BOARD OF WATER SUPPLY

CITY AND COUNTY OF HONOLULU
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June 3, 2016

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And

Mr. Steven Y.K. Chang
State of Hawaii
Department of Health
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Honolulu, Hawaii 96801-3378

Dear Messrs. Pallarino and Mr. Chang:

Subject: Board of Water Supply (BWS) Comments to the Work Plan / Scope of Work, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, Red Hill Bulk Fuel Storage Facility

The BWS and its consultants have reviewed the document titled "Work Plan / Scope of Work, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, Red Hill Bulk Fuel Storage Facility" (WP), dated 4 May 2016, under the Administrative Order on Consent (AOC) Statement of Work (SOW) Sections 6 and 7. Our review of the WP also includes information and statements from the Tuesday 10 May 2016 meeting concerning the AOC scopes of work for AOC SOW Sections 6 and 7. The BWS provides the following comments and recommendations to the WP with the goal of ensuring that all work conducted under the final document will produce defensible scientific and engineering results needed to continue to protect our drinking water supplies from past and future fuel releases from the Red Hill Bulk Fuel Storage Facility (RHBFSF).

The following section provides a summary of the most important comments and recommendations, followed by the individual detailed comments. The last section lists the references cited.

Summary Comments and Recommendations

1. Continued Reliance on Assumptions That Have Yet to be Tested

The WP relies on three untested assumptions 1) the valley fill units (valley fill and underlying saprolite) in Moanalua and Halawa valleys act as barriers to groundwater flow between the RHBFSF and the nearest BWS water supplies; 2) regional groundwater flow is from northeast to southwest near the RHBFSF; and 3) drilling and installing monitoring points in the vadose zone will likely remobilize fuel. Our previous letters to you have repeatedly stated that: 1) there are no direct data to show that the valley fill units are barriers to groundwater flow and contaminant migration; 2) at present there are too few wells to understand the groundwater flow directions and rates in the Halawa and Moanalua valleys; and, 3) monitoring wells and soil borings can be safely drilled and constructed through contaminated zones without either carrying contaminants downward as the borehole advances or, when completed, acting as a vertical pathway for the downward movement of petroleum contaminants.

Basing the groundwater flow and transport modeling (Appendix H) on assumed valley fill barriers in the absence of direct evidence is neither conservative (in an engineering sense) nor defensible. At present, there are no borings that delineate the lithology and dimensions of valley fill materials in these valleys and recent USGS pump test data revealed responses to BWS Halawa shaft pumping changes at several RHBFSF monitoring wells. The WP's failure to address the data gaps for the valley fill units should be rectified immediately and the groundwater flow and transport models should not include valley fill barriers in Moanalua and Halawa valleys until and unless there is direct evidence that the valley fill units in these valleys will prevent migration of groundwater and contaminants from the RHBFSF to BWS water supplies or the surrounding clean aquifer. We ask that the regulatory agencies, the US Environmental Protection Agency (EPA) and the Hawaii Department of Health (DOH), acknowledge this untested assumption and accompanying critical data gaps and take responsibility for ensuring that the Navy provide the necessary information. Otherwise, the regulatory agencies may be perceived as ignoring their public trust responsibility to protect our drinking water resource.

The conceptual site model and numerical model for groundwater flow near the RHBFSF and its vicinity should be based on site-specific data, not an assumed groundwater flow pattern. Available data are sufficient to define the mauka to makai flow (mountain to sea) direction for the aquifers to the east, but 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. The TEC (2010) letter report revealed that correcting for the errors in the head measurements known at that time yielded a groundwater flow direction to the northwest and indicated

the need for one or more monitoring wells be installed along that northwesterly direction. The WP should be revised to include a sufficient number of monitoring wells that will help directly estimate groundwater flow directions and rates from the RHFSF toward Halawa shaft change during pumping at the Red Hill and Halawa shafts. The model updates in Appendix H should be revised to use the data from these new monitoring wells to determine a defensibly conservative set of boundary conditions. Any model revisions made prior to filling this critical data gap should conservatively assume groundwater flow is from the RHBFSF toward Halawa shaft or instead create boundary conditions that are sufficiently distant that they allow groundwater flow directions between the RHBFSF and the nearby water supplies to be determined by local stresses such as pumping at those water supplies and hydrogeologic features.

