DEPARTMENT OF HEALTH
Contested Case Hearing Re Red Hill Permit Application
19-UST-EA-01
Supplemental Testimony of Curtis Stanley

This supplemental testimony was prepared in response to the Written Testimony of Nicole M. DeNovio ("Dr. DeNovio") and the report incorporated into that testimony entitled "Evaluation of Hydrology, Groundwater Flow and Contaminant Fate and Transport," both of which are dated December 29, 2020 (collectively, the "DeNovio Testimony PDF"). Dr. DeNovio's report and testimony contain errors that lead to incorrect conclusions regarding site conditions and environmental protectiveness. The details related to the Navy's review of Dr. DeNovio's report and associated inaccuracies are provided in Table 1. This table is formatted to describe particular issues noted in her report along with a brief response describing errors and other concerns. The following testimony addresses these errors to show that:

1. Dissolved fuel concentrations in groundwater have been stable or decreasing during the 15-plus years of groundwater monitoring indicating no new impacts to groundwater during that time period and that ongoing natural attenuation is occurring.
2. The groundwater monitoring well network, designed in consultation with DOH, EPA, and others meets DOH's requirements and guidance and confirms that groundwater impacts are isolated to the area near the Facility tanks.
3. The basaltic lava rock formation between the tanks and the groundwater has a significant holding capacity to retain petroleum releases.
4. Data confirm that both natural source-zone depletion and monitored natural attenuation are remediating the releases via natural processes and keeping the drinking water safe.
5. Data demonstrate that the soil vapor monitoring is effective at detecting releases.
6. The groundwater modeling efforts, conducted in consultation with DOH, EPA, USGS,

and others, reflect the local geologic conditions and data.

7. No separate-phase fuel product has been measured in any groundwater monitoring well.

8. Dr. DeNovio's overall conclusions regarding the potential environmental impacts of the Facility are not correct.

1. Historical releases resulted in impacts to the groundwater that are confined to the vicinity of the tanks and have been stabilized by natural bioremediation and attenuation processes.

Dr. DeNovio states that "Groundwater sampling concentrations from monitoring wells in the heart of the Facility show statistically significant trends for total petroleum hydrocarbon middle distillates (TPH-d) from 2015 to present,"[1] and the attached report also states that "trend analysis indicates the potential for ongoing impacts" to the aquifer.[2] Table 2.2-1 of the report tabulates 24 trend analyses of partial data sets, only one of which showed an upward trend. Dr. DeNovio states that this single trend "is inconsistent with wide-spread biodegradation of historical fuel releases or fuel released in 2014."[3] The full environmental dataset, however, shows that ever since groundwater monitoring began in 2005, the near-tank wells have either stable or decreasing concentration trends, depending on the individual monitoring well and constituent

[1] DeNovio at 3 ((DeNovio Testimony PDF page no. 3).

[2] Golder at 21 (DeNovio Testimony PDF page no. 34).

[3] Golder at 32 (DeNovio Testimony PDF page no. 45).

evaluated. The full dataset also shows that the "perimeter" wells discussed in the FER, including the drinking water wells, have not been impacted by releases.

The analyses presented in Table 2.2-1 and Figures 2.2-11 and 2.2-12 of Dr. DeNovio's report are based on a cherry-picked subset of the environmental data that does not reflect the long-term trends evident in the complete dataset. As shown on Figure 1, below, analyses of the complete TPH dataset for the three wells near the tank farm clearly indicate decreasing concentration trends in RHMW02 and RHMW01 over the course of the monitoring program and a flat trend in RHMW03. Figure 1 also shows that concentrations in RHMW03 have always been less than the environmental action level (EAL),[4] and concentrations in RHMW01 have consistently been below the EAL since 2008.

An important point that is not discussed by Dr. DeNovio is that TPH in RHMW03 (as well as in RHMW01 and RHMW03) was also analyzed by silica gel cleanup (SGC) analyses as well as additional analyses of natural attenuation parameters ("NAPs"). SGC is a technique that is used to differentiate petroleum hydrocarbons from polar material

[4] EALs are used to "identify *potential* environmental hazards. Under most circumstances…the presence of a chemical in soil, soil vapor, or groundwater at concentrations below the corresponding Tier 1 EAL can be assumed to *not* pose a significant threat to human health and the environment." State of Hawai'i, Department of Health, Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater ("EHE Guidance"), available at https://health.hawaii.gov/heer/files/2019/11/Volume-1-HDOH-2017.pdf , p. vii (emphasis added). "Actual site conditions could differ, causing the contaminants to pose a much *lower* threat to human health and the environment than a simple, action level evaluation might imply." EHE Guidance, p. 3-5 (emphasis added).

(non-hydrocarbon material associated with decomposition of organics) that comprise TPH. The Navy conducted SGC analysis, which is recommended in DOH's TGM for sites with TPH to further understand if attenuation and biodegradation is taking place. At Red Hill, multiple rounds of SGC analyses have confirmed that TPH detected in near tank monitoring wells consists mostly of polar compounds, indicating both that the TPH is not associated with a recent release and that natural bioremediation and attenuation processes are at work. These SGC data refute Dr. DeNovio's hypothesis that the trend is "inconsistent with wide-spread biodegradation of historical fuel releases."[5]

Furthermore, there is no evidence that petroleum has moved to perimeter monitoring wells or drinking water supply wells, which indicates that the historical releases are naturally attenuating and stable in the environment. According to DOH guidance, petroleum impacts "rarely extend more than 150 meters from the original release area in the absence of MTBE [methyl tert-butyl ether] or other persistent and highly mobile chemicals."[6] Natural attenuation of petroleum constituents is recognized by state and federal environmental regulators as a way "to remediate fuel components from leaking underground storage tanks."[7]

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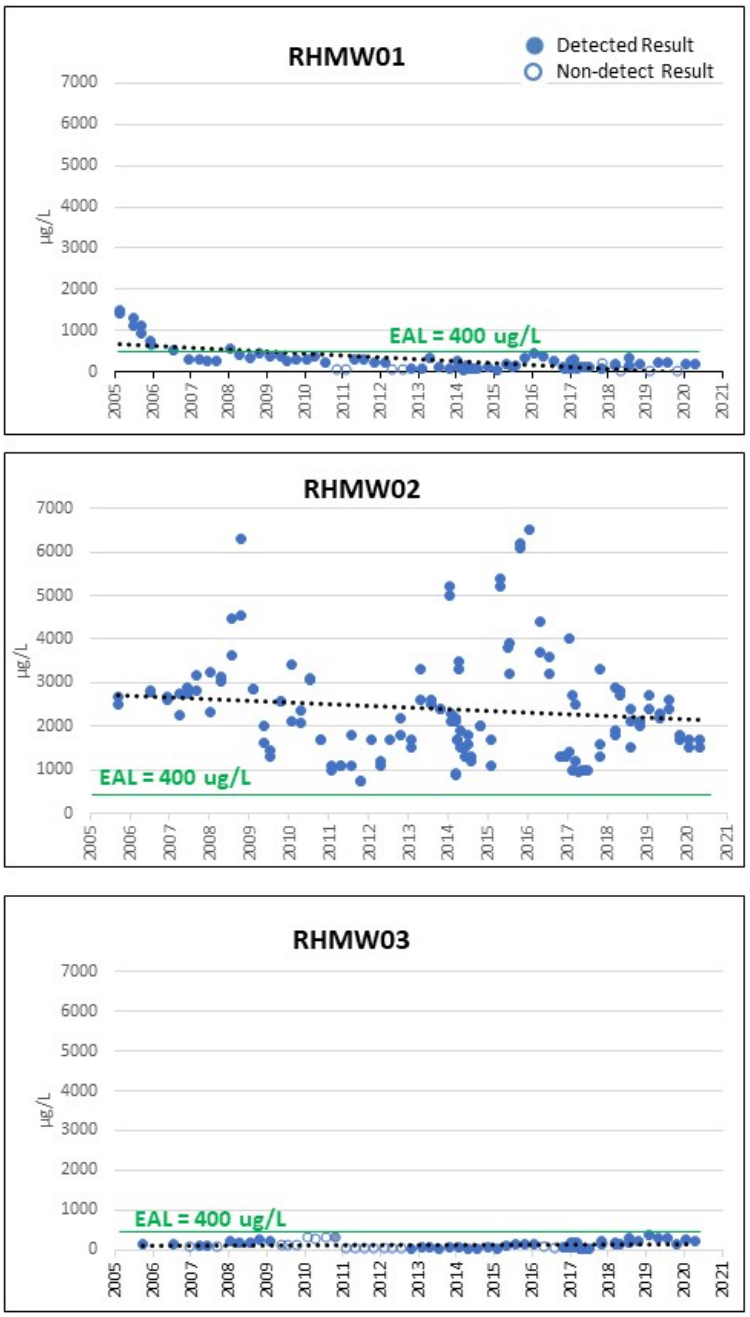
[5] Golder at 32 (DeNovio Testimony PDF page no. 45).

[6] TGM, App. 19-A "Long-Term Management of Petroleum-Contaminated Soil and Groundwater."

[7] US. EPA, Research Advances Monitored Natural Attenuation (MNA) Techniques for Effective Site Cleanup, available at http://hawaiidoh.org/references/USEPA%202007d.pdf, and cited in DOH's guidance, TGM "Master Reference List," available at http://www.hawaiidoh.org/tgm-pdfs/TGM%20Section%2022.pdf.

Dr. DeNovio states that "the documented 2014 fuel release corresponds to increases in fuel constituents observed in groundwater,"[8] referencing Figure 2.2-4. This slide does not account for the significantly increased sampling of RHMW02 that occurred after the 2014 release (increasing from 8 COPC samples in the year prior to the release to 23 COPC samples in the year after the release). Since RHMW02 (and other near-tank wells) is where most of the COPCs and other analytes have been detected, of course the number of detects would go up significantly since the wells with the detects were being sampled more frequently after the release. This is not a result indicative of trends in groundwater concentrations, rather is attributable to increased sampling of wells with known detects. Relatedly, and to the contrary, the chemistry lines of evidence described in the CSM demonstrate that the 2014 release did not impact groundwater. As can be seen on Figure 2, below, the normalized ratio of detects per sample indicate a modest range of variability over the years, likely associated with the use of multiple labs. This figure also depicts a modest rise in the ratio prior to the 2014 release in 2013 (when there was no fuel in Tank 5). In 2014, the ratio decreases and then goes back up in 2015. This range of modestly elevated ratios in the 2013 – 2015 time period is actually lower than other observed ratios in the past and again is likely due to the use of multiple labs over time which conduct TPH analyses in a slightly different manner between labs resulting in different results for the same sample.

[8] Golder at 23 (DeNovio Testimony PDF page no. 36).



Observed Trend

RHMW01:
TPH-d concentrations show an overall decreasing trend over time.

No detections above the EAL after 2008.

RHMW02:
TPH-d concentrations have varied with an overall decreasing trend over time.

This is the only well in the monitoring network in which concentrations typically exceed the EAL.

RHMW03:
TPH-d concentrations have remained steady and relatively low over time.

No detections above the EAL during any monitoring event.

Figure 1: The complete data set for TPH-d concentrations over time in RHMW01, 02, and 03

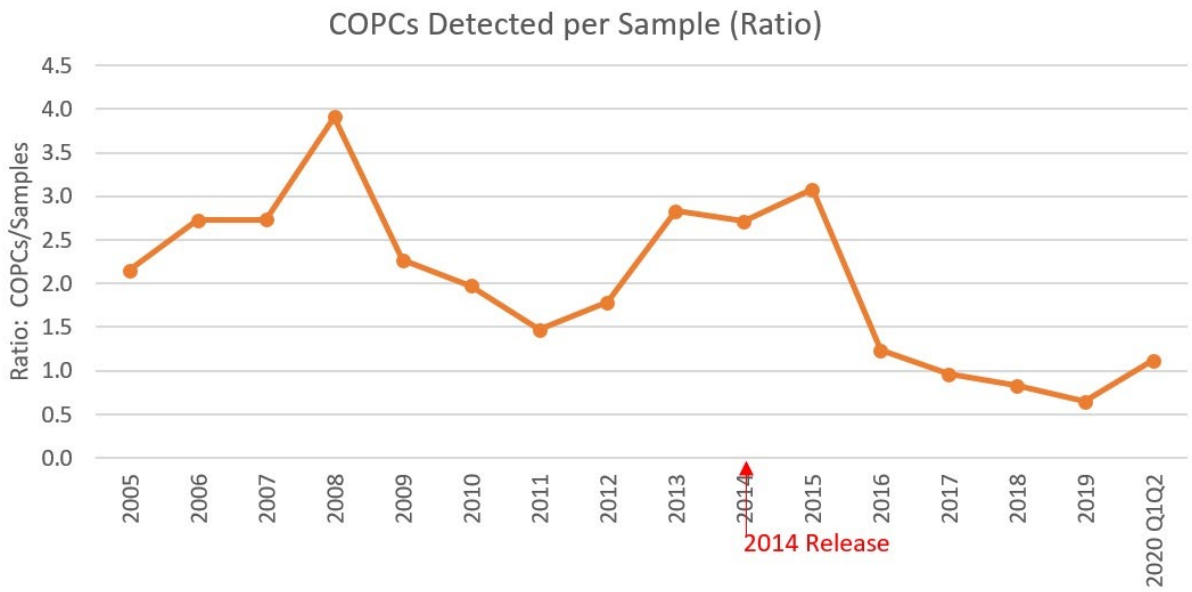


Figure 2. COPC Detection Ratio.

2. The groundwater monitoring well network was designed in consultation with DOH, EPA, and others; satisfies DOH's guidance; and delineates impacts above the EALs, as recommended by DOH.

Dr. DeNovio characterizes the groundwater monitoring well network as "sparse" and the monitoring wells as improperly constructed. However, the well network is sufficiently dense to demonstrate that impacts to the groundwater are confined to the area immediately below the tanks, and the construction of the wells conforms to DOH guidance. As Figure 3, below, shows, monitoring well RHMW02 is the only monitoring well that consistently exhibits detectable concentrations of petroleum "chemicals of potential concern" ("COPCs") at concentrations exceeding EALs. The two monitoring wells closest to RHMW02, and in close proximity to the tanks (RHMW01 and

RHMW03) are less impacted, typically exhibit detectable concentrations of COPCs at concentrations less than EALs, and the detectable concentrations are comprised of mostly polar material, indicative of naturally occurring biodegradation. All the other groundwater monitoring wells (the perimeter wells surrounding the tank farm), including the nearby drinking water well, normally do not have detectable levels of fuel-related analytes.[9] The Navy continues to plan additional expansions to the groundwater monitoring well network, after expanding it from 6 monitoring wells in 2013 to 19 in 2020 (with an additional 8 wells planned in the near future). We also note that DOH reviewed and approved the locations and construction of the wells installed by the Navy. Although Dr. Denovio suggests that more wells might be desirable in the immediate vicinity of the tank farm, early discussions with the regulators during AOC scoping identified concerns over installation of groundwater monitoring wells in the immediate vicinity of the tanks, which could create conduits to the aquifer should a hypothetical future release occur. DOH agreed that additional wells near the tanks could be counterproductive, and such wells have been unnecessary to delineate the impacts.

