Red Hill Administrative Order on Consent, Attachment A Scope of Work 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 Contaminate 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 Dean Tufts, CEC, USN
Regional Engineer, Navy Region Hawaii

Date: 5/4/16

# 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

**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**

**May 4, 2016**

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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# 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

**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**

**May 4, 2016**

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

# EXECUTIVE SUMMARY

This Work Plan (WP) and Scope of Work (SOW) describes the activities planned for investigation and remediation of petroleum product releases and protection and evaluation of groundwater at Red Hill Bulk Fuel Storage Facility (RHSF), Joint Base Pearl Harbor-Hickam, Hawai‘i.

RHSF is the state’s largest field-constructed underground storage tank (UST) complex, located in the south-central portion of the island of O‘ahu, Hawai‘i. It is owned and operated by the United States (U.S.) Department of the Navy (DON; “Navy”). The Facility contains 18 active and 2 inactive USTs operated by the Naval Supply Systems Command Fleet Logistics Center, Pearl Harbor, Hawai‘i. Each UST has a capacity of approximately 12.5 million gallons. The USTs currently contain Jet Fuel Propellant (JP)-5, JP-8, and Marine Diesel Fuel (F-76). The bottoms of the USTs are located approximately 100 feet (ft) above a major groundwater aquifer, which is used which is used to feed both the Navy and the City and County of Honolulu drinking water sources.

In the course of refilling Tank 5, after scheduled maintenance, a fuel release was discovered and verbally reported to the State of Hawai‘i Department of Health (DOH) on January 13, 2014. A release of JP-8 from Tank 5 was confirmed and reported to DOH on January 23, 2014. The volume of fuel released was estimated to be 27,000 gallons. The Navy is investigating the cause and impacts of the reported release from Tank 5 in consultation with U.S. Environmental Protection Agency (EPA) Region 9 and DOH (herein referred to as the “Regulatory Agencies”).

This investigation will be performed by the Navy and Defense Logistics Agency (DLA) in order to address the goals and requirements of the Administrative Order on Consent (AOC) (EPA Docket No: RCRA 7003-R9-2015-01; DOH Docket No: 15-UST-EA-01) issued by EPA Region 9 and DOH. This investigation specifically addresses the AOC Statement of Work Section 6, Investigation and Remediation of Releases, and Section 7, Groundwater Protection and Evaluation, which have the following agreed-upon purposes:

> Section 6: *“The purpose of the deliverables to be developed and the work to be performed under this Section is to determine the feasibility of alternatives for investigating and remediating releases from the Facility.”*
>
> Section 7: *“The purpose of the deliverables to be developed and the work to be performed under this Section is to monitor and characterize the flow of groundwater around the Facility. Navy and DLA shall update the existing Groundwater Protection Plan 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 in this Section shall be used to inform subsequent changes to the Groundwater Protection Plan. The deliverables and work to be performed under this Section may include the installation of additional monitoring wells as needed.”*

Activities conducted under this WP/SOW will be performed in accordance with applicable State and Federal regulations, and in conjunction with the activities and procedures specified in the RHSF Monitoring Well Installation WP (DON 2016) and the RHSF *Groundwater Protection Plan* (DON 2014). As agreed upon by the Parties in AOC Scoping Meetings, this WP/SOW with the RHSF Monitoring Well Installation WP will intend to fulfill the following AOC Statement of Work requirements:

- Section 6.2 Investigation and Remediation of Releases SOW
- Section 7.1.2 Groundwater Flow Model SOW

- Section 7.2.2 Contaminant Fate and Transport (CF&T) Model SOW
- Section 7.3.2 Groundwater Monitoring Well Network SOW

The findings of this investigation will be used to prepare the AOC Statement of Work Section 6.3 *Investigation and Remediation of Releases Report*, Section 6.5 *Investigation and Remediation of Releases Decision Document and Implementation*, Section 7.1.3 *Groundwater Flow Model Report*, Section 7.2.3 *CF&T Model Report*, Section 7.3.3 *Groundwater Monitoring Well Network Report*, and Section 7.3.5 *Groundwater Monitoring Well Network Decision Document and Implementation*.

Scoping Meetings were held among the Parties of the AOC (the Regulatory Agencies, Navy, and DLA), and their consultants, with partial attendance by representatives from the State of Hawai‘i Department of Land and Natural Resources' Commission on Water Resource Management in October 2015 and November–December 2015 to discuss the activities and analyses proposed by the Navy and DLA to address the objectives and requirements of the AOC Statement of Work. Based on those meetings and ensuing correspondence, seven tasks were developed and agreed upon by the Parties (Navy, DLA, and the Regulatory Agencies) to address the objectives and requirements identified in AOC Statement of Work Section 6 and Section 7.

Together, this WP/SOW, the Groundwater Flow and CF&T Modeling WP/SOW (included as Appendix H to this document), and the Monitoring Well Installation WP (published under separate cover) outline the proposed approach for satisfying the objectives and requirements of AOC Statement of Work Section 6 and Section 7. The seven tasks identified to achieve those objectives and requirements are as follows:

- *Task 1: Evaluate subsurface geology:* Collect new data, compile and evaluate existing and new data, and develop a site-specific geological conceptual site model to inform the other tasks in this investigation.
- *Task 2: Investigate LNAPL* [light non-aqueous-phase liquid]: Conduct a pilot-scale electrical resistivity (ER) survey to evaluate the feasibility of locating non-aqueous-phase liquid (NAPL), identify potential preferential flow pathways, and map the structural geology of the RHSF area with minimal intrusive impact.
- *Task 3: Identify COPCs* [chemicals of potential concern]: Collect and analyze groundwater samples for site-specific COPCs and for natural attenuation parameters.
- *Task 4: Expand the monitoring network:* Install new groundwater monitoring wells to optimize and refine the existing monitoring network of five inside-tunnel and five outside-tunnel sampling locations. During eight quarterly monitoring events, collect groundwater flow data and conduct groundwater sampling at all monitoring locations in the newly expanded groundwater monitoring network.
- *Task 5: Update the existing groundwater model:* Input and assess newly collected data and update the existing groundwater flow model to support and refine the contaminant fate and transport (CF&T) model and a human health risk assessment, and to evaluate remedial alternatives.
- *Task 6: Update CF&T model and evaluate whether to perform a tracer study:* Update the existing CF&T model to refine existing site-specific risk based levels (SSRBLs), assess potential impacts to groundwater by modeling different hypothetical release scenarios, and evaluate remedial alternatives.

- *Task 7: Evaluate remedial alternatives:* Identify and assess the feasibility of potential technologies for remediating LNAPL in the subsurface and dissolved COPCs in groundwater.

In accordance with the AOC Statement of Work Section 6 and Section 7, nine reports and two decision documents are required to be submitted by the Navy and DLA, both during and following the investigation:

- *Groundwater Flow Model Progress Reports:* Brief status reports will be submitted to the Regulatory Agencies every 4 months, beginning 4 months after approval of the final version of this WP/SOW. Five progress reports are anticipated.
- *Groundwater Flow Model Report:* This report will summarize the methodology and results of the groundwater flow modeling efforts to refine the existing groundwater model, improve the understanding of the direction and rate of groundwater flow around RHSF, and evaluate potential exposure routes. It will be submitted within 24 months of approval of this WP/SOW.
- *Investigation and Remediation of Releases Report and Decision Document:* This report will summarize the results of the field investigation and groundwater flow and CF&T evaluations, and the human health risk assessment. It will be submitted within 24 months of approval of this WP/SOW. Within 60 days from the Regulatory Agencies' approval of the *Investigation and Remediation of Releases Report,* the Parties of the AOC will attend an Investigation and Remediation of Releases Decision Meeting to evaluate the feasibility of investigating and remediating potential releases from the Facility to the maximum extent practicable. Within 60 days after the decision meeting, the Navy and DLA will submit to the Regulatory Agencies a Decision Document, including a proposed approach and schedule for implementation as applicable and warranted.
- *Contaminant Fate and Transport Model Report:* This report will summarize the methodology and results of CF&T modeling efforts. It will be submitted within 180 days of the final *Groundwater Flow Model Report*.
- *Groundwater Monitoring Well Network Report and Decision Document:* This report will provide a recommendation on the number and location of existing and potential new groundwater monitoring wells for Regulatory Agencies' approval. It will be submitted within 12 months from the Regulatory Agencies' approval of the *Groundwater Flow Model Report.* Within 60 days from the Regulatory Agencies' approval of the *Groundwater Monitoring Well Network Report,* the Parties will attend a Groundwater Monitoring Well Network Decision Meeting to evaluate subsequent actions for implementing the Groundwater Monitoring Well Network. Within 60 days after the decision meeting, the Navy and DLA will submit to the Regulatory Agencies a Decision Document for the Groundwater Monitoring Well Network, including a proposed approach and schedule for implementation as applicable and warranted.

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## CONTENTS

**APPENDIXES**

**FIGURES**

TABLES

# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| °C | degree Celsius |
| µg/L | microgram per liter |
| µg/m$^3$ | microgram per cubic meter |
| AHA | activity hazard analysis |
| AOC | Administrative Order on Consent |
| API | American Petroleum Institute |
| AVGAS | aviation gasoline |
| bgs | below ground surface |
| BTEX | benzene, toluene, ethylbenzene, and xylene |
| BWS | Board of Water Supply, City and County of Honolulu |
| C.F.R. | Code of Federal Regulations |
| CF&T | contaminant fate and transport |
| CLEAN | Comprehensive Long-Term Environmental Action Navy |
| COC | chain of custody |
| COPC | chemical of potential concern |
| COR | Contracting Officer’s Representative |
| CSM | conceptual site model |
| CTO | contract task order |
| DL | detection limit |
| DLA | Defense Logistics Agency |
| DLNR | Department of Land and Natural Resources, State of Hawaiʻi |
| DoD | Department of Defense, United States |
| DO | diesel oil |
| DOH | Department of Health, State of Hawaiʻi |
| DON | Department of the Navy, United States |
| DQA | data quality assessment |
| DQO | data quality objective |
| EAL | Environmental Action Level |
| EDD | electronic data deliverable |
| EHE | environmental hazard evaluation |
| ELAP | Environmental Laboratory Accreditation Program |
| EPA | Environmental Protection Agency, United States |
| ER | electrical resistivity |
| F-76 | Marine Diesel Fuel |
| ft | foot or feet |
| ft/d | feet per day |
| ft/ft | feet per foot |
| ft msl | feet above mean sea level |
| GPS | global positioning system |
| GWPP | Groundwater Protection Plan |
| HAR | Hawaiʻi Administrative Rules |
| HEER | Hazard Evaluation and Emergency Response |
| HERL | Hawaiʻi Environmental Response Law |
| HRS | Hawaiʻi Revised Statutes |
| ID | identification |
| IDW | investigation-derived waste |

| | |
|---|---|
| JBPHH | Joint Base Pearl Harbor-Hickam |
| JP | Jet Fuel Propellant |
| LNAPL | light non-aqueous-phase liquid |
| LOD | limit of detection |
| LOQ | limit of quantitation |
| LTM | long-term monitoring |
| LUST | Leaking Underground Storage Tanks |
| MADEP | Massachusetts Department of Environmental Protection |
| MCL | Maximum Contaminant Level |
| mg/L | milligram per liter |
| mg/kg | milligram per kilogram |
| mgd | million gallons per day |
| mL | milliliter |
| MODFLOW | Modular Groundwater Flow Model |
| MOGAS | motor gasoline |
| MRL | method reporting limit |
| MS | matrix spike |
| MSD | matrix spike duplicate |
| msl | mean sea level |
| MtBE | methyl tertiary-butyl ether |
| NAP | natural attenuation parameter |
| NAPL | non-aqueous-phase liquid |
| NAVFAC | Naval Facilities Engineering Command |
| NAVSUP FLC | Naval Supply Systems Command Fleet Logistics Center |
| Navy | Department of the Navy, United States |
| NCP | National Oil and Hazardous Substances Pollution Contingency Plan |
| NFA | no further action |
| no. | number |
| NSFO | Navy Special Fuel Oil |
| ORP | oxidation reduction potential |
| OSHA | Occupational Safety and Health Administration |
| OWDF | Former Oily Waste Disposal Facility |
| PAH | polynuclear aromatic hydrocarbon |
| PAL | project action level |
| PID | photoionization detector |
| POL | petroleum, oils, and lubricants |
| ppbv | parts per billion by volume |
| QA | quality assurance |
| QC | quality control |
| QSM | Quality Systems Manual |
| RCRA | Resource Conservation and Recovery Act |
| RHSF | Red Hill Bulk Fuel Storage Facility |
| SAL | soil action level |
| SCP | State Contingency Plan (Hawai'i) |
| SCR | Senate Concurrent Resolution (Hawai'i) |

| | |
|---|---|
| SDG | sample delivery group |
| SDWB | Safe Drinking Water Branch, State of Hawai‘i Department of Health |
| SHWB | Solid and Hazardous Waste Branch, State of Hawai‘i Department of Health |
| SIM | selective ion monitoring |
| SOP | standard operating procedure |
| SOW | scope of work |
| SSRBL | site-specific risk-based level |
| SVM | soil vapor monitoring |
| SVMP | soil vapor monitoring point |
| SW | Solid Waste (EPA laboratory method) |
| SWAP | Source Water Assessment Program |
| TCE | trichloroethylene |
| TGM | Technical Guidance Manual |
| TPH | total petroleum hydrocarbons |
| TPH-d | total petroleum hydrocarbons – diesel range organics |
| TPH-g | total petroleum hydrocarbons – gasoline range organics |
| TPH-o | total petroleum hydrocarbons – residual range organics (i.e., TPH-oil) |
| TVH | total volatile hydrocarbons |
| U.S. | United States |
| USGS | United States Geological Survey |
| UST | underground storage tank |
| VOA | volatile organic analysis |
| VOC | volatile organic compound |
| VPH | volatile petroleum hydrocarbons |
| WP | work plan |

# 1. Introduction

This Work Plan (WP) and Scope of Work (SOW) describes the activities planned for investigation and remediation of petroleum product releases and protection and evaluation of groundwater at the Red Hill Bulk Fuel Storage Facility (RHSF; "the Facility") operated by the Naval Supply Systems Command Fleet Logistics Center (NAVSUP FLC), Pearl Harbor, Hawai‘i. This investigation will be performed by the United States (U.S.) Department of the Navy (DON; "Navy") and Defense Logistics Agency (DLA) to address the objectives and requirements of the Administrative Order on Consent (AOC) (EPA Docket No: RCRA 7003-R9-2015-01; DOH Docket No: 15-UST-EA-01) issued by the U.S. Environmental Protection Agency (EPA) Region 9 and the State of Hawai‘i Department of Health (DOH) herein referred to as the "Regulatory Agencies."