The WP and statements from the Navy and EPA dismiss installation of more vadose zone monitoring points because, in part, such actions will remobilize fuel. This is only an unsupported assumption because monitoring wells and vadose zone monitoring points have been successfully constructed in other basalt environments through proper planning, drilling, and oversight. The EPA's stated refusal to require more vadose zone monitoring points near Tank 5 is both disappointing and surprising. It is disappointing because work products for the proposed activities under Tasks 5 through 7 in the WP depend on a defensible understanding of the vadose zone sources and their migration toward the aquifer. It is surprising because an examination of the soil vapor and groundwater data in Appendix D demonstrate that 1) there is more than one LNAPL source near Tank 5, 2) fuel vapors can migrate laterally over many tens or hundreds of feet in the vadose zone toward the monitoring points beneath the 20-foot-thick concrete plug under Tank 5, and 3) the recent extended rise in groundwater contamination corresponds to similar increases in soil vapor concentrations under Tank 5. Adding more vadose zone monitoring points at various elevations alongside Tank 5, carried out with proper planning, drilling, and oversight, will provide the Parties and all stakeholders with a more quantitative understanding of future contaminant migration from the vadose zone into our drinking water aquifer. The argument that access is limited at the ground surface of Red Hill should not be considered a limiting factor – drill pads can be constructed as evidenced by the fact that the Red Hill tanks were initially installed by drilling at the ground surface of Red Hill. Also, if the vadose zone monitoring points help identify LNAPL in the vadose zone, then remediation can be designed and installed to remove the contamination from the vadose zone before it reaches the groundwater. LNAPL in contact with the groundwater is much more difficult to remediate than LNAPL present in the vadose zone.

2. Does Not Use Available Data on Soil Vapor and Groundwater

The WP makes little use of the available data pertaining to soil vapor and groundwater levels and chemistry in the conceptual model and task sections. Tasks should be defined as much as possible using these data so that the investigation activities can be adequately planned. The most recent data from the first quarter of 2016 are not used in either text or figures but are instead restricted to tables in Appendix D. Presenting and

interpreting these most recent data should play a central role in discussing the location and migration of the fuel leaked from Tank 5 and other tanks as light non-aqueous phase liquid (LNAPL) and vapor in the vadose zone and as dissolved contaminants in groundwater. We request that the WP Tasks 2 through 7 be revised to 1) present the full data set, 2) examine relationships between soil vapor concentrations and groundwater heads and chemistry, and 3) revise the work plan activities to correspond to the findings and remaining data gaps. Specifically, the tasks should be revised to address the observed concentration changes in soil vapor and groundwater that demonstrate a continued increase since mid-2015 and mid-2014, respectively.

3. Lacks Characterization of Vadose Zone Sources and Migration

The WP has no provision for directly characterizing the fuel sources in the vadose zone in and around the tanks beyond an electrical resistivity survey intended to locate LNAPL. The available data demonstrate that contamination continues to migrate through the vadose zone, exceeding the action level, and appears to be driving an increase in groundwater contamination, exceeding the site specific risk-based level (SSRBL) and State of Hawaii Environmental Action Levels (EALs) for groundwater. As currently written, the WP has no way of determining whether fuel contamination migrates through the vadose zone as vapor, as LNAPL, as dissolved contaminants in infiltrating water, or some combination of these. Vapor migration is very likely an important process because vapors have migrated laterally beneath Tank 5's underlying concrete plug many tens or hundreds of feet to reach the soil vapor monitoring points located there. Screening of the remedial alternatives as described in Task 7 will have little to no value in the absence of information about the spatial distribution of fuel contamination or the observed rates of migration. The WP currently has no way of determining whether there is any evidence of fuel degradation in the vadose zone, e.g., levels of oxygen, carbon dioxide, and other degradation-associated compounds.

Tasks 1 and 2 under the WP should be revised to include coring, core analysis, and installation of vapor monitoring points at various elevations around Tank 5. The goal is to install vapor monitoring points that will show how fuel vapors vary with depth over time. This additional work will provide important information about the nature of the fuel contamination (LNAPL, dissolved, or vapor), where it may be located in the vertical dimension (especially given that the holes in Tank 5 spanned a range of elevations and locations), and the rates of contaminant migration as revealed by changes in vapor concentrations such as those observed beneath Tank 5 since mid-2014. The additional work will also provide the site-specific information necessary for a defensible understanding of future contamination rates and a defensible evaluation of remedial alternatives.

4. Lacks a Decision Process for Extending the Subsurface Monitoring Network

During the May 10th meeting, the Navy contractor stated that placing a single well near South Halawa Stream will determine how the valley fill unit beneath the stream affects

groundwater flow from the RHBFSF toward Halawa shaft. Neither the contractor nor the WP's Task 4 description explain how the data from only one monitoring well will be used to make that determination. Task 4 should be revised to include a priority ranking of the proposed well locations and a process (decision tree) about how decisions will be made to change well location and well installation order based on new data acquired during the drilling program. For example, the decision tree should describe the changes to well locations and order given the following possible findings at proposed RHMW11 and the ability to add monitoring well locations as needed:

- What if RHMW11 groundwater head is found to be lower than heads at upgradient wells (e.g., RHMW02, RHMW06) but higher than head at Halawa shaft?
- What if RHMW11 groundwater head is found to be significantly higher than the nearest upgradient and downgradient heads (such as would be expected for a compartmentalized zone in the aquifer)?
- What if RHMW11 does not intersect valley fill units below the water table?