[9] This discussion of the Facility monitoring well network does not include well OWDFMW01, which was installed at a different release site, and which is under a separate investigation; OWDFMW01 sporadically exhibits hydrocarbons that are not associated with releases from the fuel tanks. This discussion also does not include recently installed monitoring wells that have not been yet been included in the Quarterly Groundwater Monitoring Reports.

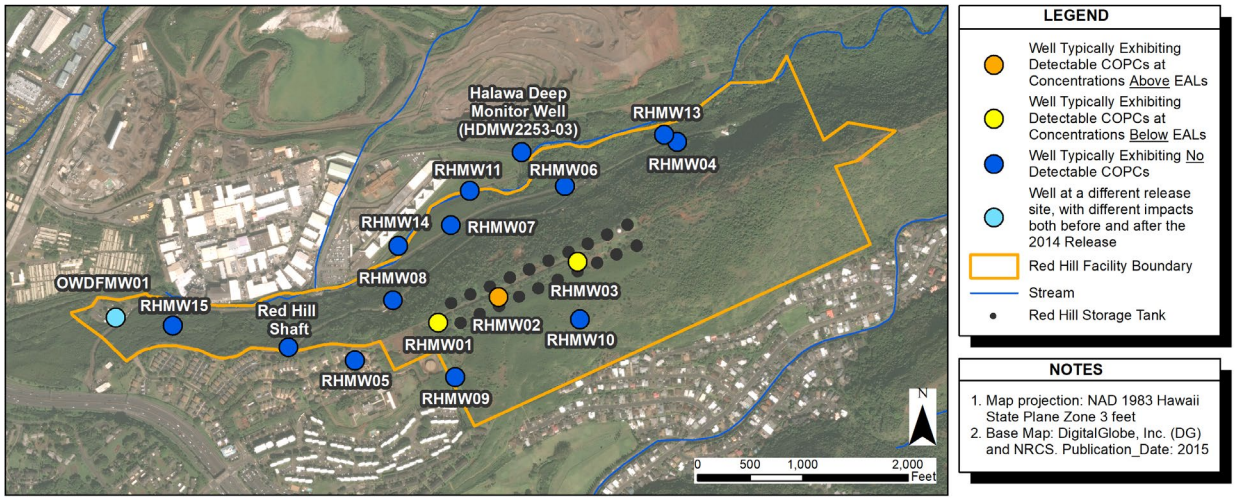


Figure 3: Summary of Groundwater Monitoring Results Demonstrating Delineation of Groundwater Impacts

Dr. DeNovio questions the reliability of data from "2-inch monitoring wells."[10] These wells conform to DOH guidance: "Typical well diameters for environmental investigations are 2 to 4 inches, depending on the objective of the well installation (e.g., site investigation [typically 2 inches] or groundwater remediation [typically 4 inches]) and the proposed monitoring and test equipment. When practical, the casing diameter should not exceed 4 inches…."[11] Wells at the site range from 2 to 4 inches in diameter, as recommended by DOH.

[10] Golder at 15 (PDF page no. 28).

[11] TGM § 6.2.1.1.

Dr. DeNovio also erroneously states that the wells have "short screen intervals" and therefore may not detect LNAPL.[12] DOH recommendations state that: "The maximum recommended screen length is typically 10 feet. The screen length should be kept as short as possible to accomplish the required task."[13] Figure 4, below, shows the dimensions of the conventional monitoring well screens installed in the unconfined basal aquifer, all of which exceed DOH's 10-foot recommendation to help assure that the screen interval would intersect the water table during different pumping conditions. These well designs were reviewed and approved by DOH prior to installation. Although RHMW01 does not intersect the water table under current pumping conditions, the Navy is planning to replace this well with a new well appropriately constructed so that the screen intersects the water table.

Dr. DeNovio also states that "Sampling methods similarly rely on dedicated pumps installed below the water table, which prevents observed LNAPL in groundwater samples."[14] However, the pumps would not prevent the observation of LNAPL, if any had ever present, because the pumps are installed 10 feet below the groundwater surface in accordance with the DOH-approved sampling and analysis plan.

[12] Golder at 16 (DeNovio Testimony PDF page no. 29).

[13] TGM § 6.2.1.1.

[14] Golder at 17 (DeNovio Testimony PDF page no. 30).

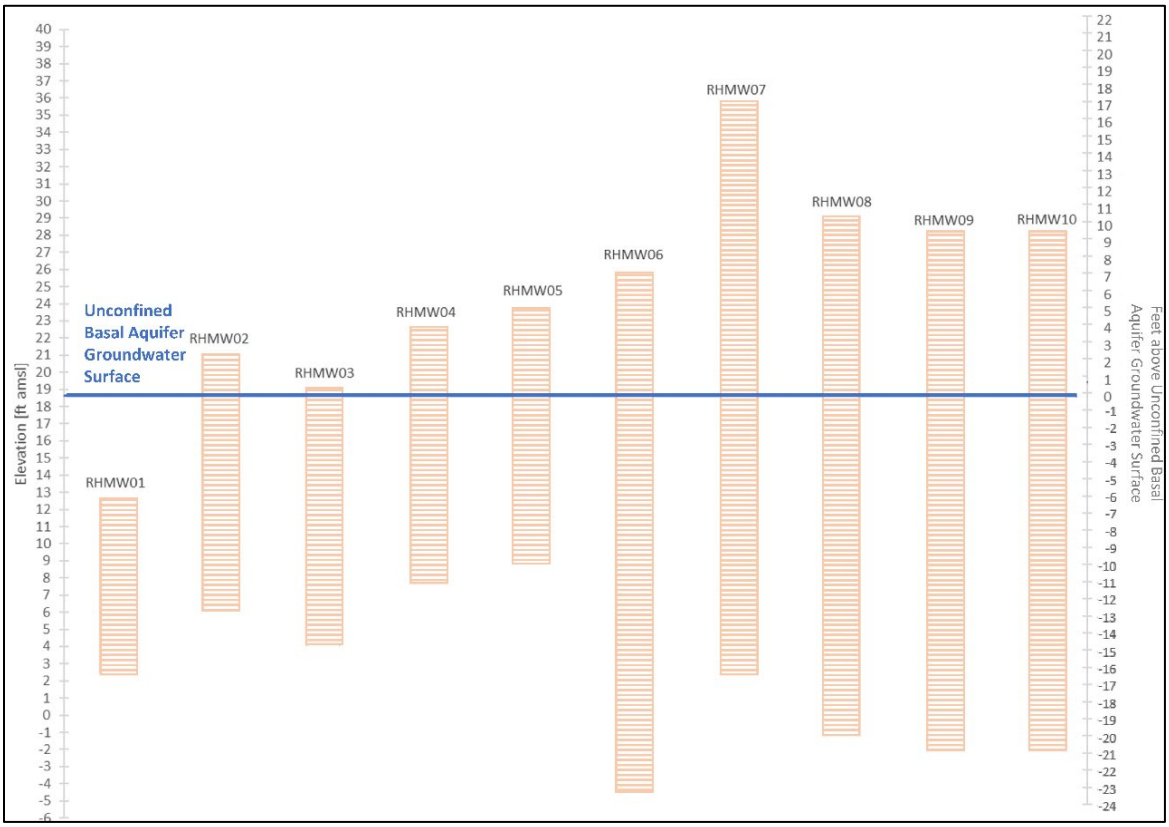


Figure 4: Dimensions of conventional groundwater monitoring well screens installed in the unconfined basal aquifer.

Four "Westbay" multilevel monitoring wells have been installed in the monitoring well network, mostly in Hālawa Valley north of the Facility. These multi-level monitoring wells, the first of their kind installed in Hawai'i, gather far more data than a conventional monitoring well and demonstrate the Navy's commitment to use of innovative technology. Unlike conventional monitoring wells, these multilevel wells allow the Navy to collect water samples, water levels, and other data from a broad range of depths at each well location. This data helped to answer some early questions regarding vertical flow and the possibility of deeper impacts from COPCs, which were ultimately not found to be

present or significant. Although they do not employ conventional screens, each of these multilevel zones includes sampling ports near the groundwater surface. Samples collected from this elevation, as well as the other elevations that the well allows sampling of, have not indicated the presence of fuel constituents from the Facility. These multilevel wells have been critical for understanding the complex geology and groundwater flow in Hālawa Valley and were installed after DOH and EPA reviewed and approved their design.

Dr. DeNovio also questioned the groundwater sampling data collected from the monitoring wells, stating that the difference between Navy and EPA laboratory results for two COPCs, TPH-d and PAHs, in 2017 "limits the interpretation of plume extent, reasonable groundwater attenuation rates, and transport velocities."[15] There are no EPA-approved methods for conducting TPH analyses (only guidance), although there are approved methods for the individual chemical constituents of TPH. Thus, EPA has issued guidance which allows for some variability in the analysis between labs. This analytical variability then results in different labs potentially reporting different TPH values (especially at low concentrations) even though they are all following the EPA guidance. This was the case with the Navy's contract lab and the EPA and actually only affected results from RHMW02 due to the high concentration of polar material. The Navy then adjusted the analytical approach to be more aligned with that of the EPA in order to get

[15] Golder at 23 (DeNovio Testimony PDF page no. 36).

more consistent results, keeping in mind that both analytical methods always conformed to EPA guidance. In addition to TPH, an extensive number of analyses have been conducted by the Navy since the beginning of the quarterly groundwater monitoring program. In an effort to present the chemical analytical program results in a relatively clear and easily comprehensible way, the FER showed that greater than 6,800 analyses of samples have been conducted for COPCs. Although the FER focused on COPC analyses, it is important to understand that the Navy has sampled and analyzed over 380 chemicals and parameters in addition to the COPCs, resulting in more than 44,000 analyses that contributed to a very comprehensive understanding of groundwater chemistry and the extent of groundwater impacts at Red Hill. All these analyses indicate that petroleum constituents due to past releases are confined to areas immediately beneath the tanks and that perimeter wells including drinking water wells have not been impacted from historical releases. The vast amounts of data are presented in the publicly available Quarterly Groundwater Monitoring Reports and are analyzed in great detail in the many additional publicly available reports cited in Section 4 of the FER.

3. The basalt formation between the tanks and the aquifer has a holding capacity and does not feature extensive vertical fracture networks.

In her report, Dr. DeNovio states: “available data does not support the Navy claims that natural attenuation processes such as Natural Source Zone Depletion (NSZD), Monitored Natural Attenuation (MNA), and Holding Capacity are preventing fuel releases from

reaching the Sole Source Aquifer."[16] The Navy has never pretended there aren't impacts to the groundwater below the tanks. As can be seen in the FER, the Navy never stated that the holding capacity "prevents" migration of fuel; rather, the holding capacity undoubtably "helps to impede" downward migration, which allows additional time for the measured NSZD to occur. Importantly, Dr. DeNovio's own statements in other sections of her report bolster the fact that the geologic formation is capable of holding released petroleum. Dr. DeNovio's Figure 2.2-5 contains direct evidence that petroleum was retained in the basalt when the soil vapor monitoring wells were installed immediately below the tanks. As shown on Figure 5, below, these cores selected by Dr. DeNovio are located in precisely the near-tank area where many different analyses confirmed that fuel is being held and subject to natural source-zone depletion ("NSZD") processes. Several sections of Dr. DeNovio's report agree that fuel is held in these areas. Biodegradation of old releases can only occur near the tanks if it is held there by the parent rock. Dr. DeNovio's report Section 2.2.3 states that visual staining of rock cores, photoionization detector ("PID") readings from rock cores, and temperature measurements all indicate that LNAPL is retained in the basalt above groundwater.

[16] Golder at 37 (DeNovio Testimony PDF page no. 50).

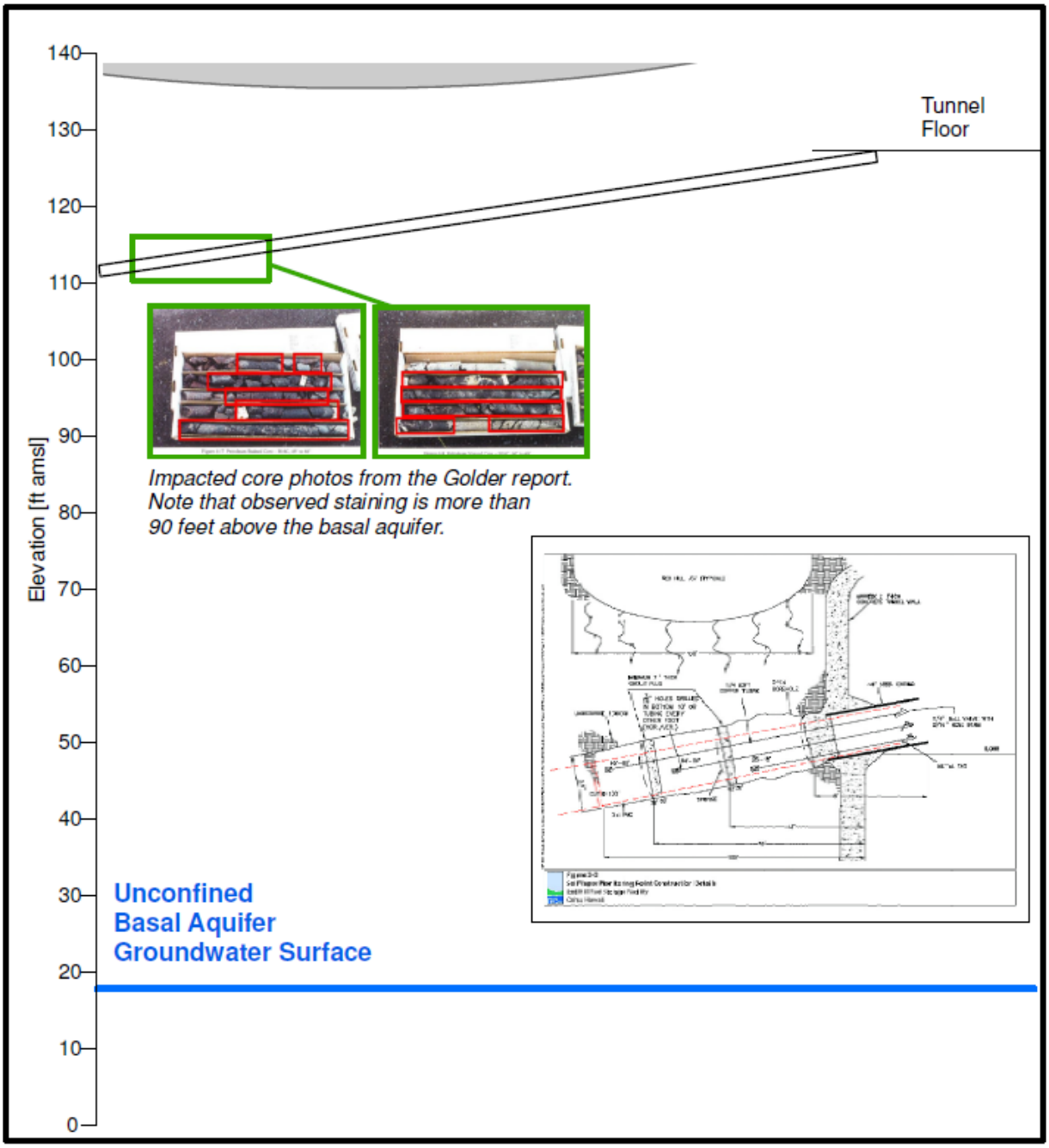


Figure 5: The impacted soil vapor monitoring wells described by Dr. DeNovio were located far above the groundwater aquifer, in the area within the rock's holding capacity.

