DEPARTMENT OF THE NAVY
COMMANDER
NAVY REGION HAWAII
850 TICONDEROGA ST STE 110
JBPHH, HAWAII 96860-5101

5750
Ser N4/ 0654
December 13, 2017

CERTIFIED NO: 7015 0640 0002 4677 9626

Mr. Bob Pallarino
U.S. Environmental Protection Agency
Region IX
75 Hawthorne Street
San Francisco, CA 94105

CERTIFIED NO: 7015 0640 0002 4677 9633

Ms. Roxanne Kwan
Hawaii State Department of Health
Environmental Management Division
Solid and Hazardous Waste Branch
2827 Waimano Home Road
Pearl City, HI 96782

Dear Mr. Pallarino and Ms. Kwan:

SUBJECT: ADMINISTRATIVE ORDER ON CONSENT STATEMENT OF WORK SECTION 6 AND SECTION 7 RISK-BASED DECISION CRITERIA AND SENTINEL NETWORK DEVELOPMENT PLANS, RED HILL BULK FUEL STORAGE FACILITY (RED HILL), JOINT BASE PEARL HARBOR-HICKAM, OAHU, HAWAII

The Risk-Based Decision Criteria and Sentinel Well Network Development Plans for Red Hill pursuant to the Administrative Order on Consent (AOC) Statement of Work (SOW) Section 6, Investigation and Remediation of Releases, and Section 7, Groundwater Protection and Evaluation are enclosed.

The Risk-Based Decision Criteria Development Plan (Enclosure 1) describes the development of risk-based decision criteria and evaluation of current site-specific risk-based levels (SSRBLs) for inclusion in AOC SOW Section 6 and Section 7 deliverables and subsequently, in an update to the Groundwater Protection Plan.

The Sentinel Well Network Development Plan (Enclosure 2) outlines the technical approach for evaluating and establishing a sentinel well network for existing drinking water production locations within the study area in order to provide early warning of potential impacts by chemicals of potential concern to drinking water production locations and monitor groundwater flow to help ensure potential contamination are adequately contained, if needed.

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If you have any questions, please contact Aaron Y. Poentis of our Regional Environmental Department at (808) 471-3858 or at aaron.poentis@navy.mil.

Sincerely,

R. D. HAYES, III
Captain, CEC, U.S. Navy
Regional Engineer
By direction of the
Commander

Enclosures: 1. Risk-Based Decision Criteria Development Plan, Red Hill Bulk Storage Facility, Joint Base Pearl Harbor-Hickam, Oahu, December 11, 2017
2. Sentinel Well Network Development Plan, Red Hill Bulk Storage Facility, Joint Base Pearl Harbor-Hickam, Oahu, December 11, 2017

Red Hill Administrative Order on Consent,
Risk-Based Decision Criteria Development Plan Deliverable

Section 6.2 Investigation and Remediation of Releases Scope of Work
Section 7.1.2 Groundwater Flow Model Report Scope of Work
Section 7.2.2 Contaminant Fate and Transport Model Report Scope of Work
Section 7.3.2 Groundwater Monitoring Well Network Scope of Work

In accordance with the Red Hill Administrative Order on Consent, paragraph 9, DOCUMENT CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is, to be the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fines and imprisonment for knowing violation.

Signature: ______________________

CAPT Richard Hayes III, CEC, USN
Regional Engineer, Navy Region Hawaii

Date: 12 DEC 2017

Risk-Based Decision Criteria Development Plan, 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

Administrative Order on Consent in the Matter of Red Hill Bulk Fuel Storage Facility, EPA Docket Number RCRA 7003-R9-2015-01 and DOH Docket Number 15-UST-EA-01, Attachment A, Statement of Work Section 6.2, Section 7.1.2, Section 7.2.2, and Section 7.3.2

December 11, 2017
Revision 00

NAVFAC
Naval Facilities Engineering Command
NAVFAC HAWAII

Comprehensive Long-Term Environmental Action Navy
Contract Number N62742-12-D-1829, CTO 0053

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Risk-Based Decision Criteria Development Plan, 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

Administrative Order on Consent in the Matter of Red Hill Bulk Fuel Storage Facility, EPA Docket Number RCRA 7003-R9-2015-01 and DOH Docket Number 15-UST-EA-01, Attachment A, Statement of Work Section 6.2, Section 7.1.2, Section 7.2.2, and Section 7.3.2

December 11, 2017
Revision 00

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Comprehensive Long-Term Environmental Action Navy
Contract Number N62742-12-D-1829, CTO 0053

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CONTENTS

FIGURES

TABLE

ACRONYMS AND ABBREVIATIONS

µg/L	micrograms per liter
AOC	Administrative Order on Consent
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
BWS	Board of Water Supply, City and County of Honolulu
CLEAN	Comprehensive Long-Term Environmental Action Navy
COPC	chemical of potential concern
CTO	contract task order
DLA	Defense Logistics Agency
DOH	Department of Health, State of Hawai‘i
DON	Department of the Navy, United States
EPA	Environmental Protection Agency, United States
ft	foot/feet
GWPP	Groundwater Protection Plan
HEER	Hazard Evaluation and Emergency Response Office, State of Hawai‘i Department of Health
HI	hazard index
HQ	hazard quotient
JBPHH	Joint Base Pearl Harbor-Hickam
JP	Jet Fuel Propellant
LTM	long-term monitoring
msl	mean sea level
NAPL	non-aqueous-phase liquid
NATO	North Atlantic Treaty Organization
NAVFAC	Naval Facilities Engineering Command
OSHA	Occupational Safety and Health Administration
PAH	polynuclear aromatic hydrocarbons
RBDC	risk-based decision criteria
RME	reasonable maximum exposure
RSL	Regional Screening Level
SGC	silica gel cleanup
SOW	scope of work
SSRBL	Site-Specific Risk-Based Level
SVOC	semivolatile organic compound
TGM	Technical Guidance Manual
THQ	target hazard quotient
TPH	total petroleum hydrocarbons
TPH-d	total petroleum hydrocarbons – diesel range organics
TPH-g	total petroleum hydrocarbons – gasoline range organics
TPH-md	total petroleum hydrocarbons – middle distillate range organics
TPH-o	total petroleum hydrocarbons – residual range organics (i.e., TPH-oil)
TUA	Tank Upgrade Alternatives
U.S.	United States
UCL	upper confidence limit
UIC	underground injection control

VOC	volatile organic compound
WP	work plan

1. Introduction

This document presents a plan to develop risk-based decision criteria (RBDC) to support the investigation and remediation of releases at the Red Hill Bulk Fuel Storage Facility ("the Facility") at Joint Base Pearl Harbor-Hickam (JBPHH), Hawai'i. The Facility is owned and operated by the United States (U.S.) Navy (DON; Navy) and is funded by Defense Logistics Agency (DLA). The RBDC developed in accordance with this plan will be used to update the Red Hill *Groundwater Protection Plan* (GWPP), ensuring that drinking water receptors are protected. The RBDC will be used in the development of Site-Specific Risk-Based Levels (SSRBLs) for the sentinel monitoring well network, as described in the *Sentinel Well Network Development Plan* (DON 2017e).

This *RBDC Development Plan* was prepared to support the investigation and remediation of releases and groundwater protection and evaluation as described in the project *Work Plan / Scope of Work* (WP/SOW) (DON 2017a). The WP/SOW presents the process, tasks, and deliverables that address the goals and requirements of Statement of Work Section 6 (Investigation and Remediation of Releases) and Section 7 (Groundwater Protection and Evaluation) of the *Administrative Order on Consent* (AOC) *In the Matter of Red Hill Bulk Fuel Storage Facility* (EPA Docket No: RCRA 7003-R9-2015-01; DOH Docket No: 15-UST-EA-01) (EPA Region 9 and DOH 2015). The AOC was issued by the U.S. Environmental Protection Agency (EPA) Region 9 and State of Hawai'i Department of Health (DOH) to the Navy/DLA in response to a release of an estimated 27,000 gallons of Jet Fuel Propellant (JP)-8 from one of the Facility's 12.5-million-gallon underground fuel storage tanks (Tank 5) that was confirmed and reported to DOH on January 23, 2014. The bottoms of the Facility's 20 tanks are located approximately 100 feet (ft) above a major groundwater aquifer, which is used to supply both Navy and the City and County of Honolulu drinking water sources.

The planning activities described in the project WP/SOW (DON 2017a) include the preparation of nine documents (including this *RBDC Development Plan*), referred to as derivative deliverables, that address specific aspects of the planning process. The flowchart presented on Figure 1 shows the sequencing of the derivative deliverables, and further detail is provided in the WP/SOW. The Facility vicinity and modeling area are shown on Figure 2.