Such a decision process may not be needed for all the proposed monitoring wells, but it should be added to address the long-standing questions about groundwater flow direction and rate between RHFSF and Halawa shaft. This task should also include a discussion of how groundwater gradients will be calculated under the dynamic pumping stresses and of how a decision will be made as to whether valley fill units in Halawa or Moanalua valleys will or will not prevent contaminant migration toward the water supplies.

5. *Ambiguous Risk Assessment*

The risk assessment does not include any details on who will define what level of risk can be tolerated. "Acceptable risk" target levels should be jointly defined by all Stakeholders before commencing the risk assessment. The Navy will determine if the existing site-specific risk-based levels (SSRBLs) will be evaluated to confirm that they remain protective of the groundwater resource. If they are found to no longer be protective, new SSRBLs will be proposed. There is no discussion on how new SSRBLs will be evaluated by the parties and the process by which they will be reviewed and/or approved. Further, discussion of subject matter expert involvement should be outlined and part of the overall risk assessment process. We recommend that the risk assessment include a critical evaluation of the basis of the DOH's Environmental Action Levels (EALs) for TPH-d and the current drinking water toxicity EALs by either the Navy or EPA and/or DOH.

Detailed Comments and Recommendations

1. Section 2.3.1.1: The first sentence incorrectly states that the Oily Waste Disposal Facility (OWDF) monitoring well (OWDFMW01) is "downgradient" of the Red Hill shaft. Data from the USGS 2015 pump test show water levels were higher than 17 feet above sea level (ft asl) whereas data from the DOH show water levels at the Red Hill shaft were between 16 and 17 ft asl during this time. Thus, the Red Hill

shaft was downgradient of the OWDFMW01 well during that time. The word "downgradient" should be removed from this sentence and Section 3.6.2.2 of the WP should be revised to present and discuss available head data from all the wells and shafts to provide a clearer understanding of groundwater heads in and around the site area with time.

The sentence: "However, the removal of the primary contamination source, reduction of infiltration, and the presence of major hydrogeologic barriers confirmed that the potential for contaminant transport to the basal aquifer was insignificant" is based on erroneous information and should be revised to state: "However, the removal of the primary contamination source, reduction of infiltration, and the presence of major hydrogeologic barriers suggest that the potential for contaminant transport to the basal aquifer may be insignificant." The evaluation of the site-specific geology given in Earth Tech (2000) and ATSDR (2005) incorrectly stated that the basal aquifer is an artesian confined system at the OWDF protected in part by an upward vertical gradient. Heads at the OWDFMW01 are very similar to those at other Red Hill monitoring wells, which are all in the unconfined basal aquifer, and show no indication of confined behavior. Moreover, total petroleum hydrocarbons – diesel range (TPH-d) have been detected at monitoring well OWDFMW01 consistently since at least late 2009. The Oki (2005) USGS groundwater flow model shows confining units are about 1,000 feet away and that the area surrounding the Oily Waste Disposal Facility is part of the unconfined basal aquifer. The presence of contaminants in the basal aquifer at OWDFMW01 indicates that either or both the Oily Waste Disposal Facility and the RHFSF are the sources, indicating that the supposed "major hydrogeologic barriers" may not impede contaminant migration through the vadose zone to the basal aquifer.

2. Section 2.3.1.1: Line 16 states "the presence of major hydrogeologic barriers" was one criterion used by the Navy and DOH to discontinue cleanup actions at the OWDF in 2000. The facility received a No Further Action determination from DOH in April 2005. Based on the recent work conducted documenting the uncertainty regarding the presence and effectiveness of the "major hydrogeologic barriers", including the continued detection of fuel contaminants at the OWDFMW01, the AOC process should include a discussion about whether additional work should be conducted at the OWDF. The Navy and DOH should consider whether the No Further Action determination remains valid given the data collected and evaluated at the OWDFMW01 since 2005.

3. Section 2.3.1.2: Line 36 states "Light non-aqueous phase liquid (LNAPL) was also detected within several slant borings located beneath the tanks but not on the groundwater table." Has any consideration been given to determine the nature and extent of LNAPL from the historic releases that occurred prior to the release at Tank 5 in January 2014? Why is there no mechanism or discussion in the AOC SOW to address such historic LNAPL issues? Should it be discussed and investigated for under the 2014 Groundwater Protection Plan?

4. Section 2.3.1.3: Lines 18 and 19 state that in the core samples, "no constituents were detected above reporting limits or associated action levels." The work plan should be revised to provide more quantitative evaluation of what was observed, even if below the reporting limits or action levels, and discuss why cores collected from under the 20-foot-thick concrete plugs had any fuel.

5. Section 2.3.1.5: Lines 34 through 40 should be revised because the dominant groundwater flow direction as stated in line 37 is to the northwest, not toward the Red Hill shaft to the southeast. Given the stated dominant gradient to the northwest, the 2007 Tier 3 risk assessment is no longer complete and this section should be revised to state that its results are only partially valid.

6. Section 2.3.2.1: Lines 35 and 36 state that the Red Hill shaft has not been "impacted by the January 2014 release". This statement is misleading and should be revised to state that fuel contaminants have been found in the Red Hill shaft but not above levels that require regulatory action.

