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JUN 17 2016

James A. K. Miyamoto, P.E.
Deputy Operations Officer
Naval Facilities Engineering Command, Hawaii
400 Marshall Road
Joint Base Pearl Harbor Hickam, HI 96860

Re: Approval in part of Red Hill AOC SOW Deliverable under Sections 6 & 7 - Monitoring Well Installation Work Plan

Dear Mr. Miyamoto:

The U.S. Environmental Protection Agency ("EPA") and Hawaii Department of Health ("DOH"), collectively the "Regulatory Agencies", have reviewed the *Monitoring Well Installation Work Plan, Red Hill Bulk Fuel Storage Facility* ("MWIWP") submitted by the U.S. Navy ("Navy") and Defense Logistics Agency ("DLA") on April 26, 2016. The Regulatory Agencies are approving the MWIWP in part, pursuant to AOC Sections 7(b)(a) and 7(b)(b). Attachment 1 to this letter provides the Regulatory Agencies' detailed comments on those portions of the MWIWP that need to be revised or addressed by the Navy before we can fully approve the MWIWP. The Navy is required to resubmit the MWIWP with revisions within 30 days of their receipt of this letter as per AOC Section 7(b).

Our purpose in approving this deliverable in part, rather than disapproving it under AOC Section 7(b)(d), is to allow the Navy to move forward in preparing for the new monitoring well installations. The Regulatory Agencies approve the locations of monitoring wells designated as RHMW08, RHMW09 and RHMW10. The Navy informed us during a June 9, 2016 teleconference that they have reconsidered their initial proposed location of RHMW11. Our comments on the Navy's new proposed location for RHMW11 are included in Attachment 1 to this letter. As discussed in our meeting on May 10, 2016 in Honolulu, we are aware that moving forward on the installation of these new wells is of the upmost importance. Therefore we wanted to approve a portion of the MWIWP and trust that this partial approval allows you to begin site preparation work as soon as possible.

In addition to our comments we have attached a copy of the MWIWP comment letter received from the Honolulu Board of Water Supply (May 27, 2016) (Attachment 2). Many of the Honolulu Board of Water Supply comments are consistent with the Regulatory Agencies comments.

If necessary, we are available to discuss our comments in more detail. Please contact us if you have any questions. Bob Pallarino can be reached at (415) 947-4128 or at pallarino.bob@epa.gov and Steven Chang can be reached at (808) 586-4226 or at steven.chang@doh.hawaii.gov.

Sincerely,

Bob Pallarino
EPA Red Hill Project Coordinator

Steven Chang, P.E.
DOH Red Hill Project Coordinator

Enclosures

cc: Mr. Stephen Turnbull, U.S. Navy

Attachment 1
Regulatory Agency Comments on April 29 2016 Monitoring Well Installation Plan, Red Hill Bulk Fuel Storage Facility

Section 1.2.1.3 – Geology and Soils, Page 1-5
Lines 34 - 37:

- This paragraph describes the lava beds in the area of Red Hill as "near horizontal". The Regulatory Agencies believe an acknowledgement of the potential for these beds to dip is important. This paragraph should end with a sentence stating that characterizing the strike and dip of the lava flows is important for understanding any product migration in the vadose zone outside of the concrete cocoon of the tanks and will be conducted as part of the overall hydrologic investigation required under Sections 6 & 7 of the AOC SOW.

Page 1-6
Lines 1 to 11:

- The geology and soils section should include a brief discussion of late stage volcanics, e.g. Salt Lake, Caprock formation, and deep stream valley fill sediments and saprolite that could act as barriers to groundwater flow.

Section 1.2.1.4 – Groundwater, Page 1-6

- This section should include a paragraph to explain that perched groundwater is likely present at many locations in the study area, 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. Perched water is common in the Halawa Valley near the area where RHMW11 is proposed. During the drilling of RHMW04 a perched water zone was encountered that extended from 85 down to about 130 feet below ground surface. A review of the boring logs for RHMW06 and RHMW07 by the Regulatory Agencies found no mention of perched water, which may have been encountered while drilling these two wells.

Lines 13-17:

- There is some uncertainty as to whether the majority of the groundwater flow is towards the harbor. The investigation that is beginning with the installation of these monitoring wells will help us understand if there are conditions present in the subsurface that would cause the groundwater to flow in directions other than towards the harbor. The last sentence in the first paragraph (line 17) should make mention of this uncertainty.
- The description of groundwater in this section fails to mention high-level dike confined groundwater.

Lines 25 – 31:

- This paragraph should clarify that while the Caprock aquifer does not extend to the areas in the vicinity of the tanks, it is present in the study area and can influence the flow of groundwater. The Caprock has the potential to divert groundwater flow and it's likely that other subsurface barriers that may confine flow exist within the study area and possibly site area.

