH-o analysis parameters, was calculated in September 2025. The MDL for TPH-d was raised from 50 µg/L to 90 µg/L (+/- 5µg/L as indicated in the specific lab reports) and the RL was raised from 150 µg/L to 270 µg/L (similar tolerances as MDL). The revised laboratory reports reflecting these MDL and RL changes for all samples collected after September 30, 2024, were received on September 24, 2025. The QC issues observed from April through September 2024 were unique to the analysis of TPH-d and were not applicable to the other methods utilized or other analytical results reported by EPA during EDWM.

For samples collected from April through September 2024, TPH-d was reported in 102 out of 220 (46%) split samples analyzed by EPA. There were no hydrocarbon mixture patterns in 100 of the 102 detections and the EPA Region 9 laboratory attributed these 100 detections primarily to noise. Since split samples collected prior to July 29, 2024, were not quenched with sodium thiosulfate in the field, this may have also contributed to error. The remaining 2 of the 102 detections were attributed to an unknown or mixed fuel or product type unrelated to jet fuel. These two samples were absent of a JP-5 signature and weathered fuel signatures in the chromatograms. These two samples were also ND for TPH-g and ND for the 20 fuel indicators and petroleum-associated compounds. The two samples did have low-level detections of naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene that were below the RLs. EPA did not find any evidence indicating an UCM related to JP-5 or other fuels.

After the extraction and analysis issues were resolved at the EPA laboratory, EPA initially detected TPH-d in two samples. One TPH-d detection would be ultimately reported as ND based on EPA Region 9 laboratory's revised MDL. For the second TPH-d detection, EPA laboratory analysts confirmed the sample's chromatogram pattern matched a diesel fuel signature, so it was reported as a TPH-d detection as noted in Table 20, above.

For the sample that was reported as non-detect, the Navy collected the sample at a residence on December 16, 2024, and EPA's split sample analysis initially reported a TPH-d concentration of 47 µg/L, the same value of the MDL for TPH-d at the time of analysis and this concentration was considered an estimated value. EPA laboratory analysts confirmed that there was an absence of a fuel or hydocarbon mixture pattern and attributed the concentration to noise. When EPA Region 9 laboratory's MDL for TPH-d was raised to 90 (± 5) µg/L in September 2024, this sample's TPH-d concentration fell below the MDL and was subsequently changed to non-detect, consistent with data reporting protocols.

The one TPH-d detection reported in the remaining 260 EPA split samples was collected at a residence on March 24, 2025, by the Navy, and EPA split sample analysis reported a concentration of 87 µg/L for TPH-d. For this specific sample, the reported concentration is between its MDL of 86 µg/L and RL of 260 µg/L and is considered an estimated value. In addition to TPH-d, this sample reported ND for the fuel and petroleum indicators in the EDWM analyte list and all analytes in the full 524.2 and 525.3 lists. Though the EPA Region 9 laboratory confirmed that the chromatogram

pattern for this TPH-d detection matched a diesel fuel signature, the pattern had a high similarity to the utilized diesel fuel standard and did not display expected weathering or slightly varying peaks that would be expected from a non-standard. The EPA Region 9 laboratory also confirmed that the pattern does not match a jet fuel signature and attributed this TPH-d detection to laboratory contamination. EPA reviewed the associated sample analyzed by the Navy and observed that it reported ND for TPH-d. EPA additionally informed the Navy and DOH of this split sample result and the Navy resampled at the same location on June 27, 2025, for a total of four samples taken in consecutive order. The Navy's four resamples of the March 24, 2025, EPA split sample reported ND for TPH-d and TPH-o. All four resamples underwent a Tier 2 analysis per the EDWM Supplemental A document. The results for the four samples were ND for a total of 143 PIANO VOCs analyzed, except for isopentane and pentane. Isopentane and pentane were detected in all four resamples at levels ranging from 0.51-2.96 µg/L and 0.80-4.38 µg/L, respectively. Isopentane was also detected in the associated trip blank at 0.47 µg/L, and ND in the method blank, suggesting transportation or laboratory contamination as a potential source of the analyte. Three out of the four resamples were ND for 79 analyzed PAHs/alkylated PAHs, with the remaining sample containing 3.12 nanograms per liter (ng/L) of biphenyl, below the RL of 9.80 ng/L. The method blank for the sample batch also yielded a biphenyl concentration of 4.57 ng/L, suggesting potential laboratory contamination. Additionally, three out of the four resamples were ND for the total 39 saturated hydrocarbons analyzed, with the remaining resample being ND for all analytes except for TPH (C9-C44) at a concentration of 27.4 µg/L, close to the MDL of 27.2 µg/L. A Technical Memo for the Navy's four resamples results was not generated. Since the initial diesel fuel result was at the MDL and was not repeatable through a split sample and four follow-up resamples, the reliability of the result as being representative of water quality is highly uncertain.

5.5.4.3 TPH-o

The TPH-o range consists of higher molecular-weight petroleum hydrocarbons that have very low volatility, solubility, and are considered combustible, rather than flammable, requiring higher temperatures to ignite. TPH-o includes compounds such as nonacosane and tritriacontane, and high molecular-weight aromatics such as chrysene and benzo[a]pyrene. TPH-o constituents can be found in products like heavy fuel oils, motor oils, lubricants, greases, and cosmetics. TPH-o was detected in 4 of 480 (0.8%) EPA split samples and 8 of 6883 (0.1%) Navy samples (Table 21). In Navy samples, concentrations ranged from 47.4 to 1,460 µg/L, while in EPA's split samples, they ranged from 110 to 130 µg/L.

In response to the EPA Region 9 QA Branch review of TPH-d, the EPA Region 9 laboratory calculated an updated MDL for TPH-o based on method blanks for Method 8015, which coincided with the annual date required by the established SOP for both TPH-d and TPH-o in September 2025. The MDL for TPH-o was raised from 100 µg/L to 120 µg/L and the RL was raised from 300 µg/L to 360 µg/L. The revised laboratory reports reflecting these MDL and RL changes for all samples collected after September 30, 2024, were received on September 24, 2025. Based on the original laboratory reports, there were no TPH-o detections below 100 µg/L that would not be reflected due to the revised laboratory reports.

The Navy followed the EDWM Plan COA 3 as follow-up for its eight TPH-o detections. In addition, for five of the TPH-o detections for samples collected on May 28, July 11, July 22, July 23 and July 24, 2024, the Navy completed a Tier 2 analysis following the EDWM Supplement A document. The eight total TPH-o detection samples were collected from two hydrants and six residences/priority buildings. The Navy did not collect split samples for EPA analysis on the days the eight Navy

samples had TPH-o detections. Three of the eight samples collected by the Navy with TPH-o detections also had TPH-d detections, discussed in Section 5.5.4.2. The two highest TPH-o detections were 1,460 µg/L, sampled at a hydrant on May 29, 2024, and 245 µg/L, sampled at a residence on July 23, 2024. The Navy attributed the 1,460 µg/L result to lubricating grease present on the hydrant at time of sampling and attributed the 245 µg/L to lab contamination, per the provided Navy tech memos for each detection. The Navy confirmed through additional technical memos sent to EPA that five out of the six other samples with TPH-o detections are non-fuel-related and attributed to lubricating grease, glove contamination, and lab contamination. For the TPH-o detection from the sample collected at Fire Hydrant #236 on April 15, 2024, the Navy did not transmit a technical memo to EPA. However, on April 24, 2024, the Navy relayed to EPA that Tier 1 analysis was undertaken. and, as part of the Navy's monthly hydrant sampling during EDWM, the Navy sampled Fire Hydrant #263 every following month until April 2025 with NDs for TPH-o, as well as Combined TPH. Furthermore, the Navy resampled for the initial April 15th detection on August 6, 2024, for a Tier 2 analysis following the EDWM Supplement A document and shared the results with EPA.

