BOARD OF WATER SUPPLY

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February 13, 2018

Mr. Omer Shalev
United States Environmental Protection Agency
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and

Ms. Roxanne Kwan
Solid and Hazardous Waste Branch
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Department of Health
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Dear Mr. Shalev and Ms. Kwan:

Subject: Board of Water Supply (BWS) Comments on the Red Hill Administrative Order on Consent (AOC) Statement of Work (SOW) Sections 6 and 7 Groundwater Modeling Working Group Meeting No. 7 held January 11, 2018

The Honolulu Board of Water Supply (BWS) offers the following comments on the above referenced meeting. In order to help communicate our comments on specific slides, we have included a copy of the Navy slide presentation from the January 11, 2018 meeting in Attachment A. Our comments focus on the development of the interim groundwater model and include previous concerns that we feel have not been adequately addressed.

General Comments:

1. Uncertainty Analysis: The Navy's approach does not include the type of uncertainty analysis that the BWS has advocated since the groundwater modeling meeting No. 3 in August 2017. There were no data presented in the January 11, 2018 work group meeting that have changed our position. In fact, the data presented during the January 11 meeting concerning the vertical and

horizontal hydraulic gradients calculated in the vicinity of RHMW11 supports the need for an uncertainty analysis.

2. Hydraulic Characterization of Basalt: The Navy modeling approach represents the basalt as a homogeneous unit across the entire model domain and across all model layers despite field data that demonstrates, in the vicinity of Red Hill, the basalt contains considerable heterogeneity and conduits such as clinker zones and lava tubes that will cause preferable flow paths. Given that numerous studies have shown that the spatial variability of the aquifer hydraulic properties is a primary factor that often prevents accurate simulations of contaminant migration and hydraulic containment of a plume, the BWS recommends that the Navy provide a more realistic representation of the basalt properties than the homogeneous representation used in previous regional-scale models of groundwater flow. Over simplifying the characteristics as the Navy's consultants insist on advocating will bias the model results.

3. Vertical Hydraulic Gradients at RHMW11: Large vertical hydraulic gradients were measured in RHMW11 before and after the Westbay packers were inflated. Both sets of measurements have implications to the site conceptual model that were not adequately addressed during the meeting. The occurrence of large vertical gradients in RHMW11 before the Westbay packers were installed indicates that large downward flow occurs in the annulus from the saprolite to the basalt. These large vertical gradients are not consistent with the Navy assumption that the saprolite has a low permeability. The occurrence of large downward vertical gradients in RHMW11 after the Westbay packers have hydraulically isolated the measurement intervals indicates that a shallow flow system in the alluvium or upper saprolite could be independent from the deeper regional flow system in the basalt aquifer. These large hydraulic gradients are not consistent with the site conceptual model presented by the Navy in September 2017. The BWS recommends that the Navy's conceptual site model be updated so that it is consistent with the large vertical hydraulic gradients measured at RHMW11 before and after the Westbay packers were inflated.

4. Horizontal Hydraulic Gradients at Red Hill: The Navy's presentation concerning horizontal hydraulic gradients was incomplete and inadequate.

    - Among the important missing data was the top and bottom of each well screen, the elevation of the tops and bottoms of the model layers at the well location, and measured water levels. The BWS recommends that the Navy tabulates the well information and provide it to the SMEs for review.

- The data analysis used to generate water level contours and hydraulic gradients were generated without adequate consideration of the location of the well screens. For instance, Well HDMW2253-03 is a deep monitoring well that extends to a depth of 1,585 feet below ground surface (bgs) but the Navy has used its water level to estimate hydraulic gradients in the shallow groundwater zone. The BWS also has similar concerns with the Navy's assumption that the measured water levels in RHMW07 are reflective of the water level in the shallow basalt flow system. The BWS recommends that the Navy revise their methods for interpreting water level measurements to adequately account for important considerations such as well screen location, vertical hydraulic gradients, and heterogeneity in the basalt hydraulic properties.

- During the Navy's discussion of the hydraulic gradients for 2006, 2015, and 2017, the Navy's consultant said that the predicted hydraulic gradients would not be used to constrain the model calibration because their directions were suspect and not believable. The BWS recommends that the Navy use the hydraulic gradient as a calibration metric but only after the Navy has revised its protocols to correct for sampling bias. The BWS also recommends that the Navy include regional hydraulic gradients (including wells outside the Red Hill footprint) as part of the model calibration process.

- The large vertical hydraulic gradients at RHMW11 and the questionable hydraulic gradients calculated from groups of wells at Red Hill indicate that the groundwater flow system is more complex than the system that the Navy portrayed when the Navy discussed their model layers. Based on the new data from RHMW11 alone, the BWS recommends that additional model layers be added to the interim model to help better represent the three-dimensionality of the groundwater flow system.