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Attachment 1
Regulatory Agency Comments on April 29 2016 Monitoring Well Installation Plan, Red Hill Bulk Fuel Storage Facility

Section 1.2.2 – Site History, Page 1-7
Line 37:

- The second paragraph of this section (lines 36-37) refers to the Navy supply well as being downgradient from the USTs. Since the actual downgradient direction in the vicinity of Red Hill has not been adequately defined this sentence should acknowledge the uncertainty, pointing out the importance of this and other investigations to characterize groundwater flow patterns beneath the foot print of the facility. It would be more accurate to state "the assumed down gradient direction" or similar since at this point since we don't know the regional gradient beneath the Facility.
- The stated distances from USTs to the RHS vary from <2000 to >4000 ft. The distance from the east end of the Red Hill Shaft infiltration gallery to UST-1 is about 1,500 ft, while the distance from west end of the infiltration gallery to UST-20 is about 4,500 ft. -Consistency is needed - when describing this important parameter. The Regulatory Agencies believe the shortest distance to the infiltration gallery is a critical parameter when characterizing risk.

Page 1-8
Lines 1 – 7:

- The construction sequence of tanks is not described accurately. Upper domes were constructed first, cavity for tank barrel and bottom blasted and excavated and then barrel and bottom of tank were constructed.

Section 2.2 – Step 2, Identify Study Objectives, Page 2-1
Lines 19-21:

- This section states that one of the principal objectives of the MWIWP is to investigate the site stratigraphy and matrix physical properties. This implies that the MWIWP is the primary plan for developing the conceptual site model for the Red Hill project. The Regulatory Agencies do not agree with this implied objective. The sentence should be revised to state: "The principal objectives of the work proposed in this WP are to install monitoring wells at four locations (shown on Figure 2), ***collect data from the boring of the wells that can be used to better understand the site stratigraphy and matrix physical properties***, and obtain additional groundwater hydrologic data.

Lines 24 -28:

- Section 2.2 of the MWIWP states that the secondary objective of the MWIWP is to evaluate the nature of petroleum product and constituent chemicals in the soil, if present in the vadose and saturated zones underlying and downgradient of the tanks. It further states that the scope of the sampling and analysis program in the MWIWP is limited to the collection of subsurface **soil**, which will only be conducted if soil is encountered at depths below the bottom of the tanks or if contaminated soil is encountered. The Regulatory Agencies require the Navy and DLA to broaden the scope of their sampling and analysis to include any unconsolidated material that is coarse grained sand or smaller grain size, e.g. clay, sands, and clinker zone sand. Any

contaminated material of this type will be sampled and analyzed if it is encountered while drilling regardless of its location.

Section 2.5 – Step 5, Develop the Analytical Approach, Page 2-2
Lines 10 – 11:

- See previous comment to sample all coarse grained sands or smaller sediments with evidence of contamination.
- This section should include a bullet specifically stating that the full length of all cores will be screened with a photoionization detector (PID) regardless of location, i.e. not just below the bottom of the tanks.

Lines 12-13:

- The Navy needs to define the term "significant contamination".
- The intention of this statement is not clear. What actions will the Navy propose to take in the event that significant contamination is detected (once "significant" is defined)?

Location Map, Page 2-3

- The blue arrow on the figure entitled "Location Map" is consistent with that shown in USGS publications. However, these publications are based on conceptual models developed decades ago and without the new water level data that has been, and will be acquired by Red Hill investigations. Furthermore, fuel related constituents have been detected in RHMW04 which suggests that at times there likely is groundwater flow from beneath the Red Hill USTs to the northwest. The arrow should be removed or otherwise modified to reflect the uncertainty.

Section 2.6.2 – Managing Decision Error, Page 2-5
Lines 7-8:

- Leveling the drilling well twice a day during drilling may not be sufficient to ensure that a well is plumb. The Regulatory Agencies' concern with this proposal is that if the well is not vertical within a known amount than water level information obtained from these wells will be suspect. With groundwater gradients of approximately 1 ft/mi. it is important that a true vertical depth survey be performed since one of the primary products of Task 5 of the Navy's proposed Scope of Work for the Investigation and Remediation of Releases is characterizing the groundwater flow gradient. The extent that a well casing deviates from true vertical will affect the accuracy of water level measurements. While it is not critical that well casing be exactly plumb, any deviation from true vertical must be known so corrections to the wire line measurements can be made. The Regulatory Agencies require that a quantitative true vertical depth analysis be done using a gyroscopic alignment instrument either during well construction or after the wells are installed so appropriate corrections can be made to wireline measured depth to water. The MWIWP needs to be revised to include a more robust method to ensure that the vertical depth of the wells are known. The Navy should refer to technical criteria developed by the National Groundwater Association (www.ngwa.org) or similar professional standards for more information on ensuring their wells are plumb.

Attachment 1
Regulatory Agency Comments on April 29 2016 Monitoring Well Installation Plan, Red Hill Bulk Fuel Storage Facility

Section 3-1 – Monitoring Well Locations, Page 3-1
Lines 34- 35:

- The Navy states that "The proposed well locations (Figure 2) were chosen based on their potential to provide more information about the site's geology and groundwater, and to fill in identified data gaps". Please provide a brief description that specifies the data gaps each well location is intended to address. The description can be included in this paragraph or in the paragraphs describing each well location on pages 3-1 and 3-2.

Section 3-1 – Monitoring Well Locations, Page 3-2
Lines 24-37:

- The Navy informed the Regulatory Agencies on a teleconference on June 9, 2016 that they have reconsidered the proposed location of RHMW11 and are seeking to install this well further south of the initial location. Before approving this new location, the Regulatory Agencies believe that further discussion is necessary in order for the Navy to adequately demonstrate the advantages and disadvantages of this relocation. As presented on the June 9, 2016 teleconference, the Navy's rationale for relocating the monitoring well location is that the new location will give better information about the geometry of the South Halawa Valley fill. This is insufficient justification for relocating the well.