The schematics on Dr. DeNovio's Figures 1-4.1[17] and 1.4-2[18] reflect conditions one might find in fractured bedrock on the mainland and do not accurately represent the multiple interbedded flows of volcanic bedrock found in Hawai'i and under the Red Hill tanks. Dr. DeNovio's Figure 1.4-1[19] depicts long vertical fractures such as those found in some mainland bedrocks, but vertical fractures typically do not pass through the multiple layers of interbedded volcanic flows found in Hawai'i and at Red Hill, which were placed during different eruption events.

4. NSZD and MNA operate at the site to limit the spread of groundwater impacts as the Navy studies confirm.

Monitored Natural Attenuation.

MNA is a process widely understood and globally recognized as a process capable of remediating dissolved constituents in groundwater. DOH and EPA are no exception. DOH specifically references and hosts on its website EPA guidance on MNA applicable to UST sites such as Red Hill. In one of these publications referenced by the DOH, EPA explains that:

> "Natural attenuation is the reduction of contaminants in soil or ground water through natural physical, chemical, or biological processes. The processes degrade or dissipate contaminants and include aerobic and anaerobic

[17] Golder at 10 (DeNovio Testimony PDF page no. 23).

[18] Golder at 11 (DeNovio Testimony PDF page no. 24).

[19] Golder at 10 (DeNovio Testimony PDF page no. 23).

biodegradation, dispersion, volatilization, and sorption. Natural attenuation can be used to remediate fuel components from leaking underground storage tanks…."[20]

Dr. DeNovio's own report ultimately concedes that the "spatial distribution of MNA parameters concentration confirmed active MNA processes in groundwater within the Tank Farm area."[21] These natural attenuation processes explain why groundwater impacts have not spread beyond the tank farm since the groundwater monitoring program began over 15 years ago.

Natural Source Zone Depletion.

Dr. DeNovio's alternative calculations of NSZD rates are based upon at least three errors. The Navy measured the rate of NSZD at the Red Hill Facility using two independent assessment methods: i) carbon dioxide flux and ii) temperature. These two methods yielded similar estimates for the rates of natural petroleum depletion at the Facility: 4,400–7,400 gallons per year for the carbon dioxide flux method and 2,600–17,300 gallons per year for the temperature method. Although neither method can provide a precise measurement of the depletion rate at the Facility (which has inherent natural variability), both methods demonstrated that natural depletion is occurring within an estimable range. Furthermore, the overlap of and general similarity between the two ranges of estimated depletion rates

[20] US EPA, Research Advances Monitored Natural Attenuation (MNA) Techniques For Effective Site Cleanup, a copy of which is hosted on the DOH website at http://hawaiidoh.org/references/USEPA%202007d.pdf.

[21] Golder at 42 (DeNovio Testimony PDF page no. 55).

(4,400–7,400 and 2,600–17,300 gallons per year) provides increased confidence that the approximate range of depletion rates has been determined.

For the carbon dioxide flux data, Dr. DeNovio conducted an alternative calculation that only considers one of the two components of the carbon dioxide flux: that measured at ground surface. The larger component of carbon dioxide flux is measured entering the Facility tunnel system, as illustrated on Figure 6, below. The tunnel ventilation system draws in air from the surrounding soil and rock, which includes carbon dioxide generated by NSZD. The tunnel is much closer to the NSZD zone than the ground surface is. Thus, the flux entering the tunnel system represents far more NSZD (3,400–6,400 gallons per year) than the surface flux component (1,000 gallons per year). Dr. DeNovio's report does not present any alternative calculations of the tunnel component, omitting it.

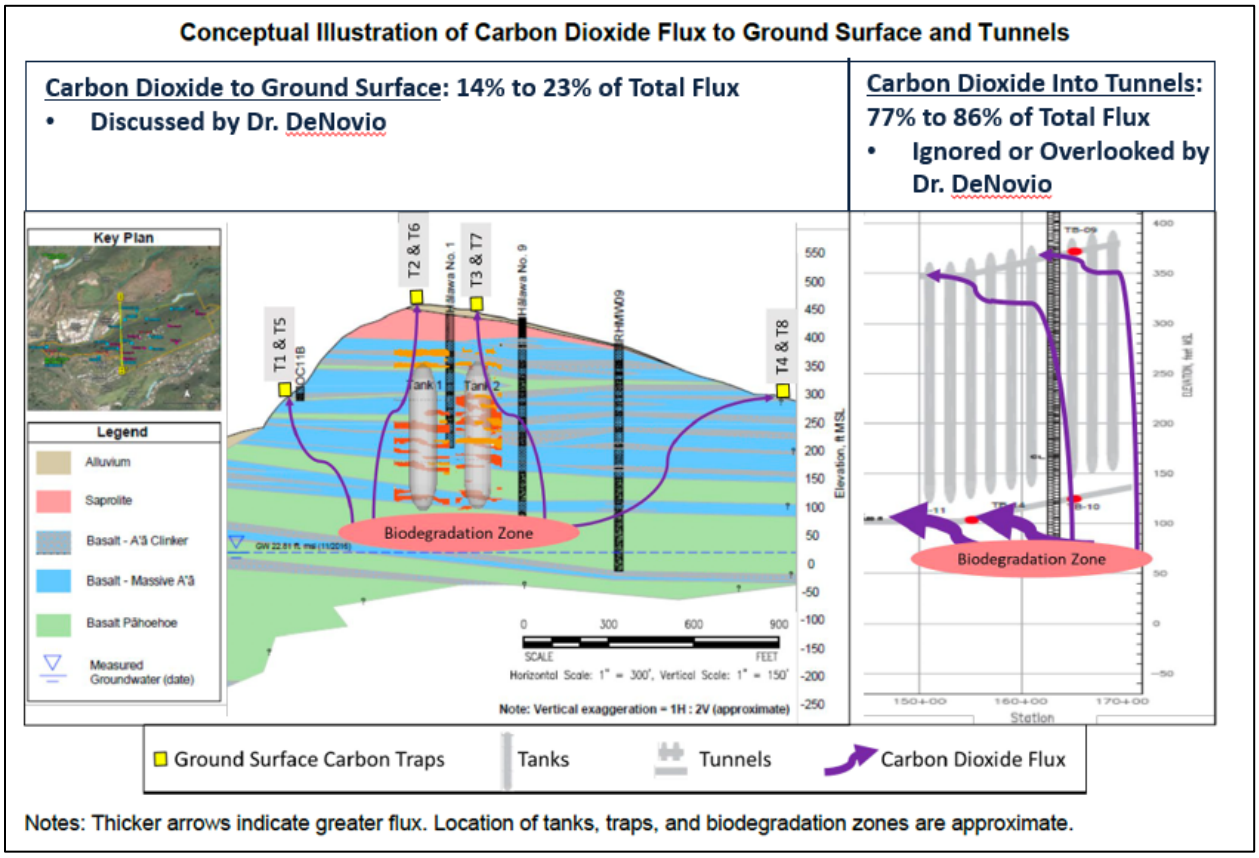


Figure 6. Dr. DeNovio's alternative NSZD calculation did not account for the largest component of carbon dioxide flux, which flows into the Facility tunnels.

Dr. DeNovio claims that "temperature differentials at the Tank Farm do not support the Navy's estimated NSZD rates."[22] First, elevated temperatures have been measured in the basalt rock formation beneath the tanks (generated by the biodegradation of residual fuels held in the vadose zone – similar to a compost pile) in the same area that other portions of Dr. DeNovio's report acknowledge contain residual fuel. In addition, both the Investigation and Remediation of Releases Report and the Groundwater Protection and

[22] Golder at 39 (DeNovio Testimony PDF page no. 52).

Evaluation Considerations for the Red Hill Bulk Fuel Storage Facility reports clearly show that the temperature data from all of the wells was considered and supported the NSZD analyses.

Dr. DeNovio offers no alternative explanation for the documented elevated temperatures in the areas nearest the tanks that are known to have been impacted by historical releases. The maximum temperature measured in the unsaturated basalt (30.1˚C, 86˚F) and the maximum temperature measured in groundwater (26.0˚C, 78˚F) below the tanks is much higher than the temperatures observed away from the tanks (typically 21˚C to 23˚C, 70˚F to 73˚F), according to the temperature data in the IRR report. These elevated temperatures are consistent with heat being generated from the degradation of petroleum fuel. As to the temperature of the rock below the tunnel, the maximum observed temperatures occur well below the base of the tanks, which means that these elevated temperatures cannot be attributed to ordinary Facility operations. As previously discussed, these temperature profiles are not seen in the unimpacted perimeter wells.

Dr. DeNovio states that "No evidence of gaseous oxygen concentration depletion has been measured at the Facility underneath the Tank Farm nor is there significant carbon dioxide production."[23] This is incorrect. The CSM report documents that decreased oxygen concentrations and elevated carbon dioxide concentrations were in fact measured

[23] Golder at 39-40 (DeNovio Testimony PDF page nos. 52-53).

in the basalt. The measured oxygen concentration in the basalt below the tanks ranged from 13.7% to 20.6% compared to 21% in atmospheric air. The carbon dioxide concentration ranged from 0.1% to 3.2% compared to less than 0.1% in atmospheric air.[24] All of this data is entirely consistent with the measured NSZD rate at the Facility.[25]

Although oxygen concentrations may be lower at other sites where NSZD is taking place, the Hawaiian basalt surrounding the Facility is far more permeable than bedrock on the mainland. Interbedded layers of Hawaiian basalt, clinker, and pāhoehoe present at the site promotes significant lateral air flow that supports the aerobic biodegradation of petroleum. This natural effect is further enhanced at the Facility, where the tunnel system operates under a negative pressure that induces air flow through the surrounding rock into the tunnel, which in turn draws atmospheric air into the formation, increasing its oxygen content and decreasing its carbon dioxide content.

5. The soil vapor monitoring wells are useful for release detection and evaluation of fuel weathering.

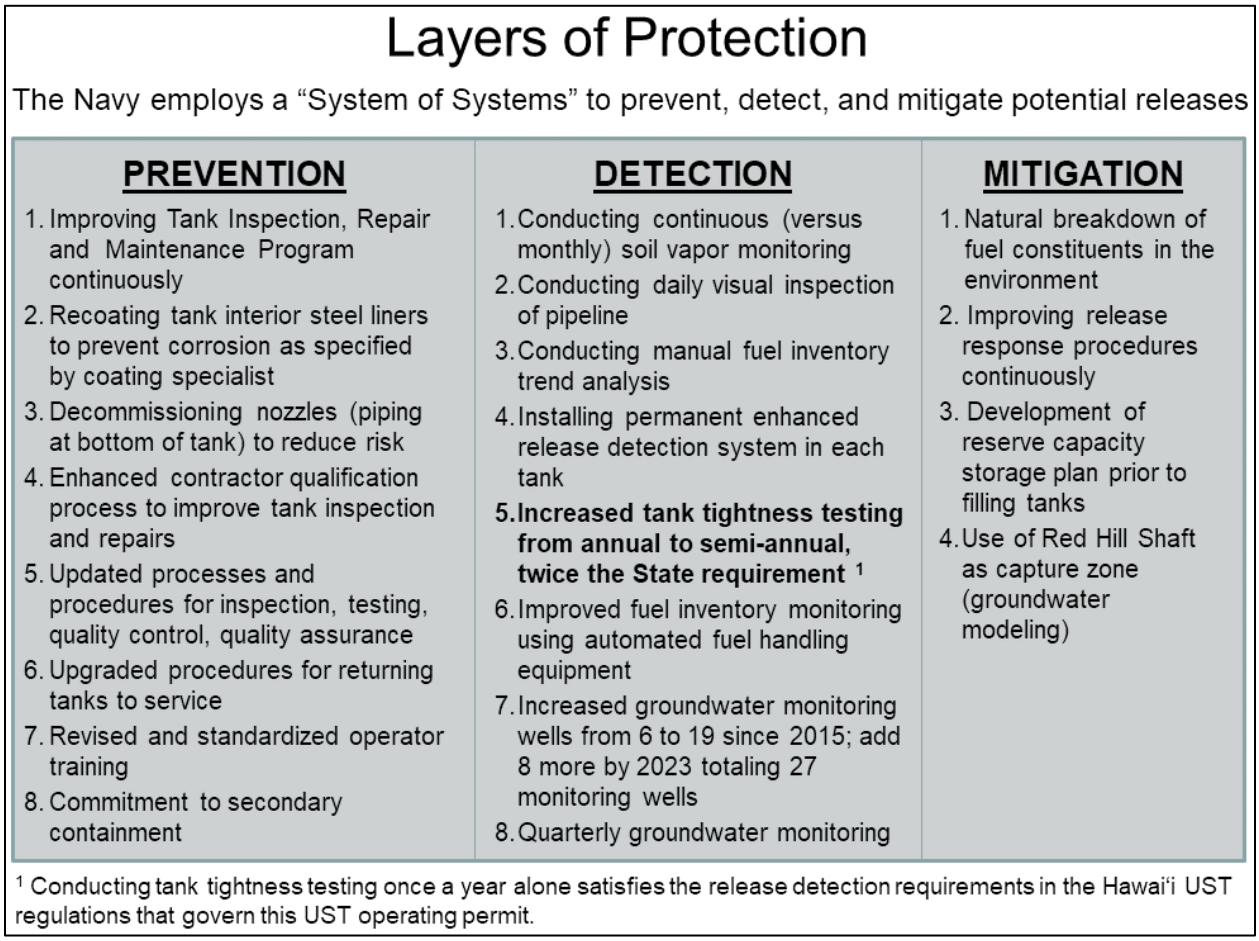
Section 2.2.3 of Dr. DeNovio's report states that "after nearly 20 years of monitoring, very little additional insight has been gained on the distribution of fuel and fuel

[24] CSM Appendix B.3, Section 3.2.2.

[25] CSM Appendix B.2, Table 4-1.

constituents in the subsurface, only adding to the considerable uncertainty regarding the nature and extent of contamination under the Facility." The network of 47 soil vapor monitoring points installed by the Navy includes 2 to 3 monitoring points installed at a shallow angle below each of the 18 active fuel tanks. The SVM system is intended primarily to monitor for releases, and, in combination with other data, has helped advance the understanding of petroleum fate and transport (including the weathering of residual fuels held in the vadose zone) at the site.

A described in the FER, soil vapor readings during the time period following the Tank 5 release in January 2014 clearly showed a response to the release and demonstrated the utility of the monitoring network for release detection. From 2008 to 2013, the highest PID reading from any soil vapor monitoring point was 64,900 parts per billion ("ppb"). However, between January and May 2014, four different soil vapor monitoring points had PID readings above 100,000 ppb, demonstrating that a release can be identified as an increase in soil vapor readings. Furthermore, as shown below on Figure 7, soil vapor monitoring is just one of many layers of protection for release prevention, detection, and mitigation.