Table 21. Summary of EPA and Navy TPH-o detections for EDWM.

Analyte	MCL[1] (µg/L)	Lab	MDL (µg/L)	RL (µg/L)	# Samples	# Detects	Highest Result (µg/L)
TPH - Oil Range Organics (TPH-o/ORO)	-	EPA	120	360	480[2]	4	130
		Navy	50	73	6883	8	1460

[1] There is no individual MCL for TPH-o, but DOH does have an EAL for Combined TPH at 91 µg/L.
[2] 490 sample results for TPH-o were reported for 480 distinct sample IDs.

EPA detected TPH-o in one sample collected at a hydrant on March 3, 2025, with a concentration of 130 µg/L. EPA laboratory analysts confirmed the sample's chromatogram pattern matched a motor oil signature, which was subsequently communicated to DOH and Navy. This concentration lays between the MDL of 120 µg/L and RL of 360 µg/L and is considered an estimated value. This sample reported detects for total alkalinity (52 mg/L) and TTHM (1.67 µg/L), as well, and non-detects for all other EDWM analytes and all analytes in the full 524.2 and 525.3 lists. Though the EPA Region 9 laboratory confirmed that the TPH-o chromatogram pattern matched a motor oil signature, it also has confirmed that the pattern does not match jet fuel and there were no detections of TPH-d, TPH-g, or the 20 additional fuel or petroleum indicators related to known fuel oil spills. The motor oil pattern and quantified TPH-o result may have resulted from the food-grade lubricant that is used on hydrants. Navy's corresponding sample did not detect TPH-o above the Navy's lower detection limit. The Navy did not collect a resample.

EPA detected TPH-o in three other samples: two residential samples collected (130 and 110 µg/L) on October 14, 2024, and one hydrant sample (120 µg/L) collected on October 21, 2024. The TPH-o levels are close to the MDL of 120 µg/L and below the RL of 360 µg/L and considered estimated values. EPA laboratory analysts confirmed that there was not a fuel mixture pattern present in all three samples and attributed the concentrations to quantification of noise. Upon completing our analysis and being unable to attribute the detections to fuels, EPA did not take further action.

5.5.5 Total Organic Carbon (TOC) and Total Alkalinity

Total alkalinity is the summation of bases (carbonate, bicarbonate, and hydroxide alkalinities) to measure the capacity of water to neutralize acids. Total alkalinity ranged from 50 mg/L to 74 mg/L in EPA split samples and 4.8 mg/L to 134 mg/L in Navy samples (Table 22). Total alkalinity is not regulated in drinking water under the SDWA.

Table 22. Summary of EPA and Navy TOC and Total Alkalinity detections for EDWM.

Analyte	MCL (mg/L)	Lab	MDL (mg/L)	RL (mg/L)	# Samples	# Detects	# Detects Above MCL	Highest Result (mg/L)
TOC	-	EPA	0.5	1.0	475	5	-	620
		Navy	0.2	0.5	6859	133	-	2
Total Alkalinity	-	EPA	5.0	10	475	475	-	74
		Navy	3.0	5.0	6857	6857	-	134

TOC is a measurement of organic carbon in a sample and is calculated by subtracting total inorganic carbon from the total carbon. TOC was detected in 5 of 475 (1.1%) EPA split samples and 133 of 6859 (1.9%) Navy EDWM samples (Table 22). Though TOC is not regulated in drinking water under the SDWA, due to the high levels reported by EPA in three samples, similar to wastewater levels, follow-up actions were taken as described below in Section 5.5.5.1.

EPA reported TOC detections in five split samples, with concentrations ranging from 0.53 mg/L to 620 mg/L. TOC was absent in the related Navy samples. For reference, wastewater influent contains TOC levels of 100 to 200 mg/L. The Navy collected the affected split samples in June 2024 (8.8 mg/L in one sample), August 2024 (0.53 mg/L to 620 mg/L in three samples), and December 2024 (520 mg/L in one sample). The EPA Region 9 laboratory observed that the media in the sample bottles were clear with no particulates, which is unusual in samples with high TOC levels, and attributed the TOC concentrations to usage of the wrong preservatives during sampling (see Section 5.5.5.1).

The EPA Region 9 laboratory requested TOC samples to be collected using 3 x 40 mL vials preserved with HCl. The Navy collected the samples that reported 520 to 620 mg/L TOC levels in vials preserved with ascorbic acid and collected the samples with lower levels (0.53 mg/L to 8.8 mg/L) in vials preserved with sodium thiosulfate. In December 2025, after EPA received the high TOC results for two samples collected in August 2025, the EPA Region 9 laboratory investigated further and analyzed a blank preserved with ascorbic acid and a blank preserved with sodium thiosulfate. The blank preserved with ascorbic acid yielded similarly elevated TOC levels (250 mg/L), and the blank preserved with sodium thiosulfate displayed an estimated concentration that was slightly below the RL of 1 mg/L for TOC. Ascorbic acid, $C_6H_8O_6$, is an organic compound and would be analytically detected as TOC based on its chemical composition. The EPA Region 9 laboratory assigned an A1 qualifier ("the sample was not properly preserved in the field") to these results and these results should not be interpreted as true TOC concentrations. One sample (A3-DL-0017762-24153-N-S), collected on June 24, 2024, yielded a TOC concentration of 8.8 mg/L and is not assigned an A1 qualifier. The sample bottle was disposed of per laboratory protocols by the time EPA's TOC investigation that occurred six months after analysis. The Navy's associated split sample was ND for TOC.

EPA discussed the incorrect preservative usages with the Navy and the Navy confirmed implementation of an automated QC system on August 29, 2024, to prevent similar instances. The EPA Region 9 laboratory reported a 520 mg/L concentration of TOC in a split sample collected on December 16, 2024, post-implementation, and confirmed the high concentration was a result of incorrect preservation with ascorbic acid. The EPA Region 9 laboratory has not reported any further detections.

5.5.5.1 Effects of Preservatives on TOC results

Navy collected split samples analyzed by EPA for TOC in work order 2408006 (sample D2-TW-0007823-24092-N-WQI-S; collected on August 9, 2024) and work order 2408010 (sample D2-TW-0007089-24092-N-S; collected on August 19, 2024) had concentrations that were >400 mg/L, which is abnormally high for JBPHH distribution drinking water samples. Upon further investigation, EPA determined that the samples were improperly collected. The EPA Region 9 laboratory observed that the affected sample bottles had sampling information label stickers placed over the manufacturer stickers that indicated the pre-preservative. The affected samples with extremely high TOC levels were collected with ascorbic acid (Vitamin C), which is an organic preservative. The EPA Region 9 laboratory suspected that the ascorbic acid preservative substantially contributed to the final concentration. To test if the ascorbic acid contributed to the TOC concentrations in the improperly preserved samples, 40 mL of DI water was spiked with 25 mg of ascorbic acid and analyzed. The resulting TOC concentration was >200 mg/L. Given that the Red Hill samples had an unknown TOC concentration before the addition of ascorbic acid, this result was evidence that ascorbic acid did influence TOC concentrations in samples D2-TW-0007823-24092-N-WQI-S and D2-TW-0007089-24092-N-S.

