BOARD OF WATER SUPPLY

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October 3, 2016

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and

Mr. Steven Chang, P.E.
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Dear Messrs. Pallarino and Mr. Chang:

Subject: Board of Water Supply (BWS) Comments on the Red Hill Bulk Fuel Storage Facility (RHBFSF) Administrative Order on Consent (AOC) Work Plans and Associated Scoping Meetings

From June 2015 to the date of this letter, the BWS has sent 34 letters on the AOC and its work plans to the AOC Parties and received only 11 responses. We strongly believe these letters demonstrate our commitment to lend our assistance and expertise in good faith and at a minimum deserve the courtesy of a reply to each one. The number of responses, however, received to date is disappointing given the serious threat these aging underground fuel storage tanks pose to the environment and our high quality drinking water resource.

The BWS continues to be concerned about the petroleum contamination that is still present in the rocks and groundwater underneath and near the Red Hill fuel tanks and the risk for potential future, perhaps catastrophic leaks. The Navy has been testing the groundwater since 2005. However, tests conducted by the Navy from 2014 to 2016 indicate the amount of petroleum contamination in the groundwater underneath Tank 5 is rising.

Navy studies and reports on the condition of the tanks also show many holes forming from corrosion of the steel tanks which is requiring the Navy to hire contractors to weld patch plates to cover the holes. Maintaining the inside of the tank but not the outside which cannot be reached is not reducing the risk of more leaks.

The BWS would like to remind the signatories of the Red Hill Bulk Fuel Storage Facility AOC of their respective mission statements and Article XI of the Hawaii State Constitution that holds all public natural resources in trust and protected for the benefit of the people of Hawaii.

In keeping with the Hawaii State Constitution, the BWS firmly maintains its position of:

1. Accepting no more fuel leaks from the Red Hill tanks and to restore the groundwater to its original pristine condition by cleaning up the fuel contamination that exists there now and preventing future leaks regardless of amount.
2. Zero risk of fuel leaks to the environment.
3. Relocating the fuel to a different facility at a different location or locations, or retrofitting all Red Hill Bulk Fuel Storage Facility (RHBFSF) active tanks with double walls (tank-within-a-tank).
4. Maintaining public transparency and not sign any non-disclosure statement.
5. Finding the 2014 fuel leak by installing more groundwater monitoring wells to get the information needed to completely understand the groundwater contamination underneath and near the tanks.

To date, the BWS has fully participated in AOC scoping discussions and shared its knowledge by submitting pages and pages of comments and recommendations to the AOC parties. So far our comments and recommendations appear to be ignored and unused.

However, your September 15, 2016 letter to the Navy and the Defense Logistics Agency (DLA) rejecting their submittal for Sections 6 and 7 which incorporated our June 3, 2016 letter has given us hope that this trend will not continue. We ask the Environmental Protection Agency (EPA) and the Hawaii Department of Health (DOH) to reply to those letters that have not been responded to. We also offer our latest comments below.

Non-Aqueous Phase Fuel in Groundwater

There are multiple lines of evidence that indicate non-aqueous phase fuel has been and continues to be present in or near monitoring well RHMW02, yet EPA and DOH have not directed the Navy to remediate this contamination of our drinking water supply aquifer. Regardless of the AOC, the EPA and DOH remain responsible for enforcing the regulations for responding to contamination of Oahu drinking water by light non-aqueous phase liquids (LNAPLs) (HAR Subchapter 7 §11-281-74(5) and CFR Title 40, Chapter I, Subchapter I, Subpart F Part 280.62(a)(5)) and those actions required by the Navy's own Groundwater Protection Plan (GWPP) (TEC, 2008; HDR, 2014).

Monitoring well RHMW02 is located near Tanks 5 and 6, both of which have held Navy Special Fuel Oil, naval distillate, and JP-5 from 1942 to about 2002 (AMEC, 2002). Tank 6 also held F-76 fuel from 1982 to 1994 (AMEC, 2002). Tank 5 was used to store JP-8 at the time of the January 2014 fuel spill.

Our understanding of the leak history at the RHBFSF is limited. Based on the reports available to BWS, we have developed the following table that outlines our understanding of reported releases and amounts. Please note that there are several reported releases that do not report a volume and that there is no data available for BWS regarding leaks after 1983, with the exception of the January 2014 27,000-gallon release of JP-8 from Tank 5.

Fuel Type	Estimated Release Volume (gallons) 1944 - 1983	Number of Releases with Unknown Volume Released
Navy Special Fuel Oil	30,500	4
Navy Distillate	0	3
Diesel Oil	0	6
Diesel Fuel, Marine	26,505	14
JP-5	71,045	7
JP-8*	27,000	0
Total	**155,050**	**34**

Notes: * = Release occurred in January 2014
No data for years between 1984 to present
Fuel type estimated release volumes and number of releases (AMEC, 2002)

One line of evidence for the presence of fuel NAPL in groundwater is the historical total petroleum hydrocarbon – diesel (TPH-d) data for groundwater at monitoring well RHMW02. Average TPH-d concentrations at RHMW02 have exceeded 5,000 micrograms per liter (µg/L) five times since 2005: once in 2008 and four times since the January 2014 fuel spill at Tank 5 (Element Environmental, LLC, 2016). The most recent sample's value was slightly below the GWPP Site-Specific Risk-Based Screening Level (SSRBL) of 4,500 µg/L (Element Environmental, LLC, 2016). According to ASTDR (2016), the water solubility for JP-5 and JP-8 is 5,000 µg/L (ATSDR, 2016), which is also the water solubility for the F-76 marine diesel fuel (CITGO, 2015) that was stored at the nearby Tank 6 (AMEC, 2002). It should be noted that the Navy uses a SSRBL of

4,500 μg/L in their GWPP which is based on their understanding of JP-5 solubility in groundwater and is not based a health-based value (TEC, 2008; HDR, 2014). TPH-d concentrations at RHMW02 have exceeded the ATSDR 5,000 μg/L fuel solubility value for JP-5, JP-8, and F-76 five times since 2005 and four times since the January 2014 fuel spill at Tank 5. The TPH-d concentrations are likely an accurate indicator of contamination from diesel fuels such as F-76, as well as the jet fuels according to statements made by the Navy during the recent risk assessment work plan meeting. Thus, the historical TPH-d concentrations indicate the presence of NAPL from one or more of the F-76, JP-5, and JP-8 fuel types in tanks in or near RHMW02.

