Technical Memorandum:

Determination if Pre-IDWST Flushing Drinking Water Data Should be Used to Evaluate Human Exposure to JP-5 Fuel in Drinking Water at the Joint Base Pearl Harbor-Hickam Water Distribution System

Revised: June 2023

The purpose of this technical memorandum is to determine if the pre-Interagency Drinking Water System Team (IDWST) flushing drinking water sampling data can be used to evaluate exposure from the release of JP-5 fuel into the JBPHH water system on 20 November 2021. This document is not intended to make any inferences or conclusions about health and/or mental health effects experienced by those exposed during that release. Potential health impacts will be better informed after the following ongoing or planned lines of effort have been published:

- Defense Health Agency (DHA) epidemiological analysis of the of JBPHH residents' medical visits and ICD-10 code diagnosis (in progress),
- Planned medical records reviews by DHA and Agency for Toxic Substances and Disease Registry (ATSDR),
- Further development of a Red Hill Registry (in progress), and
- Completion of the ATSDR Red Hill Public Health Assessment (in progress).

Introduction

On 20 November 2021, JP-5 fuel was accidentally released from the Red Hill Bulk Fuel Storage Facility to the Joint Base Pearl Harbor Hickam (JBPHH) drinking water distribution system (JBPHH system). This resulted in significant disruption to the users of the JBPHH system. Between 29 November and 13 December 2021, drinking water samples were collected by the Naval Facilities Engineering Systems Command Hawai'i Region (NAVFAC HI). In addition, between 24 November 2021 and 02 January 2022, drinking water samples were independently collected by the Hawai'i Department of Health (DOH). The purpose of collecting these samples (referred to as pre-IDWST flushing drinking water samples) was to evaluate drinking water conditions in the JBPHH system immediately following initial reports of health symptoms, fuel-like tastes, odors, and sheen in drinking water and to define the extent of JP-5 fuel contamination remaining in the JBPHH system. On 17 December 2021, DOH, Navy (including the Navy Marine Corps Public Health Center [NMCPHC]), Army, and the United States Environmental Protection Agency (USEPA) established the Interagency Drinking Water System Team (IDWST) to restore safe drinking water to communities affected by the 20 November 2021 JP-5 fuel

release. At the time the IDWST was established, the highest priority of the emergency response effort was restoring safe drinking water to users of the JBPHH system as quickly as possible and sampling was temporarily discontinued until remedial actions (e.g., flushing) were completed. By 18 March 2022, safe drinking water had been restored to all communities (i.e., the 19 flushing zones established by the IDWST) on the JBPHH system.

Purpose

The purpose of this technical memorandum (Memo) is to determine if the pre-IDWST flushing drinking water sampling data[1] obtained by NAVFAC HI and DOH can be used to evaluate exposure to JP-5 fuel in JBPHH drinking water associated with the 20 November JP-5 fuel release at Red Hill. Pre-IDWST flushing drinking water data was obtained by sampling drinking water shafts (i.e., Red Hill Shaft, Navy Aiea Halawa Shaft, and Waiawa Shaft), drinking water storage tanks, and locations throughout the JBPHH system between 24 November and 02 January 2022 from the JBPHH system. Results of the drinking water samples collected by NAVFAC HI between 29 November and 13 December 2021 were compared to the results of the drinking water samples collected by DOH between 24 November 2021 and 02 January 2022 to determine if the results and findings were similar. This report documents the lines-of-evidence approach used to determine whether or not the drinking water samples collected prior to IDWST flushing the JBPHH system (i.e., drinking water samples collected between 24 November and 20 December 2021) are appropriate for evaluating potential exposure to JP-5 fuel in drinking water after the release.

Note: JBPHH users likely smelled JP-5 as soon as it entered the JBPHH system.[2] The first report of fuel-like odors occurred on 28 November 2021 and is likely the date JP-5 fuel entered the JBPHH system. Therefore, JBPHH system users were likely not exposed to JP-5 fuel until 28 November 2021 and exposure was likely limited to a few days (e.g., 28 November and 29 November 2021).[3] However, to be protective of human health, the estimated exposure timeframe, for the purposes of this Memo, was defined as less than two weeks (i.e., 20 November 2021 to 29 November 2021), which represents the time between the initial release and when the source of contamination was eliminated and the DOH Health Advisory was issued. DOH collected samples independent of the IDWST between 24 November 2021 and 02 January 2022 which overlaps with the establishment of the IDWST on 17 December 2021 and when IDWST-Flushing began on 20 December 2021. For completeness/transparency, all of the DOH data was included in this Memo even though data collected after 20 December 2021 are not technically “pre-IDWST flushing drinking water samples.”

[1] Drinking water samples were primarily collected from outdoor spigots and hose bibs of public buildings (e.g., community centers, gas stations) or from the drinking water shafts (e.g., Red Hill Shaft, Navy Aiea Halawa Shaft, Waiawa Shaft). Drinking water samples were analyzed using both groundwater and drinking water analytical methods. For the purposes of this memo, all samples were referred to as drinking water samples, regardless of the analytical method.

[2] People are very sensitive to fuel odors. The odor threshold for Jet Fuels (represented by kerosene) (i.e., the lowest concentration of a chemical detected by the human sense of smell) is as low as 82 parts per billion (ppb) (Agency for Toxic Substances and Disease Registry [ATSDR 2017]).

[3] DOH collected two samples (raw water [DW_360-001-112421 - Raw] and chlorinated water [DW_320-011-202124 - Chlorinated]) on 24 November 2021 and analyzed the samples for TPH-G, TPH-D, and TPH-O. All results were not detected except for the TPH-O result for DW_320-011-202124 – Chlorinated which was 66 ug/L.

Memo Organization

This Memo is organized as follows:

- **Background** – Provides information regarding the Red Hill Bulk Fuel Storage Area and the timeline of events relating to the JP-5 fuel release that impacted the JBPHH system.
- **Determination of Potential Human Exposure to JP-5 Fuel** – Summarizes the contaminants of potential concern (COPCs) and estimated timeframe for human exposure.
- **JBPHH Drinking Water System Pre-IDWST Flushing Data Sources** – Presents the data evaluated in this Memo.
- **Evaluation of Pre-IDWST Flushing Drinking Water Analytical Results** – Summarizes and evaluates the analytical results for the pre-IDWST flushing drinking water samples.
- **Determination if Pre-IDWST Flushing Drinking Water Data Should be Used to Evaluate Human Exposure to JP-5 Fuel in Drinking Water at the Joint Base Pearl Harbor-Hickam Water Distribution System** – The pre-IDWST drinking water data are evaluated using multiple lines-of-evidence to determine whether or not the pre-IDWST flushing drinking water data is appropriate for use in evaluating human exposure to JP-5 fuel and other COPCs detected in drinking water.
- **Uncertainty Analysis** – Presents a summary of the key uncertainties associated with the data/information presented in this Memo.
- **Summary and Conclusions –** Summarizes the results of the lines-of-evidence evaluated to determine whether or not pre-IDWST flushing drinking water data should be used to evaluate human exposure to JP-5 fuel in drinking water.
- **References** – Provides a bibliographic list of references cited in the text.

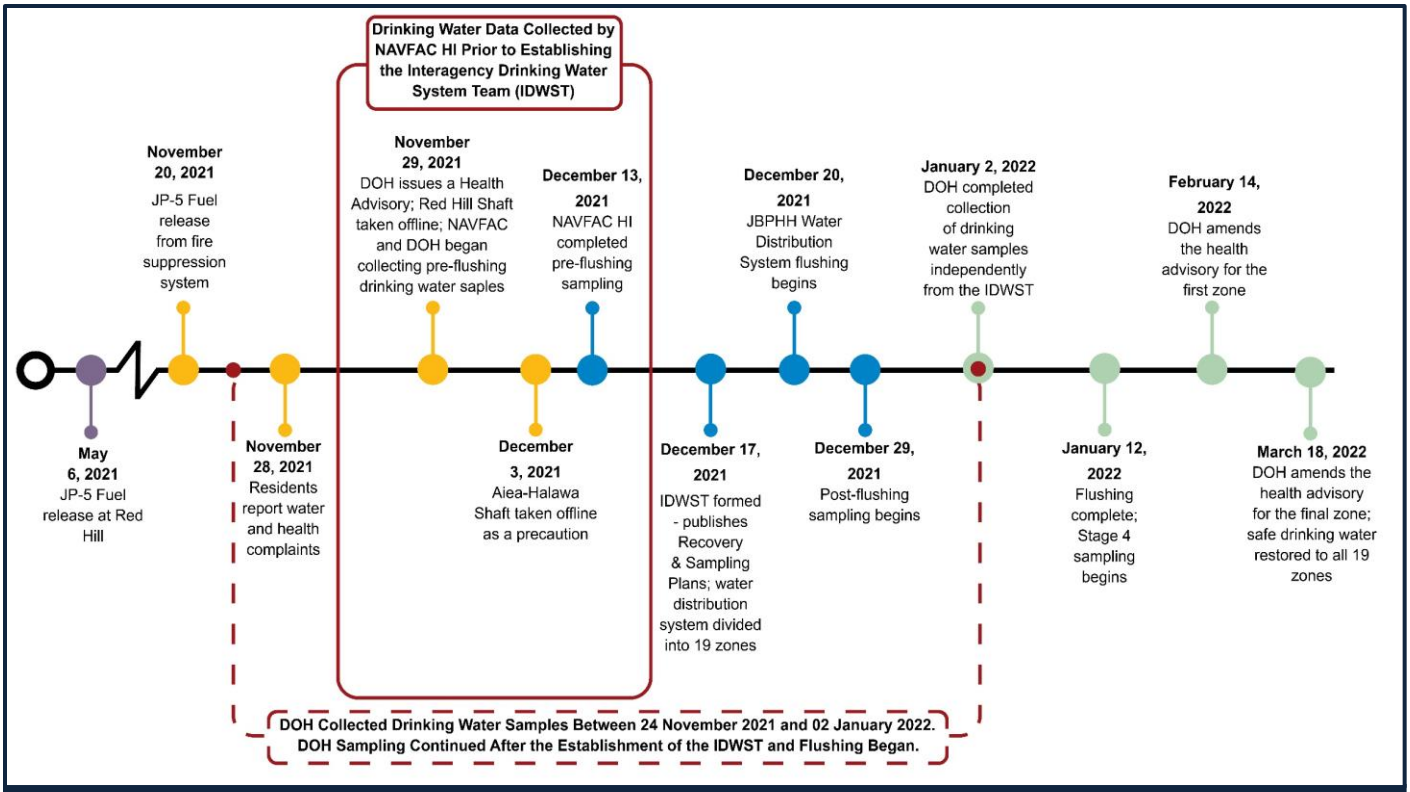
Background

The following section provides a brief summary of the Red Hill Bulk Fuel Storage Area and the timeline of events pertaining to the release of JP-5 fuel that impacted the JBPHH system on 20 November 2021.