There was also one additional EPA split sample, collected on August 12, 2024, in work order 2408006 (sample ID F2-DL-0017776-24214-N-S) that had a concentration of 0.53 mg/L, which is also abnormally high for JBPHH distribution drinking water samples. This sample was improperly preserved with sodium thiosulfate, which was not suspected to contribute to TOC concentrations since it is an inorganic salt. Nonetheless, the EPA Region 9 laboratory spiked 40 mL of DI water with 25 mg sodium thiosulfate. The EPA Region 9 laboratory determined that the preservative did not have a significant impact on the TOC concentration (i.e., if compared to an organic preservative, such as ascorbic acid); however, the sample did yield above MDL levels of TOC, similar to the sample. Upon further investigation, it was determined that sample F2-DL-0017776-24214-N-S was improperly preserved according to the analytical method, EPA 415.3, and this contributed to the elevated TOC concentration.

5.5.6 2-(2-Methoxyethoxy)ethanol (2,2MEE)

The Navy analyzed 2,2MEE on a quarterly basis from hydrants and the Waiawa Shaft. Due to 2,2MEE's distinctive presence in JP-5, EPA analyzed 2,2MEE in all received split samples. Since 2,2MEE is not a commonly monitored analyte, the EPA Region 9 laboratory did not have the analytical method for 2,2MEE already in place when 2,2MEE was added as an EDWM analyte. The EPA Region 9 laboratory was, therefore, not able to analyze for 2,2MEE until late September 2024. EPA employed an analytical method with a sensitive MDL of 0.001 µg/L, four orders of magnitude lower than the Navy's MDL of 50 µg/L. However, 2,2MEE was absent in all EPA and Navy samples (Table 23). 2,2MEE is not regulated in drinking water under the SDWA.

Table 23. Summary of EPA and Navy 2,2MEE non-detects for EDWM.

Analyte	Total EPA EDWM Samples	Total Navy EDWM Samples	EPA MDL (µg/L)	Navy MDL (µg/L)
2,2MEE	182	486	0.001	50

5.5.7 Anions

Anions are negatively charged ions that can naturally occur in aqueous environments through the dissolution of minerals and organic matter. Ortho-phosphate-p, an EDWM targeted analyte, was not analyzed in EPA split samples due to the short holding time of 48 hours. Chlorite, bromate, and chlorate were not analyzed in EPA split samples due to laboratory limitations.

Per the EDWM plan, anions were collected from the Waiawa (monthly and quarterly), Aiea-Halawa (quarterly), and Red Hill (quarterly) shafts only. Due to scheduling conflicts[107] with the Navy, EPA analyzed only one split sample for anions, cations, and silica. Bromide was not detected in EPA's split sample and was detected in 87% of Navy's EDWM samples (Table 24). Bromide is not regulated in drinking water under the SDWA. Chloride, sulfate, and fluoride were detected in the one EPA split sample and in the Navy's samples at the following respective detection rates: 100%, 100%, and 43% (Table 24). Chloride and sulfate are not regulated in drinking water under the SDWA and may be contributed to volcanic minerals naturally present in the groundwater. EPA and Navy's fluoride detections were below the regulatory MCL of 4000 µg/L.

Table 24. Summary of EPA and Navy anion results for EDWM.

Analyte	MCL (µg/L)	Lab	MDL (µg/L)	RL (µg/L)	# Samples	# Detects	# Detects Above MCL	Highest Result (µg/L)
Bromide	-	EPA	50	100	1	0	-	ND
		Navy	25	50	23	20	-	150
Chloride	-	EPA	500	1000	1	1	-	40000
		Navy	400	500	23	23	-	41700
Sulfate	-	EPA	250	500	1	1	-	6200
		Navy	400	500	23	23	-	6400
Fluoride	4000	EPA	50	100	1	1	0	360
		Navy	50	100	23	10	0	580

5.5.8 Cations and Silica

Cations are positively charged ions that can naturally occur in aqueous environments through the dissolution of minerals or in drinking water as a corrosion product of pipes and other related components. Iron and manganese may result from rusting of iron and steel pipes, and are common scale deposits in pipes, along with calcium, magnesium, and silica. Sodium and potassium are used in water softening to prevent or lessen scale buildup.

[107] EPA requested all split samples to be taken on Mondays due to shipping and holding times and was informed that sampling at the shafts depended on approved dates/times, which did not always match EPA's requested split sampling days.

Per the EDWM Plan, cations were collected from the Waiawa (monthly and quarterly), Aiea-Halawa (quarterly), and Red Hill (quarterly) Shafts only. Due to scheduling conflicts with the Navy (discussed in Section 5.5.7), EPA analyzed one split sample for cations. Iron and manganese were not detected in EPA's split sample and were individually detected in 15% and 0% (respectively) of Navy's EDWM samples (Table 25 and Table 26). The six cations (iron, sodium, potassium, calcium, magnesium, and manganese) and silica are not regulated in drinking water under the SDWA. There are non-enforceable secondary MCLs for iron at 0.3 mg/L and manganese at 0.3 mg/L. Sodium, potassium, calcium, magnesium, and silica were detected in the singular EPA split sample and all Navy EDWM samples at similar concentrations (Table 26).

Table 25. Summary of EPA and Navy cation non-detects for EDWM.

Analyte	Total EPA EDWM Samples	Total Navy EDWM Samples	EPA MDL (µg/L)	Navy MDL (µg/L)
Manganese	1	26	2.5	1.1

Table 26. Summary of EPA and Navy cation and silica detections for EDWM.

Analyte	MCL (µg/L)	Lab	MDL (µg/L)	RL (µg/L)	# Samples	# Detects	# Detects Above MCL	Highest Result (µg/L)
Iron	-	EPA	50	100	1	0	-	ND
		Navy	10	20	26	4	-	270
Sodium	-	EPA	250	500	1	1	-	23000
		Navy	51	400	26	26	-	24900
Potassium	-	EPA	1000	2000	1	1	-	1400
		Navy	250	1000	26	26	-	1600
Calcium	-	EPA	50	100	1	1	-	9600
		Navy	53	400	26	26	-	9700
Magnesium	-	EPA	250	500	1	1	-	8700
		Navy	31	200	26	26	-	9000
Silica	-	EPA	1000	2000	1	1	-	58000
		Navy	320	430	26	26	-	61800

5.5.9 Metals

Copper and lead are common materials used for service lines and in premise plumbing within homes and naturally occur in bedrock and soil. Mercury, also naturally occuring in soil and bedrock, is associated with mining, a component of batteries, used as a binding material in older pipes, and may be found in emissions from coal-powered power plants.

Copper and lead are regulated in drinking water under SDWA by a treatment technique that requires PWSs to control the corrosiveness of the provided drinking water. The current AL is 1,300 µg/L for copper and 15 µg/L for lead. If more than 10% of tap water samples exceed the ALs, the PWS must complete follow-up actions, such as improving corrosion control treatment and replacing lead service lines. An AL is not equivalent to a drinking water maximum allowable contaminant level (i.e., MCL), and an exceedance triggers specific actions by the PWS to mitigate levels but is not a violation of the SDWA. Mercury is regulated in drinking water under the SDWA with a 2 µg/L MCL.