5. Approach to Developing Groundwater Flow Model: The Navy's approach for developing the interim groundwater flow model does not provide sufficient information regarding the direction and rate of groundwater flow in the vicinity of Red Hill to support a risk assessment of contaminant migration to Halawa Shaft. The Navy's plans to develop a groundwater flow model that has been primarily calibrated using a series of "steady state" approximations with uniform hydraulic properties for the basalt, uniform properties for the saprolite, and model layers that have not been adequately vetted and are not supported by the BWS for the following reasons:

- The Navy's plan to calibrate to average water levels calculated from multiple transient water levels measured at a well greatly increases the size of the tolerance limit a model can have and still be considered to be calibrated. A tolerance limit is the maximum difference (referred to as error by the Navy) allowed between the modeled and measured water level at a well that is considered a satisfactory match. The BWS advocates the development of a transient model that is calibrated using a series of measured water levels at a well with error of plus or minus a few tenths of a foot instead of the Navy's development of steady-state models that are calibrated using water level measurements with a tolerance limit of ± 2-feet at an observation well and a tolerance limit of ± 4-feet at a pumping well.

- Given the very flat hydraulic gradient and the high transmissivity value of the basalt in the vicinity of Red Hill, the tolerance limits adopted by the Navy are set sufficiently large that the model calibration could produce a groundwater model that is unrepresentative of site conditions. The large tolerance limits for the water level targets are aggravated by the lack of any measured values of hydraulic conductivity and by the fixed values for the principle axes and vertical anisotropy for the hydraulic conductivity tensor although there are no field tests in Red Hill to justify such assumptions. The BWS recommends that the Navy fully investigate options to develop a set of calibration targets that will best support the development of a well-constrained, calibrated flow model.

- The Navy's plan to use model layers of constant thickness measured from the water table has not yet been properly justified. The BWS recommends that the Navy justify the model layering with respect to the screen intervals of the observation wells and the shafts, hydraulic gradients measured between wells assigned to the same model layers, cross-sections showing differences in the physical and hydraulic features of the basalt, evaluations of possible vertical hydraulic gradients, and vertical profiles of total dissolved solids concentrations.

6. Saprolite Extent and Hydraulic Properties: The Navy has presented field testing results that indicate that saprolite at monitoring well RHMW11 extends below the water table and likely includes zones of relatively low permeability. However, the Navy's proposed extension of saprolite with low permeability to the other valley areas is not justified based on limited testing at a single well location. Further, taking this approach in the interest of time, simplification, and making estimates based on a single data point eliminates the likelihood that Red Hill contamination

can migrate across Halawa Valley and so predetermines a conclusion. The BWS cannot support such a biased non-conservative model and such a predetermined conclusion. The BWS advocates that assumptions regarding saprolite should be conservative relative to its impact to prevent contaminant migration away from Red Hill until additional characterization of the saprolite shows otherwise.

7. Large Light Non-Aqueous Phase Liquid (LNAPL) Retention Capacity of Unsaturated Zone: The Navy conceptualized the basalt as having a large capacity to retain fuel in the vadose zone and provided calculations to show that millions of gallons of LNAPL could be spilled before any LNAPL would reach the water table. Such a conceptualization contradicts the recent observations of LNAPL reaching the groundwater near RHMW02 in 2005 and again within days or weeks after a release of approximately 30,000 gallons of fuel in January 2014. The Navy has advocated that fuel contaminants can slowly migrate toward the water table following a release of fuel from the facility, but ignores the evidence of rapid vertical migration of LNAPL to the groundwater has also occurred. The Navy's conceptual model for LNAPL migration is not consistent with measured concentrations of LNAPL constituents in groundwater and the conceptual model for LNAPL transport in basalt supported by several SMEs working for DOH and BWS. The BWS recommends that the Navy reevaluate and modify its conceptualization of LNAPL migration to include conservative assumptions for vertical migration.

8. Use of Red Hill Shaft as a Remediation Option: The Navy's approach assumes that the financial and institutional resources for groundwater remediation will be available for an unknown but potentially very long period of time. The BWS believes that the Navy has not yet demonstrated that this is a reasonable assumption. The BWS recommends that the Navy develop a groundwater model that can evaluate both hydraulic capture by Red Hill Shaft as well as the risk from contaminant migration to Halawa Shaft.

9. Groundwater Database: The Navy has not yet provided any data from their groundwater database. Without access to the site data, BWS' ability to evaluate the Navy's assumptions and modeling approach is considerably less than what it otherwise would be given access to the groundwater database. The BWS would like to know if, and when, the Navy may release the database to EPA, to DOH, and to BWS.