This investigation specifically addresses AOC Statement of Work Section 6 Investigation and Remediation of Releases, and Section 7 Groundwater Protection and Evaluation, which have the following purposes:

> Section 6: *"The purpose of the deliverables to be developed and the work to be performed under this Section is to determine the feasibility of alternatives for investigating and remediating releases from the Facility."*
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Following the completion of Scoping Meetings, the Navy and DLA have prepared this WP/SOW to describe the activities and analyses that will be undertaken to address the requirements of the AOC Statement of Work. Activities conducted under this WP/SOW will be performed in conjunction with the activities specified in the Monitoring Well Installation WP (DON 2016) and the long-term monitoring program described in the RHSF *Groundwater Protection Plan* (GWPP; DON 2014), in accordance with the AOC and applicable State and Federal regulations. As agreed upon during Scoping Meetings among the Parties, this combined WP/SOW and the Monitoring Well Installation WP intend to fulfill the requirements of the AOC Statement of Work Section 6.2 Investigation and Remediation of Releases SOW, Section 7.1.2 Groundwater Flow Model SOW, Section 7.2.2 Contaminant Fate and Transport (CF&T) Model SOW, and Section 7.3.2 Groundwater Monitoring Well Network SOW. The findings of this investigation will be used to prepare the AOC Statement of Work Section 6.3 *Investigation and Remediation of Releases Report*, Section 6.5 *Investigation and Remediation of Releases Decision Document and Implementation*, Section 7.1.3 *Groundwater Flow Model Report*, Section 7.2.3 *CF&T Model Report*, Section 7.3.3 *Groundwater Monitoring Well Network Report*, and Section 7.3.5 *Groundwater Monitoring Well Network Decision Document and Implementation*.

This WP/SOW was prepared for the Defense Logistics Agency Energy, under Naval Facilities Engineering Command (NAVFAC) contract number (no.) N62742-12-D-1829, contract task order

(CTO) no. 0053 of the Comprehensive Long-Term Environmental Action Navy (CLEAN) IV program.

The remaining sections of this WP/SOW are organized as follows:

- *Section 2:* Site Background – describes the site and its history, and summarizes previous and ongoing investigations.
- *Section 3:* Physical Characteristics – describes the physical setting, including regional and local geology and hydrology.
- *Section 4:* Scope of Work – details the seven tasks developed by the Parties to address the objectives of the AOC Statement of Work Section 6 and Section 7.
- *Section 5:* Project and Task Description – details field activities, schedule, quality objectives, and presents the current conceptual site model (CSM).
- *Section 6:* Data Generation and Acquisition – details the field sampling and analytical program, quality control (QC) measures, and investigation-derived waste (IDW) procedures.
- *Section 7:* Assessment and Oversight – identifies the data verification process, laboratory data assessment, and quality reports to management.
- *Section 8:* Data Validation, Management, and Usability – identifies how data collected for the project will be recorded, evaluated, and reported.
- *Section 9:* References – provides the sources for documents cited in this WP/SOW.

# 2. Site Background

## 2.1 SITE DESCRIPTION AND HISTORY

### 2.1.1 Site Description

RHSF is located on Federal government land (zoned F1-Military and Federal) in Hālawa Heights, approximately 2.5 miles northeast of Pearl Harbor. It is located on a low ridge on the western edge of the Koʻolau Mountain Range that divides Hālawa Valley from Moanalua Valley. RHSF is bordered on the north by Hālawa Correctional Facility and private businesses, on the southwest by the U.S. Coast Guard reservation, on the south by residential neighborhoods, and on the east by Moanalua Valley. The Hālawa Quarry is located less than a quarter mile away to the northwest. RHSF occupies 144 acres of land, and the majority of the site surface is at an elevation of approximately 200–500 feet (ft) above mean sea level (msl) (Figure 1).

RHSF currently contains 18 active and 2 inactive underground storage tanks (USTs) that are operated by NAVSUP FLC Pearl Harbor. Each UST measures approximately 250 ft in height and 100 ft in diameter and has a capacity of approximately 12.5 million gallons. The USTs are constructed of steel, encased in concrete, and currently contain Jet Fuel Propellant (JP)-5, JP-8, and Marine Diesel Fuel (F-76).

The upper domes of the tanks are 100–200 ft below ground surface (bgs), and the lower domes of the tanks are at least 100 ft above the basal aquifer, which is located at approximately 20 ft msl. The tanks are connected by upper and lower access tunnels, which contain light rail systems, water and electrical utilities, and fuel pipelines. In the lower tunnel, each tank is connected by a short access tunnel, which branches off from the main service tunnel and terminates at a “face-wall” under each tank. Ancillary piping extends from each face-wall to connect to the fuel transmission lines, which run approximately 2.5 miles from RHSF to a fuel pumping station at Joint Base Pearl Harbor-Hickam (JBPHH).

Downgradient of the tanks within the lower tunnel system, NAVFAC Hawaii operates a water pumping station at Navy Supply Well 2254-01 (sometimes referred to as the Red Hill Shaft). Navy Supply Well 2254-01 is located approximately 2,700 ft downgradient of the USTs, and draws water from a tunnel, known as an infiltration gallery, that extends across the water table to within 1,550 ft of the tanks (Figure 1). The station pumps potable water from the basal aquifer beneath Red Hill to JBPHH. The JBPHH Water System serves approximately 65,200 military customers. NAVFAC Hawaii, Utilities Energy Management, operates the infiltration galley and Navy Supply Well 2254-01. Approximately 2.4–4.4 million gallons per day (mgd), depending on season, are withdrawn from Navy Supply Well 2254-01 (DON 2014).

In addition to Navy Supply Well 2254-01, other potable water supply wells are located in the general vicinity of the Facility (Figure 2). The City and County of Honolulu Board of Water Supply (BWS) Hālawa Shaft well 2354-01 (the “Hālawa Shaft”) is located approximately 4,400 ft northwest of the USTs; on average, 11.8 mgd of potable water is withdrawn from this location, approximately 12 percent of the total supply that serves more than 600,000 people on Oʻahu. The BWS Moanalua Supply Wells (2153-10, 2153-11, 2153-12) are located approximately 6,650 ft south of the USTs and deliver potable water to the BWS (DON 2014).

Four groundwater monitoring wells (wells RHMW01, RHMW02, RHMW03, and RHMW05) are located within the RHSF lower access tunnel, and one sampling point (RHMW2254-01) is located inside the infiltration gallery of Navy Supply Well 2254-01, approximately 2,700 ft west and downgradient of the Facility USTs (Figure 1). An additional five groundwater monitoring wells (wells RHMW04, RHMW06, RHMW07, HDMW2253-03, and OWDFMW01) are located outside of the footprint of the RHSF underground tunnel system, within or just outside the site boundaries (Figure 1). Well HDMW2253-03 is located at the Hālawa Correctional Facility (outside the northern boundary of RHSF); monitoring well OWDFMW01 is located at the former Oily Waste Disposal Facility in the western portion of RHSF; and monitoring wells RHMW04, RHMW06, and RHMW07 are located on the north side of RHSF along the road to the Navy Firing Range.

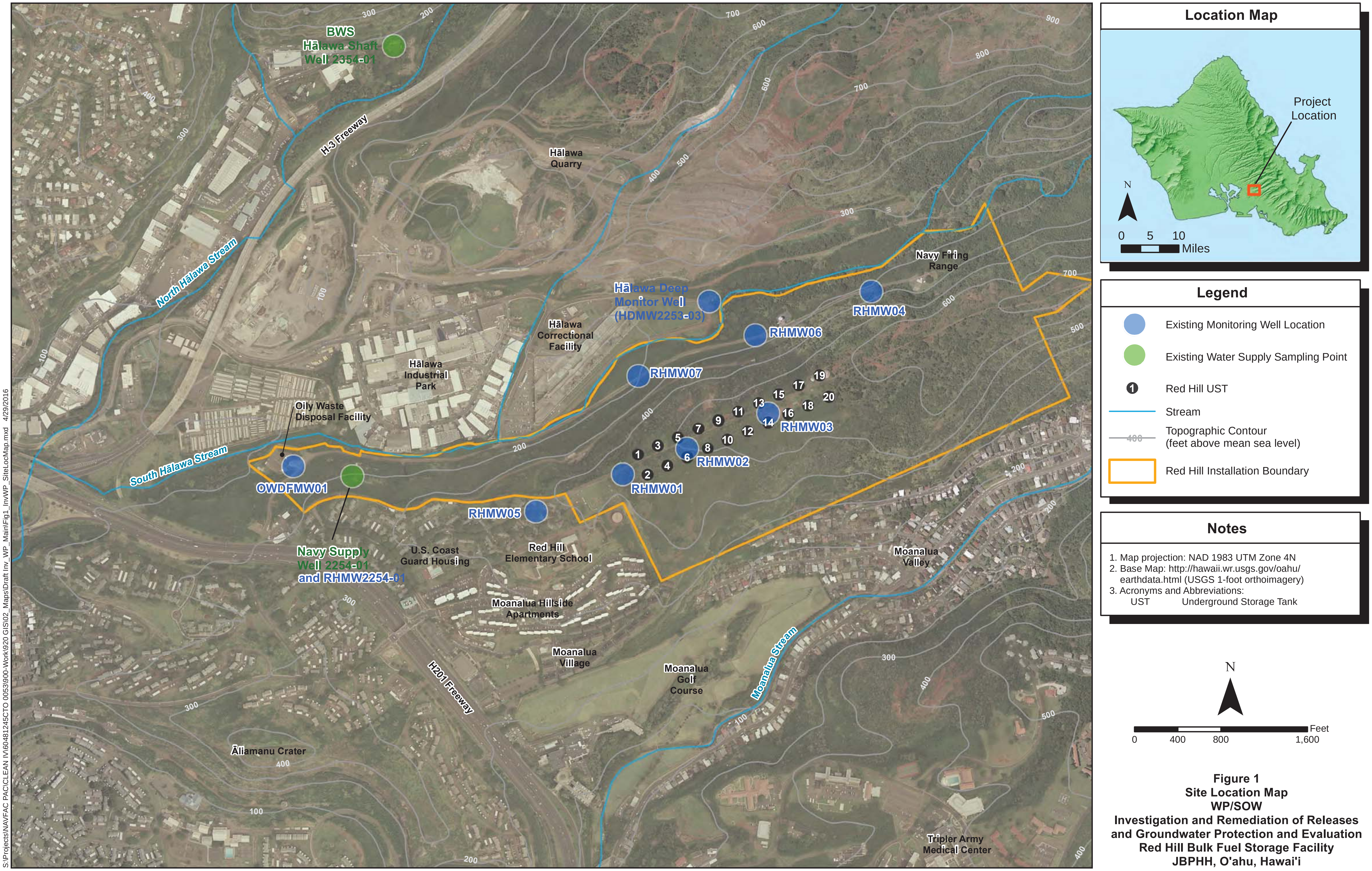
### 2.1.2 Site History

The Facility was constructed by the U.S. Government in the early 1940s to support war efforts in the Pacific during World War II, and continues to be instrumental in storing and transporting fuel to support the Navy's mission. Prior to the early 2000s, several tanks stored Navy Special Fuel Oil (NSFO), Navy Distillate, aviation gasoline (AVGAS), and motor gasoline (MOGAS); these tanks currently contain JP-5, JP-8, or F-76. The USTs, fuel distribution piping, and associated access tunnels were installed in basalt with inter-bedded volcanic tuff and breccia zones. The USTs were constructed in two parallel rows sloping toward the southwest.

Construction of RHSF began with excavation and removal of surface soil on the top of Red Hill to expose the underlying basalt. Each tank pit was then blasted from the basalt, utilizing a central vertical tunnel and radial blast tubes. Once the tank pits were created, ¼-inch steel tank segments were field-constructed and placed into the pits in sections, starting with installation of the lower tank domes. Once the lower dome of each tank was in place, a bed of concrete was placed below the bottom of the dome. The steel side walls and upper dome of each tank were then installed and encased in concrete. Upon completion of each tank, small-diameter holes were drilled in the sides of the tank and through the concrete bed. A 10-to-1 grout mixture was then injected into the surrounding bedrock at a pressure of approximately 300 pounds per square inch to close seams and fractures in the concrete liner and the surrounding bedrock (DON 1999).

Based on previous site investigations and associated analytical data, indication of fuel releases have occurred at the site, including the January 2014 release (DON 2002, 2007). However, because there was no requirement to document, report, or respond to underground storage tank releases until promulgation of the Hazardous and Solid Waste Amendments of 1984, spill and release records before that time are limited and incomplete.