  Locating this well farther south for the purpose of gathering more data in order to characterize the composition and extent of the South Halawa Valley fill is presented as an effort to obtain data to refine the groundwater models. However, the Rotzoll and El-Kadi model that AECOM and the Navy use as the starting point for their conceptual model of groundwater flow indicates that the North Halawa Valley Fill has a much greater effect on groundwater flow than the South Halawa Valley Fill. The Regulatory Agencies therefore question the benefit of better characterizing the South Halawa Valley Fill. The Regulatory Agencies also believe an important consideration for this well location is the optimum well geometry to evaluate the groundwater gradient. The original location was much better suited for evaluating the groundwater gradient from the Moanalua Aquifer to the Waimalu Aquifer. The inter-aquifer flow is a key component of the risk assessment since. If significant inter-aquifer flow does occur, contamination from the facility could be transported to the vicinity of the Halawa Shaft.

  The Navy needs to address these concerns in the revised MWIWP before the Regulatory Agencies can consider approval of the alternative location of RHMW11.

Figure 3, Geological Cross Section (Transverse), Page 3-3

- What is the basis for the extent of the Valley Fill and Saprolite areas as illustrated in Figure 3? The Navy needs to provide supporting documentation or references to support the characterization of the valley fill or clearly indicate that the extent of the valley fill depicted on the figure is speculative and not supported by geologic evidence.
- The description of RHMW11 on page 3-2 states that in order to fully investigate the extent of valley fill or saprolite this well boring may be extended if bedrock is not encountered. Figure 3

should provide an indicator to show the additional depth of RHMW11 in the event that bedrock is not encountered at the target depth.

- Since the facility is the focus of the investigation and RHMW02 is located more or less in the center of the facility, the Regulatory Agencies recommend that the X-axis be centered at RHMW02, which would make it easier to determine lateral distances from the facility.
- The figure incorrectly shows the Halawa Shaft terminating within the valley fill. The Halawa Shaft is actually a horizontal infiltration gallery in the basalt northwest of the valley fill. The Halawa Shaft is bored into the wall of North Halawa Valley so the depiction of a vertical well located in the center of the valley is inaccurate.
- Remove the word "sporadic" from Note 1 of Figure 3. Note 1 should be revised to, "Existing well logs show a complex subsurface comprised of alternating pahoehoe and a'a lava flow with clinker zones, fractures, and voids."

Figure 4, Longitudinal Cross Section. Page 3-5

- Delete the word "Geological" from the title of this figure since no geologic features are depicted in this figure.

Section 3.2.3 – Rock Coring, Page 3-8

Lines 21-22:

- Checks for perched groundwater should occur more frequently than at the beginning and end of each workday. Perched groundwater is present at many locations in the study area, including the basalt and valley fill units in the Red Hill vicinity. If only checked at the beginning and end of the day it would be easy to drill through a perched zone without knowing it. When potential perching formations are observed in the rock cores (e.g. highly weathered basalt, soil, very massive lava, etc.), the borehole should be checked for standing water.

Figure 5, Cross section of Borehole and Monitoring Well, Page 3-9

- Figure 5 indicates that bentonite chips will be used to seal the annular space between the well casing and the borehole. In a teleconference with the Navy and its contractors on June 9, 2016, the Navy indicated that it could use a bentonite slurry to seal the annular space rather than bentonite chips that require hydration. According to guidance developed by the National Ground Water Association, bentonite grout, which may include or be another term for bentonite slurry, is recommended for sealing the annulus of a well in the unsaturated zone. The MWIWP needs to provide more detail on the composition of the slurry and the method of installing it in the annular space of the wells.

Section 3.3 – Subsurface Soil Sampling, Page 3-11

Lines 2-9

- The term "soil" should be replaced with "unconsolidated material". See the Regulatory Agencies' comment on the MWIWP Section 2.2 above.

Attachment 1
Regulatory Agency Comments on April 29 2016 Monitoring Well Installation Plan, Red Hill Bulk Fuel Storage Facility

Section 3.4 – Monitoring Well Installation, Page 3-11
Lines 26-29:

- This section should include an explanation and rationale for the Navy's choice of a 30 foot screen length. Appendix I-C-1 of the MWIWP includes a discussion of appropriate screen lengths (page 16 of 44 of the section entitled "Monitoring Well Installation and Abandonment") stating that screen length should be limited to 5 to 10 feet, however longer intervals may be justified in certain circumstances.

Table 3-3, Existing and Anticipated Borehole and Well Dimensions

- Regarding Monitoring Wells RHMW2254-01 and HDMW 2253-03, since neither of these wells are screened the Navy should determine and provide the depth of the bottom of the well casing for the wells rather than stating "Not Applicable" for the screen interval.