Copper was present in all EPA split samples and in 5,326 of 5,335 (99.8%) Navy's EDWM samples (Table 27). The highest levels of copper were 280 µg/L for EPA split samples and 388 µg/L for Navy samples, below the AL of 1300 µg/L. Lead was present in 123 of 297 (41.4%) EPA split samples and in 2,956 of 5,335 (55.4%) Navy's EDWM samples (Table 27). The highest levels of lead were 3.1 µg/L for EPA split samples and 44.2 µg/L for Navy samples. During EDWM, the Navy reported one sample above the AL of 15 µg/L, with a concentration of 44.2 µg/L, and notified EPA and DOH. The Navy determined that the exceedance was associated with premise plumbing. The sample site was flushed, resampled, and the resample displayed a concentration below the lead AL. Mercury was present in 50 of 291 EPA split samples and in 13 of 5,336 Navy EDWM samples (Table 27). EPA's higher detection frequency can be attributed to a more sensitive MDL of 0.015 µg/L, compared to the Navy's MDL of 0.025 µg/L. Of EPA's total 50 detections, 29 were below the Navy's MDL. The highest concentrations were 0.047 µg/L for EPA split samples and 0.11 µg/L for Navy samples, all of which were below the Mercury MCL of 2 µg/L.

Table 27. Summary of EPA and Navy metal results for EDWM.

Analyte	MCL (µg/L)	Lab	MDL (µg/L)	RL (µg/L)	# Samples	# Detects	# Detects Above MCL/AL	Highest Result (µg/L)
Copper	AL = 1300	EPA	0.5	2	297	297	0 > AL	280
		Navy	0.5	2	5335	5326	0 > AL	388
Lead	AL = 15	EPA	0.13	1	297[1]	123	0	3.1
		Navy	0.13	0.5	5335	2956	1 > AL	44.2
Mercury	2	EPA	0.015	0.03	291	50	0 > MCL	0.047
		Navy	0.025	0.1	5336	13	0 > MCL	0.11

[1] 298 sample results for lead were reported for 297 unique sample IDs.

5.5.10 Direct Comparison of EPA and Navy Splits

The comparison of EPA split samples and only the corresponding Navy samples are summarized in Table 11 for LTM (refer to Section 4.3.2) and Table 28 for EDWM. LTM split samples were analyzed by the EPA Region 8 laboratory, the EPA Region 9 laboratory, and a subcontract laboratory. EDWM split samples were analyzed by the EPA Region 9 laboratory and a subcontract laboratory. Discrepancies in the number of EDWM split samples analyzed between the EPA and the Navy are primarily due to changes in the EDWM Plan, laboratory sample rejection, and sample collection scheduling conflicts. Explanations and examples of the primary contributors to split sample number discrepancies include:

- Samples arriving above holding temperatures may result in cancellation of analysis depending on the analysis method. For example, Volatile Organic Compound (VOC) samples that arrive above 6°C will not be analyzed by the EPA laboratory due to loss of analyte.
- Semivolatile Organic Compounds (SVOCs) that were added to the EDWM Plan target analyte list in Summer 2024 were reported by the EPA and Navy laboratories at different start dates. The analytes added to the EDWM target list are: acenaphthylene, anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, fluorene, phenanthrene, and pyrene. As stated in Section 5.4, the EPA contract laboratory began reporting for the full 525.3 list starting with samples collected on July 1, 2024. The Navy began analysis of

these compounds starting with samples collected on August 7, 2024, leading to a lower number of Navy reported results compared to EPA for the same split sample.

- 2,2MEE is analyzed per the EDWM Plan for only quarterly hydrant and Waiawa Shaft post-chlorination samples. EPA began analyzing and reporting 2,2MEE for every split sample collected on or after November 25, 2024, leading to a higher number of EPA-reported results for this analyte compared to the Navy for the same split sample.
- Analysis for EDB is listed in the EDWM Plan for only quarterly hydrants and quarterly Waiawa Shaft (post-chlorination) samples. EPA analyzed EDB as part of the full 524.2 VOC list that was reported for priority buildings, residences, monthly hydrant, and monthly Waiawa Shaft (post-chlorination) samples, leading to a higher number of EPA-reported results compared to the Navy for the same split sample.
- Cations, silica, and anions are analyzed for monthly and quarterly Waiawa Shaft (post-chlorination) and quarterly Aiea-Halawa Shaft/Red Hill Shaft samples. These analyses were conducted by the EPA Region 9 laboratory for only one sample due to scheduling conflicts (e.g., EPA requested all split samples to be taken on Mondays due to shipping and holding times and was informed that sampling at the shafts depended on approved dates/times which did not always match EPA's requested split sampling days).

Table 28. EPA and Navy EDWM comparison summary table for only samples that were collected with a split.

			EPA			*Navy*		
Analytical Method	**Analyte**	**MCL (µg/L)[1]**	**# Samples Analyzed[2]**	**# Detects**	**Highest Detection (µg/L)**	**# Samples Analyzed**	**# Detects**	**Highest Detection (µg/L)**
Volatile Organic Compounds (VOCs) EPA and Navy: EPA Method 524.2	1,2,4-Trimethylbenzene	-	454	0	-	475	0	-
	1,3,5-Trimethylbenzene	-	454	0	-	475	0	-
	Benzene	5	454	0	-	475	0	-
	Butylbenzene (n-butylbenzene)	-	394	0	-	327	0	-
	Ethylbenzene	700	454	0	-	475	0	-
	Isopropylbenzene (cumene)	-	394	0	-	327	0	-
	Propylbenzene (n-propylbenzene)	-	394	0	-	327	0	-
	sec-Butylbenzene	-	394	0	-	327	0	-
	tert-Butylbenzene	-	394	0	-	327	0	-
	Toluene	1000	454	0	-	475	0	-
	Total Trihalomethanes (TTHM)	80	454	173	38.7	474	250	41.9
	Total Xylenes (sum of o-, m-, and p-xylene)	10000	454	0	-	475	0	-

[1] MCLs are the maximum permissible levels of a contaminant in water provided by a public water system. MCLs are legally enforceable under the SDWA: https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations. Environmental Action Levels (EALs) are set by DOH and are levels below which the contaminants are assumed to not pose a threat to human health or the environment. EALs have been set for TPH (see next page). ISPs were not used for evaluation of contaminants during EDWM.

[2] Only unique sample IDs are listed; duplicate runs are not included in the listed stated number of samples or number of detects and are applicable for EDB, which was run twice with the same method for the same sample, and naphthalene, which was run by two different methods for the same sample (for more information see Footnote 4). Total trihalomethanes, TPH-o, and lead were also reported twice for the same sample ID. Please see the individual tables in the applicable 5.5 subsections for more information. Highest detections are based on the highest overall detections, including from any duplicate runs. The results of these samples are displayed with their associated sample on the EPA Red Hill Split Sample Drinking Water Results application.

			EPA			*Navy*		
Analytical Method	**Analyte**	**MCL (µg/L)[1]**	**# Samples Analyzed[2]**	**# Detects**	**Highest Detection (µg/L)**	**# Samples Analyzed**	**# Detects**	**Highest Detection (µg/L)**
EDB EPA: EPA Method 524.2 SIM Navy: EPA Method 504.1	1,2-Dibromoethane (EDB)	0.05	394[3]	0	-	63	0	-
Semivolatile Organic Compounds (SVOCs) EPA: EPA Method 525.3 (BaP), 8270E Navy: EPA Method 525.2	1-Methylnaphthalene	-	474	3	0.0041	475	0	-
	2-Methylnaphthalene	-	474	5	0.007	475	0	-
	Acenaphthylene	-	386	0	-	327	0	-
	Anthracene	-	386	0	-	327	0	-
	Benzo[a]pyrene (BaP)	0.2	473	0	-	475	3	0.03
	Benzo[b]fluoranthene	-	386	0	-	327	0	-
	Benzo[k]fluoranthene	-	386	0	-	327	0	-
	Chrysene	-	386	0	-	327	0	-
	Fluorene	-	386	0	-	327	0	-
	Naphthalene	-	474[4]	28[4]	1.5	475	1	2.32
	Phenanthrene	-	386	0	-	327	0	-
	Pyrene	-	386	0	-	327	0	-
Total Petroleum Hydrocarbons (TPH)	TPH - Diesel Range Organics (TPH-d/DRO)		260[5]	1	87	471	0	-

[3] EDB samples collected at hydrants were ran twice using Method 524.2, with an MDL of 0.25 µg/L, and Method 524.2 – low level, with an MDL of 0.0025 µg/L. 394 total samples were analyzed by the EPA Region 9 laboratory with a total of 452 sample results reported. 58 hydrants were analyzed for both Method 524.2 and Method 524.2 – low level. No detections were reported for the 452 results.