This *RBDC Development Plan* was prepared for DLA through Naval Facilities Engineering Command (NAVFAC) Hawaii under contract number (no.) N62742-12-D-1829, contract task order (CTO) no. 0053 of the Comprehensive Long-Term Environmental Action Navy (CLEAN) IV program.

RBDC are risk-based screening values for drinking/domestic use water that are protective of human health, safety, and the environment, specifically considering exposure of human receptors to chemicals of potential concern (COPCs) in the public water supply through ingestion of tap water, dermal contact, and inhalation of volatile chemicals while bathing/showering. RBDC are established for the list of COPCs presented in Section 3, and are intended to be protective of the most sensitive human receptor population, which is residents using tap water originating from groundwater at Navy Supply Well 2254-01 (Red Hill Shaft), which supplies potable water to JBPHH. These RBDC values are also protective of human populations using water from other drinking water supply systems within the study area.

The RBDC will be used to establish SSRBLs for individual wells in the sentinel monitoring well network, as discussed in Section 1.3. RBDC will be used as screening values for the tap water and are based on established regulatory limits (EPA 2017 RSLs or DOH 2017 EALs) where available or derived from toxicity data where regulatory limits are not available. Because EPA and/or Hawai‘i DOH has adopted regulatory limits for drinking water for all of the COPCs selected for this project and because there are no complete exposure routes other than those addressed by the regulatory limits developed for drinking water, the development of risk-based criteria for current COPCs is not anticipated. If additional exposure routes other than those addressed by the drinking water pathway are determined to be complete in the future, or if scientific advancements in the understanding of TPH chemistry or toxicity warrant it, it may be necessary to calculate site-specific RBDC for this site. Such calculations would be performed using standard equations and assumptions along with any site- and route-specific assumptions that may be appropriate.

The SSRBLs will be established as target groundwater concentrations at individual sentinel monitoring wells, and back-calculated from the RBDC using mass flux analyses. The SSRBLs will provide a value for individual wells that if exceeded is an indicator that that additional contingency action (e.g., further evaluation, more frequent monitoring, treatment) needs to be taken, otherwise the RBDC may be exceeded at the tap. If the concentration of a COPC in groundwater at a given monitoring well location does not exceed the SSRBL, then the concentration of that COPC should not exceed the RBDC at the tap.

The development of RBDC will support AOC Statement of Work Section 6 by providing criteria that are protective of human health, safety, and the environment associated with potential releases, and will support AOC Statement of Work Section 7 in part by establishing criteria for COPCs that will be used to ensure that drinking water is protected (EPA Region 9 and DOH 2015).

1.1 BACKGROUND INFORMATION

The Facility is located in south-central O‘ahu, approximately 2.5 miles northeast of Pearl Harbor, and occupies approximately 144 acres along the western edge of the Ko‘olau Range on a topographic ridge that divides Hālawa Valley and Moanalua Valley (Figure 2). The Facility is bordered on the north by the Hālawa Correctional Facility and private businesses in the Hālawa Industrial Park, on the southwest by the U.S. Coast Guard reservation, on the south by residential neighborhoods, and on the east by Moanalua Valley and preservation land. The Hālawa Quarry is located less than a quarter mile away to the northwest. Most of the surface topography of the Facility lies at an elevation of approximately 200–500 ft above mean sea level (msl).

The Facility overlies the Moanalua System of the Honolulu Aquifer Sector and the Waiawa System of the Pearl Harbor Aquifer Sector. These are unconfined basalt aquifers at the Facility. Toward the ocean, the basal aquifer dips below and becomes confined by overlying sedimentary material, including terrestrial deposits, reef limestone, lagoonal clays, and shoreline sands, collectively known as caprock. Taken as a single unit, the hydraulic conductivity of the caprock tends to be lower than the underlying basalt, retarding the discharge of groundwater to the ocean. The confining action of the caprock produces artesian groundwater flow and creates numerous springs around Pearl Harbor but not near the Facility. The depth from the ground surface to the aquifer is between 400 and 500 ft on the Red Hill ridgeline and 81 ft at Navy Supply Well 2254-01. Valley fill material and saprolite underlie both North and South Hālawa Valleys north of the Facility and Moanalua Valley south of the Facility; valley fill and saprolite consist of lower-permeability material that may act as a hydraulic barrier where present beneath the basal water table.

Note: The initial purpose and goals of each derivative deliverable are presented in the project WP/SOW (DON 2017a, Table 2-1). The purpose and goals will be reviewed by the Regulatory Agencies and AOC SMEs prior to preparation. Each derivative deliverable will be submitted for Regulatory Agency and AOC SME review. Comments received will be addressed, and revised deliverables will be submitted after Regulatory Agencies' concurrence on comment responses has been received.

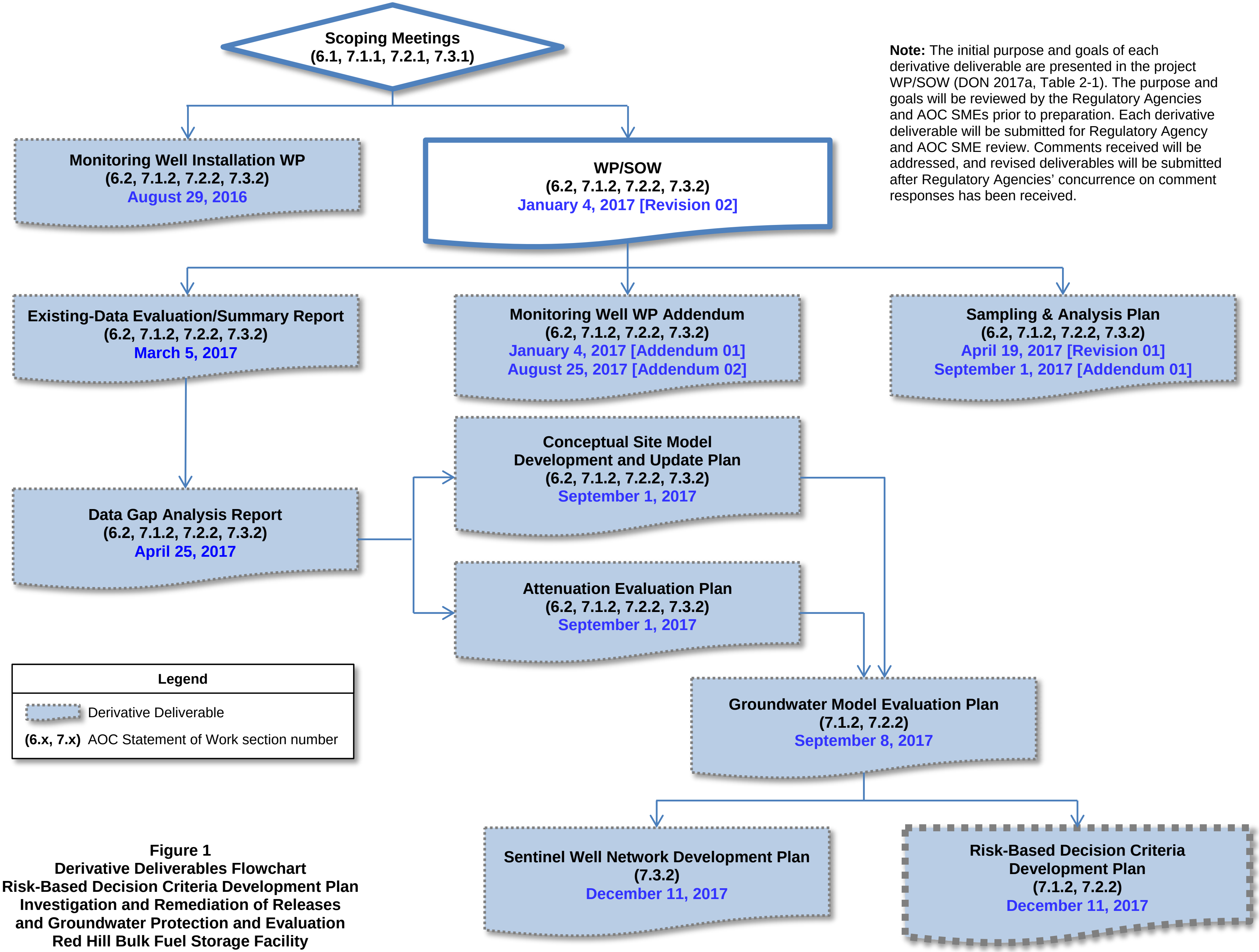

Figure 1
Derivative Deliverables Flowchart
Risk-Based Decision Criteria Development Plan
Investigation and Remediation of Releases
and Groundwater Protection and Evaluation
Red Hill Bulk Fuel Storage Facility
JBPHH, Oʻahu, Hawaiʻi