Red Hill Bulk Fuel Storage Area

JP-5 fuel (along with marine diesel and JP-8 fuel) is stored at the Navy's Red Hill Bulk Fuel Storage Facility (facility) to support military operations in the Pacific. The facility was built and became operational during World War II and can store up to 250 million gallons of fuel. The facility includes 20 steel lined tanks encased in concrete. Each tank has a storage capacity of 12.5 million gallons. The tanks are connected to three pipelines (approximately 2.5 miles in length) that supply the fueling piers at Pearl Harbor. A pump station, located near Pearl Harbor, controls the filling of the tanks and dispensing of fuel to ships and aircraft at JBPHH. As of 2022, 18 tanks are operational and two tanks are offline. On 7 March 2022, the Department of Defense (DoD) announced the facility will be permanently decommissioned and all fuel will be drained from the tanks (DoD 2022).

Timeline of Events



JP-5 Fuel Release to the JBPHH System Timeline of Events

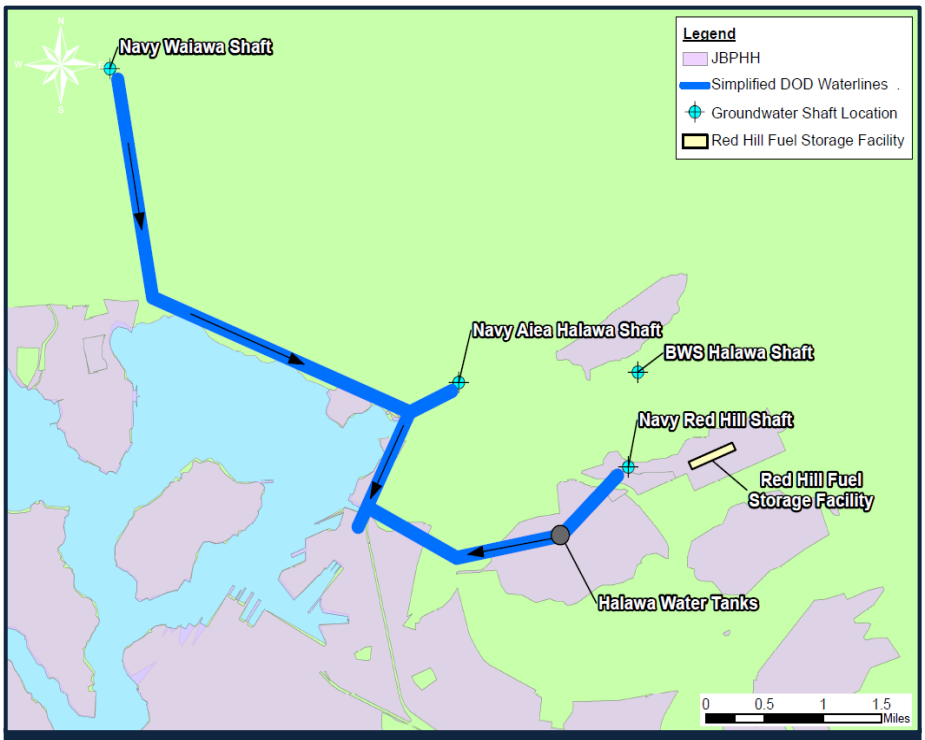
A timeline of events is summarized below:[4]

- **6 May 2021** – 20,957 gallons of fuel were released at the Red Hill Bulk Fuel Storage Facility. A total of 1,580 gallons of fuel were recovered at that time and 19,377 gallons of fuel was transferred to and was retained in the Red Hill fire suppression system (which was not known at the time).
- **20 November 2021** – A Red Hill employee who was driving a rover that was towing additional carts inadvertently struck the fire suppression system retention line drain valve, cracking the PVC pipe. Although not known at the time, this retention line contained JP-5 fuel that was not recovered from the 6 May 2021 spill. Approximately 15,415 gallons of fuel was recovered after the 20 November 2021 release. Up to 5,542 gallons of fuel was not recovered from the fire suppression line. Some or all of the unrecovered fuel (i.e., 5,542 gallons) contaminated the Red Hill Shaft and entered the JBPHH system which had an approximate storage volume of 21.2 million gallons at the time of the release.[5]

[4] This summary provides a high-level review of the timeline of events and focuses on milestones specifically relevant for evaluating human exposure to JP-5 fuel.

[5] The approximate storage volume includes system piping and associated storage tanks (does not include shafts).

- **28 November 2021** – DOH and the Hawai'i Poison Center began receiving reports of health symptoms, fuel-like tastes, odors, and sheen in drinking water (tap water) from residents at JBPHH.
- **29 November 2021** – The Red Hill Shaft, which supplied drinking water to the JBPHH system, was taken offline.[6] DOH issued a health advisory for the JBPHH system. DOH recommended that JBPHH system users avoid using tap water for drinking, cooking, or oral hygiene and, if a fuel-like odor was present, users should avoid using the water for drinking, cooking, bathing, dishwashing, laundry, or oral hygiene (DOH 2021).[7] People are very sensitive to fuel odors. The odor threshold for Jet Fuels (represented by kerosene) (i.e., the lowest concentration of a chemical detected by the human sense of smell) is as low as 82 parts per billion (ppbV) (Agency for Toxic Substances and Disease Registry [ATSDR 2017]). This corresponds to a liquid concentration of < 1.53 µg/L, which is below the DOH project screening level of 266 µg/L.[8] NAVFAC HI began collecting drinking water samples from drinking water shafts (i.e., Red Hill Shaft, Navy Aiea Halawa Shaft, Waiawa Shaft) and outdoor spigots and hose bibs from buildings throughout the JBPHH system.



JBPHH Drinking Water Sources Before 29 November 2021

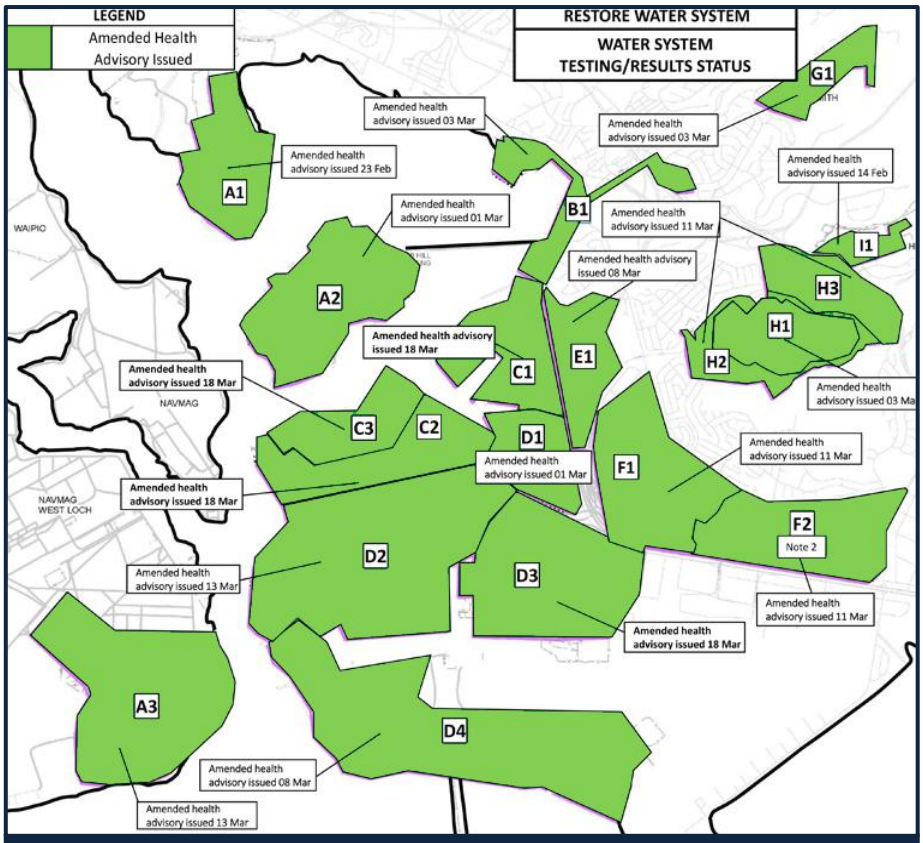
> "The DOH recommends **all Navy water system users** avoid using the water for drinking, cooking, or oral hygiene. Navy water system users **who detect a fuel odor** from their water should avoid using the water for drinking, cooking, bathing, dishwashing, laundry, or oral hygiene (brushing teeth, etc.)."
>
> – DOH, Health Advisory issued on November 29, 2021

[6] Per the USEPA's National Enforcement Investigations Center (NEIC) Report which that states that the Red Hill Shaft was not fully taken off-line until November 29, 2021 at 1500 hours, local time (USEPA 2022).

[7] The DOH Health Advisory is available at: https://health.hawaii.gov/news/files/2021/11/21-165-DOH-advises-Navy-water-system-consumers-not-to-drink-consume-tap-water.pdf.

[8] 82 ppbV (air) = 402 µg/m3 (air) = 1.53 µg/L (liquid source): Assuming 25 degrees Celsius, a dimensionless Henry's Law Constant = 0.263, and molecular weight of 120 grams/mole. Parameters obtained from EPA's November 2022 Regional Screening Levels Table for Total Petroleum Hydrocarbons (Aromatic Medium): https://www.epa.gov/risk/regional-screening-levels-rsls.

- **3 December 2021** – Due to its proximity to the Red Hill Shaft, the Navy Aiea Halawa Shaft was taken offline out of an abundance of caution. Since 3 December 2021, drinking water to the JBPHH system has been supplied solely by the Waiawa Shaft.[9]
- **17 December 2021** – DOH, Navy (including the NMCPHC), Army, and USEPA established the IDWST to restore safe drinking water to communities affected by the 20 November 2021 release. The IDWST developed and published the Drinking Water Distribution System Recovery Plan that established 19 flushing zones and outlined the approved methods for flushing the JBPHH system in each flushing zone. The IDWST developed and published the Drinking Water Sampling Plan to outline drinking water sample locations, sampling procedures, chemicals analyzed, and reporting requirements.



JBPHH Drinking Water Distribution Flushing Zones and Amended Health Advisories. Accessed from JBPHH-safewaters.org

- **20 December 2021** – The IDWST began flushing the JBPHH system (e.g., water mains and laterals) with clean (i.e., unimpacted) drinking water supplied from the Waiawa Shaft.
- **29 December 2021** – The IDWST began collecting post-flushing drinking water samples from the JBPHH system in accordance with the Drinking Water Distribution System Recovery Plan and the Drinking Water Sampling Plan.
- **12 January 2022** – Flushing of the JBPHH system was complete. The IDWST began collecting tap water samples from residential and non-residential buildings in accordance with the Drinking Water Sampling Plan.
- **14 February – 18 March 2022** – DOH amended the health advisories on a zone-by-zone basis starting on 14 February 2022.[10] The final health advisory (for Zone D3) was amended on 18 March 2022. On a

[9] No COPCs were detected in samples collected from the Waiawa Shaft between 29 November and 13 December 2021 (see Table 1).
[10] The first health advisory was amended for Zone I1.

zone-by-zone basis, safe drinking water was restored to communities (i.e., the 19 flushing zones established by the IDWST) affected by the 20 November 2021 release. The Navy began performing long-term monitoring (LTM) of drinking water, which will occur periodically over the course of two years after each health advisory was amended to ensure drinking water remains safe for consumption long-term.[11] The LTM serves as a surveillance tool intended to continuously ensure drinking water supplied by the JBPHH system meets all State and Federal drinking water standards and is free of petroleum contamination.