7. Section 2.3.2.2: Pages 2-14 to 2-16 discuss the groundwater chemistry results for the monitoring wells through the end of 2015 and refer to Appendix D. The text in this section and the plots of groundwater concentrations in Appendix D should be revised to include the results from the first quarter of 2016. The tables in Appendix D present the most recent results whereas the plots and the work plan text do not. The latest results should be included in the work plan because: 1) they are already available and 2) they show that the rise in TPH-d at Red Hill monitoring well RHMW02 observed in the 2015 data continues into 2016, yielding the highest value yet seen, 6,500 micrograms per liter (µg/L).

8. Section 2.3.2.2: Page 2-16, Lines 5 and 6 state "previous TPH-d peak did not correspond to any release for the USTs." This statement should be analyzed more closely. The USTs have had a history of unreported releases and a release could have occurred in 2012 that was not reported.

9. Section 2.3.2.2: Page 2-16, Lines 26 and 27 state "if TPH-d concentrations significantly increase, the monitoring frequency should be increased to monthly." The definition of "significant" increase should be provided in the WP. The BWS considers the increasing concentrations of TPH-d in monitoring well RHMW02 to be significant and, therefore, it is recommended that the monitoring frequency be increased to monthly for this well and those nearby.

10. Section 2.3.2.3: Page 2-17, Lines 4 through 16 state increasing trends in soil vapor concentrations above action levels are required to trigger additional actions. Although the soil vapor concentrations above action levels were observed in the shallow zone below Tank 5, no additional actions were taken because Tank 5 is currently empty. This approach should be reconsidered as the increases in the shallow zone below Tank 5 are likely due to the presence of LNAPL in the

subsurface. Vadose zone characterization work in the area should be conducted to determine the horizontal and vertical extent of the LNAPL plume.

11. Table 1: Pages 2-18 through 2-23 – Specific references should be provided in order for the BWS to review the documents used to develop this table and confirm the accuracy of the information. The summarized information does not provide reference information and there does not appear to be reference information in Section 9, References.

12. Section 3: the significance of the historic Hawaiian town sites and the other culturally sensitive historic sites within Halawa Valley should be discussed in this section.

13. Section 3.6.1: Lines 20 through 25 describe two aquifer types, basal and caprock. This text should be revised to explain that perched groundwater is present at many locations, including the basalt and valley fill units in the Red Hill vicinity. The explanation should include what is known about perched water occurrences at Red Hill.

14. Section 3.6.1: Lines 39 through 41 should be revised to explain that Hunt (1996) also stated that the effects of the geohydrologic barriers may diminish along the inland direction and that he chose North Halawa Valley as a geohydrologic barrier on the recommendation of a colleague, not on the basis of direct evidence about groundwater head or geologic observations.

15. Section 3.6.2: The sentence on Lines 17 through 20 should be removed. The 2007 report contains no direct evidence that shows the North Halawa valley fill unit near Halawa shaft extends below the water table or that geologic materials at the regional water table have a low permeability. The report in question only assumed that a low permeability valley fill unit is present at the water table near Halawa shaft.

16. Section 3.6.2: The sentence spanning lines 23 and 24 should be revised to state that there is no evidence that the Halawa shaft is "cross-gradient" from the RHBFSF. The report in question assumed that the regional gradient was to the southwest and this assumption was contradicted by the TEC (2010) letter report.

17. Section 3.6.2: Lines 31 and 32 state "This well extracts an average of 4 million gallons per day (mgd) and up to 18 mgd of groundwater". These pumping rates contradict the pumping rates stated in WP Section 2.1.1: Line 32 and should be revised to be consistent with each other and accurate.

18. Section 3.6.2: Figure 6, which is used to justify some of the proposed well locations, requires extensive revision before it begins to reflect available data and previous work. Its depictions of the assumed width and depth of the valley fill and saprolite in the North and South Halawa valleys do not take into account the available data thus

is misleading and could lead to incorrect choices for proposed well locations. The depicted widths of Halawa valley fills a this cross-section location are exaggerated by at least 50% beyond those shown in Sherrod et al. (2007) or Stearns (1939). A brief physical visit to South Halawa valley will reveal that deep valley fill (greater than 50 feet in thickness) is confined only to the eastern branch of South Halawa Stream and does not extend to the western branch. The depicted depths of valley fill and saprolite also appear exaggerated and Figure 6 should be revised to reflect Plate 1 of Izuka (1992) and Figure 25 in Wentworth (1942). Please see Figure 1 in our letter "Board of Water Supply (BWS) Comments to the Monitoring Well Installation Work Plan, Red Hill Bulk Fuel Storage Facility" dated May 27, 2016 (BWS 2016), which presents part of Wentworth's Figure 25.