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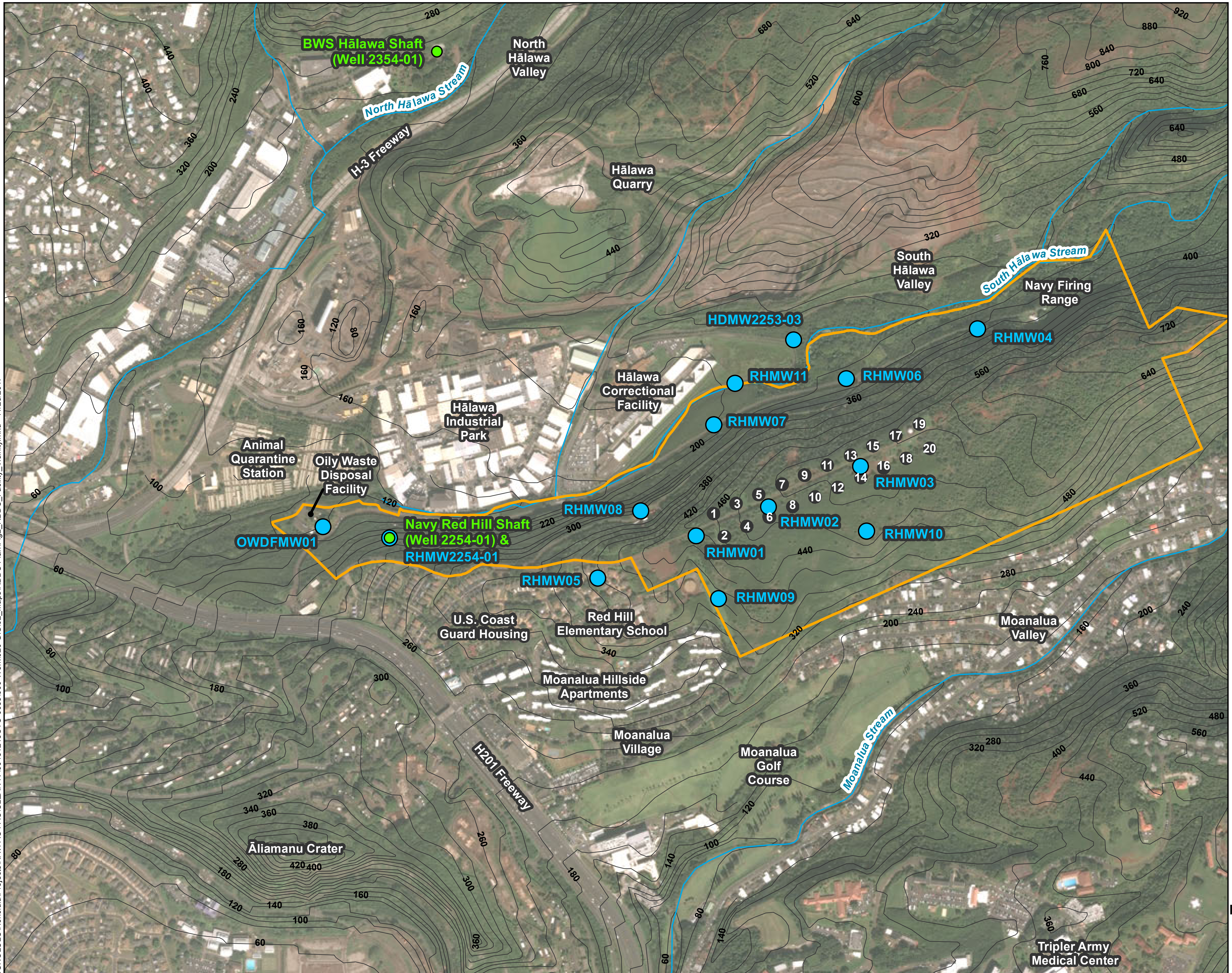
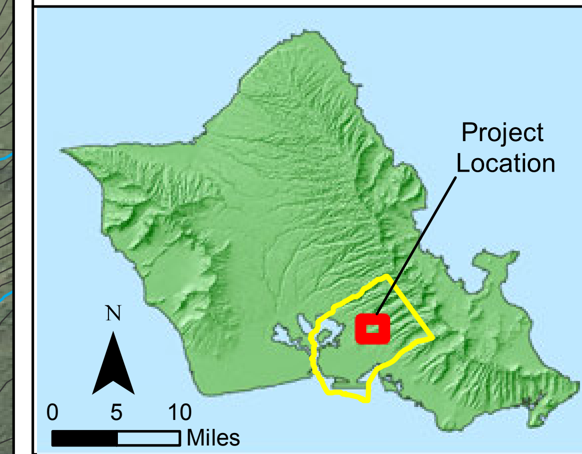


Location Map



Legend

- Red Hill Installation Boundary
- Existing Monitoring Well Location
- Existing Water Supply Well
- Stream
- 400 Topographic Contour (feet above mean sea level)
- Red Hill Fuel Storage Tank
- Groundwater Model Area

Notes

1. Map projection: NAD 1983 UTM Zone 4N
2. Base Map: DigitalGlobe, Inc. (DG) and NRCS. Publication_Date: 2015

N

0 1,000 2,000 Feet

Figure 2
Red Hill Bulk Fuel Storage Facility and Vicinity
Risk-Based Decision Criteria Development Plan
Investigation and Remediation of Releases and Groundwater Protection and Evaluation
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

\\HONOLULU\Honolulu\Projects\NAVFAC PAC\CLEAN IV\60481245CTO 0053\900-Work\920 GIS\02_Maps\RBDC Plan\Fig2_RBDC_Facility_Vicinity.mxd 11/28/2017

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The Facility contains 18 active and 2 inactive underground fuel storage tanks that are operated by the Navy. Each tank has a capacity of approximately 12.5 million gallons. The tanks are accessed via a tunnel system that connects to Pearl Harbor. Kerosene-based jet fuels stored at the Facility have included JP-5, JP-8, and F-24. In addition, Marine Diesel Fuel F-76 has been stored at the Facility. In January 2014, the Navy reported that JP-8 fuel was released from Tank 5. The bottoms of the tanks at the Facility are located approximately 100 ft above the underlying basal aquifer. The groundwater surface lies at an elevation of approximately 16 ft msl in the vicinity of the Facility. The nearest surface water bodies, South Hālawa and Moanalua Streams, are approximately 600 ft and 1,800 ft away from the nearest tanks, respectively. However, these are both losing streams that lie at a higher elevation than the aquifer and the tank bottoms.

The aquifer underlying the Facility is landward of the underground injection control (UIC) line and is currently used as a drinking water source. The nearest water supply source is Navy Supply Well 2254-01 (Red Hill Shaft), located approximately 2,600 ft west of the tank farm. This supply well provides potable water to the JBPHH water system, which serves approximately 65,200 military customers. The infiltration gallery supplying Navy Supply Well 2254-01 extends across the water table to within 1,530 ft of the underground tanks. At sampling point RHMW2254-01 located adjacent to the Well 2254-01 pumping station, total petroleum hydrocarbons (TPH), naphthalene, 1- and 2-methylnaphthalene, and toluene have been detected but not at concentrations above the DOH Tier 1 Environmental Action Levels (EALs) (DOH 2017). The Tier 1 EALs are conservatively estimated screening-level concentrations of contaminants in groundwater below which the contaminants can be assumed to not pose a potential adverse threat to human health and the environment. However, exceedance of an EAL does not mean that significant health or environmental concerns do exist, only that additional, more site-specific evaluation is warranted. The DOH EALs have been recently updated (DOH 2017), and the EALs for human toxicity and gross contamination (taste and odor) are equal to or higher than the previous EALs. The 2017 EALs for aquatic habitat protection are lower for some chemicals than are the previous EALs, but aquatic habitat EALs are not applicable to the drinking water pathway, and as discussed in Section 2.4, ecological pathways are not considered in this *RBDC Development Plan*.

1.2 PURPOSE

The main risk driver for the Facility is the potential impact of an inadvertent fuel release to groundwater that is the source of drinking water at Navy Supply Well 2254-01. For this reason, a program of long-term monitoring (LTM) of groundwater was implemented at the Facility in 2005. Thirteen wells are currently sampled and analyzed on a minimum of a quarterly basis. The purpose of developing RBDC is to help ensure that drinking water is protected from potential releases at the Facility. The purpose of developing SSRBLs is to use the LTM system of sentinel monitoring wells to identify the magnitude of any releases in areas downgradient of the Facility and determine the potential for COPCs in groundwater migrating to the public water supply to exceed RBDC and pose a potential risk to human health.

1.3 APPROACH

The RBDC will be used to establish criteria that are protective of the drinking water receptors. The approach will include the following:

- Establish RBDC that ensure the drinking water receptors are protected and are applied to the tap water source.
- Use the RBDC for each COPC in the calculation of SSRBLs.
- Apply the use of the RBDC and SSRBLs to update the Red Hill GWPP and ensure protection of the water supply.