Determination of Potential Human Exposure to JP-5 Fuel

Exposure is defined as the contact between a chemical, or chemical mixture (e.g., JP-5 fuel), and a receptor (e.g., a person who drank the water from the JBPHH system at the time of [and after] the release). An exposure assessment is the process of estimating or measuring the exposure (i.e., the amount, frequency, and duration of exposure) of a group of receptors (i.e., population) to contaminants of potential concern (COPCs). Characterizing the COPCs identified in the JBPHH system and estimating an exposure timeframe is crucial for determining whether or not the data are appropriate for use in an exposure assessment.

Contaminants of Potential Concern (COPCs)

Under the IDWST Drinking Water Sampling Plan, drinking water samples were analyzed for metals, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), synthetic organic compounds (SOCs), total petroleum hydrocarbons (TPHs), total organic carbon (TOC), and free chlorine.[12,13] The IDWST identified BTEX (benzene, toluene, ethylbenzene, xylenes [total]), 1-methylnaphthalene, 2-methylnaphthalene, naphthalene, and total TPH (i.e., the sum of TPH-Diesel [TPH-D], TPH-Gasoline [TPH-G], and TPH-Heavy Oil [TPH-O]) as COPCs due to their association with fuels. TOC and free chlorine measurements were collected to provide another line-of-evidence for evaluating drinking water quality.

Estimated Exposure Timeframe

On 13 June 2022, the Vice Chief of Naval Operations (VCNO) published the *Command Investigation into the 6 May 2021 and 20 November 2021 Incidents at Red Hill Bulk Fuel Storage Facility* report (Department of the Navy 2022). Results of the investigation determined that the release of JP-5 fuel to the JBPHH system occurred on 20 November 2021. Residents using drinking water provided by the JBPHH system for consumptive purposes (e.g., drinking, bathing, oral hygiene) started reporting health symptoms, fuel-like tastes, odors, and sheen in drinking water on 28 November 2021. On 29 November 2021, the Red Hill Shaft was taken offline,

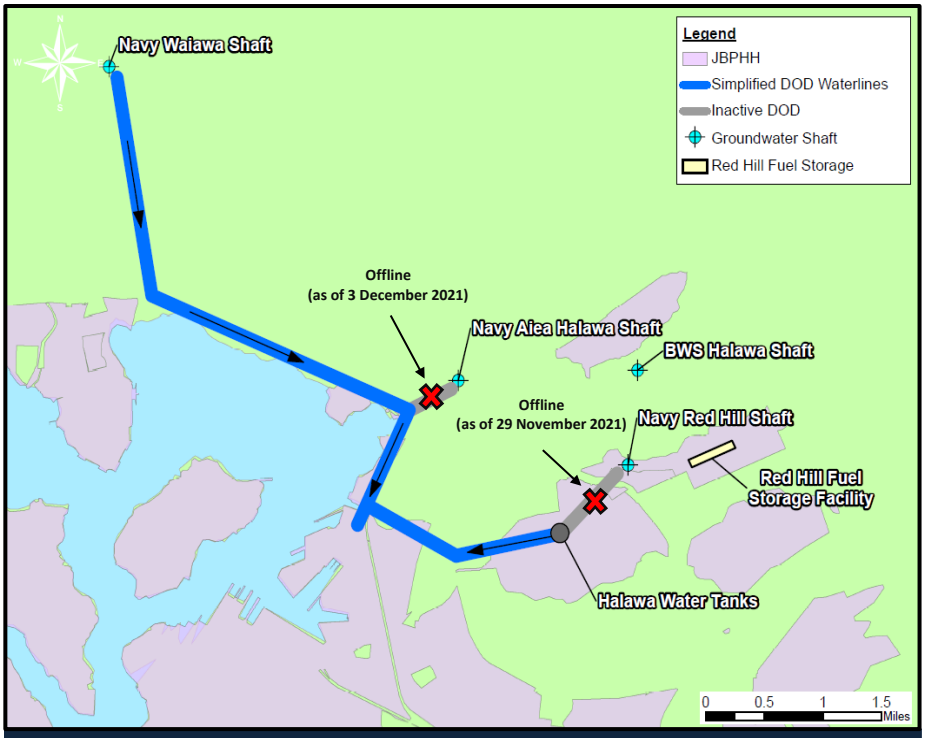
[11] Long-term monitoring will be performed in accordance with the Drinking Water Long-Term Monitoring Plan (LTM Plan) finalized in June 2022, which supersedes the LTM program developed under the SAP. In accordance with the LTM Plan, drinking water samples will be collected in each of the 19 flushing zones established by the IDWST. For the first three months (months 0 – 3) after each health advisory was amended, drinking water samples will be collected monthly. Starting four months after the health advisory was amended up until 24 months after the health advisory was amended (months 4 – 24), drinking water samples will be collected every six months.

[12] Total TPH is reported as the sum of TPH-diesel (TPH-D), TPH-oil (TPH-O), and TPH-gasoline (TPH-G).

[13] Free chlorine is analyzed in the field at each sample location.

and clean drinking water was supplied from the Waiawa Shaft and Navy Aiea Halawa Shaft. Data suggests, the estimated exposure timeframe during which residents were potentially exposed to the highest concentrations of JP-5 fuel was between 20 November and 29 November 2021 (i.e., less than two weeks). The estimated exposure timeframe is based on the following:

- The release of JP-5 fuel occurred at the Red Hill Shaft on 20 November 2021. The Red Hill Shaft was taken offline on 29 November 2021, following the first report of health symptoms, fuel-like tastes, odors, and sheen in tap water.
- Starting 29 November 2021, water in the JBPHH system was continuously replaced (and diluted) with clean water from the Waiawa Shaft and the Navy Aiea Halawa Shaft (until taken offline on 3 December 2021).[14]
- DOH issued a health advisory advising users of the JBPHH system to not use tap water for consumptive (e.g., drinking, cooking, oral hygiene) purposes on 29 November 2021. Residents of the JBPHH system were supplied bottled water and no longer used water from the JBPHH system for consumptive purposes if users complied with DOH Health Advisory. Note: Some individuals may not have followed the recommendation and continued to be exposed through consumption of drinking water, to include bathing and showering.[15] However, based on the reduction in average daily demand (20.8 million gallons per day (MGD) to 11 to 14 MGD), most users appear to have followed the recommendations outlined by DOH (Board of Water Supply [BWS] 2021 and NAVFAC HI).
- The Navy Aiea Halawa Shaft was taken offline on 3 December 2021 due to its proximity to the Red Hill Shaft. After 3 December 2021, 100% of the drinking water supplied to the JBPHH system was supplied by the Waiawa Shaft[16], which was not impacted by the JP-5 fuel release.



JBPHH Drinking Water Sources After 3 December 2021

[14] No COPCs were detected in samples collected from the Waiawa Shaft between 29 November and 13 December 2021 (see Table A-1).
[15] An understanding of individual behaviors helps to estimate the degree of exposure that occurred. Water related behaviors include water-consumption and showering or bathing patterns.
[16] The Waiawa Shaft is located approximately 6 miles northwest, and upgradient, of the Red Hill Shaft.

JBPHH Drinking Water System Pre-IDWST Flushing Data Sources

NAVFAC HI JBPHH Drinking Water System Pre-IDWST Flushing Data Summary

Data included in this evaluation was provided by NAVFAC HI.[17] A total of 195 drinking water samples were collected and analyzed between 29 November and 13 December 2021. Samples were primarily collected from outdoor spigots and hose bibs of public buildings (e.g., community centers, gas stations) or from the drinking water shafts (e.g., Red Hill Shaft, Navy Aiea Halawa Shaft, Waiawa Shaft). Drinking water samples were analyzed using both groundwater and drinking water analytical methods.

Drinking water samples are typically analyzed using drinking water analytical methods because they are more sensitive (i.e., these methods can detect chemicals at lower concentrations) and account for chlorine interference. Groundwater used as drinking water is typically treated prior to being conveyed to public water systems and consumed by the public. One step in the drinking water treatment process is disinfection. Disinfection is the process of adding chemical disinfectants, most commonly chlorine, to drinking water to kill any parasites, bacteria, and viruses. The addition of chemical disinfectants (e.g., chlorine) protects the water as it travels through the distribution system and prevents growth of parasites, bacteria, and viruses. Water distribution companies and local water quality control boards monitor the amount of chlorine in drinking water to ensure the levels do not pose a threat to human health. Chlorine in water does not pose a risk to human health if the amount of chlorine is below the USEPA maximum contaminant level (MCL) of 4.0 milligrams per liter (mg/L; 4,000 micrograms per liter [µg/L]) established as part of the Safe Drinking Water Act of 1974 (SDWA; U.S. 1974). When analyzing drinking water samples, it is important for the lab to take into account that residual amounts of chlorine are likely present in the water.

Many environmental labs can perform groundwater analytical methods in high capacity with a quick turnaround time; however, these methods are less sensitive and do not account for chlorine interference. Groundwater analytical methods are commonly used in emergency responses when quicker lab turnaround times are required. Many of the pre-IDWST flushing drinking water samples were analyzed using groundwater analytical methods to provide an initial estimate of chemical concentrations and aid DOH and the Navy in making emergency response decisions. The use of groundwater analytical methods was intended to provide quick water quality data to support emergency response decisions.

Drinking water samples were collected by the NAVFAC HI on a daily basis starting 29 November 2021. EPA has established requirements for receiving, storing, and analyzing environmental samples. Under these requirements, EPA established maximum holdings times, depending on the chemicals being analyzed. Labs are required to analyze each drinking water sample within a certain time window after receiving the sample for data quality and assurance purposes. Due to the large volume of samples collected, a single lab was not able

[17] This evaluation was developed using the summary tables provided by NAVFAC HI on 13 June 2022. The NMCPHC requested the original analytical lab reports and electronic data delivery (EDD) files from NAVFAC HI on 10 May 2022 and 16 June 2022. The original reports and EDDs were provided on 9 August 2022.

to analyze all samples in a reasonable turnaround time. There are no analytical labs in Hawaii that are approved by DOH to analyze drinking water samples using all analytical methods required for this incident; therefore, samples had to be sent to analytical labs in the continental U.S. Drinking water samples needed to be collected, packaged, and shipped off-island, further limiting the analytical labs available to analyze the samples.[18] Drinking water samples were sent to two labs: Eurofins TestAmerica Seattle and Weck Laboratories, Inc. Samples analyzed using groundwater analytical methods had a quicker turnaround time at the lab; therefore, Eurofins TestAmerica Seattle had a larger capacity for the number of samples that could be received and analyzed.