Specific Comments

- Slide 11. Measured water levels in in the Westbay well RHMW11 are 80 feet higher in the shallow zone (Zone 8A) than they are in the deeper zones

(Zones 1-5). The Navy's conceptual model of groundwater flow assumes the water level is the same in the shallow and deep zones. It appears that the Navy will ignore the water level results from RHMW11 in developing the groundwater model. This field data demonstrates that conditions are complex, are not yet understood by the Navy, and the Navy model is too simple to provide realistic and reliable answers. The complex hydrogeology in the vicinity of RHMW11 is evidence that the Navy needs to incorporate more layers and a better understanding of the basalt hydrology in their model.

- Slide 11 (continued). The following questions need to be answered by the Navy's conceptual model. Why does a large vertical groundwater gradient exist at RHMW11? Is it flow from the quarry, recharge from South Halawa Stream, high recharge from precipitation in the valley or some other condition/mechanism? Does the elevated water table in RHMW11 affect flow within the basalt aquifer?

- Slide 12. The Navy presented field test results indicating that the saprolite at RHMW11 has a relatively low permeability. However, the field tests may have produced low permeability values because of problems with the testing method and AECOM has said that it will conduct more tests to indicate whether a problem exists. AECOM stated that results from a seismic survey support the notion that a thick and extensive zone of saprolite exists in the valley around RHMW11. Survey results were not ready for presentation at this meeting but will be provided at the next meeting.

- Slides 29 to 32. Groundwater flow directions calculated from average water levels for 2006, 2015, 2017 as well as the November 2016 synoptic monitoring study are not consistent with the conceptual flow model of groundwater flowing in the general direction of Pearl Harbor. Several groups of wells indicate an up-hill groundwater flow direction. These results are likely due to spatial heterogeneity and vertical hydraulic gradients in the basalt that are ignored in the Navy's analysis. The Navy has decided not to use flow directions calculated from field data to help constrain the model calibration. This field data demonstrates that conditions are complex, are not yet understood by the Navy, and the Navy model is too simple to provide realistic and reliable answers. Additional model layers and hydrologic data are needed to adequately represent groundwater flow in the basalt aquifer. The unexplained flow directions demonstrate the need for an uncertainty analysis.

- Slides 29 to 32 (continued). The potential fate and transport of fuel off-site from Red Hill is better represented by regional gradients as observed between wells at Red Hill and those elsewhere in the basalt aquifer rather than between wells at Red Hill alone. It is therefore important to determine whether flow directions from a similar analysis involving wells both inside and outside of Red Hill make sense and, if so, include them in the model calibration.

- Slides 82 to 86. The Navy presented preliminary results from their model showing that no groundwater from Red Hill can be captured by Halawa Shaft. However, the Navy model does not consider any spatial variability or heterogeneity in the basalt aquifer hydraulic properties. The Navy argues that adding heterogeneity in the basalt aquifer properties is unnecessary complexity. The BWS continues to be concerned that the Navy will discount the importance of heterogeneity as "unnecessary complexity" to avoid addressing model uncertainty.

- Slides 126 to 128. The Navy presented a spreadsheet model that claimed that millions of gallons of LNAPL can be held by the vadose zone. The claim was challenged because the spreadsheet model ignores the physics associated with LNAPL migration and ignores the fact that LNAPL has already reached the water table. Fenix Grange indicated that DOH may have their consultant Gary Beckett provide the group with a model that shows that the unsaturated zone below the tanks has a much lower capacity to retain LNAPL. If the Navy can argue that the unsaturated zone can retain a large volume of LNAPL, that argument may be used to underestimate the risk of leaks to contaminate receptor wells such Halawa Shaft and Moanalua Wells.

- Slides 126 to 128 (continued). The Navy views the LNAPL migration as occupying a pervasively, laterally large extent in the unsaturated zone as it moves downward. As a result, the unsaturated zone is perceived by the Navy to act as a sponge that holds LNAPL and limits its downward migration. In reality, LNAPL migrates along narrow, preferential flow pathways that follow fractures or small portions of high permeability clinker zones.

We continue to ask that the Navy distribute meeting handouts and other information documents two weeks prior to the start of each meeting to ensure subject matter experts, the BWS, and other stakeholders are afforded the opportunity to thoroughly review the materials ahead of time. We also request that the Navy and its contractors provide copies of all materials disclosed at the meeting that they committed to share with subject matter experts.

Thank you for the opportunity to comment. If you have any questions, please feel free to call Erwin Kawata at 808-748-5080.

Very truly yours,

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Enclosure: Attachment A, Navy Slide Presentation Dated January 11, 2018