The second line of evidence for the presence of fuel NAPL in groundwater is historical naphthalene concentrations in groundwater at RHMW02. Naphthalene is a carcinogenic constituent of jet fuels and F-76 fuel stored at the RHBFSF and has effective solubility values of about 360 to 960 μg/L in JP-8, about 260 μg/L in JP-5, and about 660 to 2060 μg/L in F-76 fuel based on our calculations using mass fractions and pure phase solubilities at 25 degrees Celsius from the ATSDR (2016) and mass fractions from Ritchie et al. (2003). Average naphthalene concentrations at RHMW02 exceeded 200 μg/L eight times and 300 μg/L twice during 2006 and 2008 (Element Environmental, LLC, 2016). These observed concentrations were above or near the effective solubility of JP-5 and near that for JP-8 during 2006 and 2008, indicating that fuel NAPL was likely present in or near RHMW02. These observed naphthalene values likely indicate a fuel release that occurred in 2006 or earlier. Since late 2014, observed average naphthalene concentrations have reached values between 100 and 150 μg/L on five occasions (Element Environmental, LLC, 2016). These values are a significant fraction of the effective solubility for JP-5 and JP-8, and thus corroborate the presence of fuel NAPL in or near RHMW02.

Another line of evidence for the presence of fuel NAPL in groundwater is that the observed concentrations of naphthalene have exceeded or approached 1% of the pure phase solubility values. As stated in the EPA website Contaminated Site Clean-up Information (https://clu-in.org/): *As a rule of thumb, if dissolved concentrations are at or above 1 percent of effective solubility, it is likely that the well is completed in the vicinity of a NAPL zone* (EPA, 1997 and 2001). Pure phase solubility at 25 degrees Celsius for naphthalene is 31,700 μg/L (ATSDR, 2016). RHMW02 naphthalene concentrations have exceeded 1% of the pure phase solubility value (317 μg/L) twice from 2006 to 2009 and recently approached about 50% of this value (Element Environmental, LLC, 2016), demonstrating that fuel NAPL has entered the well or is currently near to the well.

The fuel NAPL near monitoring well RHMW02 has been and will continue to degrade the water quality of our drinking water aquifer. The BWS requests that EPA and DOH require the Navy to investigate and remove the NAPL in and around monitoring well RHMW02 and anywhere else in the surrounding vicinity of the RHBFSF.

Parties Appear to Ignore Agreed-Upon Groundwater Protection Plan (GWPP)

As outlined in the GWPP, groundwater action levels used for decisions at the RHBFSF include general DOH Environmental Action Levels (EALs) for groundwater protection and SSRBLs for TPH-d and benzene (TEC, 2008; HDR, 2014). The actions to be taken for exceedances at specific monitoring wells and for specific categories are listed in Table 4-2 of the GWPP (TEC, 2008; HDR, 2014). The actions to be taken are dependent on the concentration of a compound at a specific well related to EALs and SSRBLs and groundwater concentration trends:

> **Results Category 1**: Result above detection limit but below drinking water EAL and trend for all compounds stable or decreasing.
>
> **Results Category 2**: Trend for any compound increasing or drinking water EAL exceeded; as specified in the GWPP, trends are to be evaluated using the Mann-Kendall statistical test.
>
> **Results Category 3**: Result between 1/10X SSRBL and SSRBL for benzene, or between 1/2X SSRBL and SSRBL for TPH.
>
> **Results Category 4**: Result exceeding any SSRBL or fuel NAPL is measured or observed.

From comparison of concentrations in Navy monitoring wells to EALs and SSRBLs, groundwater concentrations in samples collected from monitoring wells RHMW01, RHMW02, and RHMW03 indicate required action-level responses that fall into Category 2. The Category 2 response can be determined from the exceedance of drinking water EALs, as noted in the Second Quarter (April) Groundwater Monitoring Report (Element Environmental, 2016). However, trend analysis of the data has not been conducted using the Mann-Kendall nonparametric statistical test as outlined in the GWPP (TEC, 2008). The Navy has been remiss in evaluating trends per the GWPP and should immediately begin evaluating for statistically significant trends for all contaminants of concern. Category 2 triggers quarterly monitoring reports sent to DOH and development of a program to determine the source of the leak. Even though increasing concentrations for various constituents since 2014 have been attributed to a known release in 2014, it is imperative that constituents be continually evaluated for changes in relative concentrations so that new releases, should they occur, can be detected as early as possible. The BWS understands that the quarterly monitoring work has been initiated for these monitoring wells, but the BWS has seen no evidence that the Mann-Kendall nonparametric statistical test been performed. The BWS requests that either the DOH and EPA provide evidence of such analysis or require the Navy to follow their own GWPP and perform the analysis.

Since 2005, TPH-d concentrations in monitoring well RHMW02 have exceeded SSRBLs 6 times, and 4 of those have been since the first quarter of 2014. The response to an exceedance of the SSRBLs falls into Category 4. Category 4 responses indicate very specific actions and responses that the Navy has, in part, neglected to implement. The responses required by Category 4 include (lettering from GWPP):

A. Send quarterly reports to DOH

C. Notify DOH verbally within 1 day and follow with written notification in 30 days

D. Notify NAVSUP FLC PH Chain of Command within 1 day

E. Send Type 1 Report to DOH

- Re-evaluate Tier 3 Risk Assessment/groundwater model results
- Proposal to *DOH* on a course of action

F. Send Type 2 Report to DOH – Proposal for Groundwater Treatment

I. Remove sampling pumps (see Appendix C), measure product in pertinent wells with interface probe, re-install pumps if product is not detected.