During Tank 5 refilling operations, a fuel release was discovered and verbally reported to DOH on January 13, 2014. A release of JP-8 from Tank 5 was confirmed and reported to the DOH in writing on January 23, 2014. The volume of fuel lost from Tank 5 was estimated at 27,000 gallons. Following the reported release, water samples were collected from Navy Supply Well 2254-01 and the following BWS wells: Hālawa Shaft, Hālawa Wells, ‘Aiea Wells, ‘Aiea Gulch Wells, and Moanalua Wells. Test results from Navy Supply Well 2254-01 and the BWS wells' samples indicated that no petroleum constituents had reached the groundwater in the months following the release (RHSF Task Force 2014).



## Legend

| | |
|---|---|
| ● | Existing Monitoring Well Location |
| ● | Existing Water Supply Sampling Point |
| ❶ | Red Hill UST |
| — | Stream |
| —400— | Topographic Contour (feet above mean sea level) |
| ▭ | Red Hill Installation Boundary |

## Notes

1. Map projection: NAD 1983 UTM Zone 4N
2. Base Map: http://hawaii.wr.usgs.gov/oahu/earthdata.html (USGS 1-foot orthoimagery)
3. Acronyms and Abbreviations:
   UST Underground Storage Tank

**Figure 1**
**Site Location Map**
**WP/SOW**
**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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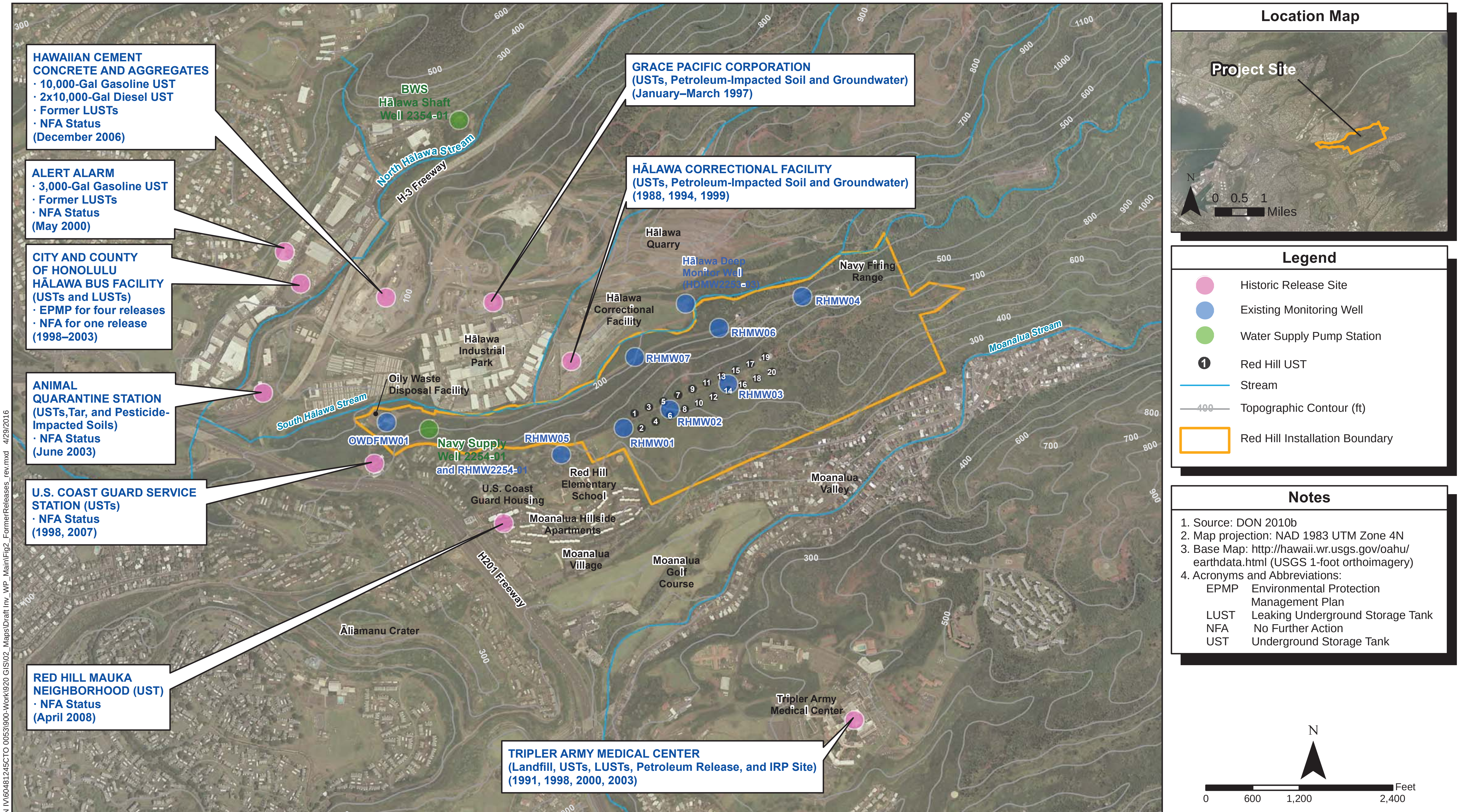

**HAWAIIAN CEMENT CONCRETE AND AGGREGATES**
- 10,000-Gal Gasoline UST
- 2x10,000-Gal Diesel UST
- Former LUSTs
- NFA Status

(December 2006)

**ALERT ALARM**
- 3,000-Gal Gasoline UST
- Former LUSTs
- NFA Status

(May 2000)

**CITY AND COUNTY OF HONOLULU HĀLAWA BUS FACILITY (USTs and LUSTs)**
- EPMP for four releases
- NFA for one release

(1998–2003)

**ANIMAL QUARANTINE STATION (USTs,Tar, and Pesticide-Impacted Soils)**
- NFA Status

(June 2003)

**U.S. COAST GUARD SERVICE STATION (USTs)**
- NFA Status

(1998, 2007)

**RED HILL MAUKA NEIGHBORHOOD (UST)**
- NFA Status

(April 2008)

**GRACE PACIFIC CORPORATION**
(USTs, Petroleum-Impacted Soil and Groundwater)
(January–March 1997)

**HĀLAWA CORRECTIONAL FACILITY**
(USTs, Petroleum-Impacted Soil and Groundwater)
(1988, 1994, 1999)

**TRIPLER ARMY MEDICAL CENTER**
(Landfill, USTs, LUSTs, Petroleum Release, and IRP Site)
(1991, 1998, 2000, 2003)

## Legend

| | |
|---|---|
| ● | Historic Release Site |
| ● | Existing Monitoring Well |
| ● | Water Supply Pump Station |
| ❶ | Red Hill UST |
| — | Stream |
| —400— | Topographic Contour (ft) |
| ▭ | Red Hill Installation Boundary |

## Notes

1. Source: DON 2010b
2. Map projection: NAD 1983 UTM Zone 4N
3. Base Map: http://hawaii.wr.usgs.gov/oahu/earthdata.html (USGS 1-foot orthoimagery)
4. Acronyms and Abbreviations:

| | |
|---|---|
| EPMP | Environmental Protection Management Plan |
| LUST | Leaking Underground Storage Tank |
| NFA | No Further Action |
| UST | Underground Storage Tank |

Figure 2
Area Wells and Historic Release Sites
WP/SOW
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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## 2.2 REGULATORY BACKGROUND

### 2.2.1 Groundwater Protection Plan (DON 2008a, 2009, 2014)

The GWPP was developed to mitigate the risk associated with inadvertent releases of fuel from RHSF. The GWPP was initially published in 2008 (with revisions in 2009) and was reviewed and updated in 2014. The interim update also fulfills the February 12, 2014 DOH request to modify the Plan in accordance with the format for Environmental Hazard Evaluations (EHEs) specified in the DOH Hazard Evaluation and Emergency Response (HEER) *Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater* (DOH 2011) (the "DOH-HEER EHE Guidance").

The GWPP presents a strategy designed to ensure that the Facility and Navy Supply Well 2254-01 continue to operate at optimum efficiency in the future. The GWPP focuses on long-term mitigation, and is not an emergency response plan. The Plan documents steps that are to be taken to prevent unacceptable risks associated with Facility releases. These steps include:

- Implementation of a tank inspection and maintenance program.
- Description of soil vapor monitoring (SVM) program.
- Description of groundwater sampling and risk assessment.
- Implementation of a groundwater monitoring program that will provide warning of potential unacceptable risks to human health.
- Establish responsibilities and response actions that will be implemented when groundwater action levels are exceeded.
- Periodic market survey to evaluate best available leak detection technologies for large field-constructed fuel storage facilities, such as Red Hill.

These steps are in accordance with the Hawai‘i Environmental Response Law (HERL), UST Program, and State Contingency Plan (SCP). The steps are intended to protect human health and the environment from non-catastrophic chronic (i.e., 10 gallons per minute or less) releases of petroleum, oils, and lubricants (POL), and are not intended to address risks associated with a catastrophic release of fuel to the environment resulting from a large rupture in the steel tanks or piping system, which would require emergency response actions outside the scope of the GWPP.

In accordance with the Plan, the Navy conducts:

- Quarterly groundwater monitoring; currently the monitoring network consists of ten sampling locations (five inside-tunnel locations and five outside-tunnel locations; see Section 2.3.2.2). A database of chemical results from the groundwater sampling events is maintained, and results are reported to DOH on a quarterly basis. The Plan provides site-specific risk-based levels (SSRBLs) for total petroleum hydrocarbons (TPH) – diesel range organics (TPH-d) and benzene. The Plan provides a table of recommended responses to contaminant levels and trends in each of the four Facility wells and sampling point RHMW2254-01 in the Red Hill Shaft.
- Monthly SVM is done using the existing boreholes beneath each of the active tanks (see Section 2.3.2.3). Soil vapor is analyzed for total volatile hydrocarbons (TVH) with calibrated field instruments and evaluated for changes in concentration.

- All USTs in the Facility are maintained in accordance with the modified American Petroleum Institute (API) 653 procedure. The Navy provides the results of the API inspections and maintenance reports to DOH upon request.

The GWPP also provides an overview of actions that would be required to remediate the basal drinking water aquifer if a large release of fuel were to migrate to the water table. Well head treatment facilities could potentially be required at Navy Supply Well 2254-01 if such a release were to occur and migrate to the groundwater.

### 2.2.2 Senate Concurrent Resolution 73 (RHSF Task Force 2014)

On April 2014, the State of Hawai‘i Legislature adopted Senate Concurrent Resolution (SCR) 73, which requested DOH to convene a task force to study the effects of the January 2014 fuel tank leak at RHSF. The task force members included DOH, EPA, the Navy, one member of the State House of Representatives, one member of the State Senate, the Hawai‘i Department of Land and Natural Resources (DLNR), the BWS, and two members of the community.

On January 20, 2015, the Red Hill Fuel Storage Facility Task Force submitted a report to the State of Hawai‘i Legislature pursuant to SCR 73. The report presented the Task Force’s findings and recommendations regarding four topics: 1) short- and long-term effects of the leak at RHSF, including effects relating to the health of residents, safe drinking water, and the environment; 2) response strategies to mitigate the effects of future leaks at RHSF; 3) ways to improve communication between the Navy, the State, and the public in the event of future leaks at RHSF; and 4) implications of closing RHSF.

Recommendations and comments agreed upon by the Task Force included: installation of additional groundwater monitoring wells to adequately assess groundwater hydrology and support fate and transport models; continued reporting to DOH by BWS and the Navy; that all parties have demonstrated and will continue to be committed to communicating with the public for any matters of public interest regarding RHSF; and that the legislature should encourage DOH, EPA, and the Navy to finalize an agreement for RHSF that protects drinking water resources, appropriately responds to releases of petroleum, and minimizes the threat of potential future releases.

### 2.2.3 Applicable Regulations

In response to the January 2014 fuel leak, EPA and DOH negotiated an AOC with the Navy and DLA (EPA Region 9 and DOH 2015). The AOC included Attachment A, the Statement of Work, which outlined the activities to be conducted and analyses to be performed. The AOC requires the Navy and DLA to take actions, subject to DOH and EPA approval, to address fuel releases and implement infrastructure improvements to protect human health and the environment. The Parties to the AOC have conducted Scoping Meetings to address the requirements of the AOC Statement of Work, resulting in 27 agreements and eight action items for the AOC Statement of Work Section 6 and Section 7, which are presented in Appendix A.1 and discussed in more detail in Section 4. The investigation will be conducted in accordance with the agreed-upon items, and statutes and regulations promulgated under the Resource Conservation and Recovery Act of 1976 (RCRA) and chapters 340E, 342D, and 342L of the Hawai‘i Revised Statutes (HRS).

### 2.2.4 Regulatory History of the Facility

A chronological listing of regulatory issues and submitted documents regarding the Facility UST petroleum releases, as of August 21, 2014, is presented in Appendix A of the *Interim Update,* *Red Hill Bulk Fuel Storage Facility Final Groundwater Protection Plan* (DON 2014). A chronological list of submitted documents regarding groundwater sampling events is presented in each quarterly groundwater monitoring report.

## 2.3 SUMMARY OF RHSF ENVIRONMENTAL INVESTIGATIONS

### 2.3.1 Previous Investigations

#### *2.3.1.1 OILY WASTE DISPOSAL FACILITY (DON 1996, 2000)*

Between 1990 and 2000, the Navy investigated an oily waste disposal basin located approximately 600 ft west (downgradient) of Navy Supply Well 2254-01 under the DOH Hazard Evaluation and Emergency Response (HEER) Program. An interim removal action was initiated to remove the former stilling basin—the primary source of contamination at the Former Oily Waste Disposal Facility (OWDF)—and underlying soil contamination. A low-permeability geosynthetic cap was installed over the excavation. Petroleum waste was found to have infiltrated to a perched water-bearing zone beneath the basin, but was not detected in the underlying basal aquifer. Qualitative fate and transport characterization conservatively concluded that the fate and transport pathway for contaminants to the basal aquifer was potentially complete. However, the removal of the primary contamination source, reduction of infiltration, and the presence of major hydrogeologic barriers confirmed that the potential for contaminant transport to the basal aquifer was insignificant. Therefore, no further cleanup actions were warranted for the OWDF. The Navy received a concurrence letter for a No Further Action determination for the OWDF on April 11, 2005 (DOH 2005).