Section 3.5 – Surveying, Page 3-12
Lines 5 – 12:

- The groundwater flow gradient is a regional problem involving the possibility of groundwater flow from the Honolulu Aquifer to the Pearl Harbor Aquifer. Measuring the groundwater flow gradient requires measuring water levels in wells from the Moanalua Ridge to well west of North Halawa Valley. The TOC elevation of all wells used in the gradient calculations and in the calibration of the groundwater flow model need to be accurately surveyed to a common vertical datum. The Regulatory Agencies strongly recommend the Navy consult with the National Oceanic and Atmospheric Administration's National Geodetic Survey (NOAA NGS) before beginning this work. The Regulatory Agencies can provide the Navy or their contractor a point of contact at NOAA NGS.

Section 4.3.9 – Subsurface Soil Sampling, Page 4-7
Lines 34-35:

- This section states that samples will be collected and handled in accordance with Navy procedures as presented in attachments located in the appendix to the MWIWP. These procedures provide a number of options and are generic procedures. The Regulatory Agencies require the Navy to include specific details on soil/sediment collection procedures that will be used at the Red Hill study area, including specifications on the type of sample containers that will be used. These details should also be included in Table 5-1.

Lines 35-37:

- Revise the sentence beginning on line 35 to read"*The subsurface soil samples will be inspected* ***for evidence of contamination (visual, olfactory, elevated PID readings) in order*** *to evaluate the potential migration of LNAPL and associated constituents.*"

Table 5-2, Geotechnical Sample Details for Monitoring Well Installation WP, RHSF, Page 5-3

- Table 5-2 indicates that laboratory analyses of a material listed as a solid matrix contained in cores will be performed. Please provide a description of what type of material that the tests

specified in this table will be performed on. Providing references to Department of Navy protocols does not provide a sufficient level of detail.

Table 5-3, Potable Water Sample Details for Monitoring Well Installation WP, RHSF, Page 5-4

- The purpose of including Table 5-3 is unclear to the Regulatory Agencies. Please provide additional details on the contents of Table 5-3, including sample collection procedures.

BOARD OF WATER SUPPLY

CITY AND COUNTY OF HONOLULU
630 SOUTH BERETANIA STREET
HONOLULU, HI 96843

May 27, 2016

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Mr. Steven Y.K. Chang, P.E., Chief
State of Hawaii
Department of Health
P.O. Box 3378
Honolulu, Hawaii 96801-3378

Dear Messrs. Pallarino and Chang:

Subject: Board of Water Supply (BWS) Comments to the Monitoring Well Installation Work Plan, Red Hill Bulk Fuel Storage Facility

The BWS and its consultants have reviewed the document titled "Monitoring Well Installation Work Plan, Red Hill Bulk Fuel Storage Facility" (MWIWP) dated 29 April 2016 as discussed at the Tuesday 10 May 2016 meeting concerning the Administrative Order on Consent (AOC) work plans for Statement of Work (SOW) Sections 6 and 7. The BWS provides the following comments and recommendations to the draft MWIWP 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.

Section 1 – Background

Section 1.2.1.4 *Groundwater* should be revised to explain that perched groundwater, implications of which are discussed in Section 3.2 *Drilling*, 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.

The *Groundwater* sub-section should be revised to explain that the basal aquifer beneath the Red Hill Bulk Fuel Storage Facility (RHBFSF) was designated as a Sole Source Aquifer in 1987 under Section 1424(e) of the Safe Drinking Water Act.

Section 2 – Project Quality Objectives

Section 2.2 *Step 2- Identify the Study Objectives* states that a "...secondary objective is evaluate the nature of petroleum product and constituent chemicals in soil, if present in the vadose and saturated zones underlying and downgradient of the tanks." The proposed well locations are far from the tanks and will only provide any information about fuel contamination in the vadose zone materials "underlying and downgradient" of the tanks if the fuel has migrated long distances laterally from the tanks. Thus the proposed well locations will not likely achieve this important objective and will likely fail to achieve the goal stated in the second sentence of Section 2.1: "Additional monitoring wells are proposed to allow for monitoring the potential migration of light non-aqueous phase liquid (LNAPL) to the groundwater,...". The MWIMP should be revised to include drilling, coring, and installation of vadose zone monitoring wells much closer to the tanks to determine the nature, extent, and migration of fuel contamination in the vadose zone because

1) The roughly 30,000 gallons of fuel released in January 2014 have not yet been mapped out in the sub-surface; and,
2) This large quantity of fuel will likely serve as a continuous source of contamination to our drinking water for years to come.

Section 2.3 *Step 3- Identify the Information Inputs* states that groundwater elevation data will be obtained. This text should be revised to explain that a high-quality survey, such as the first order survey mentioned by Dr. Delwyn Oki of the United States Geological Survey (USGS) during the most recent AOC SOW meeting, will be necessary to obtain sufficient accuracy of groundwater elevations.