[4] Naphthalene was analyzed using both 8270E and 524.2, as part of the full method analyte list. EPA Region 9 laboratory began reporting the full method analyte list for 524.2 starting with samples collected on June 10, 2024, for additional insight on other potentially hydrocarbon associated analytes outside of the EDWM analyte list. A total of 876 results were reported for naphthalene for the entirety of EDWM. The 474 samples listed is the number of samples collected for SVOC 8270E analysis. The 28 detections listed is the number of detections for unique sample IDs. There were 29 total naphthalene detections for 28 unique sample IDs.

[5] TPH-d results are only listed for EPA split samples collected September 30, 2024-March 31, 2025, due to EPA Region 9 laboratory discrepancies related to the extraction and analysis of TPH-d. Refer to Sections 5.5.4.2 and 6.1.2.2 for more information.

			EPA			*Navy*		
Analytical Method	**Analyte**	**MCL (µg/L)[1]**	**# Samples Analyzed[2]**	**# Detects**	**Highest Detection (µg/L)**	**# Samples Analyzed**	**# Detects**	**Highest Detection (µg/L)**
EPA: EPA Method 8015C Navy: EPA Method 8260D (TPH-g), EPA Method 8015D (TPH-d/o)	TPH - Gasoline Range Organics (TPH-g/GRO)	Combined TPH EAL = 91	475	0	-	475	0	-
	TPH - Oil Range Organics (TPH-o/ORO)		480[2]	4	130	480	0	-
Total Organic Carbon (TOC) EPA: EPA 415.3 Navy: SM 5310	Total Organic Carbon (TOC)	-	475	5[6]	620,000[6]	475	2	1000
Total Alkalinity SM 2320 B	Total Alkalinity	-	475	475	74000	475	475	79300
2,2MEE EPA: Region 9 SOP 3915 Navy: EPA Method 8270E SIM	Diethylene glycol methyl ether (2-(2-methoxyethoxy)ethanol; 2,2MEE)	-	182	0	-	62	0	-
Anions EPA and Navy: EPA Method 300.0, Rev. 2.1	Bromide	-	1	0	-	4	3	88
	Chloride	-	1	1	40000	4	4	41700
	Fluoride	4000	1	1	360	4	3	470
	Sulfate	-	1	1	6200	4	4	6400
Cations and Silica EPA and Navy: EPA Method 200.7	Calcium	-	1	1	9600	5	5	9300
	Iron	-	1	0	-	5	0	-
	Magnesium	-	1	1	8700	5	5	8800
	Manganese	-	1	0	-	5	0	-

[6] The five TOC results were confirmed to be associated with the usage of an incorrect preservative and assigned an A1 qualifier (A1: the sample was not properly preserved in the field). Refer to Section 5.5.5 for more information. Note: the values listed in this table were converted to µg/L for consistency with the other analytes displayed in this table. The values listed in Section 5.5.5 are in mg/L, the unit commonly used for bulk water quality parameters like TOC and Total Alkalinity.

			EPA			*Navy*		
Analytical Method	**Analyte**	**MCL (µg/L)[1]**	**# Samples Analyzed[2]**	**# Detects**	**Highest Detection (µg/L)**	**# Samples Analyzed**	**# Detects**	**Highest Detection (µg/L)**
	Potassium	-	1	1	1400	5	5	1500
	Silica (SiO2)	-	1	1	58000	5	5	61400
	Sodium	-	1	1	23000	5	5	24500
Metals	Copper	1300[7]	297	297	280	295	290	275
	Lead	15[7]	297[2]	123	3.1	295	16	1.8
EPA and Navy: EPA Methods 200.8 and 245.1 (Hg)	Mercury	2	291	50	0.047	295	0	-

[7] Lead and copper do not have set MCLs. An AL is a measure of the effectiveness of corrosion control treatment by a public water system. The 15 µg/L AL listed for lead was effective during the time of EDWM and was lowered to 10 µg/L at the federal level effective November 1, 2027. Additional action must be undertaken by the water system if more than 10% of tap water samples exceed the action level (40 CFR § 141.80(c)). Hawai‘i is implementing the federal Lead and Copper Rule and does not have a separate MCL or AL. For more information on the Lead and Copper Rule: https://www.epa.gov/sites/default/files/2019-10/documents/lcr101_factsheet_10.9.19.final_.2.pdf.

6.0 Evaluating the Presence of Residual Fuel in the Drinking Water System

EPA has:

- Required[37] and reviewed robust sampling by the Navy through both LTM and EDWM.
- Reviewed Navy TPH and fuel indicator data, including lab reports, chromatograms, and the 2024 Tech Memo released independently by the Navy.
- Reviewed the 2024 NewFields investigation prepared for DOH.
- Conducted independent analysis of Navy collected drinking water split samples.
- Conducted inspections[79] and investigations of the Navy's PWS and sampling protocols.

As discussed in Section 2.2, 8015 is a preferred analytical method for petroleum hydrocarbons due to its ability to detect organic, carbon-based compounds commonly associated with fossil fuels, among other organic compounds. However, 8015 does not differentiate between petroleum fuels, food-grade petroleum products, such as mineral oils and non-food-grade petroleum products. Due to these limitations, EPA and the Navy have utilized 8015 as a screening tool for the Red Hill incident investigation, coupled with analyzing for other fuel-indicator compounds via methods such as 524.2 for VOCs and 525.2, 525.3, and 8270E for SVOCs, respectively, to understand if a detection of TPH was related to a specific petroleum compound. For detections of TPH during EDWM, the Navy completed additional analysis of the results via Tier 1 (e.g., review of chromatograms), as required per the EDWM Plan. The Navy also elected to complete other extensive analyses, such as 8260D PIANO, for some TPH detections following Tier 2 in the EDWM Supplemental A document to confirm if a potential detection of TPH was attributed to an impact in the PWSs from a fuel release. These additional analyses are the critical underpinning of the multiple lines of evidence that substantiate EPA's conclusion that the PWSs have recovered from the Red Hill incident and do not otherwise exceed state or federal drinking water standards.

There were multiple challenges to assessing the PWSs with respect to the presence of petroleum contamination. These include:

- Limitations of analytical methods.
    - Little separation between analytical RLs and the TPH ISP (for emergency response and LTM).
    - Non-discriminating nature of TPH analyses (reports naturally occurring organic matter as petroleum).
- Weathering and possible alteration of fuel profiles from phase-partitioning and chlorination of drinking water.
- Potential for presence of historic releases of fuel oils in addition to JP-5.
- Number of connections and complexity of the distribution system.
- Transient nature of impacts.
- Differing expertise among EPA, DOH, and Navy in developing the best approaches to discern the character and source of petroleum impacts detected in the PWSs.