A total of 114 drinking water samples were sent to Eurofins TestAmerica Seattle of Seattle, Washington for analysis using the following non-drinking water (i.e., groundwater) analytical methods:

- BTEX, Naphthalene, and TPH-G using USEPA Method 8260B
- TPH-D and TPH-O using USEPA Method 8015B
- TPH-D and TPH-O with Silica Gel Cleanup using USEPA Method 8015B[19]

The remaining 81 drinking water samples were analyzed at Weck Laboratories, Inc. of Hacienda Heights, California for analysis using the following drinking water analytical methods:

- Metals using USEPA Method 200.8/245.1[20]
- VOCs using USEPA Method 524.2/524.2M/524.3
- SVOCs using USEPA Method 525.2
- TPH-D and TPH-O using USEPA Method 8015[21]
- TPH-G using USEPA Method 8260B[18]

Two groups of drinking water samples were collected: (1) shaft and storage tank samples and (2) JBPHH system samples. The first group (shaft and storage tank samples) includes all drinking water samples collected from the Red Hill Shaft, Navy Aiea Halawa Shaft, Waiawa Shaft, drinking water treatment facilities, and drinking water storage tanks. The second group (JBPHH system samples) includes all drinking water samples collected from residential and non-residential buildings within the JBPHH system.[22] While the following discussion addresses all drinking water data, this evaluation focuses on the drinking water samples collected from the JBPHH system. These samples are more representative of the water potentially consumed by

[18] Drinking water samples collected by DOH were also sent off-island for analysis. DOH samples were sent to Eurofins TestAmerica in Monrovia, California.
[19] TPH-D and TPH-O results using Silica Gel Cleanup were not included as part of this evaluation. Silica gel cleanup procedures are typically used on soil samples and not drinking water samples. Silica gel cleanup procedures are appropriate when there is strong evidence to support that naturally occurring organic material would impact and/or result in elevated analytical results.
[20] Antimony, arsenic, barium, beryllium, cadmium, copper, lead, nickel, selenium, and thallium were analyzed using USEPA Method 200.8. Mercury was analyzed for using USEPA Method 245.1.
[21] Diesel, oil range, and gasoline range TPHs (TPH-D, TPH-O, and TPH-G, respectively) were analyzed using groundwater analytical methods since there is currently no established drinking water analytical methods for these chemicals.
[22] Most of the samples collected within the JBPHH system were collected from outdoor spigots or hose bibs.

residents using household taps. Samples collected from drinking water supply shafts, drinking water treatment facilities, and storage tanks are not representative of the water consumed by residents using tap water supplied by the JBPHH system. Samples collected from the Navy Aiea Halawa Shaft were collected after the shaft was taken offline on 3 December 2021. At this time, drinking water was not supplied from the Navy Aiea Halawa Shaft to the JBPHH system.

To support initial emergency response investigative activities, NAVFAC HI collected total organic compound (TOC) samples from residential and non-residential buildings throughout the JBPHH system. TOC testing is performed in the field using handheld equipment. TOC measurements can be reported quickly and provide an indication of potential fuel presence; however, TOC measurements are not specific to TPHs nor confirm that TPHs are present in the water. TOC measurements are also impacted by natural sources of organic compounds in groundwater, such as organic matter in soil and organic matter in surface waters that infiltrate the subsurface to groundwater. TOC measurements were used as a tool for determining where to collect drinking water samples for laboratory analysis, as well as a measurement of water quality. The following sections summarize the shaft and storage tank and JBPHH system drinking water samples and TOC samples collected between 29 November and 13 December 2021.

Shaft and Storage Tank Drinking Water Sampling Summary

Sixty drinking water samples were collected from drinking water shafts, drinking water treatment facilities, and/or storage tanks between 29 November and 13 December 2021. Thirty-two of the 60 samples were sent to Eurofins TestAmerica Seattle for analysis using non-drinking water (i.e., groundwater) analytical methods. Twenty-eight of the 60 samples were sent to Weck Laboratories, Inc. for analysis using drinking water methods. Analytical results for drinking water samples collected from drinking water shafts are provided in Table A-1 of Attachment A. Shaft and storage tank drinking water sample summary statistics are presented in Table 1 below.

Table 1. Shaft and Storage Tank Drinking Water Sample Summary Statistics (29 November – 13 December 2021)

Constituent of Potential Concern (COPC)	Number of Detections out of Number of Samples	Minimum Detected Concentration (µg/L)	Maximum Detected Concentration (µg/L)	Average Detected Concentration (µg/L)[a]	DOH Project Screening Level (µg/L)[b]
Benzene	0/60	ND	ND	ND	5.0
Toluene	0/60	ND	ND	ND	1,000
Ethylbenzene	1/60	0.88	0.88	0.88	700
Xylenes (Total)	3/60	0.69	4.8	2.3	10,000
Naphthalene	6/32[c]	0.084	3.8	0.75	17
1-Methylnaphthalene	0/32[c]	ND	ND	ND	10

Constituent of Potential Concern (COPC)	Number of Detections out of Number of Samples	Minimum Detected Concentration (µg/L)	Maximum Detected Concentration (µg/L)	Average Detected Concentration (µg/L)[a]	DOH Project Screening Level (µg/L)[b]
2-Methylnaphthalene	0/32[c]	ND	ND	ND	10
Total TPH	30/60	31	920 (only four of the 60 samples exceeded the DOH Project Screening Level of 266 ug/L)	170	266

Notes:
Exceeds DOH Project Screening Level as of 09/2022
[a] Average concentrations were calculated using detected results only; therefore, the reported average concentration is an overestimate of the actual average concentration.
[b] The screening levels presented in this table are based on the DOH project screening levels developed in the Drinking Water Sampling Plan and as updated in the Drinking Water Long-Term Monitoring Plan.
[c] These constituents were only analyzed at Eurofins TestAmerica Seattle.
ND: non-detect
µg/L: micrograms per liter

Benzene, toluene, 1-methylnaphthalene, and 2-methylnaphthalene were not detected in any shaft and storage tank drinking water sample. Ethylbenzene was detected in one out of 60 samples at a concentration of 0.88 µg/L, which is below the DOH project screening level of 700 µg/L. Xylenes (total) were detected in three out of 60 samples at concentrations between 0.69 µg/L and 4.8 µg/L, which are below the DOH project screening level of 10,000 µg/L.

Total TPH was detected in 30 out of 60 shaft and storage tank drinking water samples at concentrations between 31 µg/L and 920 µg/L. Only four samples exceeded the DOH project screening level of 266 µg/L and are summarized below:

- Total TPH was detected at a concentration of 920 µg/L on 5 December 2021 from the Navy Aiea Halawa Shaft (Pre-Chlorination)
- Total TPH was detected at a concentration of 730 µg/L on 7 December 2021 from the Navy Aiea Halawa Shaft (Pre-Chlorination)
- Total TPH was detected at a concentration of 676 µg/L on 8 December 2021 from the Navy Aiea Halawa Shaft (Pre-Chlorination)
- Total TPH was detected at a concentration of 550 µg/L on 8 December 2021 from the Navy Aiea Halawa Shaft (Pre-Chlorination)

All total TPH exceedances occurred at the Navy Aiea Halawa Shaft and were collected pre-chlorination. All four samples were analyzed at Eurofins TestAmerica Seattle using groundwater analytical methods. There were no field observations of a fuel like odor or sheen at this location. Navy Aiea Halawa Shaft post-chlorination samples also were collected on 5 December, 7 December, and 8 December 2021. All results were non-detect except for the post-chlorination sample collected on 5 December 2021 with a result of 68 µg/L which is below the DOH project screening level of 266 µg/L.

NAVFAC HI JBPHH Drinking Water System Pre-IDWST Flushing Data Summary

One hundred thirty-five drinking water samples were collected from outdoor spigots and hose bibs throughout the JBPHH system between 29 November and 13 December 2021. Eighty-two of the 135 samples were sent to Eurofins TestAmerica Seattle for analysis using non-drinking water (i.e., groundwater) analytical methods. Fifty-three of the 135 samples were sent to Weck Laboratories, Inc. for analysis using drinking water analytical methods. Analytical results for drinking water samples collected from the JBPHH system (i.e., outdoor spigots and hose bibs) are provided in Table A-2 of Attachment A. JBPHH system drinking water sample summary statistics are presented in Table 2 below.

Table 2. JBPHH System Drinking Water Sample Summary Statistics (29 November – 13 December 2021)

Constituent of Potential Concern (COPC)	Number of Detections out of Number of Samples	Minimum Detected Concentration (µg/L)	Maximum Detected Concentration (µg/L)	Average Detected Concentration (µg/L)[a]	DOH Project Screening Level (µg/L)[b]
Benzene	0/135	ND	ND	ND	5.0
Ethylbenzene	0/135	ND	ND	ND	700
Toluene	0/135	ND	ND	ND	1,000
Xylenes (Total)	0/135	ND	ND	ND	10,000
Naphthalene	4/82[c]	0.12	0.21	0.16	17
1-Methylnaphthalene	0/82[c]	ND	ND	ND	10
2-Methylnaphthalene	0/82[c]	ND	ND	ND	10
Total TPH	38/135	72	184	92	266

Notes:

Exceeds DOH Project Screening Level as of 09/2022

[a] Average concentrations were calculated using detected results only; therefore, the reported average concentration is an overestimate of the actual average concentration.

[b] The screening levels presented in this table are based on the DOH project screening levels developed in the Drinking Water Sampling Plan and as updated in the Drinking Water Long-Term Monitoring Plan.

[c] These constituents were only analyzed at Eurofins TestAmerica Seattle.

ND: non-detect

µg/L: micrograms per liter

No COPC concentrations in JBPHH system drinking water samples collected between 29 November and 13 December 2021 exceeded DOH project screening level exceedances. Benzene, ethylbenzene, toluene, xylenes (total), 1-methylnaphthalene, and 2-methylnaphthalene were not detected in any JBPHH system drinking water samples. Naphthalene was detected in four out of 82 samples at concentrations between 0.12 µg/L and 0.21 µg/L, which are below the DOH project screening level of 17 µg/L. Total TPH was detected in 38 out of 135 samples at concentrations between 72 µg/L and 184 µg/L, which are below the DOH project screening level of 266 µg/L.

Total Organic Carbon (TOC) Measurements

TOC measurements were collected from drinking water at 869 locations. These measurements were collected in the field. The purpose of these samples was to rapidly characterize drinking water quality and the potential extent of TPH contamination. TOC test results report chemicals that contain carbon and is not specific to TPHs. Many carbon-containing chemicals occur naturally in the environment. Therefore, a detection of TOC does not necessarily mean there is TPH in the drinking water. TOC measurements are commonly used as a screening

tool to provide an indication of potential petroleum-related contamination in drinking water. TOC measurements are provided in Table A-3 of Attachment A. TOC measurement summary statistics are provided in Table 3 below.