Figure 2, which depicts the proposed locations of the new monitoring wells, includes an arrow showing the direction of regional groundwater flow to be roughly south-southwest. This arrow is misleading and should be removed because there is no direct evidence to support such a flow direction. The direction of regional groundwater flow is still uncertain in this area and remains an important question; the depicted arrow indicates only an **assumed** regional flow direction because there is no substantial evidence available yet for flow direction. It is important to note that changes in the pumping rates at the Halawa and Red Hill shafts and other nearby locations can significantly affect heads and therefore groundwater flow direction - see the discussion of "storage head" in Wentworth (1942 and 1951) and Mink (1980). Thus is it is important to report pumping rates and volumes pumped when reporting heads. Also, there is indirect evidence for a northwest flow direction:

1) A number of reports state that groundwater flows from Moanalua valley to Halawa valley and that there is significant uncertainty whether the South and North Halawa valleys act as barriers to flow, including Wentworth (1942), Wentworth (1951), and Mink (1980);
2) A contour plot of observed groundwater heads from the TEC (2010) report shows groundwater flows across Halawa valley to the northwest toward Halawa shaft;

3) Contours of simulated heads in the scenario with no valley fill in groundwater from Oki (2005) show groundwater flowing from the Red Hill vicinity across Halawa valley toward Halawa shaft; and
4) Fuel contamination has been frequently observed at Red Hill Monitoring Well (RHMW)-06, RHMW-07, and the Commission on Water Resources Management (CWRM) Halawa Deep Monitor Well (HDMW) 2253-03, all of which are located to the northwest of the tanks. It is important to note that the CWRM Halawa Deep Monitor Well is also located north of South Halawa stream.

The third bullet item in Section 2.5 *Step 5- Develop the Analytic Approach* should be revised to clarify what will be done if "soil is present below the bottom of the tanks". The material below the tank bottoms is likely to basalt, not soil and none of the proposed wells will intercept the material directly beneath the tanks.

Section 2.6.2 *Managing Decision Error* states that errors in ensuring installation of vertical monitoring wells will be minimized by levelling the drilling rig at least twice per day during drilling. The level of the drill rig is not the only factor important to ensure drilling a "vertical" borehole. Other factors include bottom-hole weight (bottom-hole drill assembly) and rate of advance, which together should be balanced so the drill bit doesn't deflect as it encounters various basaltic intraflow structures. To accurately determine if each borehole is vertical, the driller should stop and trip-out of the hole and run a gyroscopic alignment survey once a day during drilling.

Section 2.7 *Step 7- Develop Plan for Obtaining Data* repeats the statement that the proposed well locations will provide information about "...the nature and extent of LNAPL ... within the vadose zone...". This sentence and all other text should be revised to either 1) explain that the proposed well locations are likely to provide information about LNAPL nature and extent in the vadose zone only if the fuel has migrated long distances laterally or 2) add borings nearer to the tanks that will be much more likely to be useful in mapping out LNAPL nature and extent in the vadose zone.

Section 3 – Monitoring Well Network Design and Rationale

Section 3.1 *Monitoring Well Locations* provides the reasons underlying proposed choices. None of the reasons include providing information about the nature, extent, and migration of LNAPL within the vadose zone cited in Sections 2.2 and 2.7. Please revise all sections to be consistent about the objectives and how the proposed monitoring wells will achieve those objectives.

The second paragraph of Section 3.1 states that "The number of locations proposed in the vicinity of the underground storage tanks (USTs) was limited due to the lack of exposure pathways and to minimize the creation of migration pathways between possible vadose zone contamination and the groundwater aquifer." This statement is both misleading and incorrect. None of the proposed locations are in the "vicinity of the USTs"; this incorrect statement should be revised to eliminate the factual error. Creation of migration pathways by drilling can be entirely avoided with proper planning, drilling, and oversight. A monitoring well 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 contaminants. It requires advanced planning and equipment that can implement a cement pressure grouting program within the borehole to seal off a contaminated zone before continuing the advancement of the borehole. Such grouting programs are routinely performed within the drilling industry (for example, see Chapter 10 Well Drilling Methods, Section on Grouting and Sealing Well Casing, p. 317-331, in Driscoll, F.G., 1986, Groundwater and Wells, 2nd edition: Johnson Screens, St. Paul, Minnesota, 1089 p. or Section 10 in the Australian Drilling Industry Training Committee Limited, 1997, Drilling – The manual of methods, applications, and management: CRC Press LLC, Boca Raton, Florida, 615 p.). Why doesn't this work plan include such a cement grouting procedure? It will allow for a more efficient and cost-effective method to cope with either perched water or contaminated zones without having to resort to abandoning the borehole if more than one zone is encountered.

Figure 3, which is used to justify some of the proposed well locations, requires extensive revision before it begins to reflect available data and previous work.

1) Figure 3 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 all available data; thus are misleading and could lead to incorrect choices for proposed well locations. Even if the authors of the MWIWP had relied only on Sherrod et al. (2007) or Stearns (1939), the depicted widths of Halawa valley fills are exaggerated by at least 50% beyond those sources. 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 3 should be revised to reflect Plate 1 of Izuka (1992) and Figure 25 in Wentworth (1942). The enclosed Figure 1 to this letter reproduces the relevant part of Wentworth's Figure 25, which shows two end members, A and B, for the depth of valley fill in the two valleys. Only one deep well (CWRM Deep Monitoring Well HDMW2253-03) has been installed in this area of Halawa valley since Wentworth (1942) and this well appears to intersect the eastern part of the South Halawa valley fill.

2) The proposed monitoring well Red Hill Monitoring Well (RHMW) 09 location is in very close proximity to a monitoring well being planned to be installed by the BWS. We recommend re-locating RHMW09 to the south side of Halawa Valley, along South Halawa stream, within the Red Hill Bulk Fuel facility boundary, such as the location shown in the enclosed Figure 2.