6.1 Total Petroleum Hydrocarbon Testing and Results

Combined TPH was selected as the primary indicator in the Red Hill incident investigation to screen for the presence of fuel in the drinking water. The method to test for TPH is not typically

used in drinking water and there are no set standards. EPA and DOH selected 8015 for TPH as it was the closest to a catch-all test to ensure that fuel contamination was not being missed through testing of individual parameters (see discussion in Section 6.2). Based on the detailed investigations into TPH detections, corroboration through EPA split samples, and analysis of chromatogram outputs, EPA's analysis does not support the presence of residual fuel in the PWSs. The subsections below will expand upon this conclusion.

6.1.1 TPH Sampling Data

As part of EDWM, the Navy took 6,888 TPH samples and analyzed them for TPH-g, TPH-d, and TPH-o. Combined TPH was detected at 12 of 3,785 (0.32%) locations. Of the detections, two samples were above 266 µg/L. Additionally, EPA analyzed 480 samples for combined TPH; however, results from 220 TPH-d analyses experienced QC issues and were not reported (see Section 5.5.4.2).

The results have not identified JP-5, and while there have been a few detections of unknown composition (not JP-5 or a known fuel type), given the nature of the potential problem of a fuel spill migrating to a drinking water source, detections would be observed at a high frequency which was not the case. In other words, the potential JP-5 or fuel component detections are not expected to be episodic.

6.1.1.1 Navy/EPA TPH Split Samples Comparison

EPA and Navy performed split sample analysis, as described in Section 5.5, to independently evaluate the validity of the data, including for the TPH measurement performed using 8015C for EPA analysis and 8015D for Navy analysis. As previously mentioned in Section 2.2, the differences between the methods are minimal and expected to yield similar results. The TPH measurement and results are described in Section 5.5.4.

When comparing two different laboratory-generated data sets, it is necessary to estimate the uncertainty (i.e., sources of error) of the calculated concentrations. The analytical protocol for 8015 involves sample collection, preservation, preparation and analysis, all of which may have uncertainties.

EPA's split sample analysis was generally consistent with the Navy's results. The two analytical methods for TPH supported each other, and additional analyses for fuel-indicator compounds via 524.2, 525.2, 525.3, and 8270E corroborated the conclusion that there was no evidence of fuel.

6.1.1.2 Collection

Samples collected for comparison should be collected so that they represent each other. Grab samples that are collected in series (see Section 4.3.2) may demonstrate variance in concentration as a function of short-term variations between different segments of water. Estimations based on assumptions or high-resolution grab sampling could be used to estimate the short-term variance in concentrations. To the EPA Region 9 laboratory's knowledge, there were no sampling studies to estimate variance completed by either EPA or the Navy. Care should be taken when comparing grab samples that were collected in series.

As previously noted, the Navy was responsible for collecting drinking water samples for Navy's and EPA's analyses. EPA's September 2024 Field Sampling Audit (see Section 5.3.2) found that the Navy's sample collection practices generally maintained appropriate sample integrity. EPA had not

reviewed any data or other evidence to suspect improper or fraudulent actions by the Nay with respect to sample collection and analysis.

6.1.1.3 Preservation

The primary potential source of error during sample preservation is loss of analyte, either through transformation or degradation. Inadequate preservation could also cause a false positive. For example, using a preservative that contains carbon, such as ascorbic acid, in vials used for TOC analysis will yield a high TOC concentration (as discussed in Section 5.5.5.1). A lack of preservation may also result in a false positive due to interactions between analytes, such as what the Navy described in the 2024 Tech Memo[76] with the interaction between the surrogate o-terphenyl and residual chlorine in drinking water samples. Sample preservation techniques are intended to stabilize the sample to prevent loss of analyte and are tailored to the analytes and matrix in the analytical method. Preservation should be identical for all samples to prevent inadequate levels of preservation or variations in preservation from influencing the sample results. While the sample preservation techniques have been proven effective for the target analytes within the methods for drinking water, the fuel mixture adds complexity to the matrix. Neither Navy nor EPA performed an estimation of the effectiveness of the sample preservation techniques for drinking water containing a fuel mixture with a similar composition to what is found at Red Hill, especially with respect to bromine and chlorine.

6.1.1.4 Preparation

The analytical protocol for 8015 involves an extraction step to prepare the sample for the instrumentation. The introduction of noise increases with increasing sample preparation procedures. The primary source of error during the sample extraction is analyte loss, which can be estimated with surrogate recovery. The estimate of loss from surrogate recovery is not perfect because the surrogate used for 8015 (specifically for TPH analysis) is detected as a single peak while a fuel is detected as a pattern with multiple peaks over a range and the single surrogate does not perfectly represent the entire fuel pattern. The EPA and Navy used hexacosane and ortho-terphenyl (OTP) as surrogates, respectively. There was no statistical difference in mean surrogate recovery between the samples, blanks, matrix spikes and blank spike groups (p=0.65) for the EPA results (see Table 29). The Navy reported out OTP recovery for samples and “labQC”, which includes blank spikes, blank spike duplicates, and matrix blanks (Table 29). Care should be taken when laboratories use different extraction procedures and surrogates, but if the surrogate is fairly representative of the analyte (in this case analytes), the estimated uncertainty related to recovery is expected to be somewhat accurate for that extraction and adds credibility to detections of the target analyte or the lack thereof.

Table 29. Mean percent recovery and %RSD of hexacosane and OTP during EDWM.

Surrogate	Mean Percent Recovery in blanks (n)	% RSD	Mean Percent Recovery in samples (n)	% RSD
Hexacosane (EPA)	97 (26)	23	100 (255)	33
OTP (Navy)	95 (7001*)	21	96 (7050)	35

* Reported as "labQC" which includes blank spikes, blank spike duplicates, and matrix blanks.

6.1.1.5 Analysis

EPA concurs with the limitations of using 8015 for TPH analyses in drinking water samples as discussed by NewFields Environmental Forensics Practice, LLC on request by DOH (see Section 2.3.1 and Section 4.5.2). Many laboratories will have difficulty recognizing chromatogram patterns in samples with low-level concentrations, as expected in drinking water samples. This may further complicate a comparison between the Navy and EPA laboratories due to the Navy laboratory's use of a quadratic curve fit for quantification and EPA's use of average response factor. 8015 is finalized under the SW-846 Compendium[115] and SW-846 Compendium 8000C, Section 11.5.3 states that "care MUST be exercised to assure that the results from this equation are real, positive, and fit ***in the range*** of the initial calibration". Thus, the best practice is to run standards down to the concentration reported. Ideally those standards should be the fuel from the leaking tank (as stated in 8015). If an analyst is asked to recognize and compare patterns that have a distribution of hydrocarbons that trail off on the ends, at a low level these may not be detected and difficult to recognize, thus a potential source of error.

The ten points below make up a summary of the analytical uncertainty related to using 8015, specifically for the TPH ranges found in the Red Hill drinking water samples.

1. 8015 is not an approved drinking water method. The scope and application of methods are considered in method developed for SW-846 (see Section 2.0), and the procedure (8015) is developed to generate data consistent with the application of screening for TPH in the environment (i.e., groundwater, not treated drinking water).
2. 8015 does not specifically or exclusively quantify petroleum hydrocarbons.
3. 8015 measures all extractable organics.
4. 8015 is a total/bulk and non-selective method that does not give specific information about detected compounds and thus, it is necessary to evaluate individual analytes to assess possible fuel contamination in drinking water.
5. 8015 detects polar compounds containing carbon (biogenic organic compounds, natural organic matter, and dissolved organic matter), non-dissolved hydrocarbons, and dissolved hydrocarbons that are aliphatic and aromatic. The list of possible compounds that would produce a signal when using 8015 is extensive.
6. EPA used a purchased JP-5 standard rather than a fuel sample[116] from Red Hill. Fuels are complex mixtures that can vary in composition based on origin, refining process and from batch to batch. Analytical standards that are purchased may vary from the fuel release being investigated, which is why 8015 mentions ideally getting a sample of specific fuel from the incident being investigated for comparison. This variance can contribute to misinterpretation of patterns that may not accurately match the pattern of the fuel of interest.
7. 8015 states that if this method is used for hydrocarbons, it should be "limited to analysts experienced in the interpretation of hydrocarbon data". Inexperienced interpretations of data generated via 8015 may be erroneous.