Table 3. TOC Measurement Summary Statistics (29 November – 13 December 2021)

Constituent of Potential Concern (COPC)	Number of Detections out of Number of Samples	Minimum Detected Concentration (µg/L)	Maximum Detected Concentration (µg/L)	Average Detected Concentration (µg/L)[a]	DOH Project Screening Level (µg/L)[b]
Total Organic Carbon (TOC)	60/869[c]	500	10,600 (only five of the 869 samples exceeded the DOH Project Screening Level of 4,000 ug/L)	1,600	4,000

Notes:
Exceeds DOH Project Screening Level as of 08/2022
[a] Average concentrations were calculated using detected results only; therefore, the reported average concentration is an overestimate of the actual average concentration.
[b] The screening levels presented in this table are based on the DOH project screening levels developed in the Drinking Water Sampling Plan and as updated in the Drinking Water Long-Term Monitoring Plan.
[c] Results for 182 of the samples collected reported TOC as "trace" which means TOC was detected, but not detected at a measurable level (i.e., the concentration was below the equipment reporting limit).
ND: non-detect
µg/L: micrograms per liter

TOC was detected in 60 out of 869 drinking water samples at a reportable concentration between 500 µg/L and 10,600 µg/L. Only five samples exceeded the DOH project screening level of 4,000 µg/L and are summarized below:

1. TOC was detected at a concentration of 10,600 µg/L on 1 December 2021 from 569 Dewart Lane. TOC was detected at a trace level (i.e., TOC was detected below the equipment reporting limit and could not be measured) at a nearby sampling location (567 Dewart Lane) on 1 December 2021.
2. TOC was detected at a concentration of 4,574 µg/L on 1 December 2021 from 2853C Kaee Loop. There were no additional samples collected between 29 November and 13 December 2021 on Kaee Loop; however, five TOC measurements were collected at Hapue Loop, an adjacent neighborhood. The results were: 942 µg/L (2873 A Hapue Loop), 474 µg/L (2864 A Hapue Loop), trace (2873 A Hapue Loop), trace (2865 Hapue Loop), and non-detect (2873 Hapue Loop). TOC results from Hapue Loop, an adjacent neighborhood, were below the DOH project screening level of 4,000 µg/L.
3. TOC was detected at a concentration of 9,827 µg/L on 2 December 2021 from 1028 Meae Street. There were no additional samples collected between 29 November and 13 December 2021 on Meae Street.
4. TOC was detected at a concentration of 8,652 µg/L on 2 December 2021 from 4013 Nonnan Street. TOC was non-detect at a nearby sampling location (4043 Nonnan Street) on 2 December 2021.
5. TOC was detected at a concentration of 6,589 µg/L on 2 December 2021 from 1676 Nye Circle. TOC was detected at a trace level (i.e., TOC was detected, but was detected below the equipment reporting

limit and could not be measured) and non-detect in two nearby sampling locations (1626 Nye Circle and 1624 Nye Circle, respectively) on 2 December 2021.

TOC exceedances were isolated events and did not indicate a JBPHH system-wide issue. In other words, results of the TOC measurements demonstrate that TPH did not impact the entire JBPHH system and the DOH project screening level exceedances for TOC are likely associated with premise plumbing[23] at the specific sampling location. High levels of TOC could be driven by high amounts of bacteria, microbes, or other organic matter in water at these five locations.

DOH JBPHH Drinking Water System Pre-IDWST Flushing Data Summary

Between 24 November 2021 and 02 January 2022, DOH collected and analyzed 204 drinking water samples for the EPA drinking water quality standards and 150 drinking water samples for TPHs and carbon ranges.[24, 25] These samples were analyzed by the Hawaii State Laboratory Division. Drinking water samples were collected from 176 locations. Location types included drinking water shafts, fire hydrants, residences, non-residences, and schools. Samples were primarily collected from bathroom sinks, kitchen sinks, or other indoor faucets from residences and public buildings, such as community centers, elementary schools, museums, and local gyms. All samples were analyzed using EPA drinking water analytical methods and groundwater analytical Method 8015B for TPH-D, TPH-G, TPH-O, and the TPH carbon ranges. The following table summarizes the results for drinking water samples collected by DOH.

Table 4. DOH Drinking Water Sample Summary Statistics (24 November – 02 January 2022)[b]

Constituent of Potential Concern (COPC)	Number of Detections out of Number of Samples	Minimum Detected Concentration (µg/L)	Maximum Detected Concentration (µg/L)	Average Detected Concentration (µg/L)[a]	DOH Project Screening Level (µg/L)[b]
Benzene	0/194	ND	ND	ND	5.0
Ethylbenzene	0/194	ND	ND	ND	700
Toluene	0/194	ND	ND	ND	1,000
Xylenes (Total)	2/194	0.60	1.6	1.1	10,000
Naphthalene	Not Analyzed	–	–	–	17
1-Methylnaphthalene	Not Analyzed	–	–	–	10

[23] Premise plumbing, as defined by EPA, refers to the portion of a water system including devices (e.g., hot water heaters, HVAC humidifier), fixtures (e.g., showers, faucets, outdoor spigots), and drains (e.g., sinks, toilets) connected to the main distribution system via service lines. For the purposes of this Memo, premise plumbing refers to the devises, fixtures, and drains at residences, schools, child development centers, and other buildings that are supplied drinking water from the JBPHH system. TOC results could be impacted localized issues (e.g., leaks) in service lines at specific locations.

[24] Drinking water analytical results for the samples analyzed for the EPA drinking water quality standards was provided to the Navy by DOH on 21 October 2022. In February 2023, the Navy contacted DOH to determine if there was additional analytical data for drinking water samples collected between 29 November 2021 and 02 January 2022. Specifically, if DOH had any TPH-related results. DOH provided additional laboratory analytical data on 1 March 2023.

[25] The IDWST began flushing the JBPHH system (e.g., water mains and laterals) with clean (i.e., unimpacted) drinking water supplied from the Waiawa Shaft on 20 December 2021. The DOH data set includes drinking water samples that were collected on 20 December 2021 (and up to 02 January 2022) that are not technically pre-IDWST flushing samples. However, these samples were included in this summary because they were not collected under the auspices of the IDWST.

Constituent of Potential Concern (COPC)	Number of Detections out of Number of Samples	Minimum Detected Concentration (µg/L)	Maximum Detected Concentration (µg/L)	Average Detected Concentration (µg/L)[a]	DOH Project Screening Level (µg/L)[b]
2-Methylnaphthalene	Not Analyzed	–	–	–	10
Total TPH[c]	38/149	49	280 (only three of the 149 samples exceeded the DOH Project Screening Level of 266 ug/L)	136	266
C25 – C28	1/149	66	66	66	n/a[d]
C6 – C44 Total	30/149	51	270	129	n/a[d]
C8	18/149	78	250	170	n/a[d]
C8 – C44	18/149	200	400	308	n/a[d]

Notes:

Exceeds DOH Project Screening Level as of 08/2022

[a] Average concentrations were calculated using detected results only; therefore, the reported average concentration is an overestimate of the actual average concentration.

[b] The screening levels presented in this table are based on the DOH project screening levels developed in the Drinking Water Sampling Plan and as updated in the Drinking Water Long-Term Monitoring Plan.

[c] Excludes the Red-Hill Shaft Sample that was collected on 12/05/2021. The Total TPH concentration in Red-Hill Shaft was 150,000 ug/L.

[d] The individual carbon ranges are included in the Total TPH assessment/evaluation and do not have a DOH Project Screening Level. TPH is typically defined as carbon chains in the range of C6 through C40+. Each petroleum product contains a variety of mixtures that contain many hydrocarbon compounds. JP-5 fuel is a refined type of kerosene typically consisting of C9 – C16 paraffins, cycloparaffins, aromatic hydrocarbons, and olefins.

ND: non-detect

µg/L: micrograms per liter

No drinking water samples were analyzed for naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene. A total of 149 samples were analyzed for TPH-D, TPH-G, and TPH-O (excluding the 12/05/2021 sample from the Red-Hill Shaft). Total TPHs (i.e., the sum of TPH-D, TPH-G, and TPH-O) were detected in 38 out of 149 drinking water samples. Three out of the 149 samples exceeded the DOH project screening level of 266 µg/L for TPHs and are summarized below:

- Total TPH was detected at a concentration of 270 µg/L on 17 December 2021 from 1167 Hekau Street, which slightly exceeded the DOH project screening level of 266 µg/L. Total TPH was also analyzed from 1167 Hekau Street on 7 December. Total TPH was detected at a concentration of 58 µg/L on 7 December 2021, which is below the DOH project screening level of 266 µg/L. The Total TPH results on 7 December 2021 were driven by TPH-O, which was not detected in the 17 December 2021 sample. The Total TPH results on 17 December 2021 were driven by TPH-G, which was not detected in the 7 December 2021 sample. On 8 December 2021, a drinking water sample was collected from a nearby location (i.e., 1156 Hekau Street) and Total TPH was non-detect. Based on the fact the Red Hill Shaft (i.e., source of TPH contamination) was taken offline and clean water was flushed through the JBPHH system starting 29 November 2021, it is not likely that Total TPH concentrations would increase at that location. No information was provided regarding the sample collection method or field observations (e.g., fuel odor, sheen in tap water) to compare the water quality or potential sources of contamination at the time of collection.

- Total TPH was detected at a concentration of 269 µg/L on 17 December 2021 from 1824 Palm Ave, which slightly exceeded the DOH project screening level of 266 µg/L. Total TPH was analyzed at two additional locations on Palm Ave (i.e., 1813 Palm Ave and 1838 Palm Ave). Total TPH was non-detect on 15 December 2021 from 1813 Palm Ave. Total TPH was detected at a concentration of 69 µg/L on 17 December 2021 from 1838 Palm Ave, which is below the DOH project screening level of 266 µg/L for Total TPHs. Total TPH results from these residences demonstrate that TPH exceedance was localized and may be associated with premise plumbing at the specific location with the exceedance versus a system-wide or area-wide impact.
- Total TPH was detected at a concentration of 280 µg/L on 17 December 2021 from 134 Ley Court, which exceeded the DOH project screening level of 266 µg/L. Total TPH was analyzed at two additional locations on Ley Court (i.e., 148 Ley Court and 128 Ley Court). Total TPH was detected at a concentration of 110 µg/L on 17 December 2021 from 128 Ley Court, which is below the DOH project screening level. Total TPH was detected at a concentration of 250 µg/L on 17 December 2021 from 148 Ley Court, which is below the DOH project screening level.

These concentrations were also elevated compared to drinking water samples collected prior to 17 December 2021, which is unusual given that the Red Hill Shaft (i.e., source of contamination) had been taken offline approximately two weeks prior and clean water was being supplied to the system from the Waiawa Shaft. To accurately evaluate this data, more information regarding data quality (e.g., QA/QC procedures, data validation) is necessary to gain a better understanding of the data, its quality and other considerations for interpreting the results.