#### *2.3.1.2 RHSF SITE CHARACTERIZATION AND FACILITY INVESTIGATION (DON 1999, 2002)*

The Navy initiated a site characterization and facility investigation at RHSF in 1998 to evaluate potential fuel releases, which were suspected based on Facility records. The site characterization was conducted in two phases: Phase I Research Activities, and Phase II Field Investigation Activities. Slant borings were drilled and sampled under each of the 20 USTs. Additionally, two vertical borings were drilled and sampled within the lower access tunnel, directly downgradient from the tanks. A single groundwater monitoring well was installed into the basal aquifer at this location. Groundwater samples were collected from this well (subsequently renamed RHMW01; see Figure 1) and analyzed for petroleum constituents.

The results indicated that petroleum had been released from several USTs, as observed in core samples and indicated by the groundwater data. A preliminary screening-level risk evaluation was conducted and indicated that seven constituents were detected in core samples at concentrations of potential concern: ethylbenzene, methylene chloride, 2-methylnaphthalene, naphthalene, phenanthrene, TPH extractables (hydrocarbon range $C_{10}$–$C_{28}$), and an unknown hydrocarbon compound. Three constituents were detected in groundwater at concentrations of potential concern: bis(2-ethylhexyl)phthalate, lead, and TPH extractables ($C_{10}$–$C_{28}$). Light non-aqueous-phase liquid (LNAPL) was also detected within several slant borings located beneath the tanks, but not on the groundwater table. Based on the preliminary screening-level risk assessment results, the report recommended a comprehensive assessment of human health risks potentially associated with the Facility.

After evaluating the site investigation results, the DOH Solid Waste Branch requested that quarterly groundwater monitoring be conducted, a Tier 3 risk assessment be conducted to evaluate the risk to Navy Supply Well 2254-01, and a contingency plan be developed to protect the well from future contamination.

#### *2.3.1.3 RHSF TECHNICAL REPORT (DON 2007)*

The Navy initiated a two-phase site investigation of RHSF in 2004:

- Phase I included one round of groundwater sampling and analysis (September 2005) for petroleum constituents from sampling point RHMW2254-01 and four Facility wells (RHMW01 and the three then-newly installed wells RHMW02, RHMW03, and RHMW04); and one round of soil vapor sampling from soil vapor monitoring points (SVMPs) under Tanks 2, 14, and 16.
- Phase II included a regional pumping test to calibrate the groundwater flow model; one round of groundwater sampling (July 2006) from the four wells and RHMW2254-01; one round of soil vapor sampling from SVMPs under Tanks 6, 10, 11, and 12; development of a 3-D groundwater model from a DOH regional model to simulate CF&T; a Tier 3 risk assessment; and development of mitigation steps for a contingency plan.

Results of the site investigation are summarized below:

- *Nature and Extent of Contamination:* The investigation analyzed rock cores from three borings advanced to install the new monitoring wells (drilled in volcanic bedrock where no petroleum-impacted material was expected), groundwater from RHMW2254-01 and the four Facility wells, and soil vapor from SVM wells in slant borings underneath seven USTs:
  - *Rock Cores*: Rock samples were analyzed for petroleum constituents; no constituents were detected above reporting limits or associated action levels.
  - *Groundwater:* In the first round of groundwater sampling, TPH-d concentrations exceeded the DOH Environmental Action Levels (EALs) for drinking water at all wells except RHMW2254-01. No evidence of petroleum was observed at RHMW2254-01. Groundwater from RHMW02, located near Tanks 5 and 6, had the highest concentrations of petroleum compounds, and RHMW02 was the only well in which target volatile organic compounds (VOCs) and semivolatile organic compounds were observed; the TPH-d, TPH–gasoline-range organics (TPH-g), trichloroethylene (TCE), naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene concentrations reported for the RHMW02 sample exceeded one or more drinking water action levels. The total lead concentration reported for an (unfiltered) groundwater sample from RHMW01 was above the drinking water action level, but the dissolved (filtered) lead concentration reported for this well was below the action level; therefore, the exceedance was not considered appropriate for risk assessment. (Samples for analysis of dissolved COPCs are filtered to remove particulates as required to quantify concentrations in the dissolved [i.e., bioavailable] phase.) Results for the second round of groundwater sampling were similar to those of the first round, except TCE was not detected.
  - *Soil Vapor:* Soil vapor samples were collected to evaluate the health risk associated with intrusion of soil vapor into the Red Hill tunnels and evaluate the SVM wells as potential leak detection devices. Samples were collected in summa canisters in slant borings beneath Tanks 2, 14, 16 (Phase I) and Tanks 6, 10, 11, and 12 (Phase II) and analyzed by EPA Method TO-15 for VOCs. The risk to industrial workers was found to be insignificant. Total target VOCs greater than 100 micrograms per cubic meter ($\mu g/m^3$) were observed in SVMPs beneath Tanks 6, 11, 12, and 14. The report recommended evaluating these tanks for potential leaks, and because soil vapor provided additional verification of leaks (while noting the current implementation's limitations),

recommended periodic soil vapor sampling to evaluate chemical concentration trends (increasing concentrations would indicate leaks).

- *Fate and Transport Modeling:* The Navy collaborated with the University of Hawai‘i at Manoa to develop a localized numerical 3-D groundwater model to assess how water moves between and within the Waimalu, Moanalua, and Kalihi Aquifer systems. Contaminant transport simulations were conducted to estimate the dissolved concentrations of chemicals of potential concern (COPCs) in groundwater at the Facility monitoring wells that would result in COPC concentrations exceeding drinking water action levels at the nearby municipal water supply wells. Simulations were run under an average pumping scenario and a drought condition (representing a worst-case scenario). The following conclusions are based on the modeling results:
  - Infiltration of contaminated rainwater at the Facility is not likely to present unacceptable risk to receptors exposed to water pumped from Navy Supply Well 2254-01.
  - Valley fills in the North Hālawa Valley and Moanalua Valley are effective barriers to particle migration of water beneath the Facility. Simulations showed that contaminated water from beneath the Facility would not migrate to the BWS Hālawa Shaft or BWS Moanalua wells.
  - In order for contaminants to reach the Navy Supply Well 2254-01 infiltration gallery at concentrations exceeding the DOH EALs, the transport simulations required that a hypothetical extended source of fuel as LNAPL on the groundwater table approach within 1,100 ft of the infiltration gallery, assuming that benzene was the main petroleum constituent of concern in the hypothetical fuel release.
- *Risk Assessment:* A preliminary evaluation concluded that there were no significant exposure pathways for ecological receptors and no sensitive species were noted in the immediate vicinity of the Facility. A Tier 3 human health risk assessment identified the contaminant pathways of concern as exposure to groundwater from the drinking water wells and intrusion of soil vapor to indoor air. The primary potential environmental risks at the Facility were determined to be due to a hypothetical future scenario in which groundwater from beneath the site was extracted for residential tapwater use, including drinking. The evaluation noted that no extraction wells lie in the vicinity of the simulated groundwater plume, and none are known to be planned. In addition, if a future release were to produce a large secondary source of LNAPL that migrated to the groundwater and downgradient toward the infiltration gallery, dissolved contaminants or free-product could result in unacceptable concentrations of petroleum constituents in the Navy Supply Well 2254-01 potable water system, which could cause the system to be unavailable for an undetermined period. According to the fate and transport modeling simulations, a JP-5 LNAPL plume would be required to extend to within approximately 1,100 ft of the Navy Supply Well 2254-01 infiltration gallery for benzene to exceed the Federal Maximum Contaminant Level (MCL) and DOH Tier 1 EAL. This could result from a release large enough to result in 16,000 gallons of non-aqueous-phase liquid (NAPL) reaching the groundwater. It was estimated that a release this size could take 5–6 years (after the product reached the groundwater) to cause concentrations of petroleum constituents to exceed screening levels in the infiltration gallery of Navy Supply Well 2254-01; larger releases could significantly decrease this time period. This conclusion was based on an assumption that benzene would be a significant component of the hypothetical fuel release.

- *Conclusions and Recommendations:* The report noted the lack of a method to determine whether the RHSF USTs have chronic leaks, and that the increasing age of RHSF increases the chance that both the metal tank liners and the concrete foundation walls may eventually degrade, making future releases more of a concern. To be protective of human health and the groundwater resources, the report recommended that a contingency plan be reviewed and implemented to ensure that future releases from the Facility do not continue to place the groundwater resource at risk.

#### *2.3.1.4 TANK 17 REMOVAL ACTION REPORT (DON 2008b)*

In June 2008, the Navy conducted a limited removal action and site characterization investigation after approximately 4 gallons of JP-5 fuel were released from overhead piping in the Facility lower access tunnel adjacent to Tank 17 on March 4, 2008. The removal action and investigation was conducted as part of the release response activity required by HRS Title 19, Chapter 342L and HAR Title 11, Chapter 281, Subchapters 1–10 (DOH 2000a). The fuel was released to a pile of excavated soil covered with plastic sheeting and migrated into an adjacent trench covered with plywood. The removal action removed most of the fuel; excavation was halted when further excavation would have required engineering controls and additional removal of the concrete tunnel floor.

The *Removal Action Report* included an EHE conducted to assess the hazards associated with the petroleum-impacted material that remained in place. The risk drivers were evaluated as TPH-d and TPH-g, and contemporary DOH EALs for soil contamination were used as screening levels. The EHE concluded that gross contamination left in place, impact to terrestrial receptors, soil gas intrusion to indoor air from the impacted material remaining in place, and leaching of contaminants from impacted material left in place to infiltrating groundwater posed no significant environmental hazards.

#### *2.3.1.5 TYPE 1 LETTER REPORT (DON 2010a)*

In 2010, the Navy prepared a *Type 1 Letter Report* in accordance with the requirements of the RHSF GWPP (DON 2008a) after concentrations of petroleum hydrocarbons in groundwater beneath RHSF exceeded levels associated with Category 4 status as defined in the GWPP. The Letter Report re-evaluated the Tier 3 Risk Assessment and the groundwater model assumptions and results presented in the 2007 RHSF *Technical Report* (DON 2007), and provided a proposal to DOH regarding a course of action. To help reassess the threat to water supply wells in the study area, an additional groundwater monitoring well (RHMW05) was installed between the USTs and the Navy Supply Well 2254-01 infiltration gallery, approximately 600 ft from the infiltration gallery, and added to the quarterly groundwater monitoring program.

The re-evaluation of groundwater flow direction/gradient showed a local flow direction from the USTs toward Navy Supply Well 2254-01, as expected, at a gradient of approximately 0.00022 ft/ft. The evaluation also showed a regional component flowing toward the northwest, at a gradient of approximately 0.00028 ft/ft. The re-evaluation of the DON (2007) Tier 3 Risk Assessment showed that the results remained valid. This is because the Tier 3 Risk Assessment assumed a worst-case scenario, i.e., that the dominant groundwater flow direction places the infiltration gallery of Navy Supply Well 2254-01 directly downgradient from the USTs.

The future course of action proposed in the Letter Report included conducting another re-evaluation of the Tier 3 Risk Assessment/groundwater model if TPH-d results again exceed the computed maximum solubility of JP-5 (as had occurred twice by the time of the report), and if the results of a detailed chromatographic evaluation indicate that the TPH fraction consisting of fuel hydrocarbons exceeds the computed solubility of JP-5 (4,500 micrograms per liter [µg/L]). The recommended re-evaluation included investigating the validity of the 4,500 µg/L solubility limit and re-computing the distance from the edge of a free product plume to TPH-g/TPH-d compliance using the measured TPH concentration and a degradation rate of 0.007 per day. The Letter Report stated that using these data, new SSRBLs could be established for the monitoring wells based on distance from the eastern end of the infiltration gallery for Navy Supply Well 2254-01.

The Letter Report further recommended that at least one more round of split samples be collected for analysis of TPH-g, TPH-d, and Massachusetts Department of Environmental Protection (MADEP) volatile petroleum hydrocarbons (VPH)/TPH analysis to help establish whether TPH-d concentrations that may be measured at the Facility’s non-potable wells (RHMW01, RHMW02, RHMW03, and RHMW05) are attributable to fuel hydrocarbons or to polar, less toxic, non-fuel organic compounds. The Letter Report noted that monitoring well RHMW05 was of greatest concern because the TPH-d concentrations reported for this well had been consistently greater than the DOH EALs at that time, and that because of its proximity (approximately 600 ft) to Navy Supply Well 2254-01, modified SSRBLs for TPH-d and TPH-g should be established and the GWPP should be revised as appropriate.

### 2.3.2 Ongoing Investigations

On January 13, 2014, in response to a leak discovered through inventory monitoring, NAVSUP FLC Pearl Harbor began emptying Tank 5. The transfer of over 11 million gallons of JP-8 was completed on January 18, 2014.

At the time of the January 2014 leak, liquid was observed weeping from the wall of the Red Hill tunnel near the lower exterior of the material encasing the tank. A sample showed that the liquid was JP-8 fuel. Groundwater samples were collected from monitoring wells RHMW01, RHMW02, RHMW05, and RHMW2254-01 on January 15 and 16, 2014. Follow-up response actions are summarized below.