3) Figure 3 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 the recommended revised Figure 3. Installing the monitoring well on the east side of

South Halawa Valley closer to South Halawa stream will provide a better understanding of any head changes caused by valley fill.

4) At present Figure 3 only shows a combined valley fill and saprolite unit. What are the other units and where do they occur?

5) The BWS Halawa Shaft is projected into the valley fill in Figure 3 which is factually incorrect. Figure 3 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 3 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 3 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.

6) Given that the North and South Halawa valley fill units were created by incision by meandering streams and later backfilling, defining the width and depth of these units will require more than a single new monitoring well in the Halawa valley area.

The title for Figure 4 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.

Sections 3.2, 3.3, 3.4, and 3.5 describe drilling, sampling, monitoring well construction, and surveying, respectively. There are unexpected but large differences between the text descriptions of the monitoring well construction requirements and those shown on Figure 5. For example, the text does not specify what type of grout should be used for the conductor casing, but in Appendix A, Procedure I-C-1 indicates that it should be cement grout like that indicated on Figure 5. None of these text sections, nor Appendix A, Procedure I-C-1, provide specifics with regards to how the cement grout seal will be emplaced in the annulus. This is a significant concern since improper placement of the cement grout within the annulus between the conductor casing and the borehole can create open voids within the annulus and provide a potential vertical pathway for contaminate movement. Given the number of monitoring wells that the Navy has constructed, it is expected that the Navy should have specific plans and procedures for this critical aspect of monitoring well construction.

Another major concern is that below the bottom of the conductor casing the specified grout used to create the seal changes from the far more effective cement to the less effective bentonite. Figure 5 indicates that bentonite chips will be used for a seal in the portion of the borehole hole (potentially spanning more than 200 feet of annulus) from the bottom of the conductor casing to the top of the filter pack. It would be extremely difficult to emplace dry bentonite chips over such a very long interval and achieve a proper seal between the well casing and borehole wall. Such problems likely to be encountered using dry bentonite chips is "bridging" (leaving gaps). Also after the bentonite chips are emplaced they have to be hydrated (to achieve a seal) by adding

water to the borehole. However, any bridging within the emplaced bentonite chips will also likely cause incomplete hydration of the bentonite chips and result in a defective bentonite seal. Also the in-well hydration of the dry bentonite chips calls for the introduction of non-formational water to be introduced into the basalt vadose zone which could potentially mobilize contaminants, if present. A better approach would be to use cement grout slurry, or even a bentonite slurry (allowed for in Section 4.3.4, lines 6 – 17) and emplace it using a tremie pipe for this portion of the well seal.

The text sections of this work plan cite American Society for Testing and Materials (ASTM) standards for logging core. The ASTM standard contains generic descriptions and procedures that are of little general usefulness for logging basaltic core for a hydrogeologic/environmental assessment project – like this project. The work plan doesn't contain any details concerning how the various important basalt intraflow structures (e.g., flow top breccias (clinker sub-types), accretionary lava clasts, simple vesicular flow tops, vesicular flow lobes, inflated pahoehoe lobes, spatter-fed pahoehoe lobes, lava tubes, a'a columnar dense interiors, flow-bottom breccias, normal flow bottoms, flow levees, tumuli, rootless spatter cones, etc.) will be included in the descriptive and photo logs or how to recognize and identify the difference between tectonic fractures, primary cooling joints, and drilling-induced fractures. Additionally, the text sections of the work plan fail to provide any direction, guidance, or procedures for how basaltic core should be photographically documented, preserved, and archived other than the generic recommendations from in the ASTM standards. The MWIWP should be revised to state that all cores from new monitoring wells, as well as, cores from existing wells should be logged to note these important intraflow structures, tectonic fractures, primary cooling joints, and drilling-induced fractures.

None of the above described short-falls in basalt core logging, critical component to understanding the geology and hydrogeology beneath the Red Hill area, are addressed in Appendix A - Procedure I-E Soil and Rock Classification. Of the 17 pages in this procedure that specifically address identification and classification of soil (sediments) and rock, 15 pages of the 17 pages are devoted to procedures for describing and classifying soils (sediment) and only 2 pages out of the 17 pages are devoted to describing and classifying generic "rock" which includes basalt. Despite the acknowledged importance of correctly identifying basalt flow features and structures (intraflow structures) in the core, the proposed procedure fails to provide specifics for identifying and describing basalt intraflow structures. The MWIWP should be revised to provide guidelines for identifying, characterizing, and logging these key features.

The MWIWP should be revised to state that all logs, photo logs, and cores from existing and new wells will be made available for inspection on request by Subject Matter Experts and their contractors.

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,

ERNEST Y. W. LAU, P.E.
Manager and Chief Engineer

Enclosures

Figure 1 – Geologic Cross-Section Through Halawa Valley from Wentworth (1942)
Figure 2 – Suggested Alternative Location for RHMW09

References

Izuka, S.K. 1992. Geology and Stream Infiltration of North Halawa Valley, Oahu, Hawaii. USGS Water-Resources Investigations Report 91-4197.

Mink, J.F. 1980. State of the Groundwater Resources for Southern Oahu. Prepared for the Honolulu Board of Water Supply, 148 p.