A summary of DOH data is provided in Table B-1 of Attachment B.

Evaluation of Pre-IDWST Flushing Drinking Water Analytical Results

The pre-IDWST drinking water analytical results were evaluated to identify any trends in COPC concentrations and determine if COPC concentrations exceed DOH project screening levels. COPCs were detected in few pre-IDWST flushing drinking water samples.

NAVFAC HI Shaft and Storage Tank Drinking Water Sampling Summary

Results of the pre-IDWST flushing drinking water samples collected by NAVFAC HI from shafts and storage tanks are summarized below:

- Benzene, toluene, 1-methylnaphthalene, and 2-methylnaphthalene were not detected in any drinking water samples collected.
- Ethylbenzene was detected in one out of 60 (1.7%) drinking water sample at a concentration of 0.88 µg/L, which is below the DOH project screening level of 700 µg/L.

- Xylenes (total) were detected in three out of 60 (5.0%) drinking water samples at concentrations ranging between 0.69 µg/L and 4.8 µg/L, with an average concentration of 2.3 µg/L. All results were below the DOH project screening level of 10,000 µg/L.
- Naphthalene was detected in six out of 32 (18.8%) drinking water samples at concentrations ranging between 0.084 µg/L and 3.8 µg/L, with an average concentration of 0.75 µg/L. All results were below the DOH project screening level of 17 µg/L.
- Total TPHs were detected in 30 out of 60 (50%) drinking water samples at concentrations ranging between 31 µg/L and 920 µg/L with an average concentration of 170 µg/L. Only four results exceeded the DOH project screening level of 266 µg/L. The four exceedances occurred at the Navy Aiea Halawa Shaft between 5 December and 8 December 2021, after the Navy Aiea Halawa Shaft was taken offline. The Navy Aiea Halawa Shaft exceedances took place at the pump-head, prior to chlorine disinfection. Water supplied for drinking water purposes is disinfected using chlorine. Since these samples were collected pre-chlorination, these samples are not representative of drinking water quality in the JBPHH system. No TPH exceedances occurred in samples collected downgradient of the Navy Aiea Halawa Shaft chlorinator.

Comparison of NAVFAC HI and DOH JBPHH Drinking Water System Pre-IDWST Flushing Data

As summarized in Table 5, the pre-IDWST flushing drinking water data collected by NAVFAC HI is very similar to the pre-IDWST flushing drinking water data collected by DOH. Overall, both datasets demonstrate a lack of a system-wide impact from JP-5 fuel and key observations are summarized below:

- Benzene, ethylene benzene and toluene were not detected in any of the NAVFAC HI samples (0/135) and were also not detected in any of the DOH samples (0/194).
- Xylenes (Total) were not detected in any of the NAVFAC HI samples (0/135) and were only detected in (2/194) of the DOH samples. The maximum concentration detected in the DOH samples was 1.6 µg/L which is significantly less than the DOH Project Screening Level of 10,000 µg/L.
- Total TPH was detected in 28.1% (i.e., 38/135) NAVFAC HI samples and 25.5% (i.e., 38/149) DOH samples. The range of detected concentrations were similar in both the NAVFAC HI and DOH drinking water samples:
    - NAVFAC HI: 72 – 184 µg/L
        - None (0/135) of the samples exceeded the DOH Project Screening Level for Total TPH of 266 ug/L.
    - DOH: 49 – 280 µg/L
        - Only three (3/149) of the samples exceeded the DOH Project Screening Level for Total TPH of 266 ug/L.

Table 5. Comparison of NAVFAC HI and DOH Pre-IDWST Flushing Drinking Water Sample Summary Statistics

Constituent of Potential Concern (COPC)	Number of Detections out of Number of Samples		Minimum Detected Concentration (µg/L)		Maximum Detected Concentration (µg/L)		Average Detected Concentration (µg/L)[c]		DOH Project Screening Level (µg/L)[a]
	NAVFAC HI	DOH	NAVFAC HI	DOH	NAVFAC HI	DOH	NAVFAC HI	DOH	
Benzene	0/135	0/194	ND	ND	ND	ND	ND	ND	5.0
Ethylbenzene	0/135	0/194	ND	ND	ND	ND	ND	ND	700
Toluene	0/135	0/194	ND	ND	ND	ND	ND	ND	1,000
Xylenes (Total)	0/135	2/194	ND	0.60	ND	1.6	ND	1.1	10,000
Total TPH	38/135	38/149	72	49	184	280[d]	92	136	266

Notes:

Exceeds DOH Project Screening Level as of 08/2022

[a] The screening levels presented in this table are based on the DOH project screening levels developed in the Drinking Water Sampling Plan and as updated in the Drinking Water Long-Term Monitoring Plan.

[b] Excludes the Red-Hill Shaft Sample that was collected on 12/05/2021. The Total TPH concentration in Red-Hill Shaft was 150,000 ug/L.

[c] Average concentrations were calculated using detected results only; therefore, the reported average concentration is an overestimate of the actual average concentration.

[d] Only three of the 149 samples exceeded the DOH Project Screening Level of 266 ug/L.

ND: non-detect

µg/L: micrograms per liter

NAVFAC HI and DOH JBPHH Drinking Water System Pre-IDWST Flushing Data Summary

Results of the pre-IDWST flushing drinking water samples collected by NAVFAC HI and DOH from the JBPHH system are summarized below:

- Benzene, ethylbenzene, toluene (0 of 329 samples), 1-methylnaphthalene, and 2-methylnaphthalene (0 of 82 samples) were not detected in any drinking water samples collected.
- Xylenes (Total) were detected in two of 329 (< 1%) drinking water samples. All results were below the DOH project screening level of 10,000 µg/L.
- Naphthalene was detected in four of 82 (4.9%) drinking water samples at concentrations ranging between 0.12 µg/L and 0.21 µg/L. All results were below the DOH project screening level of 17 µg/L.
- Total TPHs were detected in 76 of 284 (26.8%) drinking water samples at concentrations ranging between 49 µg/L and 280 µg/L. Only three of the 284 (1%) samples exceeded the DOH Project Screening Level of 266 µg/L.

Results of the NAVFAC HI TOC measurements collected for pre-IDWST flushing drinking water samples are summarized below:

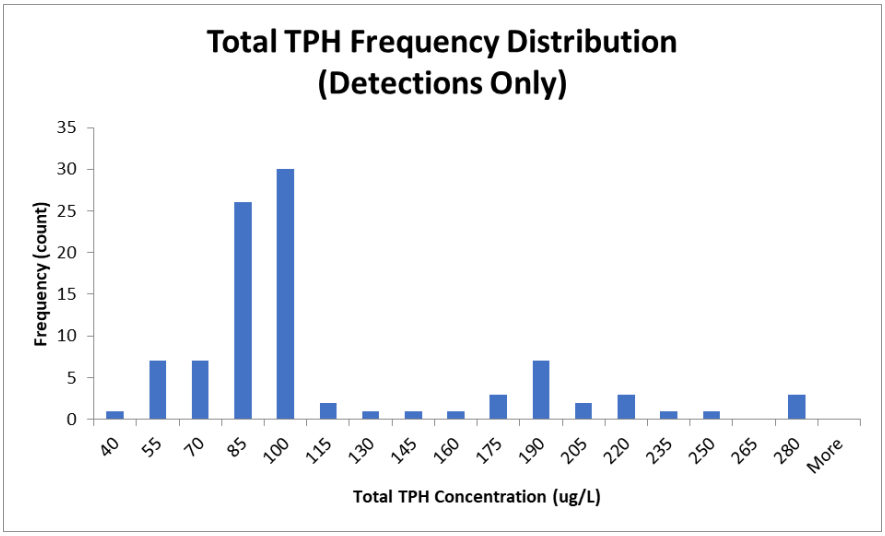
- TOC was detected in 242 of 896 (27.0%) samples; however, 182 samples were detected below the equipment reportable level of 200 µg/L. Sample results detected below the reportable level are reported as "trace." Only five results exceeded the DOH project screening level of 4,000 µg/L. TOC measurements were collected in the field to provide a rapid assessment of drinking water quality. TOC measurements were used to indicate the potential extent of TPH contamination. An exceedance of the project screening level does not necessarily mean the drinking water has been impacted by TPH.

Drinking water standards are legal limits set to control the level of contamination in drinking water. The limit reflects the level of contamination that is protective of human health. A detection does not mean there is cause for concern. Chemicals detected at concentrations above drinking water standards (i.e., MCLs, EALs, ISPs) could pose an unacceptable risk to human health.

- Results of the TOC testing does not demonstrate a JBPHH system-wide issue. In other words, results of the TOC measurements demonstrate that TPH did not impact the entire JBPHH system and the DOH project screening level exceedances for TOC are likely associated with premise plumbing at the specific sampling location.

The available data demonstrate a lack of a JBPHH system-wide impact associated with JP-5 fuel. Total TPH was detected in 76 of 284 (26.8%) drinking water samples collected throughout the JBPHH system by NAVFAC HI and DOH; however, only three of the 284 (1%) samples exceeded the DOH Project Screening Level of 266 µg/L. TPH detections were typically isolated and no spatial pattern was observed. Results for other COPCs (i.e., benzene, ethylbenzene, toluene, and xylenes [BTEX]) that are commonly associated with TPHs (BTEX are typically associated with gasoline and are not associated with JP-5 fuel) were non-detect (note: xylenes were detected in two of 329 (< 1%) but well below the DOH project screening level) in drinking water samples collected throughout the JBPHH system. Naphthalene was detected in less than five percent of drinking water samples collected throughout the JBPHH system; however, all detected concentrations were below the DOH project screening level and detections were isolated (i.e., detections did not occur in drinking water samples collected nearby each other and/or from two drinking water samples collected from the same location). It is important to note that the pre-IDWST flushing drinking water data was not validated. In the drinking water

samples where TPHs were detected, there is limited variability in the concentrations reported by the laboratory. Approximately seventy-four (73.9%) of the samples where TPHs were detected had concentrations between 40 and 100 µg/L.