1.3.1 RBDC Derivation

The proposed approach to deriving RBDC for COPCs in groundwater that will be used as drinking water originating from Navy Supply Well 2254-01 is summarized below. The COPCs identified for the Facility are discussed in Section 3 and consist of a list of individual chemicals as well as some chemical mixtures. The RBDC for the selected COPCs that are individual chemicals are the lower of the EPA (2017) Regional Screening Levels (RSLs) and the DOH (2017) EALs, which are based on cancer or non-cancer human health effects (Section 4). RBDC will be applied directly to the tap water source. This screening comparison will evaluate if there is potential risk to residents using groundwater as tap water.

For COPCs that are mixtures, such as TPH-diesel range organics (TPH-d) or TPH-middle distillate range organics (TPH-md), TPH-gasoline range organics (TPH-g), and TPH-residual range organics (TPH-o), no EPA RSLs are established. There are, however, DOH EALs available for these TPH groups. The TPH analysis will be conducted for two sample preparation methods: with and without silica gel cleanup (SGC). The polar fraction is inferred to be indicative of metabolites from biodegradation of the hydrocarbons in the fuel. As discussed in Section 3.2, SGC will be used to separate polar and non-polar compounds. TPH concentrations will be compared to DOH EALs for TPHs for both methodologies:

- Samples for which SGC is not performed
- Samples for which SGC is performed (non-polar TPHs)

For all COPCs, separate comparisons will be performed using health-based EALs as well as taste- and odor-based EALs. For TPH, an additional evaluation of the potential concerns associated with degradation products will be conducted as needed. Adjustments to the EALs for TPH-d or more detailed TPH fractional analysis may be considered, depending on the results of the initial comparisons against the EALs for TPH-d. Based on the current site data, an evaluation of TPH beyond a comparison with DOH EALs is not anticipated unless additional exposure routes other than those addressed by drinking water are determined to be complete in the future, or scientific advancements in the understanding of TPH chemistry or toxicity warrant such an evaluation.

1.3.2 SSRBL Derivation

SSRBLs will be established for each sentinel monitoring well by back-calculating a concentration from the RBDC. The RBDC will be applied to the tap water source, and the back-calculation will factor in mass flux to establish the SSRBL concentration for each sentinel monitoring well. The SSRBL will be used as an indicator that the RBDC may be exceeded at the tap water source if the SSRBL is exceeded.

1.3.3 Use of RBDC and SSRBLs

As described in the *Sentinel Well Network Development Plan* (DON 2017e), sentinel monitoring wells will be used to:

- Ensure a sufficient capture zone is created if needed to contain a release by pumping Navy Supply Well 2254-01 to contain COPCs.
- Determine if COPC concentrations at the sentinel monitoring wells indicate that additional contingency action is needed to ensure that drinking water remains safe for residential use.

The RBDC and SSRBLs will be identified as action levels that will be presented in the forthcoming Red Hill GWPP Update to determine if additional contingency action is needed to protect the drinking water supply.

Because of the conservative nature of the RBDC and SSRBLs, an exceedance of the SSRBLs will not necessarily suggest an unacceptable risk or hazard exists at the tap water source. Water from sampling point RHMW2254-01 adjacent to Navy Supply Well 2254-01 will also be monitored to ensure that RBDC at the supply well are met. The need to address exceedances of SSRBLs at the monitoring wells will be a two-step process, i.e., it will not be based solely on the comparison of site concentrations with SSRBLs. The RBDC for carcinogenic COPCs will be based on a target cancer risk of 1E-06, which is at the most conservative level of the EPA risk management range of 1E-06 to 1E-04. The RBDC for non-carcinogenic COPCs will be based on a hazard quotient (HQ) of 0.1 to ensure that cumulative risk and hazard are considered. If there are no exceedances of the SSRBLs, then cancer risk and non-cancer hazard that pose a potential threat to receptors will be considered unlikely, and no cumulative risk/hazard calculations will be needed. If exceedances are identified, then the cumulative risk and hazard will be calculated. The non-cancer hazard will be determined using screening criteria based on a HQ=1. If cancer risk is within or exceeds the risk management range or if the cumulative non-cancer hazard index (HI) is greater than 1, then the need for additional contingency action (e.g., further evaluation, more frequent monitoring, treatment) will be determined to address the exceedance.

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2. Risk-Based CSM/Risk Problem Formulation

The risk-based conceptual site model (CSM) and problem formulation provide the context for the pathways and human receptors selected as the basis for the RBDC. Several exposure pathways are potentially complete across the project area; the rationale for the selection of relevant pathways and receptors for groundwater exposure is detailed below.

2.1 Risk-Based Conceptual Site Model

The risk-based CSM is a representation of the chemical source, exposure pathways, and potential receptors. It is used to guide the evaluation of potential exposures for human health and ecological receptors so that relevant pathways, exposure routes, and ultimately risks can be evaluated in the human health risk assessment. Only potentially complete exposure pathways are evaluated quantitatively in the risk assessment, consistent with EPA (1989) guidance.

A complete exposure pathway includes all the following elements:

- Chemical source(s)
- Affected media
- Chemical release and transport mechanisms
- Potential routes of exposure
- Potential human or environmental receptors

The absence of any one of these elements results in an incomplete exposure pathway, which does not warrant further evaluation. The risk-based CSM (Figure 3) visually depicts the potential current and future exposure pathways at the Facility.

Each identified exposure route will be assessed as potentially complete, potentially complete but insignificant, or incomplete in accordance with the following criteria:

- *Potentially complete:* Exposure pathways that include all the above elements
- *Potentially complete but insignificant:* Exposure pathways identified as potentially complete but not likely to pose a potential for adverse effects to human health
- *Incomplete:* Exposure pathways that are not complete and therefore will not affect human health

2.2 Groundwater Investigations and Modeling

Groundwater is not extracted for water supply from directly beneath the tank farm, but drinking and other residential use of water from water supply wells near the tank farm have been identified as potentially complete exposure pathways. In addition to Navy Supply Well 2254-01 located within the Facility boundary, City and County of Honolulu Board of Water Supply (BWS) municipal water supply wells Hālawa Shaft (2354-01) and Moanalua Wells (2153-10, -11 and -12) are located approximately 4,400 ft northwest and 6,650 ft south of the Facility's tank farm, respectively. The potential for groundwater beneath the Facility to migrate to these municipal wells is being evaluated in the project's groundwater modeling effort.

Navy Supply Well 2254-01 (Red Hill Shaft) is located approximately 2,600 ft west of the tank farm. A groundwater modeling effort conducted as part of a previous Facility investigation (DON 2007) indicated that Navy Supply Well 2254-01 and its associated horizontal infiltration gallery intercept a significant portion of groundwater that passes beneath the Facility. At sampling point RHMW2254-01 adjacent to the Well 2254-01 pumping station, TPHs, naphthalene, 1- and 2-methylnaphthalene, and toluene have been detected but not at concentrations above the EALs.

Therefore, Navy Supply Well 2254-01 represents the current focus for the potential residential exposure points, i.e., residential taps. If the sentinel monitoring well network (DON 2017e) reveals that contaminated groundwater may also affect the other drinking water sources, the RBDC and SSRBLs (associated with appropriate sentinel monitoring wells) also will be used to evaluate potential risk to residents that use those water sources. Water supply wells identified within the groundwater model area are shown on Figure 4; additional detail is presented in the *Groundwater Model Evaluation Plan* (DON 2017d).

2.3 EXPOSURE PATHWAYS

As noted below, various potential exposure pathways are considered for receptors across the Facility. This subsection discusses those pathways that are specific to the development of the RBDC (Section 2.3.1) as well as pathways that are recognized as potentially complete for the Facility but are not relevant to development of the RBDC (Section 2.3.2).

Exposure routes and receptors associated with potentially contaminated groundwater are identified based on various factors:

- Contaminant source (release from Facility fuel storage tanks)
- Contaminated media (groundwater)
- Chemical migration pathways (groundwater flow)
- Exposure pathways (ingestion, dermal contact, inhalation)
- Current and future human receptors (offsite residents)

2.3.1 Pathways Incorporated into RBDC Development

Human exposure to groundwater as drinking water from the water supply wells and their distribution system is the primary potentially complete exposure pathway for Facility releases. Other pathways recognized in the risk-based CSM (e.g., direct exposure to soil, inhalation of soil gas, vapor intrusion, exposure via garden irrigation) were identified as incomplete exposure pathways or insignificant pathways compared to exposure to tap water. Therefore, no quantitative evaluation of these supplementary lower-exposure pathways is proposed since evaluation and protection of residential tap water exposures would also be protective of the other water-related pathways.