#### *2.3.2.1 TANK 5 RELEASE RESPONSE REPORTS (DON 2014–2016)*

In response to DOH release response letters dated February 12, 2014 and February 26, 2014, Commander Navy Region Hawaii prepared Initial and Quarterly Release Response Reports in accordance with the DOH HEER *Technical Guidance Manual* [TGM] *for the Implementation of the Hawai‘i State Contingency Plan* (DOH 2009) (the “DOH-HEER TGM”). The reports describe actions taken by the Navy in response to the January 2014 Tank 5 fuel release to ensure the drinking water around the Facility remains safe. These efforts include evaluating the feasibility of alternatives for investigating and remediating releases from the Facility, installing new monitoring wells, and continuing efforts to monitor and characterize the flow of groundwater around the Facility.

All response reports state that groundwater at the Red Hill Shaft has not been impacted by the January 2014 release.

#### *2.3.2.2 GROUNDWATER MONITORING PROGRAM (DON 2005–2016)*

The Navy’s monitoring program at RHSF requires quarterly groundwater monitoring events at inside-tunnel sampling locations and outside-tunnel wells. Quarterly groundwater monitoring has been conducted since 2005, and the results of each monitoring event are reported to DOH. The groundwater samples are analyzed for petroleum constituents and the data are compared to DOH Tier 1 EALs for groundwater at sites where groundwater is a current or potential drinking water resource and a surface water body is not located within 150 meters of the release site. In accordance with the RHSF GWPP (DON 2014), the TPH-d and benzene concentrations reported for the groundwater samples are also compared to SSRBLs developed by modeling the fate and transport of petroleum hydrocarbons in groundwater between RHSF and the closest water supply well (Navy Supply Well 2254-021). The SSRBLs represent the estimated concentrations of TPH and benzene in groundwater at RHSF MW locations that would result in exceedances of the DOH EALs at Well 2254-021. SSRBLs have been developed for three of the wells, RHMW01, RHMW02, and RHMW-03 (DON 2014), and will be developed for the other existing and proposed wells, as warranted, as the required data become available.

The inside-tunnel monitoring system is described in the GWPP (DON 2014) and consists of the following five sampling locations (Figure 1):

- RHMW2254-01 is a sampling point located inside the infiltration gallery approximately 10–20 ft from Navy Supply Well 2254-01.
- RHMW01 is a monitoring well located downgradient of all of the USTs.
- RHMW02 is a monitoring well located next to Tank 6, toward the middle of the USTs.
- RHMW03 is a monitoring well located next to Tank 14, toward the upgradient portion of the USTs.
- RHMW05 is a monitoring well located downgradient of RHMW01 and upgradient of sampling point RHMW2254-01.

The outside-tunnel monitoring system consists of the following five wells (Figure 1):

- Hālawa Deep Monitor Well 2253-03 (“HDMW2253-03”) is located at the Hālawa Correctional Facility, north of the Facility.
- Oily Waste Disposal Facility Monitoring Well 01 (“OWDFMW01”) is located approximately 600 ft west and downgradient of Navy Supply Well 2254-01.
- RHMW04 is an onsite background monitoring well located hydraulically upgradient of the USTs.
- RHMW06 is an onsite monitoring well installed north of the USTs and RHMW03 in September 2014, in response to the January 2014 release (DON 2015b).
- RHMW07 is an onsite monitoring well installed north of the USTs and RHMW01 in October 2014 in response to the January 2014 release (DON 2015b).

Overall COPC trends for the inside- and outside-tunnel sampling locations as reported in the quarterly groundwater monitoring reports are as follows; cumulative groundwater measurements and analytical results from the long-term groundwater monitoring program are presented in Appendix D:

- *Inside-Tunnel Wells:* COPC trends for inside-tunnel sampling locations are summarized below:
  - *RHMW01:* The COPC concentrations reported for recent rounds of quarterly sampling have been consistent with the historical data for RHMW01. TPH-d has historically been detected at concentrations above the DOH Tier 1 EAL; however, TPH-d concentrations have shown an overall decreasing trend from a high of 1,500 µg/L in February 2005.

  - *RHMW02:* TPH-g, TPH-d, 1-methylnaphthalene, 2-methylnaphthalene, and naphthalene have historically been detected at concentrations above the DOH Tier 1 EALs. During the October 2015 monitoring event, TPH-d was detected at its highest historical concentration (above the SSRBL), and concentrations of 1-methylnaphthalene, 2-methylnaphthalene, and naphthalene showed an increasing trend since 2014. The concentrations of TPH-g remained below the DOH Tier 1 EALs and were comparable to concentrations detected during the previous event. TCE was detected once in RHMW02 in September 2005 in the primary sample at a concentration above the DOH EAL for drinking water toxicity; however, TCE was not detected in the duplicate sample or in the subsequent samples, indicating this may have been an anomalous result.

  - *RHMW03:* COPCs detected during recent rounds of quarterly sampling showed a slight increasing trend. TPH-d and TPH-o have historically been detected at concentrations above the DOH Tier 1 EALs. The TPH-d concentration detected in RHMW03 during the October 2015 monitoring event (130 μg/L) exceeded the DOH Tier 1 EAL and was the highest concentration detected since October 2010.

  - *RHMW05:* COPC concentrations detected during recent rounds of quarterly sampling have been consistent with the historical data for RHMW05. TPH-d has not been detected at concentrations above the DOH Tier 1 EAL since the first four sampling events conducted at RHMW05 between May 2009 and January 2010. The recent data suggested that elevated COPC concentrations detected in samples collected from monitoring wells located adjacent to the USTs are not migrating in the downgradient direction.

  - *RHMW2254-01:* COPC concentrations detected during recent rounds of quarterly sampling have been consistent with the historical data for RHMW2254-01. Although the method reporting limits (MRLs) for TPH-d were above the DOH Tier 1 EAL in several results prior to August 2010, TPH-d has never been detected in RHMW2254-01 at a concentration above the DOH Tier 1 EAL. COPC concentrations reported for samples from RHMW2254-01 have not been increasing and no EAL exceedances have been observed, indicating that elevated COPC concentrations detected in samples collected from other monitoring wells within RHSF are not migrating or impacting the Navy's potable water source.

  The monitoring reports recommended continuation of the quarterly groundwater monitoring program at RHSF; monthly free product measurements at RHMW01, RHMW02, RHMW03, and RHMW05; and monthly SVM.

- *Outside-Tunnel Wells:* COPC trends for outside-tunnel wells are summarized below:

  - *HDMW2253-03:* TPH-d was detected in this well in the July 2015 event at a concentration below the DOH Tier 1 EAL. With the exception of a possibly erroneous result obtained during the event in April 2014, TPH-d concentrations have not exceeded the DOH Tier 1 EAL in well HDMW2253-03 since January 2013.

  - *OWDFMW01:* TPH-d and TPH-residual range organics (also known as TPH-oil [TPH-o]) were detected at concentrations exceeding their respective DOH Tier 1 EALs in both samples collected from this well during the July 2015 sampling event. The TPH-d concentrations (3,000 and 3,100 μg/L) exceeded the previous historical high concentrations from November 2012 (2,500 μg/L in both primary and duplicate samples) and represent a significant increase in concentration since the two previous events. The TPH-o concentrations detected during the July 2015 event (330 and 390 μg/L) were approximately three times the concentrations detected during the April 2015 event

(110 and 140 μg/L), which was the first time since 2012 that samples from the well were analyzed for TPH-o. Concentrations of all other COPCs detected during recent rounds of quarterly sampling are consistent with historical data. The analytes detected in groundwater at this downgradient location do not appear to be related to petroleum product released at RHSF for several reasons: the previous 2012 TPH-d peak did not correspond to any release from the USTs; the monitoring wells between the OWDF and the USTs did not show similar increases in TPH-d; the OWDF is downgradient of the capture zone of the Navy Supply Well; and the chromatographs of the samples taken from the OWDF (which have a few distinct sharp peaks) do not resemble those from the in-tunnel wells (which show a TPH-characteristic spread).

- *RHMW04:* COPC concentrations detected during recent rounds of quarterly sampling have been consistent with the historical data for RHMW04. TPH-d and TPH-o were not detected during the October 2015 event, but they were detected during the July 2015 event at concentrations above the previously reported concentrations but below the DOH Tier 1 EALs. Concentrations of all other COPCs detected during this round of quarterly sampling were also below DOH Tier 1 EALs.

- RHMW06: This well was installed in September 2014 and first sampled in October 2014. As of the October 2015 monitoring event, no COPCs have been detected at concentrations exceeding the DOH Tier 1 EALs.

- *RHMW07:* This well was installed and first sampled in October 2014. As of the October 2015 monitoring event, no COPCs have been detected at concentrations exceeding the DOH Tier 1 EALs. The groundwater levels measured during the 2015 monitoring events indicate a higher groundwater elevation at RHMW07 compared to other wells in the monitoring program.

The monitoring reports recommended continued groundwater monitoring at RHSF, noting that if the TPH-d concentrations significantly increase, the monitoring frequency should be increased to monthly. The February 4, 2016 scoping completion letter (Appendix A.2) approved the revised COPC list for the groundwater monitoring network, which is discussed in more detail in Appendix G.

#### *2.3.2.3 SOIL VAPOR MONITORING PROGRAM (DON 2008–2016)*

In accordance with the RHSF GWPP (DON 2014), as-needed and monthly SVM sampling is conducted using SVMPs installed in the existing boreholes beneath each of the active USTs in the Facility. Soil vapor concentrations at the existing boreholes beneath the active tanks in RHSF are measured to support leak detection and the groundwater monitoring program. SVM can provide information to confirm potential leaks identified by the automatic tank gauging system and shorten response time in the event of leaks. Because the soil vapor concentrations are read with a photoionization detector (PID), which measures the total VOC concentration in the soil vapor, SVM results cannot be used to assess risks to human receptors exposed via the vapor intrusion pathway.

Monthly SVM is conducted at 18 of the 20 tanks at RHSF. Tanks 1 and 19 are out of service and are not included in the SVM program. Three SVMPs are located under each of Tanks 2–18 and 20. SVMPs are identified as “S” for shallow or located in front of the tank, “M” for mid-depth or located near the middle of the UST, and “D” for deep or outer edge of the UST. Soil vapor is monitored for TVH using a PID at each of the SVMPs. PID readings at each SVMP are compared to historical results and evaluated for trends, and results are also compared to action thresholds (i.e., 280,000 parts per billion by volume [ppbv] for jet fuels and 14,000 ppbv for tanks containing diesel). The WP for long-term monitoring at RHSF recommends aggressive actions to assess the integrity of the tank system and address a potential fuel release if TVH concentrations exceeding the action thresholds are detected (DON 2010b).

The March 2016 monitoring event (Round 95 of the SVM program) indicated relatively stable trends for most tanks, with the exception of Tank 5, Tank 11, and Tank 18. A sharp decrease in soil vapor VOC trends was observed for SV18S and SV18D, while increasing trends were observed for the three SV05 monitoring points. The Tank 11 and Tank 18 concentrations are all below the soil vapor screening criteria of 280,000 ppbv (jet fuels) and 14,000 ppbv (diesel); however, the Tank 5 shallow monitoring point showed an exceedance. There has been an increasing trend of soil vapor VOC concentrations at Tank 5 since June 2015, with the December 2015 and the January, February, and March 2016 results exceeding the action level of 280,000 ppbv. Based on the December 2015 action level exceedance, the December 2015 *Soil Vapor Sampling Report* (DON 2015c) recommended action to assess the integrity of the Tank 5 system and, if it is uncertain whether a leak exists, collect soil vapor samples for laboratory analysis. However, Tank 5 is currently empty. Additionally, the increases in soil vapor VOC concentrations at the SV05 monitoring points are lower than the increases observed between April 2014 and June 2014, soon after the recorded Tank 5 release.

Results of long-term SVM at RHSF are depicted on charts and in tables in Appendix D.

### 2.3.3 Historical Records Review of Neighboring Properties

In accordance with Agreed-Upon Item 6 (Appendix A.1), a review of offsite contaminant sources was conducted. DOH Solid and Hazardous Waste Branch (SHWB) UST/Leaking Underground Storage Tanks (LUST) and HEER databases were searched for records pertaining to RHSF and neighboring properties. State databases included, but were not limited to: LUST, Registered UST, SHWS (State Hazardous Waste Sites), SWF/LF (Solid Waste Disposal Facilities), and SPILLS (Spills List). Freedom of Information Act inquiries were submitted to DOH SHWB and HEER to obtain the environmental records pertaining to these listings. Information provided in the DOH records is summarized in Table 1, and locations are depicted on Figure 2.