[115] EPA, March 2003, SW-846 8000C Determinative Chromatographic Separations: https://archive.epa.gov/epawaste/hazard/testmethods/web/pdf/method%208000c,%20revision%203%20-%202003.pdf.

[116] EPA submitted multiple requests for a sample of JP-5 from the Red Hill tanks. The Navy denied this request due to proprietary concerns.

8. 8015 for TPH requires patterns to be used to determine the mixture present by comparison.
9. 8015 for TPH requires integrating a relatively large range of the chromatogram, which increases the chance of integrating noise originating from compounds containing carbon mentioned above.

6.1.2 Quality Assurance of TPH Data

6.1.2.1 Review of Conclusions from Navy's Tech Memo

The Navy's 2024 Tech Memo concluded that low-level TPH detections observed during LTM were not associated with the November 2021 release of JP-5 and/or any other potential contamination from Red Hill in the JBPHH System and that low-level TPH detections were most likely associated with laboratory and method challenges.

EPA does not agree with the following Lines of Evidence (LOE) presented in the Navy's 2024 Tech Memo:

- Spatial and Temporal Distribution of TPH results;
- Hydraulic Modeling of the JBPHH System following the November 2021 Release;
- Side-By-Side Comparison of Laboratory Results using Sample Preparation using Separatory Funnels Without Dechlorination Versus Micro-Extraction with Quenching; and the
- Statistical Analysis of TPH Data, Chlorine Residuals and Surrogate Doses.

While EPA does not agree with all the LOEs presented in the Navy's 2024 Tech Memo, based on the results of EDWM and additional forensic analyses, EPA does concur with the general conclusions of the following LOEs:

- Detailed Review of the Analytical Methods Used to Identify and Quantify TPH; and the
- Absence of Indicator Compounds Associated with JP-5.

EPA also agreed with the steps implemented by Navy to improve the accuracy of TPH analyses and minimize sampling and analytical error and interferences including:

- Quenching drinking water samples with sodium thiosulfate to neutralize residual chlorine;
- Moving from separatory funnel to micro-extraction techniques, including a switch from methylene chlorine to hexane as the extraction solvent[117]; and
- Reduction in concentration of surrogate introduced into samples.

Overall, EPA has not reached a conclusion on the reason for the upward trends in TPH detection-frequency and TPH concentration observed during Periods 6 and 7 of LTM that spurred formation of the Navy's SWARM team (previously discussed in Section 4.3). These questions prompted in-depth evaluation and investigation during EDWM, which determined that low-level detections observed during EDWM were not fuel related. Therefore, EPA concludes that the upward trends in TPH detection-frequency and low-level TPH concentrations during LTM were likely not the result of residual fuel in the PWSs following impacts from the Red Hill incident. EPA's conclusion is supported by the lines of evidence throughout Section 6.0 of this report.

[117] Navy, April 25, 2024: Navy Tech Memo, Appendix E - Comparison of EPA Method 8015 Standard Extraction and Micro-Extraction Results (PDF page 78): https://www.navyclosuretaskforce.navy.mil/Portals/101/Tech%20Memo_JBPHH%20LOEs%20LTM%20TPH%20Detects_Redacted.pdf.

6.1.2.2 Quality Assurance Analysis of EPA Split Samples

Due to the high frequency of TPH-d levels reported in the split samples the EPA Region 9 laboratory analyzed that did not display a fuel or hydrocarbon mixture pattern, the EPA Region 9 QA Branch conducted a comprehensive data review of the TPH-d results. EPA's review included ten laboratory data packages for TPH-d samples collected between April and August 2024 (April 24, April 29, May 13, May 28, July 1, July 8, July 15, July 22, July 29, and August 5, 2024) and three random batches of laboratory data packages (collected on October 14, 2024, November 25, 2024, and March 10, 2025) for further evaluation and confirmation of data quality. EPA applied National Functional Guidelines[118] to qualify the provided TPH-d batches, evaluated the Level IV data packages, and recommended reportability and usage of data consistent with EPA protocols.

In response to the data review process and identified discrepancies and QC issues, the EPA Region 9 laboratory has issued revised reports. As discussed in Section 5.5.4.2, the issues were a result of the relocation of the laboratory and redeveloping the TPH-d extraction procedure. However, the Region 9 laboratory's TPH-d results are generally consistent with the Navy's results and reflect the challenges encountered when using 8015 as a drinking water method for the low-level detection of petroleum-related products. The extraction procedure used for TPH-d in 8015C was not operational prior to October 17, 2024, and all TPH-d data reported before this date is considered qualitative. Only 8015C TPH-d analysis was affected by the issues caused by the utilized extraction procedure. The standard suite of EPA drinking water methods was conducted on the EPA split samples and do not show any evidence of fuels related to past spills (see Section 6.2).

6.2 Presence of Fuel Indicators

In addition to using TPH, the presence of fuel in drinking water would be supported by the detection of petroleum-related analytes and key indicators of fuel. Throughout LTM and EDWM, the Navy and EPA monitored for these fuel indicator compounds, analyzing a total of 386 to 473 split samples taken for each compound using the methods 524.2 and 525.3. See Table 30 below for a summary of the key fuel indicator compounds, Table 28 for the associated analytical methods, and the additional discussion in Section 5.5.

Table 30. Key indicators of fuel and petroleum-associated compounds analyzed under EDWM.

JP-5 Key Indicators	Detected (Y/N)	Detections Above MCL or ISP?	Petroleum Associated Compounds	Detected (Y/N)	Detections Above MCL or ISP?
Benzene	N	N	Acenaphthylene	N	N
n-Butylbenzene	N	N	Anthracene	N	N
sec-Butylbenzene	N	N	Benzo[a]pyrene	N	N
Tert-Butylbenzene	N	N	Benzo[b]fluoranthene	N	N
Ethyl Benzene	N	N	Benzo[k]fluoranthene	N	N
Isopropylbenzene	N	N	Chrysene	N	N
n-Propylbenzene	N	N	Fluorene	N	N

[118] EPA National Functional Guidelines for Organic Superfund Methods Data Review, November 2020: https://www.epa.gov/sites/default/files/2021-03/documents/nfg_for_organic_superfund_methods_data_review_november_2020.pdf.

JP-5 Key Indicators	Detected (Y/N)	Detections Above MCL or ISP?	Petroleum Associated Compounds	Detected (Y/N)	Detections Above MCL or ISP?
Toluene	N	N	Phenanthrene	N	N
1,2,4-Trimethylbenzene	N	N	Pyrene	N	N
1,3,5-Trimethylbenzene	N	N	Ethylene Dibromide	N	N
Total Xylenes (sum of o-, m-, and p-xylene)	N	N			
1-Methylnaphthalene	Y	N			
2-Methylnaphthalene	Y	N			
Naphthalene	Y	N			
2-(2-Methoxyethoxy)-Ethanol (2,2MEE)	N	N			

The summarized results for the key indicators of fuel and petroleum-associated compounds analyzed during EDWM are described in their respective sections under Section 5.5 and briefly listed as detected or non-detected in Table 30. Of the 386 to 473 split samples taken for each of the petroleum-associated compounds listed above, there were no detections of petroleum, with limited exceptions discussed in the next paragraph. Of the compounds detected, none were detected above the MCL.