Human exposure to water from supply wells near the Facility helps to form potentially complete groundwater exposure pathways. Potential COPC impacts to Navy Supply Well 2254-01 form the most plausible complete risk pathway. Potential COPC migration to the BWS municipal water supply wells Hālawa Shaft and Moanalua Wells are also potentially complete pathways, which are being further evaluated through ongoing modeling and field efforts.

ONTRIBUTING SOURCE	TRANSPORT MECHANISM & EXPOSURE MEDIUM	EXPOSURE ROUTE*	Resident (Adult/Child)	Onsite Occupational Worker	Onsite Construction Worker	Onsite Visitor
Releases from Red Hill Fuel Storage Tanks						
Surface Soil	Direct Contact with Surface Soil [a]	INGESTION:	Incomplete	Incomplete	**Potentially Complete**	Incomplete
		DERMAL:	Incomplete	Incomplete	**Potentially Complete**	Incomplete

Rationale: Direct contact with surface soil is not a complete exposure pathway because any soil contamination is localized at the Facility, where there are no current residents and where future residential use is not likely.

Within the Facility, only construction workers (utility workers) in an excavation would be potentially exposed to soil, which is otherwise inaccessible.

ONTRIBUTING SOURCE	TRANSPORT MECHANISM & EXPOSURE MEDIUM	EXPOSURE ROUTE*	Resident (Adult/Child)	Onsite Occupational Worker	Onsite Construction Worker	Onsite Visitor
Subsurface Soil	Direct Contact with Subsurface Soil	INGESTION:	Incomplete	Incomplete	**Potentially Complete**	Incomplete
		DERMAL:	Incomplete	Incomplete	**Potentially Complete**	Incomplete

Rationale: Direct contact with surface soil is not a complete exposure pathway because any soil contamination is localized at the Facility, where there are no current residents and where future residential use is not likely.

Within the Facility, only construction workers (utility workers) in an excavation would be potentially exposed to soil, which is otherwise inaccessible.

ONTRIBUTING SOURCE	TRANSPORT MECHANISM & EXPOSURE MEDIUM	EXPOSURE ROUTE*	Resident (Adult/Child)	Onsite Occupational Worker	Onsite Construction Worker	Onsite Visitor
Subsurface Soil	Volatilization & Dispersion to Tunnel Air	INHALATION:	Incomplete	**Potentially Complete**	**Potentially Complete**	**Potentially Complete**

Rationale: Inhalation of soil vapor VOCs in ambient air is not a complete for the resident exposure pathway because any soil contamination is localized at the Facility, where there are no current residents and where future residential use is not likely.

Because the Facility is an active workplace, although receptors within the tunnel may be exposed to volatile chemicals, they are assumed to be covered under the Navy's OSHA programs.

ONTRIBUTING SOURCE	TRANSPORT MECHANISM & EXPOSURE MEDIUM	EXPOSURE ROUTE*	Resident (Adult/Child)	Onsite Occupational Worker	Onsite Construction Worker	Onsite Visitor
Subsurface Soil	Infiltration to Groundwater	INGESTION:	**Potentially Complete**	**Potentially Complete**	Incomplete	Incomplete
		DERMAL:	**Potentially Complete**	**Potentially Complete**	Incomplete	Incomplete
		INHALATION (BATHING/SHOWERING):	**Potentially Complete**	Incomplete	Incomplete	Incomplete
		INHALATION/ VAPOR INTRUSION:	Insignificant	Insignificant	Insignificant	Insignificant

Rationale:

For the RBDC development, the exposure point for groundwater is the residential tap.

Direct exposure to groundwater and inhalation of VOCs while bathing are considered potentially complete pathways for residents that use groundwater in the area as a drinking water source. Residents could be exposed to chemicals directly by drinking tap water. Residents could be exposed through dermal exposure while washing hands or showering/bathing. Finally, residents could be exposed to volatile chemicals via inhalation while showering/bathing.

Onsite occupational workers could potentially be exposed to drinking water due to the proximity of a Navy drinking water supply well downgradient of the Facility. Bathing, however, is not a realistic scenario for occupational workers.

Due to the depth to groundwater (400–500 feet bgs), there is not a complete exposure pathway for construction workers in an excavation.

Visitors are not expected to drink any water while on site; therefore, this pathway is considered incomplete.

Inhalation of indoor or outdoor air is considered insignificant because groundwater is too deep for any appreciable migration of VOCs to indoor or outdoor air to occur; any such exposure is expected to be insignificant compared to exposure via the direct use of tap water for residents and also insignificant for people in the tunnel compared to VOC inputs to tunnel air from releases to soil and current Facility operations.

ONTRIBUTING SOURCE	TRANSPORT MECHANISM & EXPOSURE MEDIUM	EXPOSURE ROUTE*	Resident (Adult/Child)	Onsite Occupational Worker	Onsite Construction Worker	Onsite Visitor
	Groundwater Discharge to Surface Water	ALL PATHWAYS:	Incomplete	Incomplete	Incomplete	Incomplete

Rationale: There are no surface water bodies where groundwater discharges to surface water on site. Although there might be groundwater discharge locations close to Pearl Harbor, any exposure to off-site receptors at these locations is considered insignificant as Pearl Harbor is approximately 2 miles from the Facility.

ONTRIBUTING SOURCE	TRANSPORT MECHANISM & EXPOSURE MEDIUM	EXPOSURE ROUTE*	Resident (Adult/Child)	Onsite Occupational Worker	Onsite Construction Worker	Onsite Visitor
	Use of Groundwater for Irrigation	ALL PATHWAYS:	Insignificant	Incomplete	Incomplete	Incomplete

Rationale: Groundwater could be used to irrigate gardens at local residences and could be used to irrigate the nearby golf course. Exposure to volatile COPCs in groundwater would be limited due to volatilization during irrigation. Further, exposure to volatile or non-volatile components of COPCs is expected to be insignificant for residents compared to direct contact of groundwater as a drinking water source. There is not a complete pathway for onsite receptors.

Red outlined cells indicate the pathways that are relevant to the RBDC development.

*A potentially complete exposure pathway includes all of the following elements:

- Sources and type of chemicals present
- Affected media
- Chemical release and transport mechanisms
- Known and potential routes of exposure
- Known or potential human receptors

Insignificant exposure pathway = pathway is potentially complete, but not likely to pose a potential for adverse effects to human health.

Incomplete exposure pathway = pathway is not complete and therefore will not affect human health.

Figure 3
Human Health Exposure Pathway Evaluation for Groundwater
Risk-Based Decision Criteria Development Plan
Investigation and Remediation of Releases and Groundwater Protection and Evaluation
Red Hill Bulk Fuel Storage Facility
JBPHH, Oʻahu, Hawaiʻi

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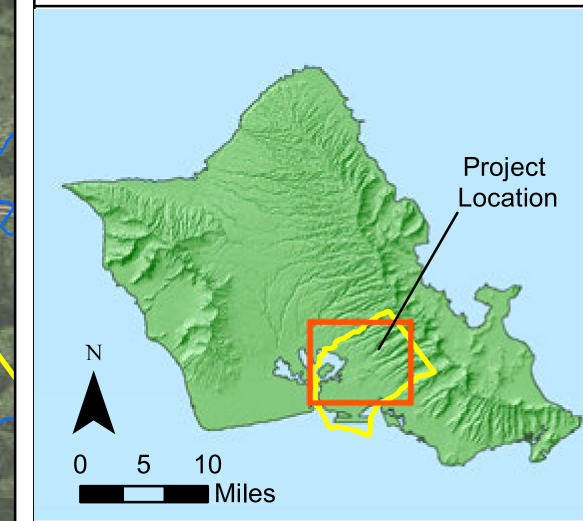
Location Map



Legend

- Supply Well with Pumping Data
- Supply Well without Pumping Data
- Groundwater Model Area
- Red Hill Installation Boundary and Fuel Storage Tanks
- Stream

Notes

1. Map projection: NAD 1983 UTM Zone 4N
2. DigitalGlobe, Inc. (DG) and NRCS. Publication_Date: 2015

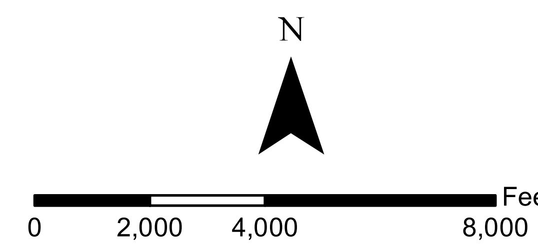


Figure 4
Water Supply Wells within the Model Area
Risk-Based Decision Criteria Development Plan
Investigation and Remediation of Releases and Groundwater Protection and Evaluation
Red Hill Bulk Fuel Storage Facility
JBPHH, O'ahu, Hawai'i

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2.3.2 Pathways Excluded from RBDC Development

The vapor intrusion pathway for nearby residents is considered an insignificant pathway. This is due to the depth of groundwater in the residential areas adjacent to the Facility and the fact that the vast majority of the fuels stored at the Facility have very little volatile content.