Layers of Protection

The Navy employs a "System of Systems" to prevent, detect, and mitigate potential releases

PREVENTION	DETECTION	MITIGATION
1. Improving Tank Inspection, Repair and Maintenance Program continuously	1. Conducting continuous (versus monthly) soil vapor monitoring	1. Natural breakdown of fuel constituents in the environment
2. Recoating tank interior steel liners to prevent corrosion as specified by coating specialist	2. Conducting daily visual inspection of pipeline	2. Improving release response procedures continuously
3. Decommissioning nozzles (piping at bottom of tank) to reduce risk	3. Conducting manual fuel inventory trend analysis	3. Development of reserve capacity storage plan prior to filling tanks
4. Enhanced contractor qualification process to improve tank inspection and repairs	4. Installing permanent enhanced release detection system in each tank	4. Use of Red Hill Shaft as capture zone (groundwater modeling)
5. Updated processes and procedures for inspection, testing, quality control, quality assurance	**5. Increased tank tightness testing from annual to semi-annual, twice the State requirement [1]**	
6. Upgraded procedures for returning tanks to service	6. Improved fuel inventory monitoring using automated fuel handling equipment	
7. Revised and standardized operator training	7. Increased groundwater monitoring wells from 6 to 19 since 2015; add 8 more by 2023 totaling 27 monitoring wells	
8. Commitment to secondary containment	8. Quarterly groundwater monitoring	

[1] Conducting tank tightness testing once a year alone satisfies the release detection requirements in the Hawai'i UST regulations that govern this UST operating permit.

Figure 7: Layers of Protection

In addition to release detection, the soil vapor monitoring results have improved understanding of the formation's holding capacity and the NSZD of historical petroleum releases. As shown on Figure 8, below, the average PID readings across all monitoring points demonstrate decreasing petroleum vapor concentrations during the early years of monitoring from 2008 to 2013, which is consistent with the natural attenuation of historical releases. Petroleum vapor concentrations increased significantly in early 2014 due to the Tank 5 release, but have decreased from 2014 to present, which is consistent

with natural attenuation of the Tank 5 release. In addition to documenting this broad trend in petroleum attenuation at Red Hill, the monthly PID readings have provided other insights into petroleum fate at the Facility. For example, the readings documented the limited lateral transport of LNAPL following the Tank 5 release, as demonstrated by high PID readings (above 100,000 ppb) observed only at the three Tank 5 monitoring points and one of the three nearby Tank 3 monitoring points (odd tank numbers run down one side of the tunnel, such that there is no other tank between Tank 3 and Tank 5). Figure 9, below, shows that the much smaller increases in PID readings observed in the other tanks are consistent with petroleum vapor migration likely associated with diffusion or air flow in the basalt attributable to tunnel ventilation, or other mechanisms. (Figure 2.2-8 of Dr. DeNovio's report uses a logarithmic scale, which hides differences in the reading between the tanks. Figure 9 in this response provides a to-scale depiction of the large differences in readings between Tank 5 and adjacent tanks.)

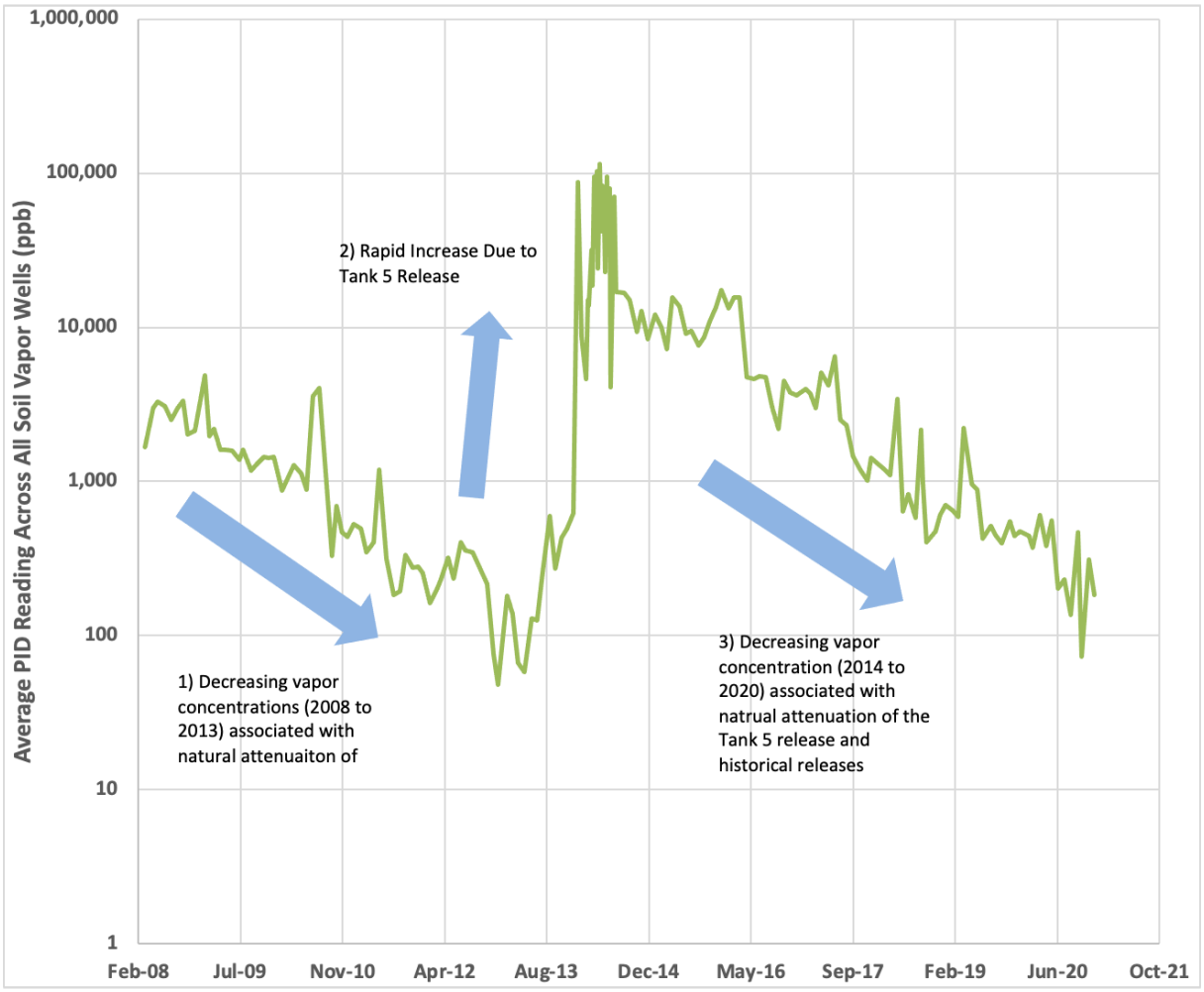


Figure 8. Average PID readings from the soil vapor monitoring well network documenting the attenuation of historical petroleum releases.

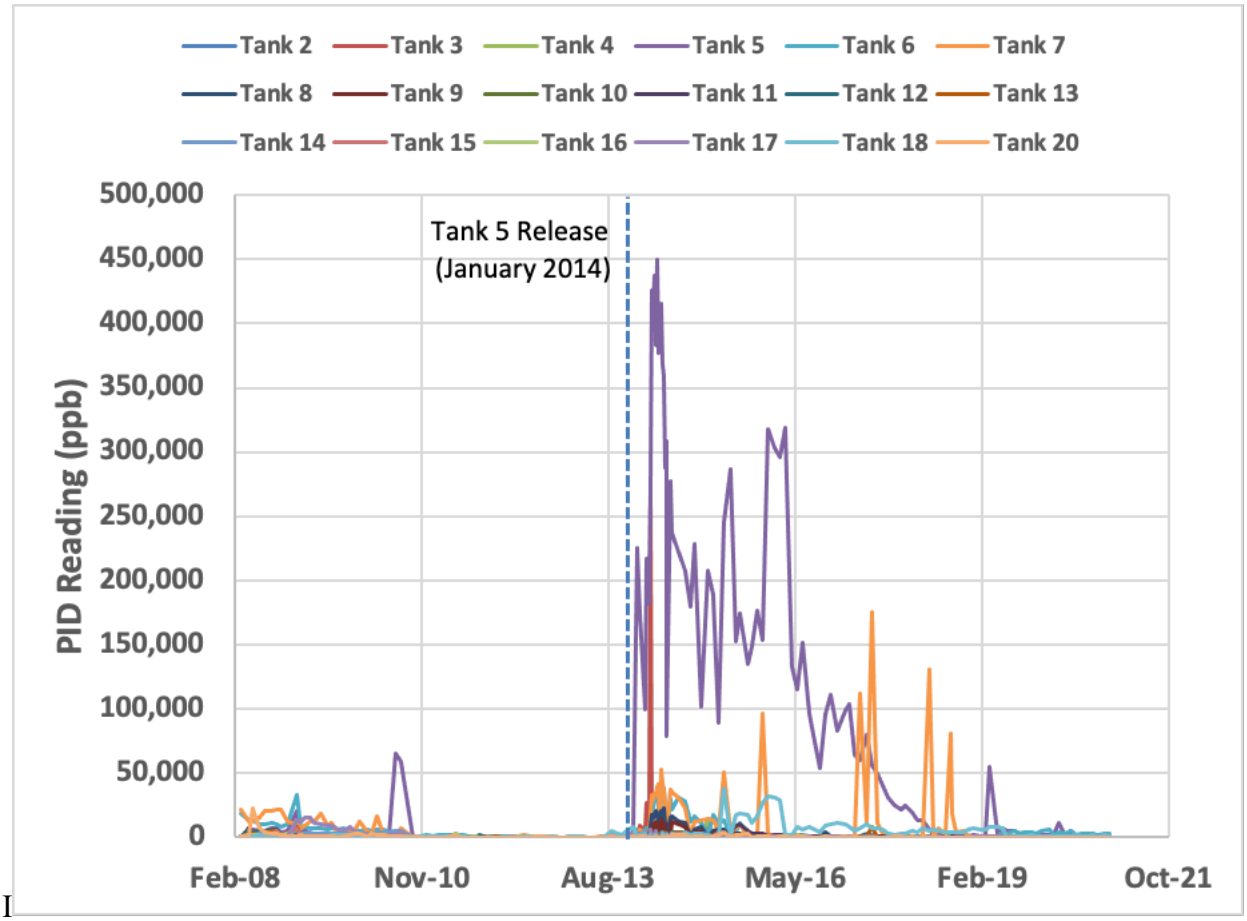


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Figure 9: PID Readings for Individual Tanks Showing Large Increase at Tank 5 Following the Tank 5 Release and Much Smaller Increases at Other Tanks.

In addition to the monthly PID monitoring program, supplemental sampling and laboratory analyses of soil vapors conducted in 2017 provided additional insights into petroleum weathering and attenuation. The details regarding this investigation and the findings are documented in the CSM.

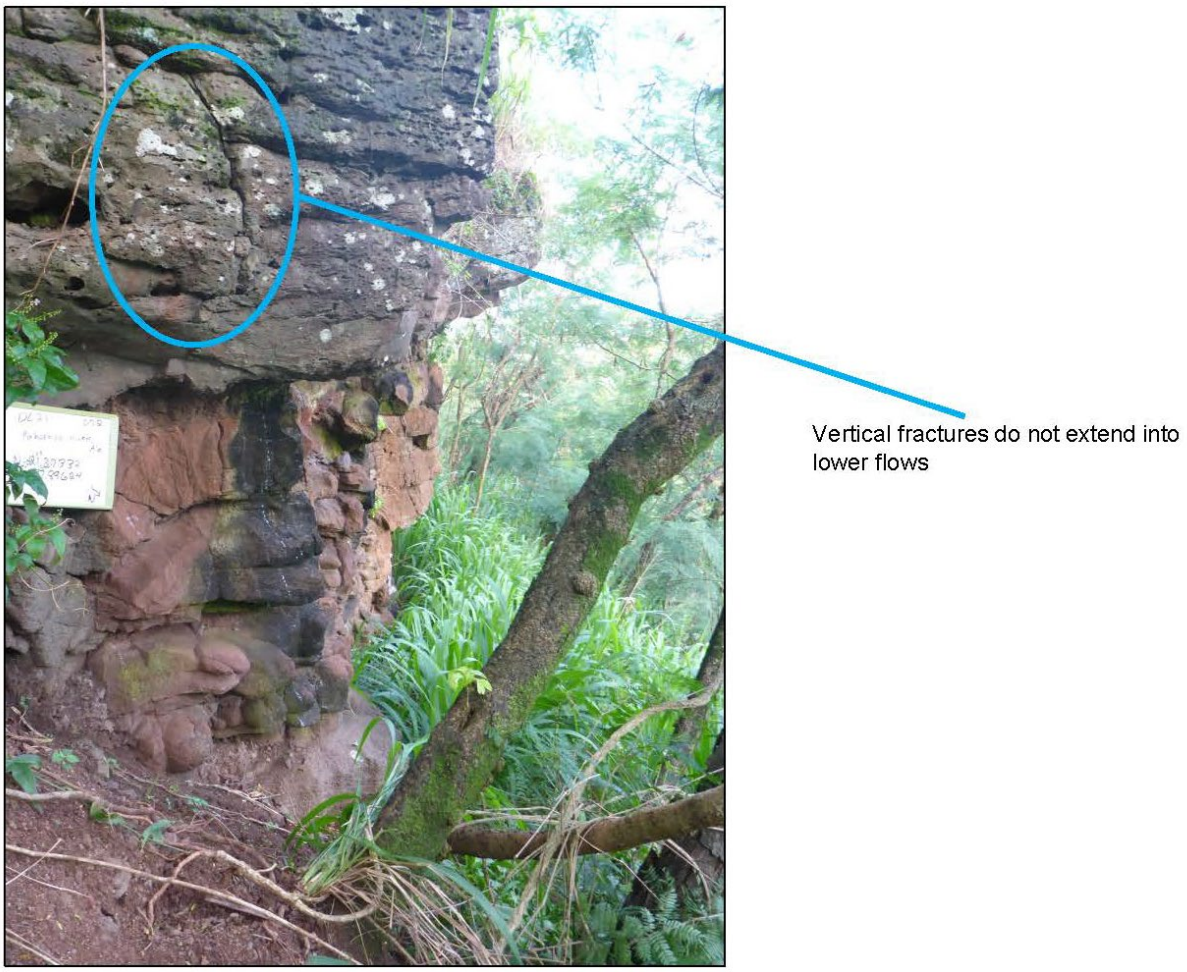
The Navy has added an additional lower action threshold to the existing monthly monitoring program so that a PID reading of 50,000 ppb or greater will result in the

immediate collection of a sample for off-site laboratory analysis. The off-site laboratory analysis will measure the degree of fuel weathering in the sample, allowing the Navy to determine whether an elevated PID reading is associated with a historical release or indicates a new release of petroleum fuel. Since this new action threshold was adopted, no PID readings of 50,000 or above have been recorded. Second, the Navy is currently designing a pilot system to evaluate the feasibility and utility of continuous soil vapor monitoring. This continuous monitoring system would measure PID readings at each soil vapor well 10 to 20 times per day rather than one time per month. This continuous PID monitoring system would allow for more rapid detections of elevated PID readings potentially associated with a new fuel release. The Navy is currently working with the DOH and experts from the University of Hawaii ("UH") on the design of this pilot system and plan to implement the pilot system in the near future.

6. Dr. DeNovio's characterization of site hydrogeology, geology, and the groundwater modeling effort relies on erroneous and outdated information.