J. Immediately evaluate tanks for leaks

K. Collect samples from nearby Halawa Deep Monitoring Well (2253-03) and OWDF MW01

M. Prepare for alternative water source at U.S. Navy Well 2254-01

N. Re-measure for product every month with reports to DOH

To our understanding, two of these required actions have not been addressed by the Navy, including items F and M (**bold** above). This is indicative of a lack of initiative on the part of the Navy to act in good faith to protect the natural resources of Hawaii, and to reduce the risk to the Navy's own water supply at Red Hill Shaft (Navy Well 2254-01). Furthermore, it is noted that in order to prepare a proposal for groundwater treatment, the extent of groundwater contamination must first be fully characterized. It is the Navy's responsibility to first implement a plan for characterizing the distribution of groundwater and vadose-zone contamination in the vicinity of tanks, especially near monitoring well RHMW02, and then design a proposal for treating contamination found in the groundwater and the vadose zone. The BWS requests that the EPA and DOH provide evidence if our understanding is incorrect and those items in bold above have been addressed. If a Type 2 Report has been submitted, please provide a copy for BWS to review. The BWS would also like to review documentation that the Navy has prepared for an alternative water source at Red Hill shaft. If those items outlined in **bold** above have not been initiated, the BWS would like the DOH and EPA to require the Navy to so implement these actions immediately as outlined in their own GWPP.

Critical Flaws in the Approaches for Flow and Transport Modeling

Based on our review of the available data, proposed work plans, and meetings with the Parties, the BWS has identified critical flaws and data gaps in the flow and contaminant transport modeling described under Section 7 of the Statement of Work (SOW) of the AOC. The EPA and DOH should direct the Navy to resolve these important deficiencies as soon as possible. Otherwise, the Parties will not achieve the stated objective for Task 7 to: "monitor and characterize the flow of groundwater around the Facility" and will put our drinking water supply at unacceptable risk.

The proposed flow modeling will not be defensible unless the following issues are resolved:

1. The regulators should direct the Navy to hire experts familiar with Oahu geology and the hydrologic and geologic scientific literature. An important example of this lack of an adequate understanding is demonstrated by Figure 6 Geological Cross Section in AECOM (2016), which exaggerates the widths of Halawa valley fills by at least 50% beyond those shown in Sherrod et al. (2007) or Stearns (1939). The authors of Section 3.6.2 and Figure 6 in AECOM (2016) have also ignored previous work by Wentworth (1942) and Izuka (1992) that show the uncertainty about the depth of valley fill sediments in Halawa valleys. Furthermore, the Navy has either ignored or is unaware that preliminary results of the 2015 USGS pump test showed responses in Red Hill monitoring wells to changes in pumping at Halawa Shaft.
2. EPA and DOH should direct the Navy to determine the thickness and properties of the valley fill sediments (in North and South Halawa valleys and Moanalua valley) and they should not allow continued use of the geometry and properties assumed in the Rotzoll and El Kadi (2007) flow model or the AECOM (2016) conceptual model. It is our view that any flow and transport model built using this unjustified assumption about the extent and properties of the valley fill sediments in both North and South Halawa and Moanalua valleys disregards the available site-specific scientific evidence and will likely lead to decisions and actions that endanger our water supply facilities and aquifer. If the Navy thinks valley fill sediments will interfere with contaminant migration from Red Hill, they should determine the hydraulic properties and three-dimensional extent of all nearby valley fill sediments (North and South Halawa Valleys and Moanalua Valley) using an extensive drilling and hydraulic testing program.
3. We have previously mentioned the large errors in elevation measurements for different groundwater monitoring wells. These errors must be corrected before the existing wells can be used to discern groundwater flow patterns or to provide data for flow model calibration. The synoptic water level measurements

proposed by the Navy should only be made after all measuring points at the monitoring wells have been surveyed to an appropriately high degree of accuracy.

4. The most defensible groundwater flow model to date, Oki (2005), has shown that the groundwater head data available for flow model calibration cannot be used to determine whether valley fill sediments in Halawa or Moanalua Valleys impede groundwater flow. Without the addition of monitoring points within and alongside the valley fill sediments, no future model calibration will be able to resolve whether the sediments impede groundwater flow from the RHBFSF toward Halawa shaft or toward the Moanalua wells. EPA and DOH should acknowledge this fact and direct the Navy to implement the necessary amount of monitoring wells, monitoring well construction and monitoring well testing to use to adequately calibrate the model.
5. Given the importance of understanding the direction of groundwater flow in and around Moanalua and Halawa valleys, EPA and DOH should direct the Navy to implement long-term monitoring of heads in the extended well network using transducers to provide sufficient data for model calibration. EPA and DOH should also instruct the Navy to conduct large scale pumping tests such as that conducted by the USGS in 2015 to generate data with which to calibrate the flow model. Such tests will require additional monitoring wells in and around the valley fill sediments in order to determine their effects on drawdown.
6. If the EPA, DOH, and Navy are unwilling to collect the necessary data to resolve the role of valley fill sediments on groundwater flow from the RHBFSF toward Halawa shaft or toward the Moanalua wells, then the regulators must direct the Navy to use a conservative approach in constructing the flow model to reflect this data gap such as that evaluated by Oki (2005). In the absence of defensible data about valley fill sediments, the flow model should conservatively assume that valley fill sediments do not significantly affect groundwater flow across Halawa and Moanalua valley. Such an appropriately conservative flow model would be similar to the "no valley fill" scenario in Oki (2005) or would reflect the available data and cross-section line A in Figure 25 of Wentworth (1942).
7. EPA and DOH must ensure that the transport modeling is carried out using the flow model constructed with this conservative assumption about valley fill sediments in North and South Halawa valleys and Moanalua valley. EPA and DOH should make it clear to the Navy and others that any modeling based on unjustified non-conservative assumptions about the valley fill properties and geometry is unacceptable.
8. The numerical model for groundwater flow near the RHBFSF and its vicinity should be based on site-specific data, not an assumed groundwater flow pattern.