**Table 1: Historical Releases at Properties Neighboring RHSF**

| Location | Description | Groundwater Monitoring Wells | Chemistry Results | Final Status |
|---|---|---|---|---|
| Red Hill Mauka Neighborhood | A release was reported on April 15, 2008 in the Red Hill Mauka Neighborhood on the Āliamanu Military Reservation, immediately north of the intersection of Tampa Drive and Forward Avenue.<br>Approximately 1–2 gallons of an unknown product were released during excavation of a 500-gallon UST, which was discovered during a redevelopment project. There were no existing records of the UST prior to its discovery, and the UST was not leaking. The redevelopment contractor removed the UST, and Tetra Tech was contracted to sample the UST's contents, the excavated soil, and the soil around the tank. | No groundwater monitoring wells were installed since the release was most likely a spill from the tank during excavation. | The sludge in the tank did not exceed the soil action levels (SALs) of any RCRA metals. The most contaminated portion of the stockpile soils contained a diesel concentration of 32,500 mg/kg and a gasoline concentration of 96.2 mg/kg. No contaminants were detected in the soil surrounding the tanks. | DOH sent a letter on September 16, 2008 for No Further Action (NFA) despite a small volume of petroleum-contaminated soil remaining in the subsurface. |
| Hālawa Correctional Facility – Medium Security Prison: May 1988 UST Leak Release | A Foster Village resident reported oil contamination and dead fish in Hālawa Stream in May 1988. A UST located in the south end of the Hālawa Correctional Facility medical unit was discovered to be leaking into Hālawa Stream.<br>Approximately 2,000 gallons of diesel fuel were recovered by oil/water separators in the South Hālawa Stream, the North Tributary Stream, and the underground pipeline in 1988. The UST and pipes had been leaking for an unknown period. Two oil/water separators were installed in 1989 and collected approximately 500 gallons of diesel by 1991. | Twenty-three soil borings were drilled in six areas; 16 of those borings were converted into groundwater monitoring wells. Quarterly groundwater monitoring was conducted between August 1992 and May 1993. | During the 1992–1993 rainy season, TPH-g was not detected, but TPH-d ranged from non-detectable concentrations to 59 milligrams per liter (mg/L) in one of the wells. Benzene and total xylenes were also measured at concentrations ranging from non-detectable to 0.22 mg/L and 0.11 mg/L, respectively. DOH did not have any guidelines on TPH-g or TPH-d at the time of publication. | In August 1993, monitoring the site was discontinued based on the results of the last Dames and Moore quarterly groundwater monitoring report. Records of this incident are not available after 1993. NFA Status was granted in 2000 according to DOH SHWB records. |

| Location | Description | Groundwater Monitoring Wells | Chemistry Results | Final Status |
|---|---|---|---|---|
| Hālawa Correctional Facility – Medium Security Prison: April 1999 UST Excavation Release | A release at the Hālawa Correctional Facility – Medium Security Prison occurred in April 1999. Two gasoline USTs (M-1 and M-2) and a smaller diesel UST (M-3) were located in the parking area adjacent to the prison wall in the western portion of the facility. Another diesel tank was located inside the prison compound adjacent to the prison wall opposite of tanks M-1 to M-3.<br>Petroleum odors in the soil and the piping systems were observed during the excavation of the USTs. A sheen was also observed on the groundwater inside of the pit. USTs and piping were observed after excavation and did not show any sign of damage or leakage despite the odor. Soil samples from the excavations and water samples from the tank pits and one GW well were collected. | One existing GW well 10 ft from tank M-1 was inspected after the release was discovered. | Results of chemical analyses following the discovery of the release were as follows:<br>• TPH-d was detected in concentrations greater than the MRL in most of the soil samples but less than the ASLG. TPH-d was also found in all of the water samples greater than the MRL.<br>• TPH-g was recorded above the MRL for one soil sample below the action level and two water samples above the action level.<br>• BTEX was encountered in one soil sample. It was encountered in two water samples at a concentration above the MRL, with benzene and toluene above the action level.<br>• Total lead was not detected in any samples.<br>• PAHs were not detected in any soil samples but were detected in four water samples above the MRL, and with two above the action level.<br>• Methyl tertiary-butyl ether (MtBE) was encountered in three samples above the MRL and action level. | The UST closure report recommended that further action should be taken to monitor the site. However, since the technique used to test the soil may have caused false positives, DOH deemed the soil contamination as negligible. The water contamination was also deemed negligible since the water was perched water and not actually from the water table under the site. Samples from existing GWM wells did not have any detects. The contractor, EKNA, wrote a letter to DOH in April 2000 requesting a NFA status. It was accepted in May 2000. |
| Hālawa Correctional Facility – High Security Prison | A diesel and a gasoline UST were excavated at the Hālawa Correctional Facility – High Security Prison. The tanks were located approximately 30 ft from the eastern wall of module A.<br>The diesel UST was removed on February 28, 1994, and eight holes were discovered. The gasoline UST was excavated a week later; no holes were visible but minor rusting was observed. Product was noted on the water surface within the excavation. No product was observed after the removal of the contaminated backfill material. | Three wells were installed around both the gasoline UST site and the diesel UST site following the extraction of soil borings. No product was found in any of these wells during subsequent sampling and gauging. | Results of chemical analyses following the discovery of the release and after excavation of the area were as follows:<br>• Initial samples taken from around the gasoline UST had detects of TPH-g and BTEX. Only benzene and ethylbenzene were detected above DOH EALs. Samples from the groundwater showed no TPH-g or BTEX above laboratory MRLs.<br>• Initial samples from the diesel tank indicated the presence of TPH-d, benzene, ethylbenzene, and xylenes. Samples from groundwater indicated the presence of ethylbenzene, xylenes, and fluoranthene. None of the tested analytes were above DOH EALs.<br>• No detects occurred in soil and groundwater samples following the overexcavation. | Because no detects were found after the overexcavation, NFA was recommended in December 1999. It was accepted by the DOH in August 2000. |

| Location | Description | Groundwater Monitoring Wells | Chemistry Results | Final Status |
|---|---|---|---|---|
| City and County of Honolulu Hālawa Bus Facility | The City and County of Honolulu (CCH) Hālawa Bus Facility is located at 99-999 Iwaena Street, in Hālawa Valley. Between 1998 and 2003, 15 USTs containing diesel, gasoline, waste oil, and mineral spirits were excavated and removed in a series of closure actions. Five releases were reported during these activities; DOH SHWB UST Section, providing facility oversight, assigned these releases the following ID numbers: 980246, 990045, 030020, 030021, and 030024.<br>• Releases 980246 and 030021 represented an area of petroleum-impacted soil located beneath the former pump islands, originating from leaks in the piping between the islands, a waste oil UST and oil/water separator, and the UST farm immediately to the southwest.<br>• Release 990045 represented an area of acenaphthene impacted soil believed to have originated from a 250-gallon waste thinner UST to the northeast of the former pump islands.<br>• Release 030020 was associated with a waste oil UST and an antifreeze UST. All constituents in the excavation were reportedly below EALs.<br>• Release 030024 was associated with a motor oil UST and torque oil UST that were located just past the northeast corner of the maintenance building. | Groundwater Data: Groundwater was believed to be at a depth of approximately 120–150 ft bgs, however, there were concerns about perched aquifers that may be seasonal or transient in nature. During the removal of the waste thinner UST (Release 990045), what was believed to be a perched aquifer was encountered at 6.25 ft bgs. The water exhibited an oily sheen, although a water sample collected from the pit exhibited non-detectable levels of TPH-g and oil. During a second investigation, approximately 700 gallons of water were pumped from the excavation. No recharge was observed. The only other time groundwater was encountered was during a 2004 site investigation of the area near the pump islands. Of five borings in the area advanced to 30–51.5 ft bgs, only one encountered groundwater, at 38 ft bgs. Recharge was reportedly slow. The boring was converted to a well, and samples obtained from it showed concentrations of MtBE exceeding DOH Tier 1 groundwater action levels. | Chemistry results by DOH Release ID:<br>• Release 980246: TPH-d, benzene, ethylbenzene, acenaphthene, and naphthalene were detected above EALs in soil samples collected from the impacted trench area.<br>• Release 990045: Acenaphthene was detected above the EALs in soil samples collected from the excavation site. TPH-d was later detected at levels above the EALs in soil samples taken from the overexcavation site.<br>• Release 030020: Waste oil and antifreeze constituents were detected in soil samples collected from the excavation site, but all constituents were below EALs.<br>• Release 030021: TPH-d was detected in soil samples collected from the UST site above the EALs after the initial excavation and overexcavation.<br>• Release 030024: TPH-o and fluoranthene were detected above EALs in the soil collected from the Hālawa Bus Facility utility room where UST piping had surfaced. | Releases 980246, 990045, 030021, and 030024 are being managed in place by an Environmental Protection Management Plan. Annual inspections of the concrete pad above the area of contamination are conducted. Release 030020 received a NFA in 2004. |
| Hawaiian Cement Concrete and Aggregates: January 1991 UST Excavation Release | In January 1991, four USTs were excavated from the Hawaiian Cement Company.<br>Staining and petroleum releases were detected below the USTs. Samples were taken from the excavation pits. | — | TPH-d, organic lead, and benzene were found in concentrations above the DOH cleanup goals. There were no detects of contaminants in samples 15 months after the release. | After September 1992, sampling showed no detects, and NFA was recommended by FOPCO. A NFA status was granted by DOH in 1995. |
| Hawaiian Cement Concrete and Aggregates: December 2006 UST Release | On December 5, 2006 an alarm condition relating to a diesel UST was discovered at the Hawaiian Cement Hālawa Valley Quarry.<br>Diesel fuel in the sump above the UST was observed, and the primary and secondary piping was replaced. Excavation activities to remove the petroleum-impacted soil were conducted in March 2007, but visual and olfactory observations noted that petroleum was still present. Additional excavation activities were performed in July 2007, and soil samples confirmed that there were no constituents above DOH SALs. | — | Initial soil samples indicated detects above the DOH Tier 1 SALs. July 2007 sampling results did not indicate any contamination above DOH SALs. | EnviroServices recommended no further action in August 2007. DOH granted NFA status in December 2007. |

| Location | Description | Groundwater Monitoring Wells | Chemistry Results | Final Status |
|---|---|---|---|---|
| Tripler Hospital: October 1991 Building 113 UST Excavation Releases | On October 31, 1991, a 550-gallon waste oil UST (Tank 10) and two 1,000-gallon gasoline USTs (Tanks 9A and 9B) were removed in front of Building 113 Motor Pool Fuel Station at Tripler Army Medical Center. A UST closure report was prepared in June 1992.<br>Soil samples taken from under and around Tank 10 indicated petroleum leakage had occurred at the site. Free product was observed floating on water during the excavation of Tanks 9A and 9B. | — | The primary contaminants found in the soil samples at Tank 10 were oil and heavy metals that exceeded DOH cleanup goals at the time of the excavation. Organic lead was found in all samples from Tanks 9A and 9B. | DOH granted NFA status for Tanks 9A and 9B in October 1997 based on the initial tank removal report and two follow-up letters. DOH granted NFA status for Tank 10 in a February 1999 letter that referred to the June 1992 report as justification. |
| Tripler Hospital: October 1998 UST Excavation Release | Two gasoline USTs (TAMC-145-1 and TAMC 145-2) were excavated from the Tripler Army Medical Center on Krukowski Road during October 20–30, 1998.<br>TAMC-145-2 showed no signs of leakage, but TAMC-145-1 had a hole at the bottom where gasoline had leaked out onto the soil below. Several gallons of gasoline were present beneath TAMC-145-1. Samples were taken from soil around the tanks, and the area of suspected contamination was overexcavated. Contamination around TAMC-145-2 may have been attributed to an adjacent UST that was previously removed (TAMC-145-3), prompting the overexcavation of the area around both former USTs. Excavation of the site was again performed in February 2012 before closure. | In 2002, 16 boreholes were advanced to determine the extent of contamination at the site. Two plumes of BTEX constituents were identified. In 2008, 26 boreholes (8 of which were converted into monitoring wells) were advanced throughout the site, and groundwater was sampled. In 2010, 20 more soil borings were advanced, and groundwater was sampled. The monitoring wells were abandoned in March 2012. | 1998 Chemical Analysis<br>• BTEX results were above the DOH Tier 1 criteria for both of the tank confirmation sample results. TPH-g did not exceed DOH criteria.<br>• After overexcavation, TAMC-145-2 met DOH criteria for clean closure, but TAMC-145-1 still had exceedances of BTEX.<br>• Samples taken from the area around the pipeline met criteria for clean closure.<br>2012 Chemical Analysis<br>• COPCs were detected well above EALs in excavated soil.<br>• Only one of the soil samples from the excavated pits contained COPCs above EALs.<br>• TBA was found at an estimated concentration above EALs in one of the water samples from rainwater accumulated in the pits. No other constituents were detected above EALs. | The site was designated to be used as a green space, and the DOH granted NFA with restrictions status in December 2012. Petroleum remains on the site, but it has been removed to a practicable extent. |