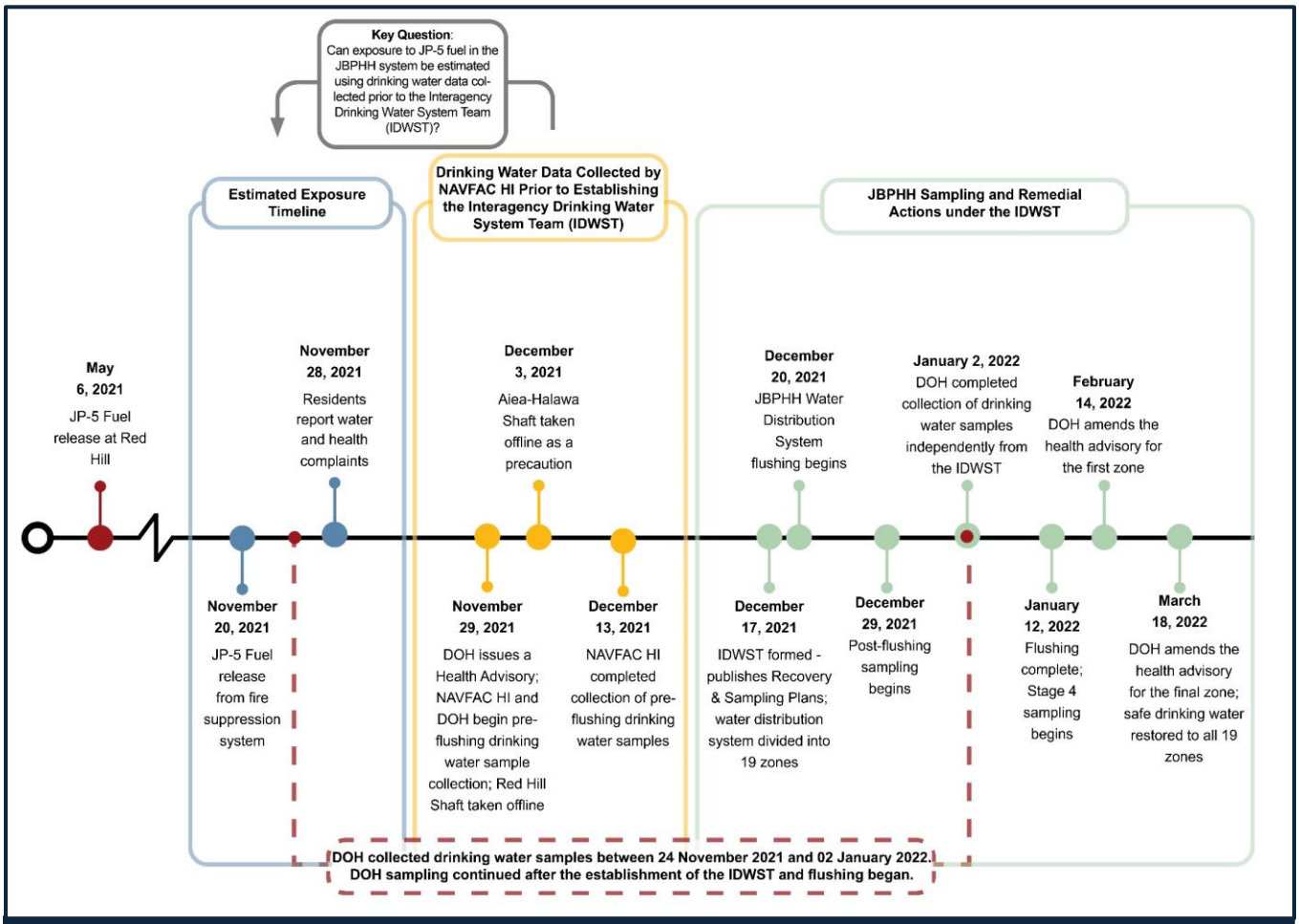


Determination if Pre-IDWST Flushing Drinking Water Data Should be Used to Evaluate Human Exposure to JP-5 Fuel in Drinking Water at the Joint Base Pearl Harbor-Hickam Water Distribution System

The Pre-IDWST Flushing Drinking Water Data collected by NAVFAC HI and DOH (and summarized in the previous section) was evaluated using multiple lines-of-evidence to determine whether or not the pre-IDWST flushing drinking water data is appropriate for use in evaluating human exposure to JP-5 fuel and other COPCs detected in drinking water. The lines-of-evidence included:

1. Evaluating the timeline of events to determine if the pre- IDWST flushing drinking water samples were collected during the probable exposure timeframe.
2. Evaluating the location (e.g., community center, residence, workplace, indoor faucet, spigot) and spatial distribution of collected pre-IDWST flushing drinking water samples to determine if the data is representative of the drinking water exposure scenario (i.e., users of the JBPHH consuming tap water) in the JBPHH system.
3. Evaluating the lab analytical data to determine if the data is of quality sufficient for use in evaluating human exposure to COPCs in drinking water.

Evaluation of Timeline of Events



Estimated Exposure and Pre-IDWST flushing Drinking Water Sampling Timeline

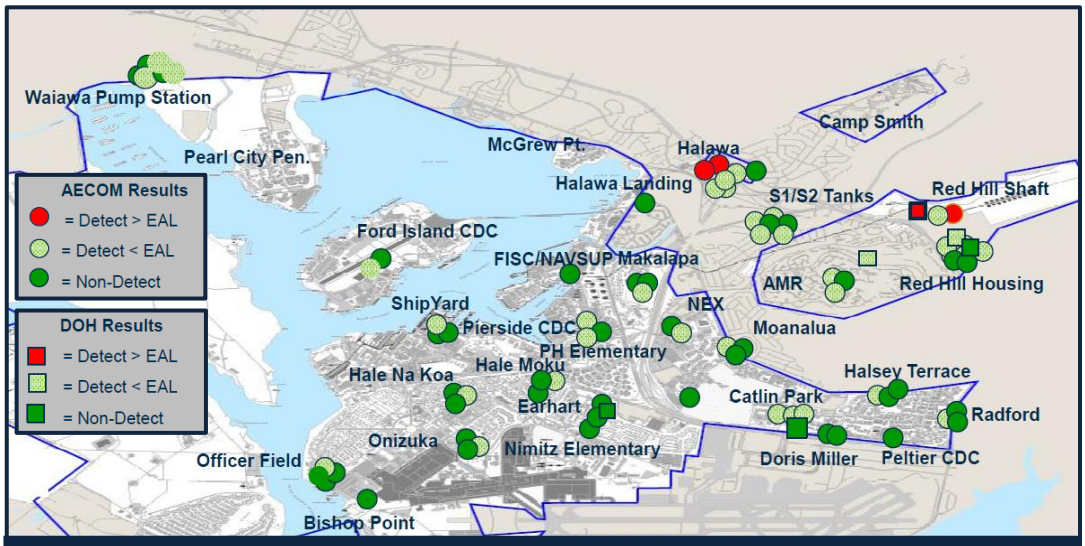
JP-5 fuel was accidentally released into the JBPHH system on 20 November 2021. The first report of health symptoms and fuel-like odors in water occurred on 28 November 2021. In response, the Red Hill Shaft (which is one of three shafts that supplies drinking water to the JBPHH system) was taken offline on 29 November 2021. Drinking water in the JBPHH system was supplied by the Waiawa Shaft and the Navy Aiea Halawa Shaft until 3 December 2021 when the Navy Aiea Halawa Shaft was taken offline due to its proximity to the Red Hill Shaft. Beginning 3 December 2021, drinking water was supplied solely by the Waiawa Shaft. The Waiawa Shaft was not impacted by the JP-5 fuel release. On 29 November 2021, DOH issued a health advisory to users of the JBPHH system to not use tap water for drinking, cooking, and oral hygiene. Water supplied by the JBPHH system could still have been used for other purposes (e.g., bathing, dish washing, and laundry) unless users detected a fuel odor from their water in which case DOH recommended users avoid using the water for all consumptive uses.

TPH exposure was likely the highest immediately following the 20 November 2021 release until the Red Hill Shaft was taken offline on 29 November 2021 and the source of JP-5 fuel contamination in the JBPHH system

was eliminated. Sampling of the JBPHH system, in response to the 20 November 2021 Red Hill Release, began on 29 November 2021, one day after the first complaint of health symptoms, fuel-like tastes, odors, and sheen in tap water and after DOH had issued the health advisory. After the health advisory was issued, residents should no longer have been using tap water for drinking, cooking, and oral hygiene if they adhered to the advisory. The Navy provided residents with bottled water for consumptive purposes. By the time sample collection began, the Red Hill Shaft had been taken offline and the JBPHH system was supplied with clean drinking water from the Waiawa Shaft and Navy Aiea Halawa Shaft.[26] Even though official flushing activities under the Drinking Water Distribution System Recovery Plan did not begin until 20 December 2021, approximately 11 to 14 million gallons of clean drinking water was being supplied to the JBPHH system each day (NAVFAC HI). After 29 November 2021, the JP-5 fuel remaining in the JBPHH system was diluted and/or flushed daily by clean drinking water from the Waiawa Shaft and the Navy Aiea Halawa Shaft.[27] By 29 November 2021, it is expected that there was limited JP-5 fuel contamination remaining in the JBPHH system. This is supported by analytical results of pre-IDWST flushing drinking water sample data (discussed earlier in this Memo).

Evaluation of Pre-IDWST Flushing Drinking Water Sample Locations and Spatial Distribution

NAVFAC HI collected pre-IDWST flushing drinking water samples primarily from outdoor spigots and/or hose bibs of community buildings such as community centers, gas stations, and chapels throughout the JBPHH system. As a result, drinking water samples were not collected at potential exposure points (e.g., household taps) and were not collected throughout the entire JBPHH system.[28] NAVFAC HI collected pre-IDWST flushing



Pre-IDWST flushing Drinking Water Sample Results for all Constituents (excluding TOC).
Note: Exceedances of the TPH DOH Project Screening Level Only Occurred at the Red Hill Shaft and the Navy Aiea Halawa Shaft.

[26] Prior to 29 November 2021, approximately 75% of drinking water in the JBPHH system was supplied from the Waiawa Shaft and the remaining 25% was supplied from the Red Hill Shaft (24%) and the Navy Aiea Halawa Shaft (1%). After 3 December 2021, 100% of drinking water in the JBPHH system was supplied by the Waiawa Shaft.

[27] The Navy Aiea Halawa Shaft was taken offline on 3 December 2021. After 3 December 2021, 100% of drinking water in the JBPHH system was supplied by the Waiawa Shaft.

[28] In December 2021, Hawaii was experiencing a peak in COVID-19 cases. Due to the high infection rate, DOH recommended that Navy personnel (and all personnel working on the Red Hill emergency response team) avoid entering homes to prevent the spread of COVID-19. As a result, drinking water samples were collected from outdoor spigots or hose bibs instead of indoor faucets.

drinking water samples from approximately 69 different locations which represents less than 1% of the 9,694 households, schools, child development centers, and workplaces within the JBPHH system. DOH collected pre-IDWST flushing drinking water samples primarily from sinks of residences, schools, and community buildings throughout the JBPHH system. DOH collected pre-IDWST flushing drinking water samples from approximately 187 different locations which represents less than 2% of the 9,694 households, schools, child development centers, and workplaces within the JBPHH system.