Direct exposure to soil and soil vapor inside the tunnel are potentially complete pathways, although the DON (2007) Tier 2 risk assessment found that the soil vapor to indoor air pathway posed negligible risk to industrial and residential receptors, based on site conditions at that time. Any potential vapor intrusion into the Facility tunnel system could not be differentiated from other sources within the tank complex. Further, because the Facility is an active workplace, potential risks from exposure to fuel-related gases inside the tunnel are addressed under the Navy's Occupational Safety and Health Administration (OSHA) program. Potential exposure to onsite groundwater is an incomplete exposure pathway because of the distance from ground surface to the aquifer (between 400 and 500 ft on the Red Hill ridgeline). At Navy Supply Well 2241-01, groundwater is as close as 81 ft to the ground surface (DON 2007), but even this depth is too great for direct exposure to occur. All potential exposure pathways for humans other than tap water exposure pathways are either incomplete or insignificant compared to tap water pathways for offsite residents and are not incorporated into the development of RBDC.

A preliminary risk assessment conducted as part of a previous Facility investigation concluded that there were no significant pathways for ecological receptors (DON 2002). DON (2007) notes that both South Hālawa Stream and Moanalua Stream are impaired streams and do not support aquatic life, with nutrient inputs, pathogens, turbidity and exotic species due to urban runoff, storm sewers, and other sources of disturbance. Further, groundwater occurs 80 ft beneath the stream beds adjacent to the Facility and does not discharge to the streams. The artesian features near Pearl Harbor noted in Section 1.1 are considered too far away (Pearl Harbor is approximately 2.5 miles from the Facility) to pose a significant concern for any ecological receptor at those locations. For these reasons, ecological risk considerations are not part of this *RBDC Development Plan.*

2.4 RECEPTORS

The focus of this *RBDC Development Plan* is the investigation of the potential effects of exposure to COPCs in groundwater under the Facility that migrates to a drinking water source for residents.

2.4.1 Receptors Incorporated into RBDC Development

The residential exposure scenario evaluated for this investigation is the same as the residential scenario that is the basis for the EPA (2017) RSLs and the DOH (2017) EALs. The EPA tap water scenario is a reasonable maximum exposure (RME) scenario which incorporates default residential exposure assumptions that represent upper-bound estimates of exposure (EPA 2017).

To evaluate potential risks to offsite residents from exposure to COPCs in groundwater used as drinking/domestic water, the exposure pathways recognized for the EPA (2017) tap water exposure scenarios provide the basis for the RBDC development. The RBDC will be applicable for residents exposed to groundwater extracted at production wells, as discussed in Section 2.3.

2.4.2 Receptors Excluded from RBDC Development

Construction workers, industrial workers, and/or visitors at the Facility may experience direct exposure to soil and soil gas (inside and outside tunnels), although as discussed in Section 2.3.2, vapor intrusion to indoor air is not currently considered a significant pathway. Although soil and soil gas pathways are included in the risk-based CSM for completeness, those pathways are not the focus of the groundwater RBDC development and are not further discussed. Further, because the Facility is an active workplace, potential risks from exposure to fuel-related vapors inside the Facility tunnels is addressed under the Navy's OSHA program.

For construction workers, potential exposure to groundwater is an incomplete exposure pathway. The distance from ground surface to the aquifer under the tank farm (between 400 and 500 ft bgs on the Red Hill ridgeline) and at Navy Supply Well 2241-01 (81 ft bgs) (DON 2007) preclude direct contact.

Direct contact to contaminated groundwater through an industrial tap water scenario at the Facility is a potentially complete pathway. Because this same pathway for residents is based on greater exposure assumptions for residents, however, the protectiveness of the RBDC is driven by the residential scenario.

For the above reasons, onsite industrial workers, construction workers, and visitors are not included in the development of RBDC for the Facility.

2.5 POTENTIAL EXPOSURE TO NAPL

There is potential exposure to non-aqueous-phase liquid (NAPL) by workers in the tunnel, but that is covered under the Navy's OSHA program. NAPL migration is being evaluated under AOC Statement of Work Sections 6 and 7 in support of the Section 3 Tank Upgrade Alternatives (TUA) decision process. Finally, it is possible that NAPL could reach Navy Supply Well 2254-01, or daylight on the side of Red Hill if a large-enough release were to occur. Contingencies are being developed so that NAPL is treated before impacts to drinking water could occur, or so that it can be properly managed if it seeps out of the side of Red Hill as part of an emergency response contingency.

The DOH EAL approach considers the presence of NAPL to represent a "free product" scenario and does not apply risk-based criteria to NAPL-impacted media. However, the gross contamination EALs, which consider aspects of solubility and saturation limits, may be used for preliminary comparisons of NAPL-related data.

3. Selection of COPCs

The COPCs selected for the development of RBDC for the Facility and the rationale for selection or rejection of candidate COPCs are discussed below.

3.1 SUMMARY OF COPC SELECTION PROCESS

The current COPCs, as presented in the AOC Statement of Work Sections 6 and 7 scoping completion letter dated February 4, 2016 (EPA Region 9 and DOH 2016), are as follows:

Fuel-Related COPCs:

- TPH-g
- TPH-d
- TPH-o
- Benzene
- Ethylbenzene
- Toluene
- Total xylenes
- Naphthalene
- 1-Methylnaphthalene
- 2-Methylnaphthalene

Additional COPCs – added per *Sampling and Analysis Plan Revision 01* (DON 2017b):

- 2-[2-methoxyethoxy]-ethanol
- Phenol

3.1.1 Rationale for Inclusion as COPCs

The January 12, 2016 Navy memorandum *COPC Recommendations, Long Term Groundwater Monitoring Red Hill Bulk Fuel Storage Fuel Facility* (DON 2016a) presents rationale for the selection of the above COPCs. TPH were selected because they were historically detected above EALs and are associated with fuels stored on site. 1-methylnaphthalene, 2-methylnaphthalene, and naphthalene were also recommended as COPCs because they were historically detected above EALs, are associated with fuels stored on site, and are recommended for analysis by DOH at sites were TPH-d may be present (DOH 2017).

BTEX (benzene, toluene, ethylbenzene, and xylenes) compounds were detected in groundwater but not at concentrations above EALs. They were recommended as COPCs, however, as they are associated with the fuels stored on site. Further, the DOH Office of Hazard Evaluation and Emergency Response (HEER) *Technical Guidance Manual* (TGM) *for the Implementation of the Hawaii State Contingency Plan* recommends specific analytes to be tested for sites with residual petroleum contamination (DOH 2016). These include:

- *For middle distillates (e.g., kerosene, diesel fuel, home heating fuel, JP-8 jet fuel):* TPH, BTEX, naphthalene, and methylnaphthalenes (1- and 2-)
- *For gasolines:* TPH, BTEX, and naphthalene

The Navy recommended that 2-[2-methoxyethoxy]-ethanol and phenol be added to the COPC list for the Facility. It is estimated that, at most, 26.4 gallons of 2-(2-methoxyethoxy)-ethanol may have been released as part of the 27,000-gallon Tank 5 fuel release in January 2014. Phenol was included because it is present at low concentrations in Marine Diesel Fuel F-76. Given the short half-lives and very low concentrations of these two chemicals in fuel (e.g., additive to bulk fuel ratios), the Navy further recommends these two chemicals be removed from the COPC list if groundwater sampling results show chemical concentrations are not detected above screening criteria, similar to the approach agreed upon for the lead scavengers (see below).

As indicated in the Sections 6 and 7 scoping completion letter dated February 4, 2016 (EPA Region 9 and DOH 2016), lead scavengers (1,2 dichloroethane and 1,2 dibromomethane) are also included in the list of analytes. These chemicals are not considered COPCs, however, and sampling for them will be discontinued if they are not detected above groundwater action levels during a sampling period of 1 year.

As is well-documented, TPH is a complex mixture of thousands of hydrocarbon chemicals, many of which have not been characterized. In addition to the individual constituents that can be identified through volatile organic compound (VOC) and semivolatile organic compound (SVOC) analyses, additional analytical methods are used to measure TPH based on carbon number range: TPH-g, TPH-d, and TPH-o. All these TPH fractions have been detected in groundwater under the Facility and are already included as COPCs, in addition to the individual indicator compound COPCs of BTEX and naphthalenes. As part of this process, DOH guidance will be followed, and it is expected that polar constituents as evidenced in samples without SGC are likely to drive health concerns for TPH.

3.1.2 Rationale for Elimination

Although DOH (2016) lists other chemicals in the recommended analyte lists, they are not included as COPCs for the Facility because they are not associated with the fuels stored at the site. For example, alkylleads are listed as fuel additives in DOH (2016), but the Facility currently stores JP-5, NATO-grade F-24 jet fuel, and Marine Diesel Fuel (F-76) and has not stored leaded fuels since 1968. Furthermore, alkylleads would quickly attenuate in the environment, and no lead scavengers have been detected in Red Hill monitoring wells.