Figure 6 shows that the proposed monitoring well RHMW11 intersects the western part of the exaggerated width for valley fill in South Halawa valley. Based on the available data, physical visits to this area, and reports cited above, this proposed well is more likely to intersect Koolau basalt than South Halawa valley fill. Consequently, the proposed location should be reconsidered using Figure 6 after the recommended revisions above. The Navy should also consider adding the CWRM's Halawa Deep Monitor Well to the cross-section.

At present Figure 6 only shows a combined valley fill and saprolite unit. What are the other units and where do they occur?

The BWS Halawa Shaft is projected into the valley fill in Figure 6 which is factually incorrect. Figure 6 should be revised to show that the shaft is northwest of the valley fill in North Halawa valley as shown in cross-section A-A' on Plate 1 in Izuka (1992). A perpendicular projection of the dot representing the shaft in the inset to Figure 6 still places the shaft outside of the valley fill to the west or northwest. The current placement and depiction of a well instead of a shaft are likely to only confuse readers. Figure 6 presently appears to imply that Halawa shaft can actually withdraw large amounts of water (6 to 10 million gallons per day) from the valley fill.

19. Section 3.6.2.1: The last sentence in this section should be revised to state that contaminated groundwater from the RHBFSF could not affect water quality in these two streams, but lateral migration of LNAPL through the vadose zone could affect water quality in these two streams.

20. Section 3.6.2.1: Figure 7 states that it is a geological cross-section. However, it does not show any geology and should instead be characterized as a schematic or longitudinal profile.

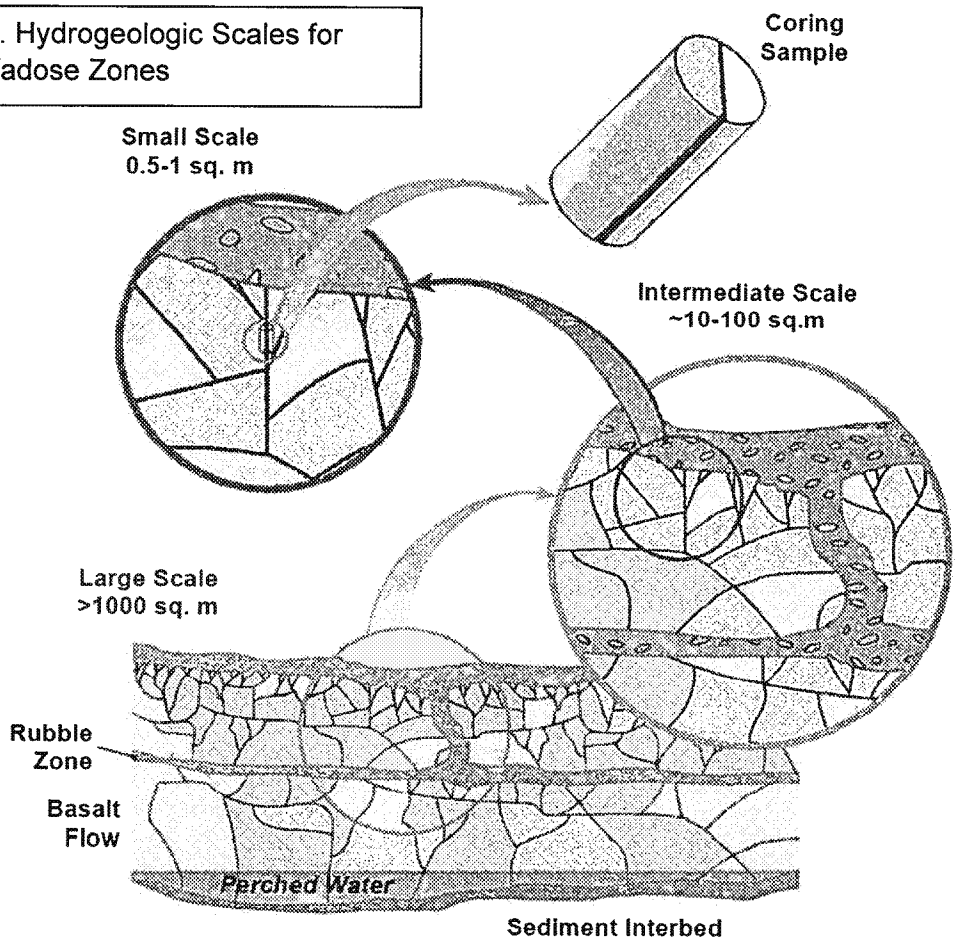
21. Section 3.6.2.2: The text in lines 2 through 17 should be removed from this section and placed in the following section, which describes hydraulic conductivity. The sentence spanning lines 14 and 15 should be revised to remove the words "and unresolvable" as this is not true. Groundwater flow patterns can be resolved wherever there are a sufficient number of wells are suitably located for the system in

question.

22. Section 3.6.2.2: The text in between lines 36 and 43 needs to be thoroughly revised to state that the effects of Halawa shaft pumping are not yet well understood and to include a discussion of the observed head changes from the recent USGS pump test that showed pumping changes at Halawa shaft did cause head changes in Red Hill monitoring wells. All text about valley fill barriers should be removed or revised to state that there is yet no direct evidence of barrier behavior by the valley fill units.