Section 1.4.1 of the report, which sets the foundation for Dr. DeNovio's conception of flow at the site, describes a fractured bedrock system that is not consistent with Hawaiian geology or conditions at Red Hill. Thus, the flow regime schematics presented on Dr. DeNovio's Figures 1.4-1, 1.4-2, and 1.4-3 are more characteristic of thick flood basalts such as one might encounter in Washington state or in continental US granitic rocks where tectonic compressional forces can create extensive vertical fractures that

extend to great depths, which may promote downward flow. However, such orientations and characteristics are not observed in fractured Hawaiian basalt, which is composed of many interbedded and distinct layers of different kinds of lava. Thus, as shown on Figure 10, below, vertical fractures and cooling joints in Hawaii and at Red Hill often only extend through individual pāhoehoe or a‘ā lava flows and do not present the same potential to facilitate downward flow as mainland rock. Moreover, as shown on Figure 10, layers of thick, continuous and relatively unfractured massive a‘ā are known to be present in Red Hill, which can impede or limit downward flow.



Thinner bedded pāhoehoe flows (top) are underlain by thicker, more resistant a'ā flows (bottom) at Red Hill. Note fractures do not extend vertically between multiple lava flows.

Figure 10: Cracks in lava rock formations at Red Hill typically do not extend through different layers of lava flow.

Dr. DeNovio characterizes the site as a "complicated network of high-speed pathways that can distribute contaminants"[26] and states that clinker and lava tubes provide preferential pathways and are highly transmissive. However, as can be seen on

[26] Golder at ii (DeNovio Testimony PDF page no. 8).

Dr. DeNovio's Figure 1.3-2, some of the clinker observed at the Facility is highly weathered, has little pore space, and is relatively impermeable, which contrasts with the loose permeable clasts described in other sections of Dr. DeNovio's report. Although clinker clasts have been observed at outcrops on and near the Facility, and in recovered core samples, such clasts were welded together by heat, often rendering them essentially impermeable. Lava tubes encountered during the Facility's construction were carefully sealed with concrete plugs to eliminate them as potential preferential pathways. Moreover, a lava tube could not realistically extend from the Facility to Hālawa Shaft (or Red Hill Shaft as described in Appendix D of the CSM) because: (1) lava tubes are primarily oriented with the general direction of pāhoehoe lava flow (and a lava tube is limited to one discrete lava flow), which the DOH and EPA agree is towards the south-southwest, not northwest in the direction of Hālawa Shaft; (2) the lava flow would have to maintain an angle of less than 1 degree to skim the basal aquifer water table surface, which is not consistent with measurements reported in the Hawaiian islands (true dip in the vicinity of the Facility has been measured at angles of 3 to 12 degrees); and (3) after lava from an individual flow drains away, the lava tube is subject to weathering and collapse. This latter condition has been observed in outcrops on and near the Facility and in core samples collected from the site. Additionally, lava tubes in saprolite, such as what is observed in South Hālawa Valley and North Hālawa Valley, are expected to collapse or become infilled (D. Thomas, UH Hilo and DOH, pers. comm. 2018). Thus, speculation about preferential pathways may have some merit, but does not support significant rapid

downward flow, nor does it suggest rapid flow northwest across the valleys towards the BWS Hālawa Shaft well, essentially perpendicular to the flow of the parent lava.

Dr. DeNovio also does not account for the thick layers of massive basalt that impede downward flow in the vicinity of Red Hill. As shown on Figure 11, below, such strata are relatively dense, typically laid in flat layers based on the flow of the parent lava, and exhibit a very low conductivity that impedes downward flow, offering protection to the aquifer below. (The sharp unweathered cracks shown in the picture resulted from drilling and do not extend vertically through the cores.)

Massive a'ā rock core from RHMW08.

Massive a'ā rock core from RHMW09.

Figure 11: Massive a'ā lava flows present at Red Hill without long vertical cracks impede downward flow.

Dr. DeNovio also describes the basal aquifer freshwater lens as a "free-floating lens above the saltwater … increasing to a few tens of feet thick towards the uplands."[27] The thickness of any freshwater lens above saltwater is described by a well-established principle, described in the USGS' publication on "Basic ground-water hydrology" as "the relationship between the true height of the water table and the thickness of the freshwater lens … referred to as the Ghyben-Herzberg relationship."[28] The relationship is governed by the density difference between saltwater and freshwater, stating that the "freshwater lens should extend to a depth below sea level equal to 40 times the height of the water table above sea level." Based on the general elevation of the water table at the Facility of approximately 18 to 20 feet above sea level, this corresponds to a freshwater-saltwater interface of approximately 720 to greater than 800 feet below sea level. This general principle applies to the site. As described in the Groundwater Flow Model Report, "The freshwater/saltwater interface that forms the bottom of the domain was taken as the 50% isochlor level from the USGS SUTRA modeling effort (Oki [USGS] 2005). The interface is deep in unconfined portions of the basalt (700–900 ft below sea level), and rapidly rises to sea level in offshore portions of the domain." Thus, as described in previous sections, in part based on comments from local experts in Hawaii, including the USGS,

[27] Golder at 8 (DeNovio Testimony PDF page no. 21).

[28] USGS Water Supply Paper 2220, *Basic ground-water hydrology*, available at https://doi.org/10.3133/wsp2220.

the Navy installed deep multi-zone wells to explore potential effects of the thick groundwater lens.

Relative to groundwater flow, Dr. DeNovio's report is somewhat correct in its generalized statement that the "direction of groundwater flow is based on the direction of the gradient and the orientations and properties of the pathways."[29] At Red Hill, the orientation of the geologic basalt flows do have an effect on the flow direction. The site geology has been characterized through detailed geologic studies, based upon which the Navy, DOH, and EPA agree upon the strike and dip (orientation) of the lava flows beneath the Facility, which highly influences the potential orientation of preferential pathways. Dr. DeNovio fails to acknowledge that the data-backed and agreed upon orientation of these basalt flows was an important foundation of the groundwater flow model. The flow of lava resulted in "anisotropy," i.e., the increased likelihood of groundwater to flow in the same direction the lava flowed more than in downwards, upwards, or in perpendicular directions. Figure 2.1-5, which is based on old data and purports to show gradients in different directions, does not account for the fact that groundwater flow directions are a function of both flow gradients and anisotropy. Moreover, this figure, taken from a 2019 DOH letter to the Navy, does not reflect the current understanding because it 1) is based on the initial CSM (which has been updated), 2) is based on old, problematic, limited water elevation data gathered prior to use of the

[29] Golder at 11 (DeNovio Testimony PDF page no. 24).

highly precise and substantially more detailed "synoptic" water level data used in the current Groundwater Flow Model Report, 3) ignores the vast amount and far more detailed groundwater data collected since that time, and 4) does not consider results of the detailed Groundwater Flow Model, which culminated a significant undertaking conducted in consultation with DOH, EPA, USGS, UH, and others.. The extensive synoptic water level data was gathered as a joint effort between the Navy, USGS, and BWS in order to obtain highly precise water level data that corresponded to variable pumping rates in nearby supply wells in the model domain. Because more and better data was collected and analyses were run, older evaluations based on limited data sets, such as those referenced in the DOH letter and Dr. DeNovio's report, are no longer considered determinative. Use of this figure in Dr. DeNovio's report ignores the information collected since that time, based on which the Navy 1) oriented the flow models to account for geologic orientation, and 2) utilized a multi-model approach that analyzed various potential aquifer characteristics to account for the geologic complexity and bound potential flow directions as described in the model report.

As described in Section 5.1 of the Groundwater Flow Model Report, "All models indicated that Red Hill Shaft captures water from the water table beneath the tanks and that its source water zone encompasses the Facility footprint uphill of the shaft when pumping at 4.65 mgd." Section 2.4 of Dr. DeNovio's report states that "Attempts to provide data-based evidence for this suggested capture have not been successful." This is incorrect. The model is based on site specific data that is described in the many reports

leading up to the model. The Navy also conducted a warm water tracer analysis that demonstrates that groundwater flow is oriented with the axis of Red Hill toward Red Hill Shaft. The Navy also continues to work with DOH and EPA and is considering additional studies beyond those required under the AOC.

Dr. DeNovio also states that "During hydraulic tests, where pumping rates are adjusted and water levels are monitored to see if there is a hydraulic response from the pumping event, there was less connection to the Facility area wells and observed changes were characterized as an 'increase in the generally gentle southwest dipping gradient' (DOH 2019)." However, these tests are used to evaluate the aquifer hydraulic characteristics, not to look for evidence of capture. Moreover, the tests indicated that Red Hill Shaft had a large connectivity to the Facility area monitoring wells. Pumping tests at Hālawa Shaft indicated that the connectivity in the northwest direction from the Facility was significantly smaller. The models were calibrated to these aquifer pumping tests and are therefore consistent with the data. As previously described, all models indicated that Red Hill Shaft pumping creates a capture zone that can contain a hypothetical release to groundwater beneath the tanks at Red Hill. Additional Contaminant Flow and Transport modeling will be conducted in the future pursuant to the AOC, and is anticipated to result in the establishment of contingency plans and sentry wells that can provide advance warning.

7 By conflating groundwater monitoring and soil vapor wells, the Report paints a misleading picture of site conditions. The actual monitoring results confirm that fuel product has never been detected in any groundwater monitoring well.

Several sections of Dr. DeNovio's report conflate the groundwater monitoring and soil vapor wells. These might be oversight or otherwise unintended, and must not be allowed to muddy the fact that fuel product has never been detected in any groundwater monitoring well. Dr. DeNovio alleges that the FER "ignores key observations that demonstrate this fuel is migrating from the Facility through the environment and into the Sole Source Aquifer," in part because "Drill core, the rock removed from boring into the ground during a subsurface investigation, contains staining, odors, sludges, and sheens from fuel products."[30] It is important point out that only the inclined soil vapor monitoring drill cores, advanced 15–20 years ago in areas close to the tank bottoms and well above the groundwater, exhibited such impacts. No groundwater monitoring wells exhibited these impacts, which therefore do not in any way suggest that such impacts have migrated to the groundwater. To put this in proper perspective, Figure 5, above, shows the relevant dimensions. Bore logs and core samples collected from groundwater monitoring wells indicate that areas of the subsurface between the vapor wells and the groundwater did not have the kinds of impacts observed in the near-tank soil vapor monitoring wells. Moreover, the Navy has clearly described the presence of LNAPL in

[30] Golder at 25 (DeNovio Testimony PDF page no. 38).

the unsaturated zone beneath the tanks, which is consistent with the holding capacity and NSZD evaluations. As to the Navy statement that "there is an indication that LNAPL is at or near the water table upgradient from RHMW02,"[31] the Navy has clearly documented the presence of LNAPL in the unsaturated zone, but this should not be confused or conflated with the presence of LNAPL in groundwater monitoring wells. Dr. DeNovio also states that "Recent investigations indicate that LNAPL, which has typically only been observed as a sheen on observed waters, is present in several monitoring wells at the site." While Dr. DeNovio's citation for this purported quotation is meaningless ("page 5-4" of some unnamed report), no groundwater monitoring wells have ever had any measurable amount of fuel product. Therefore, this quotation, if accurate, presumably refers to one of the 15- to 20-year-old investigations of vapor monitoring wells installed far above the groundwater.

[31] Golder at 28 (DeNovio Testimony PDF page no. 41).

In developing this testimony, I have relied on the analyses of several experts at AECOM and GSI, including those named in my testimony filed in this contested case dated November 25, 2020: Dr. Sorab Panday, Dr. Ileana Rhodes, Dr. Tom McHugh, Jeff Johnson, and Frank Cioffi, M.S., P.E.

Executed this 15th Day of January, 2021, Boerne, Texas

Curtis Stanley Curtis Stanley

RESPONSE TO WRITTEN TESTIMONY OF NICOLE M. DENOVIO, DATED 29 DECEMBER 2020

Table 1: Detailed Responses

Item Number	Category	PDF Page	Document Page	Section Number	DeNovio Testimony	Response
1	Sole Source Aquifer	3	3	#9a	…federally designated sole-source aquifer for which there is no reasonably available alternative	As mentioned in the Responsive Testimony of Curtis Stanley,[32] the SSA is composed of 12 aquifer systems. Impacts to a very small portion of one aquifer system within the SSA, such as those observed at Red Hill, would not necessarily impact the overall SSA.
2	Monitoring Well Network	3	3	#9c	The Navy has failed to install an adequate monitoring network to understand the location and extent of the fuel present in the subsurface or to determine where this fuel has and will go.	To date the Navy has installed 17 monitoring wells, and samples 19 monitoring locations every quarter. At least 8 additional monitoring wells are proposed for installation by 2023. These wells have delineated the extent of impacts above the EALs, as recommended by DOH, and are appropriate for characterizing flow and migration of potential fuel constituents.
3	Natural Source-Zone Depletion	3	3	#9d	The available data supports the conclusion that natural attenuation is not occurring at a rate that is sufficient to prevent the fuel constituents released into the environment from reaching the sole-source aquifer	Available data establish the fact that natural attenuation is occurring. While small amounts of fuel constituents have reached the aquifer beneath the tanks due to past releases (prior to 2005), natural attenuation and NSZD are working together to attenuate fuel in the unsaturated zone and in groundwater so that drinking water receptors are not impacted.

[32] Responsive Testimony of Curtis Stanley, dated Dec. 28, 2020 (Responsive Stanley Testimony).

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Item Number	Category	PDF Page	Document Page	Section Number	DeNovio Testimony	Response
4	Trend Analysis	3	3	#9e	Groundwater sampling concentrations from monitoring wells in the heart of the Facility show statistically significant trends for total petroleum hydrocarbon middle distillates (TPH-d) from 2015 to present.	Multiple laboratories have been used over time, and each laboratory conducts TPH analysis in a slightly different manner, resulting in a range of TPH detections that may skew long-term trend analyses. Nevertheless, the long-term trend analyses of the time period from 2005 to present show an overall decreasing trend in the near-tank monitoring wells.
5	Protection of Human Health and the Environment	4	4	#10	Given the findings and the irreplaceable nature of the sole-source aquifer, it is my opinion that Facility operation as described in the Navy's permit application is not protective of human health and the environment.	Navy studies indicate that existing contamination of the aquifer beneath the tanks is limited and will not reach drinking water supply wells. The Navy evaluation is consistent with DOH guidance,[33] and all wells other than RHMW02 are generally below the DOH EALs (after accounting for laboratory artifacts).
6	Sole Source Aquifer	7	i	Executive Summary	…a federally designated Sole-source groundwater aquifer (Sole Source Aquifer) for which there is no reasonably available alternative	As mentioned in the Responsive Stanley Testimony,[34] the SSA is composed of 12 aquifer systems. Impacts to a small portion of one aquifer system within the SSA would not necessarily impact the overall SSA, which covers close to half of the island of O'ahu.

[33] See the DOH's TGM and EHE Guidance.

[34] Responsive Testimony of Curtis Stanley, dated Dec. 28, 2020.