Questions about groundwater flow direction and rate between the Moanalua and Halawa valleys have remained since 1942 (see Wentworth, 1942; Wentworth, 1951; and Mink, 1980). Despite these questions, the Rotzoll and El-Kadi (2007) groundwater flow model assumed regional groundwater flow was from the northeast to the southwest, and instead of adopting the more defensible approach used in Oki (2005) or addressing this critical data gap, they forced the groundwater model boundary conditions to match this assumption. EPA and DOH should direct the Navy to install and monitor a sufficient number of monitoring wells that will definitively establish area-wide groundwater flow directions. If there is significant uncertainty about the regional groundwater flow direction and rate, then the flow model should be constructed using conservative assumptions about the regional direction. For example, a model that conservatively assumes groundwater flows from the RHBFSF toward Halawa shaft and a flow model that assumes groundwater flows from the RHBFSF toward Moanalua wells. EPA and DOH should make it clear to the Navy and others that any modeling based on unjustified non-conservative assumptions about the regional groundwater flow direction is unacceptable.

9. EPA and DOH should ensure that the groundwater flow model files and draft report will be peer-reviewed by the BWS and an independent third-party expert. The independent third-party expert should be hired by either the EPA or DOH.

The proposed transport modeling will not be defensible unless the following issues are resolved:

1. The regulators should direct the Navy simulate contaminant transport under a number of different source scenarios determined by the characteristics of the a'a and pahoehoe flows in the vadose and saturated zones. The scenarios should represent release and migration of different volumes (e.g., 50,000, 100,000, 1,000,000, 12,000,000 gallons, and larger (e.g., multi-tank releases) through the vadose zone surrounding the tanks. According to the cross-sections from MacDonald (1941), the upper parts of the tanks appear to abut a'a flows and the lower parts appear to abut pahoehoe flows, so the transport modeling must include migration of the released fuel volumes through the preferential pathways common to these types of lava flows.
2. EPA and DOH should direct the Navy to evaluate contaminant transport for scenarios in which the high-permeability and laterally extensive elements of Red Hill a'a flows allow the various volumes of fuel NAPL to migrate several thousands of feet away from the Red Hill tanks before entering the aquifer. Ko'olau Basalt a'a lava flows present beneath the Red Hill area are typically characterized by the presence of a jumble of irregular crustal rubble and fragmental debris ("clinker") which ranges in size from less than 0.1 inch in

diameter to greater than 2 feet in diameter (MacDonald, 1941). In most cases the a'a clinker essentially surrounds the center of the lava flow, with the thickest accumulations typically occurring on top of the flow and along its margins, i.e., levees (Wentworth, 1942; Wentworth and MacDonald, 1953; Peterson and Tilling, 1980; Lipman and Banks, 1987; Kilburn, 2000). Lipman and Banks (1987) have observed that the more typical a'a flow channel morphology can evolve into more complex alternatives. The interior (center) portion of the a'a basalt flow (Figure 3.5a) typically consist of dense, blocky jointed lava (locally called "blue rock"; Wentworth, 1945) which has a vesicularity (relative abundance of vesicles to dense basalt) as great as 50%, but more typically is less than 30% (Wentworth, 1945; Wentworth and MacDonald, 1953). In the Red Hill area, a'a lava flows range from 5 to 60 feet in thickness with the clinker portion of the flow comprising 15% to 45% of the total flow thickness (MacDonald, 1941; Wentworth, 1945; Wentworth and MacDonald, 1953). Open lava tubes are rarely found within a'a lava flows, but do exist (Wentworth and MacDonald, 1953; MacDonald, 1972; Lipman and Banks, 1987; Kilburn, 2000). EPA and DOH should direct the Navy to carry out simulations of contaminant transport from fuel NAPL where the NAPL has migrated laterally away from the tank farm hundreds to several thousands of feet through these high-permeability elements of Red Hill a'a flows.

3. EPA and DOH should direct the Navy to evaluate contaminant transport for scenarios in which the high-permeability and laterally extensive elements of Red Hill pahoehoe flows allow the various volumes of fuel NAPL to migrate several hundreds of feet away from the Red Hill tanks either in the vadose zone or in the aquifer. Ko'olau Basalt pahoehoe lava flows present beneath the Red Hill area are characterized by a relatively smooth to hummocky, glassy upper surface and the general lack of rubble and fragmental debris ("clinker") (MacDonald, 1941). Pahoehoe lava flows typically have similar flow field dimensions to a'a flow fields, but the pahoehoe lava advance rate is typically ten times slower than a'a lava flows (Kilburn, 2000). This reduced pace of lava advance allows for a crust to form across the entire flow to advance via the formation of lobes and tongues that are fed and inflated by lava moving through lava tubes. Historical pahoehoe flows that traveled the greatest distance from their source vent in Hawaii (greater than 20 miles) were emplaced primarily by lava tubes) Sterns and MacDonald, 1946; MacDonald et al., 1983; Greeley, 1987). Open lava tubes are often found in vertical and lateral exposures through pahoehoe lava flows, with small 1 foot- to 3 foot-diameter lava tubes being common while larger 5 foot to greater than 50 foot-diameter tubes being uncommon (Wentworth and MacDonald, 1953; MacDonald, 1972; Greeley, 1987; Cooper and Kauahikaua, 1992; Hon et al., 1994; Peterson et al., 1994; Kauahikaua et al., 1998). EPA and DOH should direct the Navy to carry out simulations of contaminant transport from fuel NAPL

where the NAPL has migrated laterally away from the tank farm hundreds to several thousands of feet through these high-permeability lava tubes Red Hill pahoehoe flows.