In general, outdoor spigots and hose bibs are not recommend for collecting samples representative of potential drinking water at a residence/building (typically the kitchen sink is sampled under the SDWA). The SDWA was established to protect the quality of drinking water in the U.S. The SDWA also created several exemptions which included drinking water used for non-potable services (such as outdoor watering) or other uses where drinking water is not anticipated to be used for human consumption. Outdoor faucets, spigots, and garden hoses are not regulated to drinking water standards and are not intended to provide drinking water for human consumption. Outdoor spigots and hose bibs are potentially exposed to unsanitary conditions and are susceptible to bacteria, are made of materials and/or chemicals that leach to the water, and debris build up which serve as another potential source of contamination (City of Cleveland 2018).

Since pre-IDWST flushing drinking water samples were collected from less than 1% (NAVFAC HI) and 2% (DOH) of the 9,694 households, schools, child development centers, and workplaces within the JBPHH system (and typically locations were only sampled one time) and NAVFAC HI's samples were not collected from potential points of exposure (e.g., household taps), it is highly uncertain if this pre-IDWST flushing drinking water data set is representative of drinking water consumed by residents during estimated exposure timeframe (i.e., between 20 November and 29 November 2021).

Evaluation of Pre-IDWST Flushing Drinking Water Sample Data Quality

The IDWST developed standard operating procedures (SOPs) and standardized methods for determining where drinking water samples were collected. The purpose of these SOPs was to ensure drinking water samples were representative of the JBPHH system and representative of potential exposure pathways (e.g., ingestion of tap water). Prior to the IDWST developing the Drinking Water Sampling Plan, there were no SOPs or standardized methods guiding drinking water sample collection. Pre-IDWST flushing drinking water samples were collected prior to the development of the Drinking Water Sampling Plan (published 17 December 2021) which established:

- Appropriate analytical methods for characterizing drinking water quality
- Appropriate method detection limits (MDLs) necessary for quantifying the amount of each chemical in the collected drinking water sample
- Quality Assurance/Quality Control (QA/QC) procedures required to ensure data quality
- DOH project screening levels (i.e., MCLs, DOH Environmental Action Levels [EALs], and incident specific parameters [ISPs])

- Standard procedures to ensure consistency in drinking water sample collection and to reduce potential sample inference or cross-contamination
- Procedures for selecting where drinking water samples would be collected (e.g., steps for determining which faucet to sample within a residential building, number of samples to collect per zone) to ensure drinking water samples were representative of potential exposure points and drinking water conditions throughout the JBPHH system

Pre-IDWST flushing drinking water samples were not collected in accordance with the requirements outlined in the Drinking Water Sampling Plan (as summarized above). Pre-IDWST flushing drinking water samples were analyzed using both groundwater and drinking water analytical methods.[29] Samples analyzed using groundwater analytical methods were not analyzed using MDLs below the DOH project screening levels. Therefore, a sample result could be reported as non-detect at a concentration above the DOH project screening level. Additionally, pre-IDWST flushing drinking water samples were not reviewed by a data validator to ensure the laboratories followed appropriate analytical method procedures, used appropriate MDLs, reported results accurately, and that there was no potential interference and/or contamination within the lab. Data validation is a critical step for ensuring data quality is sufficient for evaluating potential human exposure. Therefore, it is uncertain if this pre-IDWST flushing drinking water data set is of sufficient quality for use in conducting an exposure assessment of individuals who consumed drinking water that was impacted by the JP-5 fuel release.

Uncertainty Analysis

The purpose of the uncertainty analysis is to evaluate potential sources of uncertainty associated with the pre-IDWST flushing drinking water data that could influence the evaluation of human health impacts and decision-making. Uncertainty can be qualitative (i.e., lack of knowledge about the factors that affect potential exposure) or quantitative (i.e., use of incorrect or in-precise measurement methods). Key uncertainties associated with the pre-IDWST flushing drinking water data collected by NAVFAC HI between 29 November and 13 December 2021 and DOH between 24 November 2021 and 02 January 2022 are summarized below:

- **The actual exposure timeframe is unknown**. Based on several lines of evidence, such as the timing of the JP-5 fuel release (i.e., 20 November 2021), JBPHH system users reporting health impacts and fuel-like tastes, odors, and sheen on 28 November 2021, and the Red Hill Shaft (source of contamination) being taken offline on 29 November 2021, there is strong evidence to suggest exposure likely took place between 20 November and 29 November 2021 (i.e., less than two weeks); however, it is unknown if exposure occurred during that entire timeframe or for a few days.

[29] For example, NAVFAC HI collected 135 drinking water samples from outdoor spigots and hose bibs throughout the JBPHH system between 29 November and 13 December 2021. Eighty-two of the 135 samples were sent to Eurofins TestAmerica Seattle for analysis using non-drinking water (i.e., groundwater) analytical methods. Fifty-three of the 135 samples were sent to Weck Laboratories, Inc. for analysis using drinking water analytical methods.

- **Actual concentrations of JP-5 fuel in the JBPHH system during the exposure timeframe (i.e., 20 November to 29 November 2021) are unknown**. Sampling of the JBPHH system, in response to the 20 November 2021 Red Hill release, began on November 29, after the Red Hill Shaft (source of JP-5 fuel contamination) was taken offline. There were no samples collected from the JBPHH drinking water system in the time between the JP-5 release on November 20, 2021, and when the first health impacts and fuel-like tastes, odors, and sheen began to be reported on November 28, 2021, when concentrations where likely at their highest.[30]
- **Concentrations of JP-5 fuel in the JBPHH system during the probable exposure timeframe (i.e., 20 November to 29 November 2021) were likely highly variable – both spatially and temporally.** NAVFAC HI and DOH collected "snapshot" samples from 29 November 2021 through 02 January 2022. It is not known if:
    - These locations accurately represent JP-5 fuel concentrations in the area/neighborhoods proximate to their location.
    - These snapshot samples were collected at times that JP-5 fuel was moving through the system at these locations.
- **Drinking water samples may not be representative of the neighborhoods/zones with the highest potential impacts from JP-5 fuel contamination.** The neighborhoods/zones most likely impacted by JP-5 fuel are the neighborhoods/zones closest to the Red Hill Shaft. However, during the emergency response, drinking water samples were collected throughout the JBPHH system to rapidly characterize drinking water quality and the potential extent of TPH contamination. There are approximately 9,694 households, schools, child development centers, and workplaces within the JBPHH system. Due to limited lab capacities, not every location could be sampled. Consequently, drinking water samples were collected from (less than 1% [NAVFAC HI] and 2% [DOH]) of all households, schools, child development centers, and workplaces in the JBPHH system.
- **NAVFAC HI Drinking water samples were not collected from the potential exposure point (i.e., household taps).** Samples were collected from outdoor hose bibs, which are not representative of a potential exposure point (i.e., household tap), and are especially susceptible to unrelated contamination. Drinking water samples collected at household taps would have been more representative of potential JP-5 fuel concentrations being consumed.
- **No SOPs were developed prior to collecting and analyzing pre-IDWST flushing drinking water samples.** There is currently no available information documenting how samples were collected to ensure there were no data quality concerns at the time of collection (e.g., were all samples collected using the same method, were field crews trained on how to collect drinking water samples). MDLs were higher than the DOH project screening levels in some instances. Consequently, sample results could potentially exceed project screening levels for contaminants of concern, and yet be reported as non-detect.

[30] DOH collected two samples (raw water [DW_360-001-112421 - Raw] and chlorinated water [DW_320-011-202124 - Chlorinated]) on 24 November 2021 and analyzed the samples for TPH-G, TPH-D, and TPH-O. All results were non-detect except for the TPH-O result for DW_320-011-202124 – Chlorinated which was 66 ug/L.

- **Data validation was not performed on pre-IDWST flushing drinking water data to ensure the data is of good quality**. Data validation is the process of checking the accuracy and quality of source data before using the data. Data validation is a critical step for ensuring sample data is of sufficient quality for evaluating potential human exposure.

Summary and Conclusions

The pre-IDWST flushing drinking water data, collected by NAVFAC HI (between 29 November and 13 December 2021) and DOH (between 24 November 2021 and 02 January 2022), would not be appropriate for use in conducting an exposure assessment of individuals who consumed drinking water that was impacted by the JP-5 fuel release. This determination is based on the following:

- **Timeline of Events** – Pre-IDWST flushing drinking water samples were collected after the Red Hill Shaft had been taken offline and were not collected within the most likely highest estimated exposure timeframe (i.e., 20 November and 29 November 2021). Even though official flushing activities under the Drinking Water Distribution System Recovery Plan did not begin until 20 December 2021, approximately 11 to 14 million gallons of clean drinking water was being supplied to the JBPHH system each day (NAVFAC HI). After 29 November 2021, the JP-5 fuel remaining in the JBPHH system was diluted and/or flushed daily by clean drinking water from the Waiawa Shaft and the Navy Aiea Halawa Shaft (until taken offline on 3 December 2021). By 29 November 2021, there was likely limited JP-5 fuel contamination remaining in the JBPHH system.
- **Location and Spatial Distribution of Drinking Water Samples** – The neighborhoods/zones most likely impacted by JP-5 fuel are the neighborhoods/zones closest to the Red Hill Shaft. However, during the emergency response, drinking water samples were collected throughout the JBPHH system to rapidly characterize drinking water quality and the potential extent of TPH contamination. There are approximately 9,694 households, schools, child development centers, and workplaces within the JBPHH system. Due to limited lab capacities, not every location could be sampled. Consequently, drinking water samples were collected from less than 1% (NAVFAC HI) and 2% (DOH) of all households, schools, child development centers, and workplaces in the JBPHH system. In addition, concentrations of JP-5 fuel in the JBPHH system during the probable exposure timeframe (i.e., 20 November to 29 November 2021) were likely highly variable – both spatially and temporally. NAVFAC HI and DOH collected “snapshot” samples from 29 November 2021 through 02 January 2022. It is not known if:
    - These locations accurately represent JP-5 fuel concentrations in the area/neighborhoods proximate to their location.
    - These snapshot samples were collected at times that JP-5 fuel was moving through the system at these locations.

Therefore, it is highly uncertain if this pre-IDWST flushing drinking water data set is representative of drinking water consumed by residents during estimated exposure timeframe (i.e., the period between 20 November and 29 November 2021).

- **Insufficient Data Quality** – Pre-IDWST flushing drinking water data was collected prior to the IDWST developing the Sampling Plan which identified the appropriate analytical methods; QA/QC requirements and procedures; sample collection and handling procedures; and the project screening levels. There is currently no available information documenting how samples were collected to ensure there were no data quality concerns at the time of collection (e.g., were all samples collected using the same method, were field crews trained on how to collect drinking water samples). MDLs were higher than the DOH project screening levels in some instances. Consequently, sample results could potentially exceed project screening levels for contaminants of concern, and yet be reported as non-detect. Additionally, pre-IDWST flushing drinking water samples were not reviewed by a data validator to ensure the laboratories followed appropriate analytical method procedures, used appropriate MDLs, reported results accurately, and that there was no potential interference and/or contamination within the lab. Therefore, it is uncertain if this pre-IDWST flushing drinking water data set is of sufficient quality for use in conducting an exposure assessment of individuals who consumed drinking water that was impacted by the JP-5 fuel release.

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