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Item Number	Category	PDF Page	Document Page	Section Number	DeNovio Testimony	Response
7	Protection of Human Health and the Environment	7	i	Executive Summary	…human health and the environment can be considered protected only if it can be demonstrated that fuel released from the USTs, an event which is known to have occurred throughout the life of the Facility and is anticipated in the future, will not reach the Sole Source Aquifer.	This statement is incorrect. . Small amounts of fuel that reach the SSA do not threaten human health and the environment. This is discussed at length in the FER.
8	Characterization of Impacts	7	i	Executive Summary	The Navy has failed to adequately characterize the fate of fuel released from the Facility. Accordingly, there is not sufficient information to understand where past fuel releases have, or future fuel releases may arrive at the Sole Source Aquifer or what happens to the fuel constitutes once they reach this drinking water resource.	As stated in the FER, the Facility is the most extensively studied and analyzed UST system in the State of Hawai'i. A list of the Navy's substantial environmental data collection efforts is provided in the FER report. The monitoring well network has delineated the impacts in accordance with DOH guidance and confirm that impacts from historical releases remain limited to monitoring wells beneath the tanks. Outlying perimeter monitoring wells show no signs of impacts from past releases, which is consistent with the level of NSZD and natural attenuation taking place in the subsurface.
9	Sole Source Aquifer	7	i	Executive Summary	…the Sole Source Aquifer is an irreplaceable drinking water resource from which the people of Oahu rely upon for their drinking water.	As mentioned in the Responsive Stanley Testimony,[35] the SSA is composed of 12 aquifer systems. Impacts to one aquifer system within the SSA would not necessarily impact the overall SSA.

[35] Responsive Testimony of Curtis Stanley, dated Dec. 28, 2020.

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Item Number	Category	PDF Page	Document Page	Section Number	DeNovio Testimony	Response
10	Protection of Human Health and the Environment	7	i	Executive Summary	Therefore, the Facility is not protective of human health and the environment. [referring to fuel constituents in the SSA and the SSA being an irreplaceable drinking water resource]	This statement is incorrect. See Response #7 above.
11	Monitoring Well Network and Fate & Transport	7	i	Executive Summary	…the Navy has failed to install an adequate network to understand the location and extent of the fuel present in the subsurface environment or to determine where this fuel has and will go.	To date the Navy has installed 17 monitoring wells, and samples 19 monitoring locations every quarter. At least 8 additional monitoring wells are proposed for installation by 2023. In addition, many other sources of data have been integrated into the Navy's understanding of subsurface conditions as described in the FER.
12	Monitoring Well Network	7	i	Executive Summary	Releases have occurred from most of the tanks, but only two 2-inch groundwater monitoring wells have been installed within the tank area footprint.	Monitoring well diameter does not affect LNAPL detection capability. "Typical well diameters for environmental investigations are 2 to 4 inches…. When practical, the casing diameter should not exceed 4 inches…."[36]
13	Fate & Transport	7	i	Executive Summary	Accordingly, the Navy is simply incapable of assessing how fuel has and will migrate through the subsurface environment.	There are 3 monitoring wells installed beneath or near the tanks in the lower tunnel system, all of which have shown the presence of fuel constituents. See also Response #8 above.

[36] DOH TGM § 6.2.

RESPONSE TO WRITTEN TESTIMONY OF NICOLE M. DENOVIO, DATED 29 DECEMBER 2020

Item Number	Category	PDF Page	Document Page	Section Number	DeNovio Testimony	Response
14	Natural Source-Zone Depletion	7	i	Executive Summary	The available data supports the conclusion that natural attenuation is not occurring at a rate that is sufficient to prevent the fuel constituents released into the environment from reaching the SSA.	This statement is incorrect. Natural attenuation is described in more detail in the FER and associated documents. See also Response #3.
15	Natural Source-Zone Depletion	7	i	Executive Summary	The Navy's estimation of biodegradation rates is not consistent with monitoring data.	This statement is incorrect. Biodegradation rates are the primary reason that fuel constituents have not be found in perimeter monitoring wells.
16	Natural Source-Zone Depletion	7	i	Executive Summary	Specifically, thermal profiles and carbon dioxide readings are not consistent with the Navy's assumed biodegradation rates.	This statement is incorrect. Natural attenuation is described in more detail in the FER and associated documents. More details on this issue are provided in the testimonial narrative accompanying this table.
17	Natural Source-Zone Depletion	7	i	Executive Summary	Further, there is evidence of fuel constituents reaching the Sole Source Aquifer, thereby providing direct evidence that unsaturated zone, natural source zone depletion processes, are insufficient for containing the fuel constituents.	This statement is incorrect. More details on this issue are provided in the testimonial narrative accompanying this table. See also Responses #3 and 5 above.

RESPONSE TO WRITTEN TESTIMONY OF NICOLE M. DENOVIO, DATED 29 DECEMBER 2020

Item Number	Category	PDF Page	Document Page	Section Number	DeNovio Testimony	Response
18	Hawaiian Geology & Hydrogeology	8	ii	Executive Summary	The complex subsurface, characterized by a complicated network of high-speed pathways that can distribute the contaminants, does not prevent the fuel constituents from reaching the Sole Source Aquifer.	This statement is inaccurate. 1) Fractures are contained within individual lava flows and do not typically extend across multiple lava flows, and certainly do not extend across granular clinker units. This downward flow through fractures is limited. 2) Lava tubes occur within individual pāhoehoe lava flows and do not typically extend across multiple flows. In addition, the Navy conducted a study of potential lava tubes[37], and found that potential lava tubes that may exist beneath the tanks would not provide a quick flow pathway to Red Hill Shaft and certainly not to Hālawa Shaft. 3) As part of the Groundwater Flow Model Report's[38] multi-model approach, the Navy modeled a conceptual clinker unit to describe a potential fast path flow system, but such a clinker unit is not believed to exist at the site.

[37] Department of the Navy (DON). 2019. *Conceptual Site Model, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i; June 30, 2019, Revision 01* ("CSM"), Appendix D.

[38] DON. 2020. *Groundwater Flow Model Report, Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i; March 25, 2020, Revision 00* ("GWFM Report").

RESPONSE TO WRITTEN TESTIMONY OF NICOLE M. DENOVIO, DATED 29 DECEMBER 2020

Item Number	Category	PDF Page	Document Page	Section Number	DeNovio Testimony	Response
19	Regulatory Statements	8	ii	Executive Summary	The regulatory agencies with jurisdiction over the Facility have rejected the Navy's conclusions regarding the fate of the fuel released into the environment.	This statement is incorrect. The AOC Regulatory Agencies have not rejected the Navy's conclusions regarding the fate of fuel. The comment appears to refer to the regulators' disapproval of certain documents pursuant to the AOC. Disapproval of AOC documents frequently indicates that the regulators require more information before approval is possible, not that they agree or disagree with specific conclusions.
20	Regulatory Statements	8	ii	Executive Summary	To date, many of these proposed improvements are only plans that have not been approved or implemented. The most recent Navy proposals have resulted in regulatory disapproval, indicating that the Navy's approach is not in keeping with the expectations of regulatory oversight, not working, and not protective.	This statement is inaccurate. Disapproval of documents by regulators does not indicate regulatory non-compliance or lack of environmental protectiveness. See Response 19, above.
21	Sole Source Aquifer	14	1	Section 1.0	…for which there is no reasonably available alternative (Sole Source Aquifer)	As mentioned in the Responsive Stanley Testimony, the SSA is composed of 12 aquifer systems. Impacts to one aquifer system within the SSA would not necessarily impact the overall SSA.

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Item Number	Category	PDF Page	Document Page	Section Number	DeNovio Testimony	Response
22	Fate & Transport	14	1	Section 1.0	These concerns focus on the failure of the Navy to adequately characterize the nature and extent of the fuel it has released into the subsurface environment, to develop a sufficient understanding of how releases form the Facility travel into and contaminate the Sole Source Aquifer, or to implement the safeguards necessary to minimize risk and impact to drinking water resources.	Investigations of this type are continually evolving in order to meet the requirements of the AOC as well as meeting expectations by regulators, including DOH. See also Responses #8 and 11 above.
23	Regulatory Statements	14	1	Section 1.0	The regulatory agencies made clear that the Navy, in proposing Facility upgrades that go beyond what is included in the Navy's permit application, "has not demonstrated to the Regulatory Agencies that the proposed alternative is the most protective of the groundwater and drinking water resources and other options are either less protective or impractical; and that the proposed alternative adequately mitigates release risk."	The TUA is an evolving process. Once the initial TUA is approved, future TUAs will be developed (on a 5-yr time frame) that consider the latest data and R&D in order to achieve BAPT. See Response #19 above.
24	Protection of Human Health and the Environment	15	2	Section 1.0	… conclusion that the existing data, investigative activities, and technical analysis do not provide a technically justifiable basis to conclude that operations at the Facility are protective of human health and the environment.	This statement is incorrect. More details on this issue are provided in the testimonial narrative accompanying this table, as well as the FER. See also Response Items 5, 7, 8, 10, 11, and 12 above.
25	Fuel Releases	16	3	Section 1.1	At least 72 fuel release events in total have been reported by the Navy or other sources	As described in Commander Frame's testimony, records indicate that very few releases have occurred in the last 30 years.

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Item Number	Category	PDF Page	Document Page	Section Number	DeNovio Testimony	Response
26		16	3		These results indicate historical light non-aqueous phase liquid (LNAPL) releases from several of the tanks; however, the Navy was unable to determine the timing and magnitude of these releases.	As described in Commander Frame's testimony, records indicate that very few releases have occurred in the last 30 years. The LNAPL detected during installation of the SVM wells under the tanks more than 15 years ago are due to historical releases before that time.
27	Site History	16	3	Section 1.1	A deep groundwater monitoring well (HDMW2253-03) was installed at the east of Halawa Correctional Facility; 1,000 feet N of Tank 13 to monitor the groundwater between Tank Farm and Halawa Shaft	HDMW2253-03 was installed as an open borehole by the State DLNR CWRM in 2000 to monitor the freshwater/saltwater interface in this area of O'ahu; it was not installed by the Navy to monitor the water table. More recently, the Navy began to monitor this well as part of the Red Hill LTM program.
28	Hawaiian Geology & Hydrogeology	18	5	Section 1.2	…inputs of water that…either remain perched in rock layers above the regional groundwater system or migrate downward to reach the groundwater flow zones.	Observations during drilling and measured water levels indicate that the region is characterized by varying degrees of permeability. In addition, the surface of Red Hill consists of saprolite which limits rainfall percolation into the subsurface. The TFN analysis (provided in the CSM report[39]) indicated that rainfall had little impact on groundwater in this area.

[39] DON 2019 CSM report at Appendix H

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Item Number	Category	PDF Page	Document Page	Section Number	DeNovio Testimony	Response
29	Hawaiian Geology & Hydrogeology	20	7	Section 1.3.1	Clinker: Layers of coarse, fragmented (gravely) rock that often forms on the top of the aa flows. These units typically provide preferential (fast) paths for fluid through the subsurface system.	While certain clinker units are relatively unweathered and exhibit high permeabilities, other clinker is subject to more rapid weathering, or is welded by heat, rendering these clinker units relatively impermeable. This latter case represents the majority of the type of clinker at Red Hill. Unweathered and loose clinker (the less-common type observed at Red Hill) have high horizontal permeability but relatively low vertical permeability.[40]

[40] Hunt Jr., C. D. 1996. *Geohydrology of the Island of Oahu, Hawaii*. Professional Paper 1412-B. 24 Regional Aquifer-System Analysis—Oahu, Hawaii. U.S. Geological Survey.

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Item Number	Category	PDF Page	Document Page	Section Number	DeNovio Testimony	Response
30	Hawaiian Geology & Hydrogeology	20	7	Section 1.3.1	Lava tube: A natural tunnel within a solidified lava flow, formed when lava hardens at the surface and the flowing molten lava below it leaks out and leaves a void within a lava shell. These structures also provide preferential flow pathways.	During the Facilities' construction, all lava tubes were carefully sealed with concrete plugs to help eliminate potential preferential pathways. Moreover, a lava tube could not realistically extend from the Facility to Hālawa Shaft because: • Lava tubes are oriented along the axis of flow within the individual beds, which at the Facility is to the southwest (not to the northwest in the direction of Hālawa Shaft) • Valley fill and saprolite in both South and North Hālawa Valleys would act to physically cut off continuity of lava tubes. • The lava flow would have to maintain angle of less than 1 degree to remain hydraulically connected with the basal aquifer. • After lava drains away, the lava tube is subject to weathering, and is expected to collapse. . See also Response #18 above.
31	Hawaiian Geology & Hydrogeology	21	8	Section 1.3.2	This lens of freshwater is about a foot thick near the edge of the island and increases to a few tens of feet thick toward the uplands.	This statement is incorrect. The thickness of the freshwater lens in the vicinity of Red Hill is greater than 800 feet, not several tens of feet.

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Item Number	Category	PDF Page	Document Page	Section Number	DeNovio Testimony	Response
32	Hawaiian Geology & Hydrogeology	21	8	Section 1.3.2	The top of this lens is called the water table…	The term water table implies that the basal aquifer is unconfined, implying there is a direct pathway for LNAPL to pass through the unsaturated zone into the basal aquifer. Observations during drilling as well as measured water levels indicate that the basal aquifer is confined in some areas, with varying degrees of permeability observed above the basal aquifer; this complicates the pathway for LNAPL to reach the basal aquifer.
33	Sole Source Aquifer	21	8	Section 1.3.2	Oahu's basal aquifer is a unique fresh drinking water supply, for which there is no reasonably available alternative.	As discussed in the Responsive Stanley Testimony,[41] the SSA is composed of 12 aquifer systems. Impacts to one aquifer system within the SSA would not necessarily impact the overall SSA.
34	Hawaiian Geology & Hydrogeology	21	8	1.3.3	The connections that occur among layers in the unsaturated zone provide the important pathways for water from the land surface to reach the water table, which is critical for maintaining the water supply.	While this is true for many parts of Oahu, the hills in this area are overlain with saprolite (thus the name Red Hill) which limits percolation of rainfall from the surface into underlying strata.

[41] Responsive Testimony of Curtis Stanley, dated Dec. 28, 2020.

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35	Hawaiian Geology & Hydrogeology/ Natural Attenuation	23	10	Figure 1.4-1	Figure 1.4-1	The fractures depicted are not characteristic of Hawaiian basalt. As previously stated, fractures do not extend across multiple beds. However, this figure does describe residual LNAPL contained in fractures and on top of certain beds, which is consistent with the Navy's holding capacity analysis.[42]
36	Groundwater Flow	24	11	Section 1.4.1	The direction of groundwater flow is based on the direction of the gradient and the orientations and properties of the pathways	This is true, and that is why the Navy conducted extensive geologic mapping with DOH and agreed upon the strike (direction of basalt inclination) and dip for use in the flow models to evaluate groundwater flow as a result of anisotropy.
37	Hawaiian Geology & Hydrogeology	24	11	Figure 1.4-2	Figure 1.4-2	The fractures depicted are not characteristic of Hawaiian basalt, and more consistent with fractures in very thick lava flows such as exist in Washington state or in granitic rock.
38	Hawaiian Geology & Hydrogeology	25	12	Section 1.4.2	For those massive pahoehoe and aa zones, the fractures that provide a pathway for flow between the layers will be the most critical, but for the clinker and thinly layered pahoehoe flows, the bedding orientations will be the most dominant flow pathways.	Massive pāhoehoe is not generally a term associated with the thin pāhoehoe flows. The term "massive" is reserved for the core of an a'ā flow.