4. EPA and DOH should ensure that the groundwater transport model files and draft report will be peer-reviewed by the BWS and an independent third-party expert. The independent third-party expert should be hired by either the EPA or DOH.
5. EPA and DOH should ensure that these release mechanisms are included in the Task 8 Risk Assessment scope of work as they will likely have a significant impact on redistribution of fuel releases into the environment. For example, the risk assessment should include fuel NAPL migrating hundreds to thousands of feet away from the tank farm in the subsurface as well as discharging into the Moanalua and South Halawa streams.

Additional Well Locations

Given the geologic complexity and thickness of Ko'olau a'a and pahoehoe basalt flows that form the vadose zone beneath the Red Hill Facility, it is critical that a very thorough vadose zone investigation be conducted to understand where released fuel (from numerous historic releases and the most recent January 2014 release) has traveled in the subsurface. Also additional characterization of dissolved-phase contamination in the basal aquifer is necessary to assess the geometry of the current plume. Within the boundaries of the Navy property where the RHBFSF is located, a number of additional monitoring well site locations have been identified for both vadose zone monitoring wells and basal aquifer groundwater monitoring wells (see Figure 1). The red colored points represent locations for needed vadose zone monitoring wells and the blue colored points represent good locations for additional basal aquifer groundwater monitoring wells. All these proposed monitoring well locations assume that the Navy will install their proposed monitoring wells RHMW08 through RHMW11 as outlined in the Navy's Monitoring Well Installation Plan (AECOM, 2016).

The purpose of the vadose zone monitoring wells is to characterize the basalt vadose zone complexity and to install vadose zone monitoring wells to collect needed measurements of LNAPL and soil vapor. The purpose of the basal aquifer groundwater monitoring wells is to better characterize the dissolved-phase contaminant plume and to allow LNAPL measurement and groundwater sampling. Both vadose zone and basal aquifer monitoring wells would need to be constructed accordingly for data collection. Several of the proposed monitoring wells coincide with locations where monitoring wells already exist (and are being monitored), but there are issues regarding basal aquifer water level data collected from these existing wells. To address these issues, we have proposed installation of new water table monitoring wells adjacent to OWDFMW01 and the CWRM well HDMW2253-03 because fuel contaminants have been observed in these wells even though they are open 12 ft. and 50 ft., respectively, below the water table. A new water table monitoring well should be constructed adjacent to monitoring well RHMW07 to confirm its much higher water levels.

Characterization and Design for Remediation Should Begin Immediately

Given that there is currently contamination in the groundwater and until the quantitative risk and vulnerability assessment (QRVA) is completed, the risk of future releases continues. The BWS would like the Navy to proceed with the design, construction, and operation of a groundwater treatment facility at the RHBFSF. There is currently contamination in the groundwater and the risk to our drinking water supply from future releases continues to be significant based on our review of the available evidence. The QRVA may help constrain the risk from fuel contamination to our drinking water and health, but this will strongly depend on the still unfinished work plan and will likely take many months or years to complete. Therefore, the BWS requests that the Navy proceed with the design, construction, and operation of a groundwater treatment facility at the RHBFSF. This will allow the treatment of current contaminants and provide the ability to clean up continuing or future releases.

Because of the time involved to implement all sections of the AOC, the underlying aquifer is currently at risk of additional impact. An active treatment system is the only reasonable action that the Navy could take to help ensure that potential receptors, e.g., public and military water supplies, are not exposed to contaminated groundwater. The design of such a system should include additional Site characterization and pilot study work to ensure that an adequate groundwater treatment facility is constructed. Further, the design and installation of a treatment system is required because of the SSRBL exceedances observed at monitoring well RHMW02 as per the GWPP (TEC, 2008; HDR, 2014).

List of COPCs Analyzed Should Be Expanded

As was clearly outlined in our letter to the regulatory agencies dated 29 March 2016, the BWS strongly disagrees with any reduction in the list of contaminants of potential concern (COPCs) for the RHBFSF. We do not support EPA's and DOH's February 2016 approval of the reduced COPC list. Optimization of a groundwater sampling program is typically completed once a site has fully been characterized and remedial measures have already been put in place to reduce contaminant concentrations (EPA, 2005). The current disposition of the leaked fuel (historic and recent) and the environmental impacts to the vadose zone and underlying sole source aquifer are not yet adequately understood; therefore, all volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), dissolved lead, and biodegradation parameters should be considered necessary to providing valuable information on contaminant location and migration.

The current reduced COPC list is limited to those analytes associated with fuels currently stored at the RHBFSF that have been detected in monitoring wells currently sampled as part of RHBFSF groundwater monitoring activities at or above their respective Tier 1 environmental action levels (EALs) (NAVFAC, 2016a). The reduced list fails to include fuels stored in the past at the RHBFSF. According to the Navy, if a constituent is detected at a concentration that exceeds the corresponding Tier 1 EAL and is related to fuels stored at RHBFSF, then this constituent should be retained as a COPC (NAVFAC, 2016a).

A more comprehensive COPC list, not a reduced COPC list based on Tier 1 EALs, should be analyzed for the following reasons:

- The disposition of the fuel in the vadose zone and underlying aquifer is not fully understood (the site is not fully characterized).
- Contaminant concentrations indicate that non-aqueous phase fuel has been and continues to be present in or near monitoring well RHMW02 (no remedial measures have been implemented to reduce contaminant concentrations).
- Groundwater monitoring wells are sampled as part of the release detection system for the RHBFSF (NAVFAC, 2016b).