Three components of JP-5, which serve as key fuel indicators, were reported in EPA split samples at low-levels: 1-methylnaphthalene, 2-methylnaphthalene, and naphthalene. 1-methylnaphthalene was detected in three samples and ranged from 0.0026 µg/L to 0.0041 µg/L, levels below the EPA contract laboratory RL of 0.01 µg/L. 2-methylnaphthalene was detected in 5 samples, ranging from 0.003 µg/L to 0.007 µg/L, at levels below the RL of 0.01 µg/L. Naphthalene was detected in 28 samples, ranging from 0.0022 µg/L to 1.5 µg/L, and six samples had levels above the RL ranging from 0.02 µg/L to 1.5 µg/L. As stated in Section 5.5, any reported concentration below the RL is an estimated value due to a high degree of uncertainty.

The six samples with reported naphthalene levels above the RL showed no detections of other fuel key indicators or petroleum-associated compounds. There were no TPH detections associated with the six samples. The presence of naphthalene and absence of other key indicators or petroleum-associated compounds does not indicate a fuel-related source. Naphthalene is used in the production of PVC plastics and, along with its methylated derivates, 1-methylnaphthalene and 2-methylnaphthalene, in the manufacture of dyes and resins.

The lack of a fuel-related signature in a positive TPH result, along with the absence of petroleum-associated compounds and key indicators, despite low-level 1-methylnaphthalene, 2-methylnaphthalene, and naphthalene detections, does not support the presence of JP-5 or

petroleum-based fuels in the water supply. Furthermore, there were no measurable TPH levels associated with the low-level 1-methylnaphtalene, 2-methylnaphthalene, or naphthalene detections.

7.0 ACO Drinking Water Improvements

7.1 Infrastructure and Operational Improvements to JBPHH Drinking Water System

While EPA concludes that there is no evidence of residual fuel following the Red Hill incident in the PWSs, the Navy and Army are still required to improve their operational practices and drinking water infrastructure under EPA's 2023 ACO[83], as outlined in Table 31. As of the date of this report, EPA continues to actively work with Navy on fully addressing the remaining 2023 ACO requirements.

Table 31. 2023 ACO drinking water system required improvements.

2023 ACO SOW Section	Completed (Y for Yes)	Ongoing (Y for Yes)
6.1.1 Source Water Protection Plan - Phase I	Y	
6.1.2 Source Water Protection Plan – Phase II		Y
6.2 Drinking Water Long-term Monitoring Plan – Tank Inspection and Cleaning	Red Hill Tank 316, Halawa Tank S2: Y	Red Hill Tank 685 and Camp Smith Tanks: Y
6.2 Drinking Water Long-term Monitoring Plan – Cross-Connection Control Survey	Y	
6.2 Drinking Water Long-term Monitoring Plan – Reactivation of the Broken Underwater Distribution Line	Y	
6.5.1 Standard Operating Procedures for System Operators		Y
6.5.2 Asset Management Program	Y	
6.5.3 Hydraulic Model	Y	
6.5.4 Unidirectional Flushing Plan	Y	
6.5.5 Maintenance Flushing Program	Y	
6.5.6 Valve Exercising and Replacement Program		Y
6.5.7 Cross-Connection Control Program		Y
6.5.8 Capital Improvement Plan		Y (Living document)
6.5.9 Chemical Use, Storage, and Handling	Y	
6.6 Public Notice Requirements	Y	
6.7.1 Certified Operators	Y	
6.8 Risk and Resilience Assessment		Y

2023 ACO SOW Section	Completed (Y for Yes)	Ongoing (Y for Yes)
6.9 Emergency Response Plan		Y
6.10 Records		Y (Living document)
6.11 Water Quality Concern Response and Investigation Procedures		Y
6.12 Plan for Establishment of a Surveillance and Response System		Y

7.2 Groundwater Remediation

Remediation describes the process to remove, contain and/or treat environmental contamination. The overarching goals of remediation at the Red Hill facility are to protect drinking water sources and restore groundwater quality in areas impacted by petroleum contamination.

Through the EPA Administrator's authority under the Resource Conservation and Recovery Act (RCRA)[119], the 2023 ACO also requires the Navy to investigate and remediate contaminated soil and water from all historical fuel releases from the Red Hill facility. A near-term goal of remediation is to ensure the Red Hill Shaft is not re-contaminated by jet fuel remaining in the groundwater aquifer from the Red Hill incident. In response, Navy has been designing, constructing and pilot testing air sparging (AS) and soil vapor extraction (SVE) systems to treat and recover jet fuel contamination in the unsaturated zone. This work is focused on areas beneath Adit 3 where jet fuel draining from the tunnel infiltrated the underlying rock formation. Navy pilot-tested the shallow SVE system in 2024 and is currently refining its design and operational parameters to optimize performance. Navy is also pilot testing a deep SVE system to treat and remove contamination at the base of the vadose zone.

A long-term objective of remediation is to restore water quality in the Moanalua aquifer beneath the Red Hill facility. Remedial strategies will be developed after the full extent and magnitude of historical fuel releases at Red Hill are delineated. This information will be presented in a Remedial Investigation (RI) Report which the Navy anticipates will be submitted in 2029. The selection of corrective actions to restore aquifer water quality will be based on a feasibility study that balances factors such as effectiveness, reliability and implementability.

8.0 Conclusion

In the years since the incident, EPA has conducted a comprehensive assessment and oversight pursuant to the 2023 ACO of the JBPHH and AMR PWSs. EPA has not relied on any single analysis but instead weighed all lines of evidence to make a determination on whether there is credible reason to believe residual fuel remains in the PWSs following the Red Hill incident. The investigation included EPA's review of the Navy's three-year monitoring effort, EPA independent sample analyses, a series of EPA inspections and investigation of the drinking water systems,

[119] 42 U.S.C., Chapter 82, Subchapter IX, Regulation of Underground Storage Tanks: https://uscode.house.gov/view.xhtml?req=granuleid%3AUSC-prelim-title42-chapter82-subchapter9&edition=prelim.

including Navy drinking water sampling procedures, and public complaints. EPA finds that despite notable technical challenges (as described herein), the overall approach to decontamination and the subsequent evaluation of impacts is appropriate and consistent with EPA guidance and regulations.

The Navy sampled 100% of the 44 priority buildings (e.g., schools, child development centers, and medical facilities) and all accessible residences, 9,171 out of 9,884 (93%) total served by the PWSs. These service connections were confirmed through analytical data to be free of fuel or fuel indicators related to the incident. Distribution system water-quality monitoring has consistently aligned with results found in homes and buildings, demonstrating a reliable prediction of conditions at the tap and providing a clear, defensible basis for EPA's conclusion that consumers can expect water free of fuel-related contamination.

Based on the extensive spill response and recovery efforts documented in this report, EPA concludes that there is no evidence of residual fuel, or other fuel-related contaminations, remaining in the JBPHH and AMR PWSs. These PWSs have met all federal and state drinking water regulations since the UWA was last amended on March 18, 2022. EPA supports the PWSs return to routine compliance monitoring under supervision of DOH. EPA continues to work with the Navy, the Army, and DOH to improve infrastructure and operations at the two PWSs and to remediate past releases with potential to impact groundwater resources on O'ahu. These improvements better position the PWSs to address future incidents and address water quality concerns as they arise.