[42] DON. 2018. *Groundwater Protection and Evaluation Considerations for the Red Hill Bulk Fuel Storage Facility, Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i; July 27, 2018, Revision 00* ("GPEC Report").

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39	Hawaiian Geology & Hydrogeology/ Natural Attenuation	25	12	Figure 1.4-3	Figure 1.4-3	This figure does not take into account the multiple flow pathways that consist of both clinker bridges and fractures within individual beds, as was depicted in Golder Report Figure 1.3-1 and which is further described in the FER. This figure does, however, demonstrate the residual LNAPL in the unsaturated zone.
40	Hawaiian Geology & Hydrogeology	26	13	Section 1.4.2	The analysis provided by the Navy fails to consider any of the preferential fracture information needed to estimate LNAPL transport.	Preferential pathways, including those associated with fractures, are discussed in detail in the CSM report.[43] See also Response #18 above.
41	Characterization of Impacts	26	13	Section 2.0	…the foundational data remain sparse, the understanding of the subsurface remains uncertain, and the analysis of contaminant fate and transport remains incomplete.	As stated in the FER, the Facility may be the most extensively studied and analyzed UST system in the State of Hawai'i. A list of the Navy's substantial environmental data collection efforts is provided in the FER. Furthermore, extensive analysis of the data is also described in the FER.

[43] DON CSM Report, Appendix D.

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42	Regulatory Statements	26	13	Section 2.0	…the protection of human health and the environment cannot be assured. This overarching conclusion is consistent with the concerns raised by the EPA and DOH in recent disapproval of the Navy's Tank Upgrade Decision Document, which stated: "Given the very complex geology at Red Hill, a limited ability exists to determine the precise 'fate' of releases; however, there are several magnitudes of releases that should be examined for their potential fate and transport. We agree that further analysis is needed to evaluate the consequences of a range of release scenarios and identify appropriate mitigation measures."	The quote is not consistent with the regulators' statement. .The quote acknowledges that it is not possible to determine the "precise" fate of fuel released due to site complexity, but then recommends that several scenarios should be evaluated in a general fate and transport analysis, which would provide useful information. See also Response Items 5, 7, 8, 10, 11, 12, and 19 above.

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43	Characterization of Impacts	26	13	Section 2.0	First, the Navy cannot even find the fuel it has already released into the environment. Neither the vertical nor lateral extent of the contamination in the vicinity of the Facility has been characterized, and the Navy's monitoring network cannot be relied upon to even detect future fuel releases	This statement is not accurate. Residual hydrocarbon in the unsaturated zone has been evaluated through the use of boring logs, SVM monitoring, and NSZD evaluation, which demonstrate that residual hydrocarbon generally exists up to 30 feet below the tanks. This hydrocarbon has been characterized as being weathered fuel. The extent of residual hydrocarbon in the unsaturated zone is generally consistent with the holding capacity analyses. The near-tank monitoring wells demonstrate varying degrees of impacts from fuel constituents and biodegradation byproducts. Perimeter monitoring wells shown no signs of impacts due to fuel constituents, which is consistent with natural attenuation taking place that limits the extent of dissolved-phase constituents.
44	Characterization of Impacts	26	13	Section 2.0	Mr. Stanley ignores or downplays the fact that episodic fuel releases from the Tank Farm have occurred and likely will continue to occur, and that these releases have impacted the environment, including the Sole Source Aquifer	This is not true. We have stated that past releases have impacted both the unsaturated zone as well as a portion of the aquifer beneath the tanks. Examination of the release data indicates that no substantial release (other than the 2014 release) has occurred in the last 30 years. As part of the AOC, additional control measures are being evaluated to help prevent and mitigate potential future releases should they occur.

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45	Natural Attenuation	26	13	Section 2.0	Mr. Stanley relies heavily upon poorly understood, site-specific biological processes to attempt to justify the existence of past, current, and future contamination of the environment, but the available data and analysis do not support the level of natural attenuation suggested.	This statement is not true. Natural attenuation and NSZD for petroleum products have been studied for many decades across the world. This is also recognized by DOH in their EAL guidance.[44] In addition, many regulatory agencies have developed protocols for this type of evaluation. The Navy has conducted various approaches for evaluating both NSZD and natural attenuation, all of which are in general agreement. The limited extent of LNAPL in the unsaturated zone along with the very limited extent of dissolved fuel constituents in the aquifer correlate very well with the occurrence of NSZD and natural attenuation at Red Hill, as shown by various Navy studies.
46	Regulatory Statements	26	13	Section 2.0	Mr. Stanley improperly suggests the Navy should receive credit for future Facility improvements even though he admits that such work has not been approved by the necessary regulatory agencies and, in many cases, the improvement plans have been disapproved and the Navy itself has not even committed to implementing them.	Disapproval of AOC documents by regulators does not indicate rejection of Navy proposals, but often indicates that the regulators require additional information or revisions to the document. See Response 19, above.

[44] DOH EHE Guidance § 4.2.

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47	Sole Source Aquifer	26	13	Section 2.0	The Facility Environmental Report (AECOM and GSI 2020) does not demonstrate that Facility operations can be conducted in a manner that will safeguard the Sole Source Aquifer.	Impacts to the SSA are minimal and have not resulted in impacts to any water supply well. See also Response Items 5, 6, 7, 8, 10, 11, 12, 19, and 44 above.
48	Monitoring Well Network	27	14	Section 2.1	… the Navy has failed to install a monitoring network that is sufficient to characterize the subsurface conditions.	To date, the Navy has installed 17 monitoring wells and samples 19 monitoring locations every quarter. At least 8 additional monitoring wells are proposed for installation by 2023. Part of the monitoring well installation process includes detailed geologic logging, geophysical data collection, multiple water level measurements, and hydraulic testing.
49	Monitoring Well Network	27	14	Section 2.1	Without sufficient monitoring, there is simply not enough known about the potential fate of the fuel that has been and will be released from Tank Farm to conclude that operations at the Facility are protective of human health and the environment.	In addition to the wells described above, additional monitoring wells will be installed as sentinel wells to provide an early warning of potential future release as part of the AOC requirements. Also, a continuous soil vapor monitoring program is being tested that will provide an early indication of potential releases.

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50	Sole Source Aquifer	27	14	Section 2.1	To the contrary, the Facility Environmental Report (AECOM and GSI 2020) fails to recognize the Sole Source Aquifer as a receptor…	The Navy recognizes the Oahu Sole Source Aquifer as a critical resource and is taking steps to protect it. With that said, the aquifer is not considered a receptor. The ASTM standard for Risk-Based Corrective Action (which is used by the EPA and most states in developing their cleanup programs) defines a receptor as a human being (e.g., someone drinking water from a water supply well). In addition, DOH guidance has established EALs[45] that are protective of the groundwater resource, as discussed in the FER. No perimeter monitoring well or any nearby water supply well have fuel constituents that have exceeded the EALs.
51	Groundwater Monitoring	27	14	Section 2.1	With only two wells within the footprint of the Tank Farm and only three wells within 450 feet of the USTs, it is neither surprising nor remarkable that the Navy has been unable to find the fuel released from the Facility in its monitoring wells.	This statement is incorrect. The monitoring wells installed in close proximity to the tanks have exhibited impacts from past fuel releases, as described in the FER. See also Response Item # 43.
52	Monitoring Well Network	27	14	Section 2.1	Inadequate monitoring density within the Tank Farm given the size and complexity of the Facility leads to insufficient characterization or early warning of groundwater contamination.	This statement is not true. More details on this issue are provided in the testimonial narrative accompanying this table. See also Responses # 8, 11, 13, and 49 above.

[45] See DOH's EHE Guidance.

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53	Groundwater Flow	27	14	Section 2.1	Insufficient data to reliably determine the groundwater flow directions.	This statement is not true. The Navy along with BWS and the USGS have conducted synoptic monitoring with high-precision transducers. These data were then evaluated including use of a transfer function-noise analysis (TFN) that was used by the groundwater flow models. In addition, local geology considerations were discussed and agreed to with the AOC Regulator Agencies, and these were incorporated into the flow models as well in order to account for anisotropy effects on flow directions. All of this was considered as part of a multi-model approach that was designed to bound flow conditions. The models calibrated reasonably well and provide a bounded understanding of groundwater flow. In addition, the Navy has installed 17 monitoring wells and samples 19 monitoring locations every quarter. At least 8 additional monitoring wells are proposed for installation by 2023. Part of the monitoring well installation process includes detailed geologic logging, geophysical data collection, multiple water level measurements, and hydraulic testing.

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54	Monitoring Well Network	27	14	Section 2.1	Biased monitoring well construction (e.g., short screens completed below the water table) within the Tank Farm thereby reducing the applicability of the data.	The only conventional monitoring well screened below the water table is RHMW01; the Navy is replacing this well with RHMW01R. "The maximum recommend screen length is typically 10 feet. The screen length should be kept as short as possible."[46] Longer screen lengths can dilute analyte concentrations. In addition, as the Golder Report previously stated, fuel constituents dissolve out of LNAPL. Because of this, these fuel constituents would be detected in a monitoring well, even if the screen is somewhat below the water table.
55	Fate & Transport	27	14	Section 2.1	These limitations [referring to the inadequate monitoring well network] result in conclusions about the safety of operations at the Facility, at least as they concern the fate and transport of contamination from the Tank Farm, that are premature and speculative.	Fate and transport modeling will be initiated once the Groundwater Flow Model Report[47] is approved. The Groundwater Flow Model Report, Conceptual Site Model Report, and other site data provide usable information about site conditions that are relevant to fate and transport.

[46] DOH TGM § 6.2.

[47] DON GWFM Report

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56	Groundwater Flow Direction	28	15	Section 2.1	Interpretations of groundwater data from before and following the time of the 2014 release do not adequately consider limited data density and the range of plausible interpretations, including the probability of northerly contaminant transport.	The Groundwater Flow Model Report[48] considers a range of variables as discussed with the AOC Regulatory Agencies. Several of the models do indicate northerly flow in part of the model domain when Red Hill Shaft is not pumping.
57	Natural Attenuation	28	15	Section 2.1	Additionally, general water quality indicators including nitrate and dissolved oxygen should be closely examined as lines of evidence for transport and attenuation of past releases.	These parameters were evaluated by multiple analyses including a multiple impact factors analysis, which indicated that chemical constituents in outlying wells did not resemble the chemical signature in near-tank wells.
58	Monitoring Well Network	28	15	Section 2.1.1	…the Navy has installed and relies upon a sparse network of monitoring wells to characterize the subsurface environment at the Tank Farm and to determine the fate and transport of released fuel.	To date, the Navy has installed 17 monitoring wells and samples 19 monitoring locations every quarter. At least 8 additional monitoring wells are proposed for installation by 2023. Part of the monitoring well installation process includes detailed geologic logging, geophysical data collection, multiple water level measurements, and hydraulic testing.
59	Monitoring Well Network	28	15	Section 2.1.1	In addition to their small size, the usefulness of these wells to characterize the site conditions is limited by the lack of detailed geologic data (televiewer logs).	Monitoring well diameter does not affect LNAPL detection capability. "Typical well diameters for environmental investigations are 2 to 4 inches… When practical, the casing diameter should not exceed 4 inches…."[49]

[48] DON GWFM Report

[49] DOH TGM § 6.2.

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60	Monitoring Well Network & Hawaiian Geology/ Hydrogeology	28	15	Section 2.1.1	Given the heterogeneity of the subsurface and the likely preferential transport of fuel releases through the unsaturated zone, the likelihood that these two, 2-inch monitoring wells would encounter appreciable LNAPL is very small even if there was a large amount of LNAPL present under the Tank Farm.	Monitoring wells are appropriately placed to detect releases from tanks as evidenced by the groundwater quality data in wells RHMW01, RHMW02 and RHMW03. Monitoring well diameter does not affect LNAPL detection capability. "Typical well diameters for environmental investigations are 2 to 4 inches…. When practical, the casing diameter should not exceed 4 inches…."[50]
61	Monitoring Well Network	29	16	Section 2.1.1	The monitoring wells nearest the Tank Farm (RHMW-01, RHMW-02, RHMW-03) have very short if any, screen intervals placed such that LNAPL is detection is unlikely.	"The maximum recommend screen length is typically 10 feet. The screen length should be kept as short as possible." [51] More details on this issue are provided in the testimonial narrative accompanying this table.
62	Monitoring Well Network	29	16	Section 2.1.1	By decreasing the likelihood of observing LNAPL during sampling events, large amounts of LNAPL could be present and still not be detected at the wells and therefore, negative results do not provide sufficient information to make any supportable conclusion regarding the presence or absence of LNAPL.	The screen intervals and placement do not decrease the likelihood of observing LNAPL during sampling events. Negative results are reliable indications that LNAPL is not present. More details on this issue are provided in the testimonial narrative accompanying this table.

[50] DOH TGM § 6.2.

[51] DOH TGM § 6.2.

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63	Monitoring Well Network	30	17	Section 2.1.1	Some monitoring wells (like RHMW01 and deeper intervals in perimeter, multilevel wells) are screened below the water table, effectively eliminating the likelihood of observing LNAPL. Sampling methods similarly rely on dedicated pumps installed below the water table, which prevents observed LNAPL in groundwater samples. Depth-specific sampling methods would provide clearer indications of the presence of fuel and fuel constituents.	The only Red Hill monitoring well consistently screened below the water table is RHMW01; the Navy is collaborating with DOH and is replacing this well with RHMW01R. With that said, RHMW03 has had several short time intervals when the screen was below the water table, but nothing was evidenced in prior or subsequent sampling events. The OWDF well was installed by DLNR (CWRM) as part of an investigation to evaluate the freshwater/saltwater interface in this area, and has a screen that does not intercept the water table. The Red Hill network perimeter multilevel wells are not constructed with screens (https://www.westbay.com/). These multilevel wells have sampling ports right at the water table, which should be able to detect high concentrations of COPCs if LNAPL is present. Depth-specific sampling is conducted at the perimeter multi-level wells.

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64	Monitoring Well Network & Hawaiian Geology/ Hydrogeology	30	17	Section 2.1.1	The preferential flow paths through the basalts complicate monitoring, as a monitoring well must directly intersect a flow path to directly detect and for samples to be representative of the chemical composition of the contaminant transport. The lavas found at the base of the tanks are pahoehoe flows, which can hold and transmit fuels, however, the dominant lava where the Tank Farm monitoring wells are located in a massive a'a with interbedded clinker zones (Figure 2.1-4). The LNAPL leaving the near-tank area is likely to stay and follow the layers present in the pahoehoe lavas and transport laterally until the pahoehoe lavas meet the water table or significant connections are encountered through fractures or joints to the underlying a'a lavas.	The highly fractured nature of the basalt flows along with interbedded clinker allows for effective monitoring, since potential groundwater contamination including LNAPL will be more likely to distribute itself in these zones.