The long list of analytes historically included in the Red Hill LTM program are summarized in the January 12, 2016 Navy memorandum *COPC Recommendations, Long-Term Groundwater Monitoring, Red Hill Bulk Fuel Storage Fuel Facility* (DON 2016a, Table 3). Chemicals not included as recommended COPCs were not detected in groundwater throughout the LTM program and/or are not associated with fuels stored at the Facility.

The June 28, 2016 Navy memorandum *Chemicals of Potential Concern (COPCs) Recommendations, Fuel Additives, Red Hill Bulk Fuel Storage Fuel Facility* summarizes 18 chemical constituents of additives associated with fuel stored at the Facility (DON 2016b). Seven of these (four BTEX compounds, 1- and 2-methylnaphthalene, and naphthalene) are included as COPCs and are addressed above. Four of the 18 were not included as they are proprietary (trade-secret) and permitted chemicals for which no toxicological information could be obtained. Seven of the 18 chemicals have no associated regulatory screening criteria, and are present at extremely dilute concentrations in fuel and/or have very low water-solubility. Therefore, the potential for exposure to these chemicals through the residential tap water use pathway is low. Overall, the uncertainty related to exclusion of these chemicals is expected to result in minimal to low likelihood of underestimating risk.

Trimethylbenzenes (and other substituted benzenes) have been occasionally detected in groundwater. However, their detections are infrequent, they are not typically considered COPCs for gasoline or middle distillate releases per DOH (2017), and no groundwater EALs are established for these compounds. Any detections of trimethylbenzenes will be compared to the EPA tap water RSLs to confirm that they are not significant and do not need to be considered further. Similarly, while higher substituted naphthalenes may also be present, their primary value would be in source characterization. While many kinds of naphthalene compounds are used in forensic and fingerprinting evaluations, they are typically not used for risk assessment purposes due to the lack of toxicity values and are not included in regulatory guidance for TPH risk evaluation (e.g., DOH 2017, EPA 2017).

3.2 NATURE OF ANALYTICAL DATA TO BE GENERATED IN FUTURE SAMPLING

Additional COPCs may be added to the current list, based on changes in fuels stored at the Facility, other possible chemical sources identified at the Facility, or future data that will reflect ongoing advancements in the analysis and evaluation of TPH-related chemicals. At this time, carbon fractions will not be considered as COPCs. They are discussed herein and will be included in future groundwater monitoring because the analytical data for these hydrocarbon ranges help define potential sources and biodegradation.

Future sampling may also focus on documentation of TPH biodegradation in the source and plume areas. Some State agencies, including DOH, have recommended that the potential toxicity of polar degradation compounds (also known as metabolites) formed during TPH biodegradation should also be evaluated (DOH 2017). Analysis of groundwater samples with and without the SGC extraction step for the extracted sample provides analytical data that includes and excludes the polar metabolites (SGC data), or includes metabolites as well as naturally occurring organic matter compounds (non-SGC data).

Limitations and uncertainties are associated with the evaluation of metabolites. Widely accepted and commercially available analytical methods for specific TPH metabolites are currently lacking, insufficient information is available regarding their potential toxicity, and no methods are established to incorporate consideration of polar metabolites into risk assessment practices. Comparing the non-SGC result directly to a TPH-based screening level assumes that all the compounds in the sample originate from the source TPH, and that the polar metabolites (if present) are equal in toxicity to the parent TPH compounds. This is a screening-level assumption that may not be representative of actual site-related TPH toxicity. Therefore, the inclusion of metabolites in the risk assessment process for this project will be limited to qualitative evaluations of SGC and non-SGC data (or through use of total organic carbon analyses).

The Navy will follow DOH guidance, and although DOH (2016) screening guidance requires that metabolite toxicity is similar to parent compound toxicity, the guidance also notes that metabolites may be short-lived depending on the level of oxygenation and degree to which biodegradation is favored in the groundwater transport pathway. Thus, even if metabolites are found to be present at the source wells, a complete exposure pathway may or may not occur. Therefore, if metabolites are detected in the source wells (above DOH criteria), a more site-specific understanding of fate and transport and the persistence of these metabolites will be evaluated in order to ascertain the spatial and temporal trends in metabolite distributions between the monitoring wells and the public water supply.

3.3 Consideration of Additional COPC Candidates Related to Fuels That May Be Stored in the Future

The nature of the fuels that may be stored in the Facility is not likely to change appreciably in the future and is most likely limited to non-volatile fuels such as jet fuels and diesels with some minor variations in formulation. These may include additives and performance-enhancing chemicals that have not used or detected to date in historical and current groundwater data. If detected in the future, these chemicals will be included in the screening and risk evaluation process and will be considered for retention as COPCs.

4. Risk-Based Decision Criteria Derivation

The RBDC are conservative screening values intended to be protective of residents potentially exposed to Facility-released COPCs in residential tap water.

4.1 Selected Endpoints as Basis of Screening Criteria

The RBDC for Facility COPCs are based on various endpoints. For all COPCs, RBDC are the lower of the EPA (2017) RSLs for residential tap water and the DOH (2017) EALs for unrestricted use of groundwater. EPA RSLs are based on cancer (target cancer risk of 1E-06) or non-cancer health effects (target non-cancer HQ of 0.1).

4.1.1 Risk Basis of RBDC

The primary endpoint that the RBDC are intended to protect is residential exposure to groundwater at the tap. The RBDC are intended to protect residents from the potential carcinogenic and non-carcinogenic effects from drinking or dermally absorbing tap water with COPCs, or from inhaling volatile COPCs while bathing/showering. Other potential exposure pathways are considered less important for residents and are not included as the basis for RBDC development.

Because the RBDC are intended to protect people who are likely to have the greatest exposure to groundwater, the RBDC for most COPCs will be the lower of the EPA (2017) RSLs or the DOH (2017) EALs for drinking water.

Because EPA and/or DOH has adopted regulatory limits for drinking water for all of the COPCs selected for this project and because there are no complete exposure routes other than those addressed by the regulatory limits developed for drinking water, the development of risk-based criteria for current COPCs is not anticipated. If additional exposure routes other than those addressed by drinking water are determined to be complete in the future, or if scientific advancements in the understanding of TPH chemistry or toxicity warrant it, it may be necessary to calculate site-specific RBDC for this site. Such calculations would be performed using standard equations and exposure assumptions along with any site- and route-specific assumptions that may be appropriate.

The RBDC will be applied to total groundwater data and possibly dissolved concentrations for a subset of samples, to determine the influence of filtration on analytical results. This is consistent with DOH guidance for evaluation of groundwater for potable water uses (DOH [2017] Volume 2, Page 5-1).

4.1.2 Gross Contamination (Odor and Taste)

DOH (2017) provides EALs for Gross Contamination effects. These are not health-based effects but are based on other factors such as taste, odors, and sheens. The lowest EALs for TPH in groundwater are those based on gross contamination (odor) and will likely drive risk associated with TPH.

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5. Conclusions, Recommendations, and Management Considerations

Summarized below are sampling and analytical recommendations, the derived RBDC approach and selected values, recommendations for how the RBDC will be used, and recommendations for addressing the results of the SSRBL screening comparison with site data.

5.1 Sampling and Analytical Recommendations

The LTM program currently analyzes all groundwater and supply water samples for the following analyte groups:

COPCs identified in this *RBDC Development Plan* (sampling frequency is each monitoring round):

- TPH-g, TPH-d, TPH-o (by EPA 8015) (with and without SGC)
- VOCs (by EPA 8260)
- Polynuclear aromatic hydrocarbons (PAHs) (by EPA 8270 SIM)
- 2-[2-methoxyethoxy]-ethanol (by EPA 8270 Mod)
- Phenol (by EPA 8270)

Non-COPCs:

- Hydrocarbon fractionation analyses (October 2017 sampling round and as warranted in the future depending on exceedances of EALs for TPH) for the fractions that are listed in DOH (2017, Table 6-2), as follows: C5–C8 aliphatics, C9–C18 aliphatics, C19+ aliphatics, and C9+ aromatics.
- Natural attenuation parameters provide information on aquifer conditions, degradation, and other components not directly related to COPC screening comparisons. The analytical methodologies for these analytes are provided in the project *Sampling and Analysis Plan Addendum 01* (DON 2017c).

5.2 Recommended Screening Criteria

EPA (2017) RSLs and/or DOH (2017) EALs for drinking water are established for all of the COPCs identified for the current investigation, including TPH-d, TPH-g, and TPH-o. The lowest of the available values will be selected as the RBDC and the basis for the calculation of SSRBL. The preliminary RBDC are presented in Table 5-1.