23. Section 3.7.4: Lines 10 through 14 are misleading and should be removed. The statements about low vertical permeability in the basalts presented here and in Sections 3.6.2.3 and 3.7.3 may well be true at small scales on the order of 1 meter^2, but such statements are readily contradicted by the fact that recharge occurs at rates between 10 and 25 inches per year in the Red Hill vicinity (see Oki, 2005 and Giambelluca 1983 for example). The authors appear to be solely focused on the micro-scale, whereas recharge and contaminant migration occur at the intermediate to large scales (Figure 1 below, which is adapted from Figure 3 in Fabyshenko et al., 2000). If the massive components of a'a flows are so impermeable, how can

Figure 1. Hydrogeologic Scales for Basalt Vadose Zones



recharge occur at such a large rate over such a large area? If recharge is negligible

at Red Hill, why has the Navy invested so much into the system of collection trenches, sumps, and treatment units to handle infiltrating water? If the vertical permeability is so low as to impede vertical flow, why aren't they preventing the fuel contamination from migrating through the vadose zone into the groundwater, causing rising concentrations in vapor below Tank 5 and at monitoring well RHMW02? Relatively rapid migration of infiltrating water through massive basalt flows for small, intermediate, and large scales has been well established elsewhere (Fabyshenko et al., 2000; Fabyshenko et al., 2001; Baker et al., 2004), and the authors are encouraged to study these reports. As neither water nor fuel appear to have any problem moving vertically through the basalt vadose zone, this text should be revised to account for the large mass flux of water migrating through extensive areas of the basalt vadose zone.

24. Section 3.7.4: Lines 14 through 22 should be revised to remove the any mention of compartmentalization for monitoring well RHMW07. Such compartmentalization is questionable given that fuel contaminants have been detected in its groundwater and further, such conditions appear to be rarely observed in and around the RHBFSF. The section should also be revised to describe that vapor, LNAPL, dissolved contaminants, or some combination are readily migrating vertically through the vadose zone causing the observed increases in groundwater concentrations at RHMW02 and at the soil vapor monitoring points beneath Tank 5 during the last year or so.

25. Section 3.7.4: Lines 36 to 38 should be removed because fluids are already moving relatively freely through the vadose zone and the risk of remobilization can be successfully managed. The so-called "naturally existing confining layers" are not interfering with the large mass flux of infiltrating water that becomes recharge. Carefully planned, implemented, and supervised drilling and construction will prevent perched water and contaminants from being remobilized.

26. Section 3.7.4: Lines 39 and 40 should be deleted and replaced with text that describes how the vertical distribution of LNAPL pockets can be determined from a series of vertically distributed soil vapor monitoring points alongside and beneath Tank 5. Lines 41 to 43 on page 3-28 and Lines 1 to 2 on page 3-29 should be removed and replaced with a discussion of how vapor concentrations in the vadose zone can be used to identify which elevations likely contain LNAPL pockets large enough to warrant remediation. As vapor appears to have little problem moving horizontally, soil vapor extraction will likely be a successful remediation alternative.

27. Section 3.7.4: Lines 3 to 7 on page 3-29 should be removed. Dissolved oxygen levels in groundwater are not relevant to degradation in the vadose zone, which is the focus of this section. This section should be revised to state that measurements of gaseous oxygen in the vadose zone will be collected from the soil vapor monitoring points to see if there is sufficient oxygen to support degradation of fuel in

the vadose zone.

28. Section 3.7.4: Lines 8 through 12 on page 3-29 should be deleted as they are unsupported conjecture. Successful modeling requires a basic understanding of the processes and features controlling water and contaminant migration in the vadose zone, and, as explained above, there is ample site-specific evidence that fluids, whether infiltrating water or contaminants, are migrating through the vadose zone. The work plan should be revised to acquire the necessary data and understanding of the key processes and features at the correct scales.

29. Section 4.1: Lines 4 to 9 should be removed because previous studies only assumed that the valley fill units impede groundwater flow. This text should be revised to state that the role of the valley fill units remains an important data gap that must be resolved by work in Tasks 1 and 4.

30. Section 4.1: Task 1: Line 40 states "NAPL has not been observed in measurable quantities in any of the monitoring or supply wells". Define "measureable" and discuss NAPL readings observed to date.

31. Section 4.2: This section should be revised to include installation of soil vapor monitoring wells at different elevations alongside Tank 5 to: 1) determine which elevations have high or low fuel vapor concentrations, and, 2) to track the migration of contaminants through the vadose zone such as the migration indicated by the groundwater and vapor data from the last year or so.

32. Table 3: COPC List for AOC statement of Work Sections 6 and 7 Investigation – Discuss justification as to why lead scavengers (1,2-dichloroethane and 1,2-dibromoethane) are not being sampled for at Red Hill Shaft (RHMW2254-01) and why lead scavengers (1,2-dichloroethane and 1,2-dibromoethane) are only being analyzed for a period of one year of investigation groundwater sampling if results are non-detect.