| Location | Description | Groundwater Monitoring Wells | Chemistry Results | Final Status |
|---|---|---|---|---|
| Tripler Hospital: February 2000 Building 137 UST Excavation Release and Spills | A former waste oil storage UST (UST-137-4) in front of Building 137 at Tripler Army Medical Center was removed from February to May 2000. A spill occurred in September 2000 at the same site.<br>No visual or olfactory indication of a release was observed during the UST-137-4 removal. Water was observed at 7.6 ft bgs at the bottom of the extraction pit, but there was no evidence of contamination. Soil and water samples were taken for confirmation. A spill occurred at USTs 137-1 and 137-2 on two separate occasions while being filled. | For the UST-137-4 release, the installation of wells was reasoned to be unnecessary due to the low TPH levels and perched water found at the site in a September 2000 report. However, DOH requested that two wells be installed at the former UST site in order to determine if there is a perched groundwater lens at approximately 7.6 ft bgs and if petroleum contamination exists in the groundwater. Groundwater was not sampled for the spills. | At UST-137-4, total recoverable petroleum hydrocarbons were detected in two soil samples and a water sample, which indicates that a release has occurred from the tank sometime in the past. All residual hydrocarbons in the soil were below action levels. Further testing of groundwater and soil in 2004 did not indicate presence of significant petroleum contamination above action levels. The fuel spill sample results were not above the DOH Tier 1 cleanup levels except for fluoranthene in one. Samples collected a year later in July 2001 indicated that all COPCs were below Tier 1 levels. | NFA status was granted in June 2005 because lab analysis showed that all detects were well below DOH Tier 1 action levels. UST 137-1 was granted NFA status in December 2002 since there were no detects in the soil samples. UST 137-2 was granted NFA status in February 2004 after later testing showed that there were no longer any COPCs in the soil. |
| Tripler Hospital: June 2003 Building 125 UST Excavation Release | On June 19, 2003, a single-walled UST and a 55-gallon drum were removed 125 ft northwest of Building 125 at Tripler Army Medical Center.<br>The contents of the UST were unknown, and the drum was most likely used to store dry cleaning solvent. Confirmation soil samples were collected from the site. | A NFA letter indicates that a groundwater monitoring well was installed at the site and closed in 2007. No other documentation about this release is available. It is unclear whether or not the NFA letter pertains to this release. | TPH concentrations above the method detection limit but below the DOH Tier 1 SAL were detected. Lead was also detected, which exceeded the DOH Tier 1 SAL in two samples. | A NFA letter from July 2008 for a UST at former Building 125 exists, but no documentation mentioned in the letter is available. Another letter from 2009 entitled "Referral of a Regulated UST Release" refers directly to the 2004 tank closure report and implies that the project was still active. It is unclear what happened to this site. |
| Animal Quarantine Station | The animal quarantine station is located on Hālawa Valley Road in ʻAiea. The parcel of land the station is on was previously owned by the Navy during the 1940s and 1950s before the State of Hawaiʻi acquired it in 1968.<br>An unknown tar-like substance was found at several locations seeping through the asphalt of the DOH Vector Control Parking Lot adjacent to the Hawaiʻi Department of Agriculture Laboratory/Office Building. An initial investigation of the substance happened in June 2003 where various COPCs were found. Fifteen soil borings were installed around the surface release. Personnel interviews indicated that tar had been leaking from 5 years prior to the investigation (most likely from around 1999) and that the area was once used as a dumping ground. | — | Initial tar samples had detects of acetone, barium, cadmium, and chromium and lead under regulatory standards. Samples taken in 2004 detected TPH-o in three of the soil samples but did not exceed the SAL. The petroleum sample indicated high levels of TPH-o above SALs as well as 1-methylnaphthalene, 2-methylnaphthalene, fluorine, phenanthrene, pyrene, and chrysene, which do not have SALs. | A NFA status was granted in August 2006 based on the fact that the chemical analyses of the tar substance did not pose a threat to human health, site soil, or groundwater. The final decision was to leave the tar-like substance in place and conduct surface removal or disposal as necessary. |

| Location | Description | Groundwater Monitoring Wells | Chemistry Results | Final Status |
|---|---|---|---|---|
| Grace Pacific Corporation | Three USTs were removed from Grace Pacific's Hālawa location from January through March 1997.<br>Stained soil was observed on the sidewalls of the excavation, and heavy rains filled the excavation with rainwater. Soil and water (most likely runoff and not groundwater) samples were collected. The pit was overexcavated following receipt of analytical results. A Phase II environmental assessment was conducted in June and November 1997, which involved the construction of boreholes. An additional environmental assessment was conducted in September–October 1998. After a sheen was observed in the monitoring wells, free product recovery was conducted from 1998 to 2000.<br>Four trenches were excavated in the area of the former UST excavation between November 2000 and January 2001. It was discovered that petroleum contamination was only confined to shallow depths. The area of the former tank pit was excavated between January 2001 and February 2001. There were reports of free product in the groundwater that was recovered, but no records of soil or water sampling are available. The excavation was only partially backfilled.<br>In November 2001 the pit was overexcavated and a well surrounded by petroleum stained soil was encountered. The pit was backfilled and paved over. In January 2002, a trench was dug near the office building where excavation did not occur and free product was found floating on groundwater. Quarterly groundwater sampling commenced beginning October 2002 and was reduced to semiannual monitoring starting in November 2003. No contaminants were above the action level since January 2004. | Three borings, two of which were turned into groundwater monitoring wells, were constructed as part of the September–October 1998 assessment. In February 2002, seven borings were drilled, and six groundwater monitoring wells were installed at the former pit location and near the area of the shallow trench dug in January 2002. Five wells were abandoned in 2006 after no constituents were detected since 2003. Product recovery continued in MW-1a from 2002 through 2009. | TPH-d and TPH-o were detected above DOH Tier 1 Action Levels during initial sampling. During quarterly and semiannual sampling from 2002 to 2006, only PCBs and benzo(a)pyrene were detected at concentrations above DOH action levels on one or two occasions. All constituents were below DOH action levels since January 2004. | A NFA status was requested by ESI in their First Quarter 2010 Status Report. DOH responded with a letter from January 2013 stating that free product recovery efforts are no longer necessary and that MW-1 should be closed. No subsequent communications or reports are available. |
| U.S. Coast Guard Service Station | USTs were removed from Kiai Kai Hale Exchange Station off of Icarus Way in 1998 and 2007.<br>Staining and elevated PID levels were observed in the soil after the 1998 tank removals. The area was tested then overexcavated to remove the contaminated soil. Testing following overexcavation showed that the site did not appear to be impacted by petroleum. Soil sampling was performed following another UST removal in 2007. There were no signs of staining, and the UST did not show any damage. | — | In the 1998 excavation, only benzene exceeded DOH EALs in the soil samples from the excavation pit. After the site was excavated once more to remove contaminated soil, all sample results were below DOH EALs. In the 2007 excavation, xylenes and toluene were detected but not above DOH EALs. | NFA status was granted to the 1998 release in October 1999, and for the 2007 closure in May 2008. |
| Alert Alarm | In May 2000, a UST was removed from the Sentinel Silent Alarm Company property located in Hālawa.<br>A 2-inch-diameter hole was discovered at the fill end of the UST, and a black product was observed floating in the groundwater at the bottom of the excavation pit. The petroleum-impacted soil was overexcavated, and soil borings showed that the contaminant plume did not extend beyond the excavation limits. Groundwater was not observed after the initial excavation, which made it unlikely that the groundwater in the area had been impacted by the petroleum. | — | No chemicals exceeded method detection limits in the soil borings. | NFA status was granted in April 2001 according to the DOH SHWB UST database. |

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|---|---|---|---|---|---|
| — | groundwater monitoring not performed | mg/L | milligram per liter | PCB | polychlorinated biphenyl |
| ID | identification | MtBE | methyl tertiary-butyl ether | SAL | soil action level |

# 3. Physical Characteristics

## 3.1 CLIMATE

The prevailing northeast trade winds and ocean currents cause the air and water of the region to be cooler than other areas of similar latitude, where trade winds do not prevail. Northeasterly winds persist most of the year, and the northeastern, or windward, sides of the islands are commonly the wettest.

There are generally two distinct seasons for precipitation in Hawai‘i: October to April is considered the wet season, and May to September is considered the dry season. Precipitation is at a maximum at elevations between 2,000 ft and 4,000 ft msl. The amount of infiltration varies depending on location.

## 3.2 TOPOGRAPHY

Four major geomorphic provinces define the island of O‘ahu: two volcanic mountain ranges (Wai‘anae and Ko‘olau), the Schofield Plateau, and the coastal plains, which form the northwest and south island margins (Stearns and Vaksvik 1935). The Ko‘olau volcano is a shield, or dome, volcano; the windward half of it is missing because of collapse due to catastrophic mass wasting (Walker 1990). The pali (cliff line) on the east side of the range defines the predominantly stream-eroded back-collapse scarp.

The site is located on the lower portion of the southwestern wall of Hālawa Valley, the easternmost Ko‘olau stream valley emptying into Pearl Harbor. The valley was formed by the coalescence of two valley heads, drained by the North and South Hālawa Streams that merge on the Coastal Plain before emptying into Pearl Harbor.

The elevation of the site surface ranges from approximately 200 to 600 ft msl. The tops of the bulk fuel storage tanks range from approximately 100 to 200 ft bgs, and the bottoms of the USTs are approximately 100 ft above the groundwater aquifer.

## 3.3 VEGETATION AND WILDLIFE

The above-ground portion of the site is inhabited by koa haole scrub (*Leucaena leucocephala*), disturbed habitat, and landscaped area. Koa haole grows throughout O‘ahu, primarily in areas that have been disturbed by grazing or human activities. The scrub community on Red Hill is dominated by koa haole, guinea grass (*Panicum maximum*), and Chinese violet (*Asystasia gangetica*). The disturbed habitat is composed of weedy plant species that can withstand frequent disturbance by human activities or natural events. Although this vegetation does support some wildlife species, the habitat is considered to be of very low quality and is primarily used by introduced, common urban species.

Due to the highly developed nature of the site, it is not anticipated that any Federal- or State-listed threatened or endangered species occur on site. The onsite habitat is not considered sensitive and is dominated by introduced plant and animal species that have replaced native species. No native or sensitive species were observed in a 1995 biological survey of the area (DON 1996). However, no threatened or endangered species surveys have been conducted at the facility (DON 2005).

## 3.4 SOILS

Soils in the vicinity of RHSF are mapped as Helemano-Wahiawā association consisting of well-drained, moderately fine textured and fine textured soils. The surface of the basaltic flows have been weathered to form reddish-brown clayey silt, which is the basis for the local name of "Red Hill." These soils typically range from nearly level to moderately sloping and occur in broad areas dissected by very steep gulches. They formed in material weathered from basalt. Red Hill facility soils consist of clays and clayey gravels to a depth of 10 ft bgs. Along the slopes, the basaltic bedrock is covered with 10–30 ft of Koʻolau residuum. These soils were derived from weathering of the underlying basalt bedrock or were deposited as alluvium/colluvium. The younger alluvium/colluvium deposits were derived from fractured basalts and tuff. Beneath the surficial soils, alternating layers of clay and fractured basalts are encountered at depth. The western slope of the Hālawa Valley is generally barren of soil and consists of outcropping basalt lava flows to the valley floor.

## 3.5 GEOLOGY

Oʻahu is the third largest of the eight major islands of the Hawaiian Archipelago and has a land area of 596 square miles (Shade and Nichols 1996). Stearns and Vaksvik (1935, 1938) and Stearns (1939, 1940) published studies concerning the geology and groundwater resources of Oʻahu. These studies, published in Hawaiʻi Division of Hydrography Bulletins, describe the general stratigraphy and structure of Oʻahu and also illustrate the petrology of the volcanic rocks, discuss groundwater resources, and provide water well records. The Bulletins contain the first comprehensive and detailed studies of the geology and water resources of the (then) Territory of Hawaiʻi.

### 3.5.1 Regional Geology

The Koʻolau volcanic series is made up almost entirely of tholeiitic basalts and olivine basalts, and as a result, there is relatively little tuff throughout much of the Koʻolau Range. The few interbedded tuff beds amount to less than 5 percent of the whole section (Wentworth 1951). Small beds can be found near the crest of the range, and singular deposits have been found at the head of Nuʻuanu Valley, near Honolulu. A vast dike system also makes up part of the Koʻolau Series. Most dikes are vertical or nearly vertical, with some angling as low as 60 degrees (Macdonald et al. 1983).

Koʻolau lavas are of predominantly two types of extrusive rocks: pāhoehoe and aʻā. Pāhoehoe lava is characterized by vertical polygonal joints, spherical vesicles, horizontal joints, and the presence of lava tubes. Pāhoehoe is smooth, fine-grained lava with a rope-like appearance. Aʻā lava is a jagged, blocky lava flow that contains clinker beds. The aʻā lava is characterized by irregular, stretched, and deflated vesicles; massive beds that may have well-developed columnar or platy jointing; the absence of lava tubes; and clinker layers that typically bound a massive dense core or mid layer (Stearns and Vaksvik 1935). The clinker portions are extremely permeable and, therefore, are subject to more rapid chemical weathering. Koʻolau lava flows are mostly of the aʻā type with approximately 60 percent aʻā (Sherrod et al. 2007). Pāhoehoe lava dominates near the crest of the Koʻolau Range, with aʻā dominating on the periphery of the dome (Stearns and Vaksvik 1935; Wentworth 1951).

The northeastern side of the Koʻolau Volcano seems to have been subjected to several very large mass-wasting events, while the western (i.e., Central Oʻahu) portions of the shield were braced by Waiʻanae volcanics, and erosion on a much smaller and slower scale took place. The western valleys of the Koʻolau Range are choked with alluvium, as is the Schofield Plateau (Macdonald et al. 1983). Mechanical and chemical erosion of the steep escarpments within valleys produces accumulations of blocky material called colluvium. The reason for the steep, cliff-like walls similar to those found in nearby Mānoa and Pālolo valleys and many other valleys along the Ko‘olau Range is the presence of nearly horizontal beds of alternately greater and lesser resistance to erosion. More rapid erosion of the less-resistant beds, usually of a‘ā clinker, results in undercutting of the more resistant pāhoehoe layers (Macdonald et al. 1983). With time, the valley walls may retreat, but the slopes of the cliff remain steep. The predominant erosion process here is apparently due to repeated rockfall and landslide events over time, which owe to the accumulations of colluvium at the base of slope within the valleys.

After cessation of the Ko‘olau volcanics, there was a period of volcanic quiet that lasted about 2 million years. In the post-eruption stage, the volcanoes have undergone substantial modification by secondary geologic processes, including subsidence due to gravitational loading, weathering, and sedimentation. Streams cut deep, amphitheater-headed valleys into the shield and the island slowly subsided at least 360 meters. Some valleys, such as Mānoa Valley, were eroded below present sea level and accumulated coarse detrital sediments. Remnants of the old Ko‘olau shield surface take the form of planèzes between amphitheater-headed valleys (Macdonald et al. 1983; Rowland and Garcia 2004). Many of the flat-topped ridges of the Ko‘olau range are characterized by a relatively flat, gently to moderately sloping surface, or planèze, that is inferred to be a remnant slope of the former Ko‘olau shield (or perhaps preserves the old Ko‘olau shield surface) (Macdonald et al. 1983; Rowland and Garcia 2004). These form as triangular facets between steep-sided stream valleys and are common along the southern front of the Ko‘olau range, from behind Honolulu to Hawai‘i Kai.