Oki, D. 2005. Numerical Simulation of the Effects of Low-Permeability Valley-Fill Barriers and the Redistribution of Ground-Water Withdrawals in the Pearl Harbor Area, Oahu, Hawaii. USGS Scientific Investigations Report 2005-5223.

Sherrod, D.R., Sinton, J.M., Watkins, S.E., and Brunt, K.M. 2007. Geologic Map of the State of Hawai`i: U.S. Geological Survey Open-File Report 2007-1089, 83 p., 8 plates, scales 1:100,000 and 1:250,000, with GIS database.

Stearns, H.T. 1939. Geologic map and guide of Oahu, Hawaii: Hawaii Division of Hydrography, Bulletin 2, 75 p.

TEC. 2010. Type 1 Letter Report – Re-evaluation of the Tier 3 Risk Assessment/Groundwater Model & Proposed Course of Action Red Hill Bulk Fuels Storage Facility, Pearl Harbor, HI Contract #N47408-04-D-8514, Task Order 54. For G. Yamasaki, RISC Pearl Harbor. 4 May 2010.

Wentworth, C.K. 1942. Geology and ground-water resources of the Moanalua-Halawa District. Prepared for the Honolulu Board of Water Supply, 156 p.

Wentworth, C.K. 1951. Geology and ground-water resources of the Honolulu-Pearl Harbor Area. Prepared for the Honolulu Board of Water Supply, 120 p.

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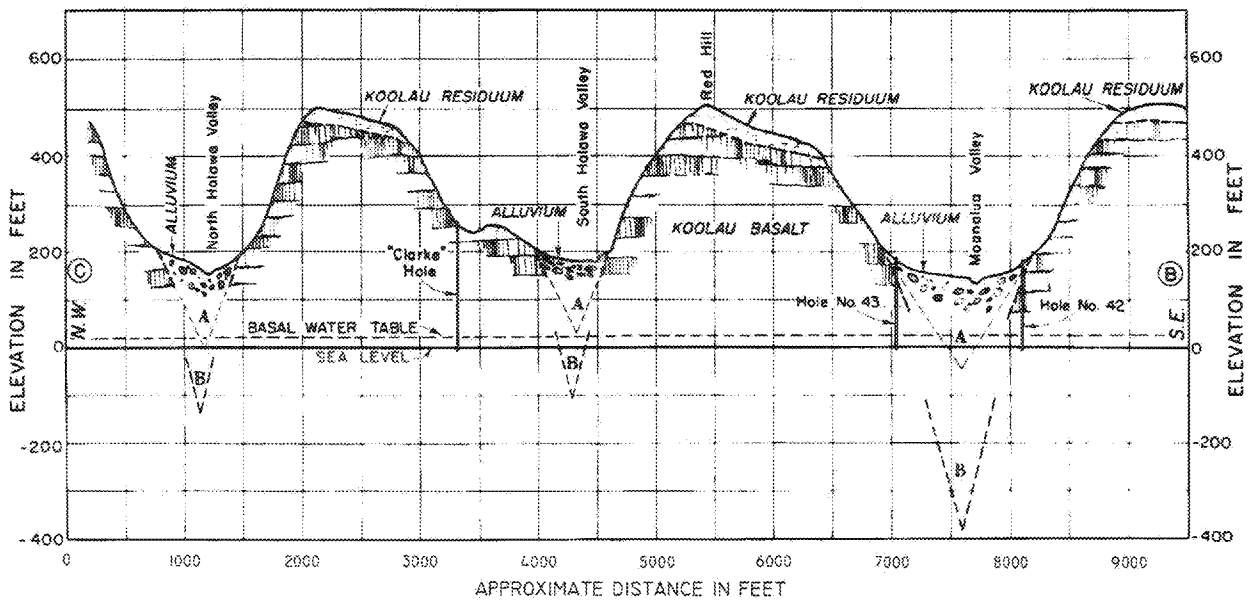
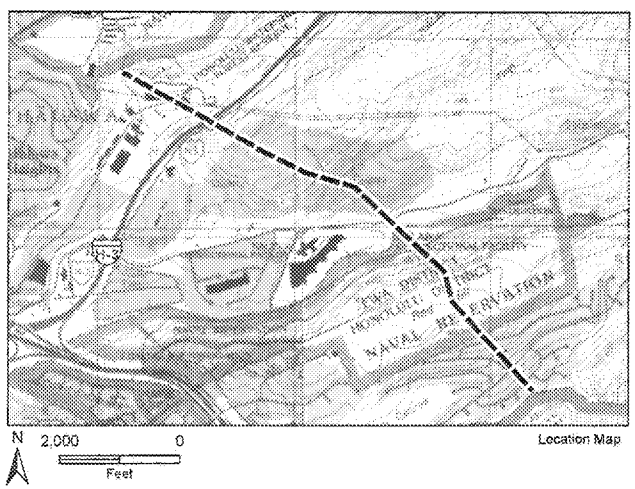