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65	Monitoring Well Network	31	18	Section 2.1.1	Based on the review of the monitoring well network within the Tank Farm footprint, there are not enough wells to reasonably interpret that no LNAPL fuel products are at the water table of the Sole Source Aquifer…	As discussed above in Response Items # 2, 7, 8, 11, 41, 43, 61, 62, the monitoring well network and other data sources provide sufficient information about groundwater conditions. There is no evidence that the 2014 release reached the monitoring wells screened in the basal aquifer. This point is further described in the CSM report by the multiple lines of evidence developed.[52] Fuel degradation byproducts (observed in RHMW01, RHMW02, and RHMW03) and dissolved fuel constituents (observed in RHMW02) are likely from pre-2005 releases. There is no evidence of fuel impacts to the perimeter wells.
66	Protection of Human Health and the Environment	31	18	Section 2.1.1	..there are not enough wells to reasonably interpret that no LNAPL fuel products are at the water table of the Sole Source Aquifer or, by extension, that operations at the Facility are protective of human health and the environment.	As outlined in the FER, operations at the Facility are designed to be protective of human health and the environment. See also Response Items 5, 7, 8, 10, 11, and 12 above..

[52] DON CSM Report, Appendix B.8, Table 6.

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67	Characterization of Impacts	31	18	Section 2.1.1	Persistent detections of TPH and individual fuel constituents in groundwater are typically interpreted to result from the presence of an LNAPL source. Due to the frequency of elevated detections in RHMW01, RHMW02, and RHMW03, along with the occurrence of occasional detections in distal wells, the Regulatory Agencies conclude it is reasonable to assume that residual LNAPL is present in the subsurface from past releases. Furthermore, despite consensus on the anticipated dilution rates caused at Red Hill Shaft, trace levels of petroleum compounds have been detected in approximately 12% of the samples collected there.4 The Regulatory Agencies interpret this information as implying that Red Hill Shaft is a likely receptor, and that some LNAPL mass from the facility may be the cause of those detections." Page 4.	This comment was offered by the regulators in response to the Navy's request for their input to help the Navy develop the groundwater flow model. The Navy agrees that LNAPL is present in the "subsurface" – for example, it is known to be present in the basalt immediately below the tanks, well above the aquifer. This does not necessarily mean that any appreciable amount of fuel product is present on the groundwater surface. Measurements taken in the field over more than 15 years have shown no LNAPL in groundwater (see FER Appendix B, Table B-1). The sporadic detections of TPH at concentrations DOH considers categorically safe (below the EALs) in perimeter wells are unrelated to fuel releases, as described in detail in Appendix C of the FER.
68	Hawaiian Geology & Hydrogeology	31	18	Section 2.1.2	It [FER] does not, however, present information concerning the current groundwater flow directions from the Facility, especially within the Tank Farm footprint where contamination was already detected in the Sole Source Aquifer.	The Groundwater Flow Model Report[53] provides a multi-model approach and description of groundwater flow directions that account for and bound a range of uncertainties that are considered in various models.

[53] DON 2020 GWFM Report

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69	Groundwater Flow	32	19	Section 2.1.2	Comments from the EPA and DOH have pointed out inconsistences and errors in the Navy's interpretation of groundwater flow directions	Since the site has complex geology/hydrogeology, EPA and DOH provided comments on the interim flow model and significant effort was undertaken to address those comments in the current Groundwater Flow Model Report.[54] Additional meetings are planned to further discuss AOC Regulatory Agency comments to determine if additional efforts are necessary to further improve the Groundwater Flow Model Report.[55]
70	Groundwater Flow	32	19	Section 2.1.2	Also, water levels in wells respond to sources of "environmental noise" such as barometric pressure changes, ocean tides, earth tides, and temperature differences. Each of these makes interpretation of groundwater flow directions confounding when the measurements are very similar over a large area. As a result, even relatively small changes in observed water levels result in the complete change of the apparent groundwater flow direction.	The Navy conducted precision surveying, gyroscopic well evals and most importantly transfer function-noise analysis to eliminate noise in the synoptic water levels.

[54] DON 2020 GWFM Report

[55] DON 2020 GWFM Report

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71	Groundwater Flow	32	19	Section 2.1.2	The actual flow paths in the saturated zone are further affected by the high heterogeneity of the subsurface. Even without considering lava tubes, the typical values of hydraulic conductivity for different lava types in Hawaii span 4 orders of magnitude (Kreyns et al. 2020) [B-388). Therefore, the placement of specific lavas along a transport or flow pathway can result in enormous differences in groundwater flow directions or contaminant arrival times.	The Navy developed a multi-model approach to evaluate and bound potential flow across a range of geologic settings.
72	Groundwater Flow	32/33	19/20	Figure 2.1-5	DOH (2019) [B-37 4) has summarized the many interpretations of potential groundwater flow directions and provided comments to the Navy in a document named "Hawaii Department of Health Evaluation of Groundwater Flow Paths in the Moanalua, Red Hill and Halawa Regions, Revision 2." DOH's findings are summarized in Figure 2.1-5, which clearly shows a component of groundwater flow direction from the Facility toward Halawa Shaft.	This is based on older reports which have now been updated in the current Groundwater Flow Model Report.[56] The referenced figure also contradicts previous statements as it does not consider anisotropy (geologic heterogeneity), which affects groundwater flow, as was previously described in the Golder Report.

[56] DON GWFM Report

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73	Geology & Hydrogeology	33	20	Section 2.1.3	… there is currently insufficient data to characterize the actual makeup of the heterogeneous basalt subsurface beneath the Tank Farm, to predict the groundwater flow direction near the Facility, to understand the volume and distribution of fuel contamination in the Sole Source Aquifer, and to evaluate the ability (or inability) of the Navy's monitoring network to detect fuel contamination. These data gaps prevent the Navy from demonstrating that the Facility can be operated in a manner that is protective of human health and the environment. The data and reporting transparency prevented further analysis of the potential impact of operating the Facility on human health and the environment.	The extensive environmental data set has delineated the extent of impacts and provided details regarding the fate and transport of released fuel product. As described in the FER, a vast amount of detail has been incorporated into the understanding of site processes. For example, results of the synoptic monitoring, TFN analysis, borehole logging, geophysics, and other studies provide an overall understanding of the characteristics of the basalt. Other studies that the Navy has conducted relative to holding capacity, NSZD, and MNA also provide a data-based understanding of the fate and transport of fuel constituents. These and other studies and data sets provide a substantial understanding of the subsurface that has reduced data gaps and demonstrate that the Facility has an adequate monitoring system that will continue to be improved over time. Finally, the monitoring system characterizes the extent of contamination as being contained beneath the tanks.

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74	Sole Source Aquifer	34	21	Section 2.2	The fact that the released fuel is present in the environment and can reach the Sole Source Aquifer is apparent from an examination of rock cores removed from under the Tank Farm, evaluation of vapor sampling results, and analysis of groundwater trend data. The conclusion that released fuel can migrate to the Sole Source Aquifer is consistent with the Navy's own recent IRR (NAVY 2020, IRR) (8-339], which acknowledges that *"there is an indication that LNAPL is at or near the water table upgradient from RHMW02."* Collectively. these data indicate that fuel releases to the Sole Source Aquifer have occurred in the past and are likely ongoing. Accordingly, operations at the Facility are not currently protective of human health and the environment.	There is no evidence that fuel releases are likely ongoing. The FER explains that Facility operations effectively prevent fuel releases. See also Response Items 5, 7, 8, 10, 11, and 12 above.
75	Fuel Releases	34/35	21/22	Section 2.2.1	At least 72 fuel release events in total, on average a release per year, have been reported by the Navy or other sources.	As described in Commander Frame's testimony, records indicate that there have been very few releases in the last 30 years.

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76	TPH	36	23	Section 2.2.2	Beginning in January 2017, split sampling was conducted during six groundwater monitoring events at select Facility monitoring wells, with samples analyzed by both the Navy contracted laboratory and the EPA Region 9 laboratory (EPA 2017a) [B-393). Analytical results initially showed large differences in recoveries for total petroleum hydrocarbons-diesel (TPH-d) and polynuclear aromatic hydrocarbons (PAHs), with data generated by the Navy contracted laboratory approximately 65% lower than results reported by the EPA Region 9 laboratory. NAVY (2020) [B-339) later reported the Navy-contracted laboratory's recoveries significantly improved after the January 2017 split sampling event by optimizing its analytical methods to better match those of the EPA laboratory. Adjustments included changes to sample preparation, extraction, concentration, and quantitation steps.	There are no EPA-approved methods for conducting TPH analyses, although there are approved methods for the individual chemical constituents of TPH. Laboratories follow EPA guidance in choosing from a range of approaches. In addition, there are multiple methods (solvent extraction method varies between EPA Method 3510 -separatory funnel -hand shake and EPA Method 3520 automated liquid/liquid extraction) for conducting TPH analyses, all of which result in a range of values that may vary from laboratory to laboratory. Normally these methods do not have large variabilities (except for low concentrations), but they do vary with the presence of polar material (organic acids due to degradation of petroleum and naturally occurring organic matter). In an effort to be better aligned with the EPA laboratory, the Navy switched from Method 3510 to 3520, which provided closer results. The only well substantially affected by this change was RHMW02. Additional analysis with silica gel cleanup indicated that the vast amount of TPH in RHMW02 was polar material rather than hydrocarbons, indicating significant biodegradation taking place rather than an ongoing release.

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77	LTM Program / Groundwater Monitoring	36	23	Section 2.2.2	Sample Collection Timing Section What is clear is that the documented 2014 fuel release corresponds to increases in fuel constituents observed in groundwater.	The increases in fuel detections are solely due to the significantly increased sampling of RHMW02 that occurred after the 2014 release (increasing from 8 COPC samples in the year prior to the release to 23 COPC samples in the year after the release). TPH has always been detected in this well; therefore, it is to be expected that sampling it more frequently results in more detections.
78	LNAPL in Rock	38/41	25/28	Section 2.2.3	LNAPL Present in Rock	LNAPL is primarily contained within the upper 30 feet of the unsaturated zone below the tanks, indicating both the holding capacity of the basalt and the fact that NSZD is taking place.
79	Soil Vapor Monitoring	42/44	29/31	Section 2.2.3	Fuel Indicators Present in Vapor	The soil vapor monitoring results provide useful information for characterizing environmental conditions at the Facility. More details on this issue are provided in the testimonial narrative accompanying this table.
80	TPH Trend	44/47	31/34	Section 2.2.4	Increasing Groundwater Concentration Trend	This section of the report cherry-picks a time frame to suggest an increasing trend. Long-term trends for RHMW01 and RHMW02 are decreasing, while the long-term trend for RHMW03 is relatively flat.
81	Episodic Fuel Release	48/49	35/36	Section 2.2.5	Episodic Fuel Release Synopsis	As described in Commander Frame's testimony, records indicate very few releases in the last 30 years. See also Response Items # 80, 81, and 82.

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82	NSZD/MNA Holding Capacity	50/56	37/43	Section 2.3	Sec. 2.3 Response Section	This section mischaracterizes the conclusions that can be drawn from the Navy's studies of NSZD, MNA, and holding capacity. More details on this issue are provided in the testimonial narrative accompanying this table.
83	Sole Source Aquifer/Protection of Human Health and the Environment	56/57	43/44	Section 2.4	The fact that historical and recent fuel releases from the Tank Farm have resulted in an administrative order forcing the Navy to complete certain Facility upgrades does not mean that releases of fuel to the Sole Source Aquifer will necessarily stop or that the Navy's future operations will be protective of human health and the environment.	The AOC occurred in response to the 2014 Tank 5 Release. As described in Commander Frame's testimony, records indicate that there have been very few releases in the last 30 years. The environmental data show that contamination is limited to the area beneath the tanks and drinking water remains safe. Continued improvements will further reduce the likelihood of future releases.

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84	TUA	57	44	Section 2.4	Finally, the recent regulatory disapproval, deficiency, and conditional approval letters indicate that the Navy's approach is not in keeping with the expectations of regulatory oversight, not working, and not protective.	The AOC provides for an iterative regulatory oversight process that incorporates disapproval and resubmission. The TUA Decision Document Deficiency Letter[57] related to Sections 3 and 4 of the AOC, which covers tank upgrade alternatives, rather than 6 and 7, which relate to environmental investigation. This disapproval requires the report to be resubmitted with additional data and analyses so that the recommendations could be better evaluated.

[57] Environmental Protection Agency, United States, Region 9; and Department of Health, State of Hawaii (EPA Region 9 and DOH). 2020. *Re: Notice of Deficiency for the Tank Upgrade Alternatives Decision Document and New Release Detection Alternatives Decision Document, for Red Hill Administrative Order on Consent Statement of Work Sections 3.5 and 4.8, October 26, 2020*.

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85	GW Modeling	57	44	Section 2.4	The Facility Environmental Report (AECOM and GSI 2020) mentions that the control of fuel releases from the Facility may be achieved if Red Hill Shaft is pumped at its regulatory-permitted pumping limit because numerical modeling performed by the Navy indicates that the fuel will be captured at the Red Hill Shaft (Sidebar 16 and page 49). EPA and DOH (2020) do not agree (page 10): "The Regulatory Agencies note that the degree of capture at Red Hill Shaft for a range of possible release scenarios has not yet been fully evaluated and remains unclear whether it is an adequate measure to prevent impact to other receptors." Historical data also do not indicate pumping at Red Hill Shaft will fully protect drinking water resources. The Red Hill Shaft has been operating since the 1940s, however detectable concentrations of fuel constituents at RHMW02 have not been observed at the Shaft consistently. Given the long history of observed contamination at RHMW02 and the pumping at Red Hill Shaft, the Navy has failed to provide direct evidence that pumping at the shaft will be a means to fully capture all contamination reaching the Sole Source Aquifer from the Tank Farm. Attempts to provide data-based evidence for this suggested capture have not been successful. During hydraulic tests, where pumping rates are adjusted and water levels are monitored to see if there is a hydraulic response from the pumping event, there was less	The presence of fuel constituents in RHMW02 has nothing to do with the evaluation of capture. The lack of fuel constituents at Red Hill Shaft is an indicator that significant biodegradation is taking place, which limits the extent of fuel constituent migration and is consistent with the Navy's findings.

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					connection to the Facility area wells and observed changes were characterized as an "increase in the generally gentle southwest dipping gradient" (DOH 2019). Consequently, using the numerical model results to support pumping Red Hill Shaft as a groundwater protection strategy is inconsistent with data and unsupported by EPA and DOH regulators resulting in an unapproved, unproven plan to protect the Sole Source Aquifer.	

AOC	Administrative Order on Consent
BAPT	best available practicable technology
BWS	Board of Water Supply, City and County of Honolulu
COPC	chemical of potential concern
CSM	conceptual site model
CWRM	Commission on Water Resource Management, State of Hawai'i Department of Land Natural Resources
DLNR	Department of Land and Natural Resources, State of Hawai'i
DOH	Department of Health, State of Hawai'i
EAL	Environmental Action Level
EPA	Environmental Protection Agency, United States
FER	Facility Environmental Report
HEER	Hazard Evaluation and Emergency Response Office, State of Hawai'i Department of Health
LNAPL	light nonaqueous-phase liquid
LTM	long-term monitoring
MNA	monitored natural attenuation
NSZD	natural source-zone depletion
OWDF	Oily Waste Disposal Facility
SSA	Sole Source Aquifer
SVM	soil vapor monitoring
TFN	transfer function-noise
TGM	Technical Guidance Manual for the Implementation of the Hawai'i State Contingency Plan

TPH	total petroleum hydrocarbons
TUA	Tank Upgrade Alternatives
USGS	United States Geological Survey
UST	underground storage tank