Specifically, the COPC list should include VOCs (EPA Method 8260 full list), SVOCs (EPA Method 8270 full list), dissolved lead, and petroleum hydrocarbon biodegradation parameters (iron, manganese, and sulfate). At a minimum all VOCs and PAHs detected since 2010, as listed in Table 1, should be included on the current COPC list.

EPA and DOH must direct the Navy to add a number of COPCs to the Navy's June 2016 list of additives to be quantified in groundwater. The following chemical additives known to have used in fuels stored over the last several decades should be added to the COPC list: 2-methoxy ethanol (EGME), diethylene glycol monomethyl ether (DiEGME), 2,6-di-tert-butyl-4-methylphenol, 6-tert-butyl-2,4-dimethylphenol, 2,6-di-tert-butylphenol, N,N'-disalicylidene-1,2-propanediamine, tertiary butylated phenol, and phenol. These include all antioxidants, not just phenol, and all fuel system icing inhibitors. Also, the Navy should provide a list of additives used in fuels that were stored at RHBFSF prior to the 1970s.

Ethylene glycol monomethyl ether (EGME or 2-methoxy ethanol, CAS number 109-86-4) was initially used as a fuel system icing inhibitor in JP-5 for many years but was replaced with diethylene glycol monomethyl ether (DiEGME or 2,2-methoxy ethoxy ethanol, CAS number 111-77-3). However, EGME and combinations of EGME and DiEGME were reported to still be in use at military bases by Ritchie et al. (2003). The Navy COPC list did not include EGME and so should be revised to include it. EPA and

DOH should direct the Navy to provide the scientific evidence that DiEGME (and EGME) have “a short half-life”, as was stated in their June 2016 list. Our review of the literature available to us revealed two papers about DiEGME degradation, both of which have no applicability to the groundwater environment beneath the RHBFSF. A theoretical model of DiEGME degradation in a five-day biochemical oxygen demand (BOD_5) test suggested that the half-life was 2 to 16 days for these conditions (Mushrush et al., 1997). Meshako et al. (1999) measured the BOD_5 for DiEGME by inoculating with the supernatant from untreated sewage and estimated that the half-life would be roughly double that from Mushrush et al. (1997). However, these studies represent the conditions expected in a sewage treatment plant and do not represent conditions in the CSM subsurface or groundwater. EPA and DOH should direct that the Navy test for these two toxic chemicals throughout the extended monitoring well network, including the oil waste disposal facility well (OWDFMW01), because the Navy has not provided evidence applicable to Red Hill groundwater in support of their statement about that short half-life.

In summary, EPA and DOH should direct the Navy to test for all the additives discussed above: EGME, DiEGME, 2,6-di-tert-butyl-4-methylphenol, 6-tert-butyl-2,4-dimethylphenol, 2,6-di-tert-butylphenol, N,N’-disalicylidene-1,2-propanediamine, tertiary butylated phenol, and phenol. Also, they should direct the Navy to provide a list of additives used in fuels stored at RHBFSF from 1942 through the 1970s and analyze groundwater for any chemicals not already included in this list.

Upper Tank Farm Holds Less Fuel but has Several Times the Number of Monitoring Wells

There are 13 Remedial Action Areas (RAA) located in the Pearl Harbor Naval Complex, Halawa Main Gate Geographical Study Area. These are located near or adjacent to the Upper Tank Farm (UTF) (DON, 2013). The Upper Tank Farm (UTF) is adjacent to the Remedial Action Area (RAA) 2 site (DON, 2012). On April 26, 2007, a diesel fuel release was detected at Tank 48 of the UTF. A 1.5-inch by 3-inch hole was discovered around the tank’s sump pit. At that time, it was estimated that approximately 359,000 gallons of DFM/F-76 had leaked into the subsurface caprock formation beneath the tank. It is estimated that approximately 5 million gallons of fuel remained in the subsurface resulting from petroleum product releases from various tanks within UTF between World War II and the 2007 Tank 48 release (DON, 2013).

Our understanding is that at least 74 monitoring wells are associated with the investigation and/or remediation of the release of Tank 48 and other releases associated with RAA-2 (DON, 2012). BWS believes that the methodology for investigation and remediation performed by the Navy at the UTF should be applied to the RHBFSF. Our understanding is that the Navy’s UTF stores a far smaller volume of fuel than the RHBFSF yet the extent of the investigation and amount of monitoring wells at the UTF far exceeds what has taken place at the RHBFSF. The BWS asks that the EPA and DOH require the Navy perform investigative work to these same or stricter standards given the direct risk the RHBFSF poses to the drinking water aquifer located directly below this facility, starting with extensive investigation work by increasing the amount of monitoring wells at the RHBFSF drastically and immediately.

CONTINUING FACILITY CONCERNS

The Navy needs to consider some of the obvious tank upgrade alternatives (TUAs) that have been omitted from the AOC SOW for Section 3.

The TUA section outline does not include or consider tank relocation as an upgrade alternative. Tank relocation should be added as an alternative to be considered as part of the cost-benefit and risk/vulnerability analysis. Closure of the Red Hill Bulk Fuel Storage Facility (RHBFSF) and relocation of the tanks to another location such as Hickman Field should be considered as an option for comparison along with other tank repair and re-design options. This option, although potentially expensive, is one of the best options from the BWS's viewpoint, as it has the greatest ability to reduce the risk of future leaks into the water supply. In addition, by relocating on Oahu, the "hardened target" strategic reasons given by the Navy as to why they cannot relocate the tanks appear (to us) to be addressed. By not considering relocation as a viable option, BWS's preferred option is not even compared and contrasted to the other options. It is important that this alternative be included in this analysis. We understand that this may have already been investigated by the Navy in 2009.

The Navy needs to evaluate the extent to which the RHBFSF tanks and associated piping systems (including the pipe supports) meet current seismic requirements.