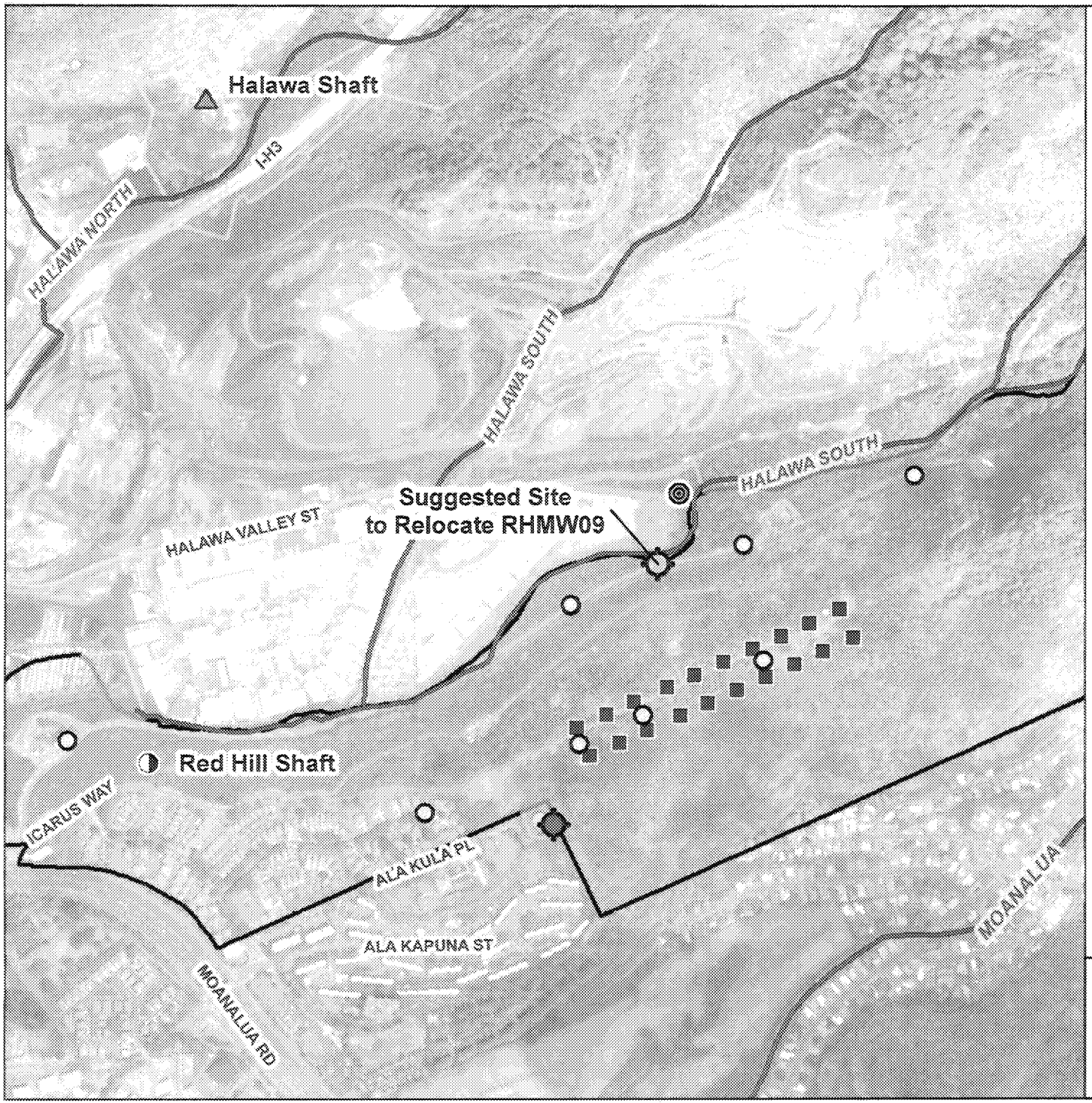
Sources:
Cross section – *Geology and Ground-Water Resources of the Moanalua-Halawa District*, C.K. Wentworth. 1942.
Topo – USGS, 7.5 minute Quad, dated 1998-99

Approximate Cross Section Location

Per Wentworth, 1942:
"Geologic cross-section from Kalihi to Aiea, along a line tangent to the several 500 foot contour loops on the spur facets. The several drill holes indicated are not on this line but each is projected into the cross-section in a position corresponding closely with its relation to the valley and the valley wall. The basal water table from Kalihi to the east side of Moanalua approximates the elevation of 24 feet (October, 1942); on the west side of Moanalua Valley is a drop of about 0.70 fee. then one to 21.7 west of South Halawa and to 19.50 west of possible rock profiles A and B are based on width and steepness of valley topography. Profile A is about the shallowest that seems plausible; profile B is no deeper than is possible if rock walls continue to steep as some revealed in Palolo Valley by drilling."

Note: The portion of the original cross-section from Kalihi to Moanalua (A to B) is not shown here.

Figure 1
Geologic Cross-Section Through Halawa Valley from Wentworth (1942)



N

900 0 900

Feet

Sources: Aerial – Oahu Imagery Service, dated 2010

Legend

- RHMW09 Recommended Alternative Location
- Planned BWS Monitoring Well
- Navy WSW
- BWS WSW
- Navy Monitoring Well
- CWRM Deep Monitoring Well
- Tank
- Stream
- Red Hill Bulk Fuel Storage Facility
- Parcel Boundary

Figure 2
Suggested
Alternative Location
for RHMW09