Although not anticipated, if additional exposure routes other than those addressed by the drinking water pathway are determined to be complete in the future, or if scientific advancements in the understanding of TPH chemistry or toxicity warrant it, it may be necessary to calculate site-specific RBDC for this site. Such calculations would be performed using standard equations and exposure assumptions along with any site- and route-specific assumptions that may be appropriate.

Endpoints other than health risk-based (i.e., odor and taste concerns) will also be addressed as needed.

Table 5-1: EPA Regional Screening Levels and DOH Environmental Action Levels for COPCs

	EPA (2017) RSL		DOH (2017) EALs							
	THQ=0.1		Table F-1a (Drinking Water)						Table F-3b (Risk-Based Screening Levels for Tapwater)	
COPC	Tap Water (µg/L)	Basis	Groundwater EAL (µg/L)	Basis	DW Toxicity	Basis	Gross Contamination	Risk-Based	Basis
Benzene	0.46	c	5	DW toxicity	5	Primary MCL	170	0.48	carcinogenic
Ethylbenzene	1.5	c	7.3	Aquatic Habitat Goal	700	Primary MCL	30	1.7	carcinogenic
Toluene	110	n	9.8	Aquatic Habitat Goal	1000	Primary MCL	40	1400	noncancer
Xylenes	19	n	13	Aquatic Habitat Goal	10,000	Primary MCL	20	210	noncancer
Methylnaphthalene, 1-	1.1	c	2.1	Aquatic Habitat Goal	27	carcinogenic	10	27	carcinogenic
Methylnaphthalene, 2-	3.6	n	4.7	Aquatic Habitat Goal	24	noncancer	10	24	noncancer
Naphthalene	0.17	c	12	Aquatic Habitat Goal	17	CDPH notification level	21	0.17	carcinogenic
TPH-g (gasolines)	—	—	300	DW toxicity	300	noncancer	500	300	noncancer
TPH-d (middle distillates)	—	—	400	DW toxicity	400	noncancer	500	400	noncancer
TPH-o (residual fuels)	—	—	500	Gross Contamination	2,400	noncancer	500	2,400	noncancer
2-[2-methoxyethoxy]-ethanol	80	n	—	—	—	—	—	—	—
Phenol	580	n	5	Gross Contamination	6,000	noncancer	5	6,000	noncancer

Shaded cell lowest relevant screening value
— not established
µg/L microgram per liter
c cancer
CDPH California Department of Public Health
DW drinking water
MCL Maximum Contaminant Level
n non-cancer

5.3 RECOMMENDATIONS FOR APPLICATION OF SCREENING CRITERIA

The screening criteria apply to residential exposures only, and the potential exposure point is water from the tap. The RBDC for drinking water and the SSRBLs derived for the monitoring wells will support AOC Statement of Work Sections 6 and 7 (EPA Region 9 and DOH 2015), in part by adding context to the understanding of COPC fate and transport. The RBDC will also be used with the sentinel monitoring well network (DON 2017e) to ensure that groundwater is protected. As stated in AOC Statement of Work Section 7, the Navy/DLA will update the current GWPP (DON 2014) to include response procedures and trigger points in the event that contamination from the Facility shows movement toward any drinking water well. The collective work done under Section 7 will be used to inform subsequent updates to the Red Hill GWPP.

The SSRBL comparisons will be protective of drinking water and will be evaluated on a well-by-well basis, i.e., areal averages or upper confidence limits (UCLs) will not be calculated. The SSRBL will be used in concert with the groundwater flow model as well as a mass flux approach to calculate COPC concentrations (SSRBLs) for each upgradient sentinel monitoring well that are expected to result in COPC concentrations equal to the RBDC at Navy Supply Well 2254-01.

5.4 RECOMMENDED DECISION-MAKING APPROACH BASED ON RESULTS OF SCREENING

As discussed in Section 1, RBDC are risk-based screening values that are protective of residential tap water use. The SSRBLs are based on the RBDC but are intended for use at individual wells in the sentinel monitoring well network. The SSRBLs are target groundwater concentrations at each individual monitoring well that indicate if the RBDC may be exceeded at the resident tap. If the concentration of a COPC in groundwater at a given monitoring well location does not exceed the SSRBL, it is likely that as groundwater migrates from that well to Navy Supply Well 2254-01, the concentration of that COPC will not exceed the RBDC. These screening values will be used as follows:

- If the detected concentration of a COPC exceeds the back-calculated SSRBL at a monitoring well location, this will indicate that the concentration in drinking water could exceed RBDC that are protective of residential tap water use. However, the need to address exceedances of SSRBLs at the monitoring well locations will be a two-step process, i.e., it will not be based solely on the comparison of site concentrations with SSRBLs.
- If there are no exceedances of the SSRBLs, then cancer risks and non-cancer hazards will be considered unlikely and cumulative risk/hazard calculations will not be needed.
- If there are exceedances of the SSRBLs, then cumulative risks and hazards will be calculated to determine if the exceedances suggest actual potential risk. If cumulative cancer risk estimates are greater than 1×10^{-6} or cumulative non-cancer HIs are greater than 1, then the need for additional contingency action (e.g., further evaluation, more frequent monitoring, treatment) will be determined to address the exceedance.

6. References

Department of Health, State of Hawaii (DOH). 2016. *Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan*. Interim Final. Honolulu, HI: Hazard Evaluation and Emergency Response Office. September.

———. 2017. "Environmental Hazard Evaluation and Environmental Action Levels." Summer 2016, revised January 2017. January 2017. http://eha-web.doh.hawaii.gov/eha-cma/Leaders/HEER/environmental-hazard-evaluation-and-environmental-action-levels.

Department of the Navy (DON). 2002. *Red Hill Bulk Fuel Storage Facility Investigation Report (Final) for Fleet Industrial Supply Center (FISC), Oahu, Hawaii*. Prepared by AMEC Earth & Environmental, Inc., Huntsville, AL. Pearl Harbor, HI: Pacific Division, Naval Facilities Engineering Command. August.

———. 2007. *Red Hill Bulk Fuel Storage Facility Final Technical Report, Pearl Harbor, Hawaii*. Prepared by TEC Inc., Honolulu, HI. Pearl Harbor, HI: Naval Facilities Engineering Command, Pacific. August.

———. 2014. *Interim Update, Red Hill Bulk Fuel Storage Facility Final Groundwater Protection Plan, Pearl Harbor, Hawaii. (January 2008)*. Pearl Harbor, HI: Naval Facilities Engineering Command, Pacific. August.

———. 2016a. *COPC Recommendations, Long Term Groundwater Monitoring, Red Hill Bulk Fuel Storage Fuel Facility. January 12*.

———. 2016b. *Chemicals of Potential Concern (COPCs) Recommendations, Fuel Additives, Red Hill Bulk Fuel Storage Fuel Facility. June 28*.

———. 2017a. *Work Plan / Scope of Work, 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; January 4, 2017, Revision 02*. Prepared by AECOM Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy, Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI.

———. 2017b. *Sampling and Analysis Plan, 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; April 20, 2017, Revision 01*. Prepared by AECOM Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy, Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI.

———. 2017c. *Sampling and Analysis Plan Addendum 01, 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; September 1, 2017, Revision 00*. Prepared by AECOM Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy, Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI.

———. 2017d. *Groundwater Model Evaluation Plan, 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; September 8, 2017, Revision 00*. Prepared by AECOM

Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy, Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI.

———. 2017e. *Sentinel Well Network Development Plan, 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; December 11, 2017, Revision 00*. Prepared by AECOM Technical Services, Inc., Honolulu, HI. Prepared for Defense Logistics Agency Energy, Fort Belvoir, VA, under Naval Facilities Engineering Command, Hawaii, JBPHH HI.

Environmental Protection Agency, United States (EPA). 1989. *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A)*. Interim Final. EPA/540/1-89/002. Office of Emergency and Remedial Response. December.

———. 2017. *Regional Screening Levels for Chemical Contaminants at Superfund Sites*. EPA Office of Superfund. June.

Environmental Protection Agency, United States, Region 9; and Department of Health, State of Hawaii (EPA Region 9 and DOH). 2015. *Administrative Order on Consent In the Matter of Red Hill Bulk Fuel Storage Facility, EPA Docket No: RCRA 7003-R9-2015-01; DOH Docket No: 15-UST-EA-01*. September.

———. 2016. “Final Scoping for AOC SOW Sections 6 and 7, and Navy’s Proposed Chemical of Potential Concern (COPC) Recommendations,” February 4, 2016. Letter from Bob Pallarino, EPA Red Hill Project Coordinator, and Steven Chang, DOH Red Hill Project Coordinator, to: James A. K. Miyamoto, Naval Facilities Engineering Command, Hawaii, Joint Base Pearl Harbor-Hickam.