33. Section 4.4: Task 4: Our initial comments for this section were sent to EPA and DOH in a letter "Board of Water Supply (BWS) Comments to the Monitoring Well Installation Work Plan, Red Hill Bulk Fuel Storage Facility" dated May 27, 2016 (BWS, 2016).

34. Section 4.4: Task 4 should be revised to include a priority ranking of the proposed well locations and a process (decision tree) about how decisions will be made to change well location and well installation order based on new data acquired during the drilling program. For example, the decision tree should describe the changes to well locations and order given the following possible findings at proposed RHMW11 and the ability to add monitoring well locations as needed:
    - What if RHMW11 groundwater head is found to be lower than heads at upgradient wells (e.g., RHMW02, RHMW06) but higher than head at Halawa

shaft?

- What if RHMW11 groundwater head is found to be significantly higher than the nearest upgradient and downgradient heads (such as would be expected for a compartmentalized zone in the aquifer)?

- What if RHMW11 does not intersect valley fill units below the water table?

Such a decision process may not be needed for all the proposed monitoring wells, but it should be added to address the long-standing questions about groundwater flow direction and rate between RHFSF and Halawa shaft. This task should also include a discussion of how groundwater gradients will be calculated under the dynamic pumping stresses and of how a decision will be made as to whether valley fill units in Halawa or Moanalua valleys will or will not prevent contaminant migration toward the water supplies.

35. Section 4.4: The WP acknowledges that the groundwater system near the RHBFSF is very dynamic in time, thus Task 4 should be revised to include long-term monitoring of heads in the extended well network using transducers to provide sufficient data for model calibration in Section 4.5.

36. Section 4.4: The synoptic water level measurements should only be made after all measuring points at the monitoring wells have been surveyed to an appropriately high degree of accuracy.

37. Section 4.5: This section should be revised to make the following changes:
    - State that modeling will begin once data have been collected and analyzed from the extended monitoring well network;
    - The conceptual and numerical models will assume valley fills units do not impede groundwater flow from the RHBFSF toward Halawa shaft and the Moanalua wells until the field characterization demonstrates otherwise;
    - The boundary conditions described in this section and Appendix H should reflect the data collected from real-time measurements of heads across the model domain. At a minimum, the boundary conditions should conservatively assume groundwater flow is from the RHBFSF toward Halawa shaft or instead create boundary conditions that are sufficiently distant that they allow groundwater flow directions between the RHBFSF and the nearby water supplies to be determined by local stresses such as pumping at those water supplies and hydrogeologic features.

38. Section 4.6: This section should be revised to include determining the different-sized areas around the tanks that will be contaminated by LNAPL and dissolved contaminants for different sizes of fuel releases.

39. Section 4.7 and Appendix F: Page 4-10, Lines 34 and 35 and the Introduction in Appendix F state that a detailed and comparative analysis of remedial alternatives will not be conducted until the investigation is completed. The detailed and comparative analysis can only be performed if the extent and disposition of the NAPL and the dissolved hydrocarbon plume is fully characterized. The WP/SOW, however, does not include any provision for NAPL characterization, any provision for vertical characterization of the dissolved plume, and does not provide for a phased approach for delineating the horizontal extent and magnitude of the dissolved plume. It would be beneficial to understand how a more detailed and comparative analysis will be performed without even a conceptual plan for locating and delineating the NAPL. Please revise this section to explain clearly how the remedial alternatives can be evaluated in a useful manner in the absence of identifying where the contamination to be removed is located in the subsurface.

40. Section 4.7: This section indicates that remedial alternatives will be evaluated using the nine NCP criteria. It seems appropriate that Appendix F would have laid out the framework for the evaluation of the remedial technologies using these criteria. Since minimal effort was applied to this preliminary and tentative remedial analysis, Appendix F could have been used to define each criterion and how the structure of the analysis would be developed. For example, will "No. 7 – Cost" include development of a cost estimate based on future or present values? Will the cost evaluation include capital expenditures, O&M costs, laboratory analyses, impacts to facility operations, etc.? Will the cost analysis include actual engineer estimates based a conceptual design or just an application of published cost data from literature? Please revise this section to define each criterion and describe in detail the evaluation framework to be used.

41. Section 5.5.2: With a reduced COPC analyte list, how can an accurate risk assessment be performed? Lines 30 and 31 state "COPC concentrations that exceed the DOH EALs may be further evaluated in a Tier II baseline risk assessment." It seems in should be a requirement that any COPC concentrations that exceed the DOH EALs should be further evaluated and that at a minimum a Tier II baseline risk assessment should be performed for each COPC exceedance.