The RHBFSF tanks were shown to be vulnerable to seismic loading when they leaked after a moderate earthquake in 1948; ongoing corrosion since then has likely made the tanks, piping, and associated utilities (including connections) even more vulnerable. Seismic design principles, codes, and methodologies have improved tremendously since the design and construction of the RHBFSF, and it is unlikely that the tanks and associated piping systems meet current seismic requirements.

The Navy should immediately perform a risk and vulnerability analysis of the current RHBFSF tank design.

There is no reason to delay a risk and vulnerability analysis of the current RHBFSF tank design. This could be done to a Level 2 evaluation now and updated to a Level 3 and 4 analysis later. This analysis would be more accurate if it was done after performing the additional tank liner characterization work outlined below. Once this analysis is complete, the various design alternatives can be compared.

The Navy needs to perform additional characterization and non-destructive examination to fully understand the condition of the steel tank liners.

The BWS remains concerned about the lack of information in the AOC SOW documentation regarding the current condition of the steel tank liners. We are aware that the steel liners in the 20 RHBFSF tanks are and have been corroding from both the inside and outside since their construction in the early 1940s (Anonymous, Undated; Weston, 2007a; Weston, 2007b). However, there is no evidence to indicate that the non-destructive testing (NDT) methods (ultrasonic, dye penetration, etc.) have been appropriately evaluated to determine the reliability of detection of flaws of a certain size. Tanks that are currently out of service can be used to determine the minimum detection limits of each technique on the actual tank liners. Many different sections of the tank liners can be examined with the various NDT methods (looking for both corrosion-induced wall loss, weld defects (cracks), and other defects). After NDT has been completed, defect-containing and defect-free areas can be cut from the tanks and examined destructively using standard metallurgical techniques to assess the validity of the NDT techniques. In addition, destructive metallurgical analysis should provide a better picture of the nature of the steel used, the size distributions of weld defects, and the distributions of inner diameter and outer diameter corrosion feature depths. Current weld patching procedures can also be performed on these tanks to determine the propensity of porosity and cracking when welding new steel to old steel. This will help the Navy understand the potential for weld defects forming in newly-patched areas.

The Navy needs to provide third-party subject matter experts access to release detection and inventory records so that the reported leak detection sensitivities can be validated.

The Navy should provide all release detection records that are available as well as any monthly visual inspections of the underground storage tank systems. The Navy has been using the Mass Technology release detection system since 2009, and a review of the records would be useful. Any additional inventory records that are available would also be helpful, regardless of the age of the records. We know that internal systems on large underground storage tanks are only effective at finding large volume releases; they are not reliable or effective for small volume releases, as pointed out in the 2010 audit by the Naval Audit Service. As such, the Navy needs to immediately validate the sensitivity of their existing leak detection technologies and explore more accurate methods of low leak rate detection and inventory control.

If you have any questions, please feel free to contact me at 808-748-5061.

Very truly yours,

ERNEST Y. W. LAU, P.E.
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Enclosures: Figure 1
Table 1

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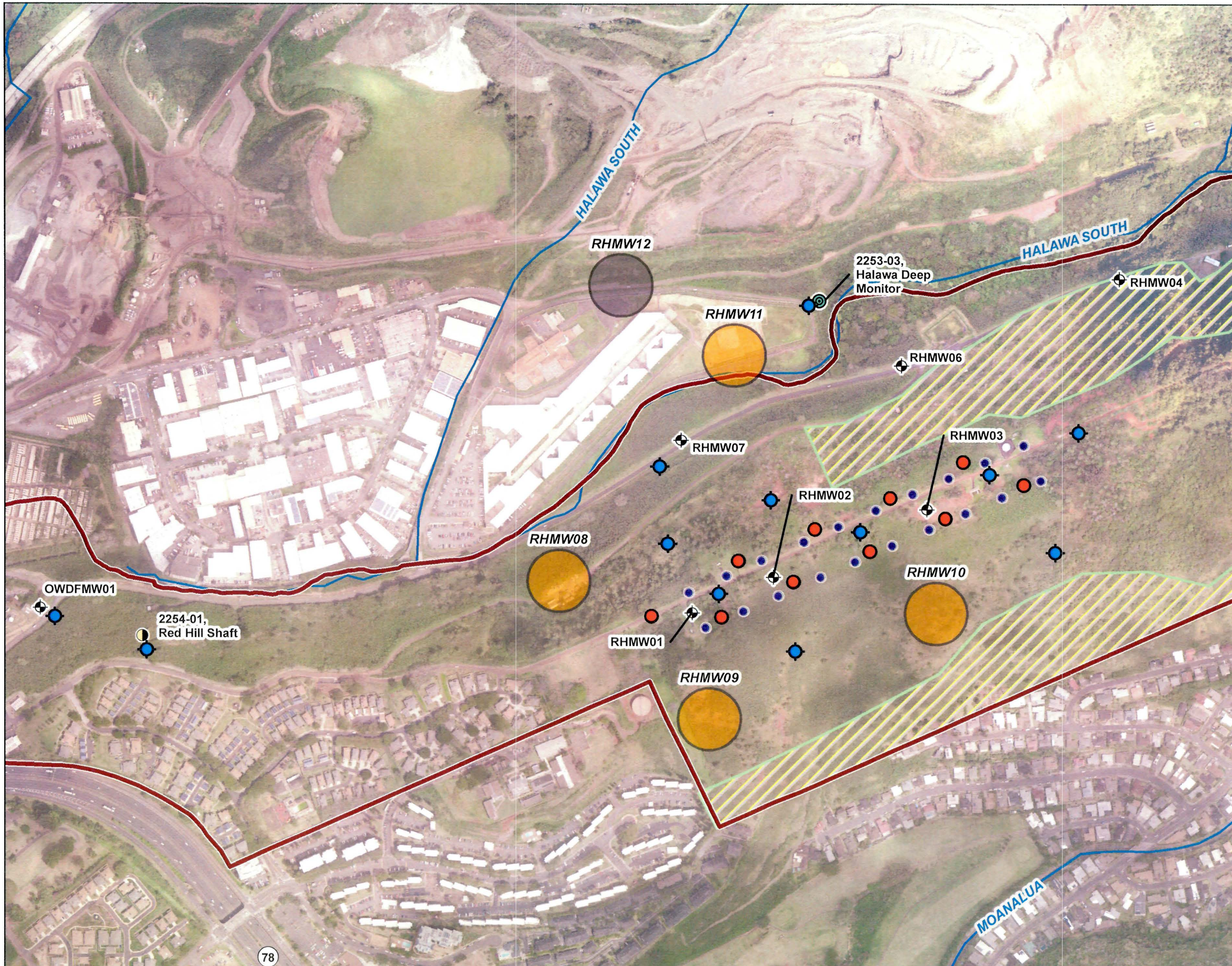