42. Appendix F: The list of remedial alternatives is incomplete. Consideration of all available reasonable technologies should be included in the analysis. This should incorporate enhancements to the core technologies. For example, heat- or steam-enhanced SVE could significantly accelerate NAPL recovery such that an evaluation separate from just traditional SVE would be warranted. Some other technologies to consider may include bioaugmentation, wellhead treatment, vacuum-enhanced NAPL recovery, stabilization/fixation, and interception barriers. Table F1 should include all technologies that were at least considered, even if the resulting "not recommended" designation is applied.

43. Appendix F: Any evaluation of remedial technologies should include a discussion and possible analysis of combined technologies. This is particularly important when evaluating technologies applied to quite different remedial goals (e.g. dissolved-phase treatment technologies versus NAPL recovery from the vadose zone), or adjusting the treatment technology to optimize cost and energy expenditure during the application (e.g. use of SVE to remediate NAPL and conversion to bioventing for residual mass removal).

44. Appendix H: Lines 25 to 30 page H-7 – see comment for Section 3.6.2 Lines 17 through 20 and for Section 4.1: Lines 4 to 9.

45. Appendix H: Lines 33 to 34 page H-7 – see comment for Section 3.6.2 Lines 23 and 24.

46. Appendix H: Lines 5 to 11 page H-8 should be revised to include mechanisms expected to accompany different sizes of fuel releases. For example, a large fuel release could lead to LNAPL flowing into one of the streams adjacent to the RHBFSF.

47. Appendix H: Lines 23 to 34 page H-8 should be revised to discuss the detections of fuel contaminants in the RHMW06, RHMW04, RHMW07, OWDFMW01, and the CWRM's Halawa Deep Monitor Well.

48. Appendix H: Lines 14 to 21 page H-11 – see comment for Section 3.6.2.2.

49. Appendix H: Section 3.4 should be revised to state that the 2007 model assumed valley fill units were present in Halawa valley and impeded groundwater flow and did not test that assumption, unlike the modeling work reported in Oki (2005). This section should be revised to state that the calibration used head data found to be erroneous because of surveying errors and so is questionable. Also, text should be added stating that the model's boundary conditions were too close to the area of interest and constrained groundwater flow throughout the domain. Figure H-4 should be removed because this model's results are based on erroneous calibration data, improperly specified boundary conditions, and untested and unsupported assumptions about the dimensions and properties of the valley fill units.

50. Appendix H: Section 3.5 Lines 27 to 29 should be revised to state that biodegradation of fuel contaminants in groundwater only occurs in parts of the aquifer with the appropriate geochemistry and the high groundwater flow rates (advection) may drive contaminants away from these favorable zones before much mass has been degraded, potentially leading to contamination of clean parts of the aquifer.

51. Appendix H: Section 4.2. This section should be revised according to the comments for Section 4.5.

52. Appendix H: Section 4.4 should be revised to follow the approach in Oki (2005) and determine whether calibration results are significantly different between a simulation without the valley fill units and a simulation with the valley fill units. If the differences are relatively small, then the model without the valley fill units should be chosen as the most conservative for predictive simulations. The calibration should be checked to ensure that the model creates simulated groundwater flow rates and directions that agree with results from the base case and no valley fill scenarios in Oki (2005).

53. Appendix H: Section 4.6 requires much more detail on the sensitivity analyses that will be performed to ensure that the model reflects an appropriate combination of choices of boundary conditions, dimensions and properties of the valley fill units (if any), and initial conditions.

54. Appendix H: Section 5 should be revised to examine a range of different fuel releases and release points. For example, a large fuel release could migrate many tens or several hundreds of feet laterally within the vadose zone before migrating down to the aquifer. Thus, the modeling should include releases into groundwater from an envelope surrounding the tanks.

55. Appendix H: Section 5.2 the last sentence on lines 20 to 21 should be revised to discuss what is meant by "reasonable" and also to discuss how the rate estimation will be carried out in the absence of data showing the extents of the geochemical zones favorable to degradation and how the uncertainty in the advective transport will be quantified and incorporated. For example, it is likely that the rate of advection is large enough to limit the residence time for contaminants within the geochemically favorable zones. This section should state that a range of conservative degradation rates will be used in the simulations, including a rate of zero.

56. Appendix H: Section 5.5.1 should be revised to reflect the statements made by AECOM and EPA during the May 10th meeting that the fate and transport modeling will assume that all of the fuel from each of the release scenarios will be present in the groundwater at the start of the simulations.

57. Appendix H: Section 5.5.5 should be revised to explain how the rate fitting process will deal with uncertainties in extent of and residence time in the geochemically favorable zones and in advection rates.

58. Appendix H: Section 5.8 should be revised to provide more detail on what will and will not be included in the sensitivity analyses.

59. During the AOC meeting on May 10, 2016, Navy representatives stated that they would provide a list of all fuel types/fuel additives that are currently stored or were

historically stored at the RHBFSF. The BWS requests that this information be provided to the BWS by June 10, 2016. The BWS also requests that the Navy begin testing all groundwater samples for those additives.

Thank you for the opportunity to comment. If you have any questions, please feel free to call me at (808) 748-5061.

Very truly yours,

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