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Sources:
Aerial – O'ahu Imagery Service, dated 2010;
Wells – CWRM, 2015.

Legend

- Navy, Proposed Monitoring Well Location
- Contingent Monitoring Well Location
- Suggested Groundwater Monitoring Well
- Suggested Vadose Zone Monitoring Well
- Inaccessible Area
- Tank
- Red Hill Bulk Fuel Storage Facility

Figure 1
Additional Monitoring Well Sites
BWS Groundwater Study,
O'ahu, Hawai'i

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TABLE 1
Suggested Minimum List of Contaminants of Potential Concern
BWS Halawa Valley Groundwater Study
O'ahu, Hawaii

COPC	Frequency of Detection (2010-2016)	Number of Exceedences - HDOH - Tier 1 EAL (µg/L) (for locations >150m from surface water)[1] (2010-2016)	EPA MCLG (µg/L)[2]	EPA MCL (µg/L)[2]	HDOH - Tier 1 EAL (µg/L) (for locations >150m from surface water)[1]	HDOH - Tier 1 EAL (for locations <150m from surface water)[1]
TPH-DRO (middle distillates)	119	64	NS	NS	100	100
Naphthalene	86	20	NS	NS	17	17
Lead, Dissolved	77	0	zero	15[3]	15	5.6
2-Methylnaphthalene	49	8	NS	NS	10	2.1
1-Methylnaphthalene	44	21	NS	NS	4.7	2.1
TPH-GRO (gasolines)	42	3	NS	NS	100	100
Fluorene	33	0	NS	NS	240	3.9
Acenaphthene	31	0	NS	NS	20	20
TPH (residual fuels)	30	11	NS	NS	100	100
Toluene	29	0	1,000	1,000	40	40
Benzene	22	0	zero	5	5.0	5
Xylenes, total	20	0	10,000	10,000	20	20
Acetone	19	0	NS	NS	1500	1500
Ethylbenzene	17	0	700	700	30	30
Phenanthrene	14	0	NS	NS	240	4.6
Benzo(a)anthracene	11	0	NS	NS	0.092	0.027
Acenaphthylene	9	0	NS	NS	240	30
1,2-Dichloroethane	4	0	zero	5	0.15	0.15
Bromodichloromethane	3	1	NS	NS	0.12	0.12
Chloromethane	3	0	NS	NS	1.8	1.8
Methylene chloride	3	0	NS	NS	4.8	4.8
Pyrene	3	0	NS	NS	68	2.0
Chloride	2	0	NS	250,000[4]	NS	NS
Fluoranthene	2	0	NS	NS	130	8.0
1,1,2,2-Tetrachloroethane	1	0	NS	NS	0.067	0.067
1,2,3-Trichloropropane	1	0	NS	NS	0.60	0.60
Anthracene	1	0	NS	NS	22	0.73
Benzo(g,h,i)perylene	1	0	NS	NS	0.13	0.1
Chloroform	1	0	NS	NS	70	70
Dibenzo(a,h)anthracene	1	1	NS	NS	0.0092	0.0092
Methyl ethyl ketone	1	0	NS	NS	7100	7100
Trichloroethylene	1	0	zero	5	5	5
1,2-Dibromoethane (EDB)	0	0	zero	0.05	0.04	0.04
Ethylene glycol monomethyl ether (EGME)	-	-	NS	NS	NS	NS
Diethylene glycol monomethyl ether (DiEGME)	-	-	NS	NS	NS	NS
2,6-di-tert-butyl-4-methylphenol	-	-	NS	NS	NS	NS
6-tert-butyl-2,4-dimethylphenol	-	-	NS	NS	NS	NS
2,6-di-tert-butylphenol	-	-	NS	NS	NS	NS
N,N'-disalicylidene-1,2-propanediamine	-	-	NS	NS	NS	NS
Tertiary butylated phenol	-	-	NS	NS	NS	NS
Phenol	-	-	NS	NS	NS	NS

Notes:
1= Hawaii Department of Health Environmental Management Division, 2011 (revised 2012). Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater Volume 1: User's Guide
2= U.S. Environmental Protection Agency, 2009. EPA 816-F09-004, National Primary Drinking Water Regulations. https://www.epa.gov/sites/production/files/2016-06/documents/npwdr_complete_table.pdf
3 = Lead and copper are regulated by a Treatment Technique that requires systems to control corrosiveness of their water. If more than 10 percent of tap water samples exceed the action level, water systems must take additional steps. For copper, the action level is 1.3 mg/L, and for lead is 0.015 mg/L.
4 = National Secondary Drinking Water Regulation
\- = never tested
EPA = U.S. Environmental Protection Agency
HDOH = Hawaii Department of Health
EAL = environmental action limit
MCLG = maximum contaminant level goal
MCL = maximum contaminant level
µg/L = micrograms per liter
m = meters
NS = no standard established