The southeastern third of Ko‘olau volcano’s remnant shield experienced a rejuvenation stage of volcanism. Most rejuvenation-stage volcanoes lie south of the erosional valleys carved out of the Ko‘olau shield and are interbedded with alluvial and marine sediments (Figure 3). These rejuvenation-stage vents and associated flows and ash deposits compose the Honolulu volcanic series, which include the landmarks of Diamond Head, Punchbowl, the Tantalus group (Roundtop, Sugarloaf, and Mount Tantalus), Hanauma Bay, Ka‘au Crater, Koko Crater, Āliamanu, and Salt Lake. These eruptions did not occur in rapid succession, but were scattered over the last 900,000 years (Walker 1990).

The Salt Lake Tuff, named for Salt Lake Crater east of Pearl Harbor, consists of subaerial gray to brown tuff containing nodules of dunite (Stearns and Vaksvik 1935). It is as much as 300 ft thick, contains upright tree molds, and passes beneath sea level. It overlies Āliamanu tuff and, in some areas, unconformably overlies eroded and dissected gravels of Ka‘ena marine terraces, which indicate it was laid down during a low stand of sea level relative to today known as the Waipi‘o stand of sea. The Salt Lake tuff is assigned middle and late Pleistocene age (Stearns and Vaksvik 1935).

The Āliamanu Tuff, named for Āliamanu Crater east of Pearl Harbor, is composed of water-laid gray to black or grayish-brown tuff, rounded gravel, and (in tunnels) large vesicular bombs and spatter (Stearns and Vaksvik 1935). It is separated from overlying Salt Lake tuff by red soil and typically overlies older alluvium. The Āliamanu tuff is assigned to an elevated stand of sea level relative to today known as the Ka‘ena stand of sea on basis of terraces, which correlates to middle and late Pleistocene age (Stearns and Vaksvik 1935).

The Āliamanu basalt occurs in the subsurface between 62 and 93 ft, where penetrated by wells at 95 ft altitude. Composed of melilite-nepheline basalt, it underlies 47 ft of Salt Lake Tuff and overlies 17 ft of older alluvium on lavas of the Ko‘olau volcanic series. According to Stearns (1940), “It appears to be lava erupted at the close of the explosive phase in Āliamanu Crater, hence is a member of the Honolulu volcanic series.” According to Macdonald and Davis (1956), the Āliamanu basalt “appears to be lava erupted at the close of the explosive phase, hence is correlative with the Āliamanu tuff.” It is not known to crop out at the surface; hence, its extent is unknown.

#### *3.5.1.1 STRUCTURE*

Fissure eruptions characterized the building of the Ko‘olau dome, as evidenced by the great number of dikes along the rift zones. In the early phases of dome building, lava apparently discharged from the summit area. This activity then ceased in favor of discharge from the lower ends of the rift zones, especially the northwest end of the dome where much flow lava has accumulated (Stearns and Vaksvik 1935). Typically, more lava is extruded along one rift zone than another, a relation that is also observed at Mauna Loa volcano on the island of Hawai‘i.

The Ko‘olau volcanic series is greater than 3,100 ft thick and composes the bulk of the lava flows and other rock types that make up the Ko‘olau Range. Pāhoehoe is predominant near the crest, with a‘ā more predominant near the periphery. Flows were extruded in a very fluid condition, similar to flows observed in historic times at Kilauea on the island of Hawai‘i. Flows occurred in fairly rapid succession, based on the absence of erosional unconformities and of extensive soil horizons.

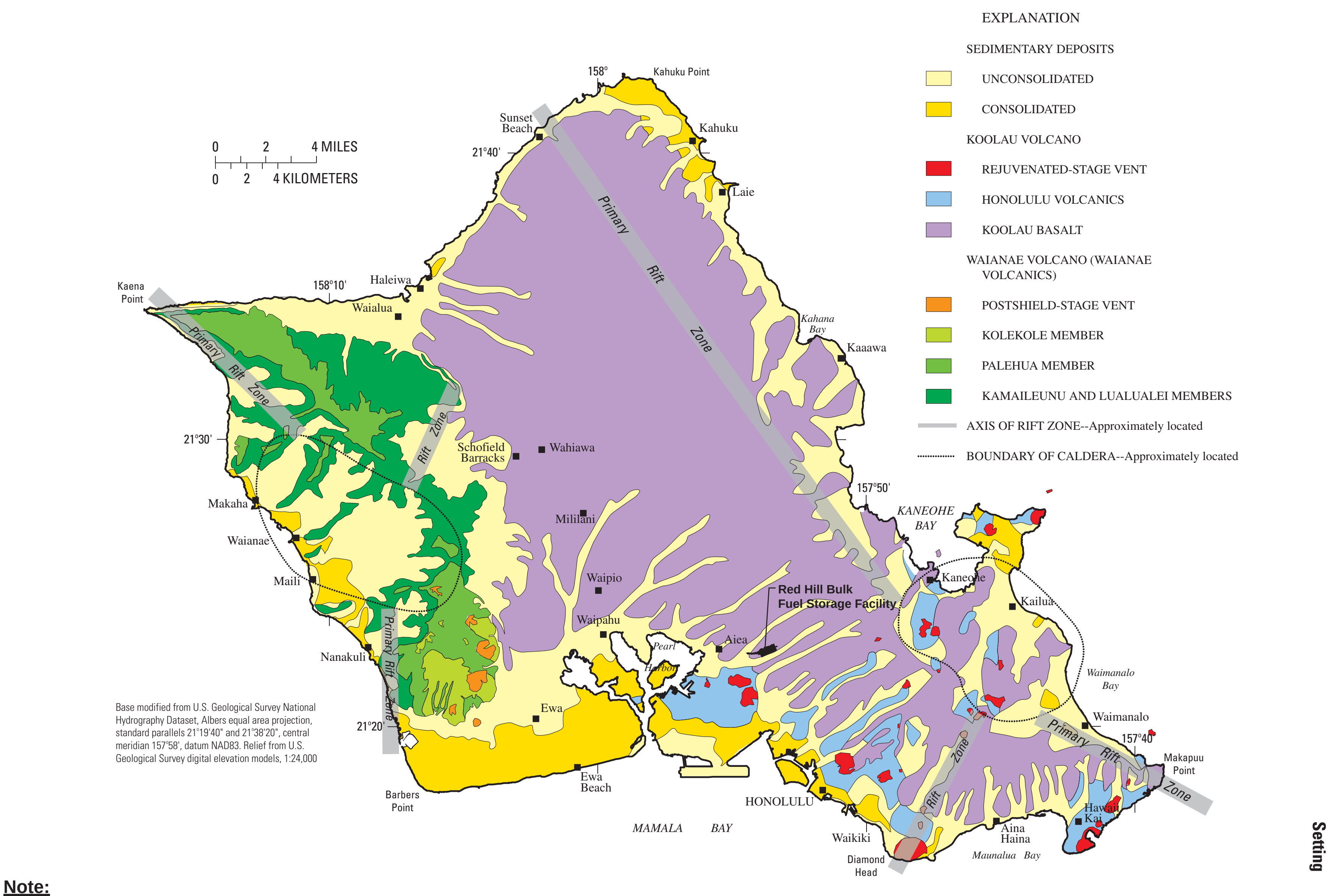
Ko‘olau basalt flows dip away from the summit and crest of the volcano. The mountain peak of Pu‘u Kōnāhuanui above Manoa Valley is near the vicinity of the summit. Lava flow bedding dips approximately 3 degrees near Ko‘olau’s summit, and reaches a maximum dip of approximately 10 degrees near the margin of the range (Stearns and Vaksvik 1935). Ko‘olau is a highly asymmetrical volcano due to ponding of lava flows on the west side against the older Wai‘anae Volcano. As such, basalt flows dip approximately 3 degrees on the west side, in the Schofield Plateau area, versus about 8 degrees on the east side (Stearns and Vaksvik 1935). There is also north to south asymmetry: 28 miles from summit area to the north end versus 9 miles from summit area to the south end.

Ko‘olau is so heavily dissected by stream erosion that it is doubtful that any part of the original volcano surface remains. Although the eruptive center is mostly eroded away, some of the divides appear to have undergone less stripping.

### 3.5.2 Site Geology

Red Hill is located on the southern edge of the Ko‘olau Range, approximately 2.5 miles northeast of Pearl Harbor.

RHSF is located along the topographic ridge that separates the Moanalua and Hālawa Valleys. The ridge drops steeply on either side with sediments deposited in the valley bottoms. The valleys on either side of the ridge were formed by fluvial erosion and are filled with sedimentary deposits including alluvium/colluvium. On the ridge, the horizon of soils and residual (weathered basalt) is approximately 15–25 ft thick. The character and condition of the rock cores reveal much of the site geology. At Red Hill, the Ko‘olau formation consists of the basaltic lava flows that erupted from a fissure line approaching 30 miles in length and trending in a northwest rift zone (Wentworth 1953). Both pāhoehoe and a‘ā lava flows are present in the Ko‘olau formation. RHSF is within the Ko‘olau volcanic series.



Base modified from U.S. Geological Survey National Hydrography Dataset, Albers equal area projection, standard parallels 21°19'40" and 21°38'20", central meridian 157°58', datum NAD83. Relief from U.S. Geological Survey digital elevation models, 1:24,000

**Note:**

**Modified from Stearns (1939); Langenheim and Clague (1987); Presley et al., 1997**

## Figure 3
## Generalized Surficial Geology, O’ahu, Hawai’i
## WP/SOW
## Investigation and Remediation of Releases and Groundwater Protection and Evaluation
## Red Hill Bulk Fuel Storage Facility
## JBPHH, O‘ahu, Hawai‘i

The presence of nearly horizontal beds of lava flows of alternately greater and lesser resistance to erosion is evident at the site, where rapid erosion of the less resistant beds, usually of a‘ā clinker, results in undercutting of the more resistant massive dense a‘ā and pāhoehoe layers. The flows vary from evenly bedded, relatively flat, and continuous to undulating and uneven.

A‘ā clinker is composed of gravel- and cobble-size rubble that resembles a conglomerate. It is usually loosely held together unless it has been welded together by heat. A‘ā clinker is extremely permeable and is therefore subject to rapid chemical weathering. Vertical fractures are also subject to rapid weathering. Similarly, the nearly horizontal contacts between pāhoehoe lava flows are susceptible to erosion even in the absence of a‘ā clinker beds. Rock layers with dense, more closely spaced fracturing are extensively weathered. A more detailed CSM of the site geology is presented in Section 3.7.

## 3.6 HYDROGEOLOGY

Hawai‘i has a wide range of climatological areas that vary in accordance with geomorphology, elevation range, and geographic position of each individual island. The windward sections of the islands generally have a consistent year-round supply of trade winds that bring brief showers and attendant groundwater recharge. The higher slopes of the windward areas receive enough rainfall to support rainforest vegetation. The leeward sides of the island are more arid. Generally, throughout the islands, the wetter season is October to April.

### 3.6.1 Regional Hydrogeology

Groundwater in Hawai‘i exists in two principal aquifer types. The most important type, in terms of drinking water resources, is the basal aquifer. The basal aquifer exists as a lens of fresh water floating on and displacing seawater within the pore spaces, fractures, and voids of the basalt that forms the underlying mass of each Hawaiian island. In parts of O‘ahu, groundwater in the basal aquifer is confined by the overlying caprock and is under pressure. Waters that flow freely to the surface from wells that tap the basal aquifer are referred to as artesian.

The other type of aquifer is the caprock aquifer, which consists of various kinds of unconfined and semi-confined groundwater. Commonly, the caprock consists of a thick sequence of nearly impermeable clays, coral, and basalt that separates the caprock aquifer from the basal aquifer. The impermeable nature of these materials and the artesian nature of the basal aquifer severely restrict the downward migration of groundwater from the upper caprock aquifer toward the lower basal aquifer. However, in the area of RHSF, there is no discernible caprock.

As part of the DOH Safe Drinking Water Branch (SDWB) Groundwater Protection Program, the State of Hawai‘i developed an aquifer classification system that is consistent with the EPA’s system. For the island of O‘ahu, the aquifer classifications are documented in *Aquifer Identification and Classification for O‘ahu: Groundwater Protection Strategy for Hawai‘i* (Mink and Lau 1990). Varied processes and stages, including shield-building volcanism, subsidence, weathering, erosion, sedimentation, and rejuvenated volcanism (Stearns 1946; Mink and Lau 1990; Hunt 1996) have imposed limits on aquifer geometries and have also produced geohydrologic boundaries that subdivide the regional aquifer system and major watershed areas (Figure 4). The island of O‘ahu has been subdivided into seven major groundwater areas that are demarcated by geohydrologic barriers (Hunt 1996).

### 3.6.2 Site Hydrogeology

RHSF is within the Ko‘olau formation, which contains one of the two main aquifers in the island of O‘ahu (Figure 5).

The project site is located in the Southern O‘ahu groundwater area, which is further divided into subordinate groundwater areas. Red Hill is within the Pearl Harbor and Moanalua subordinate groundwater areas and is part of the Waimalu Aquifer System of the Pearl Harbor Aquifer Sector (Figure 5). The groundwater elevation in the project vicinity is approximately 20 ft msl.

Aquifer status codes describe the aquifer’s water quality, utility, and vulnerability to contamination (Mink and Lau 1990). The Facility lies on the Red Hill Ridge, which is located on the boundary between the Moanalua Aquifer system, which is part of the Honolulu Aquifer sector, and the Waimalu Aquifer system, which is part of the Pearl Harbor Aquifer sector (DON 2007). Both the Moanalua Aquifer and Waimalu Aquifer systems are classified by Mink and Lau as basal, unconfined, flank-type, and currently used as a drinking water source. The aquifers are considered fresh, with less than 250 milligrams per liter of chloride, and are considered irreplaceable resources with a high vulnerability to contamination (Mink and Lau 1990).

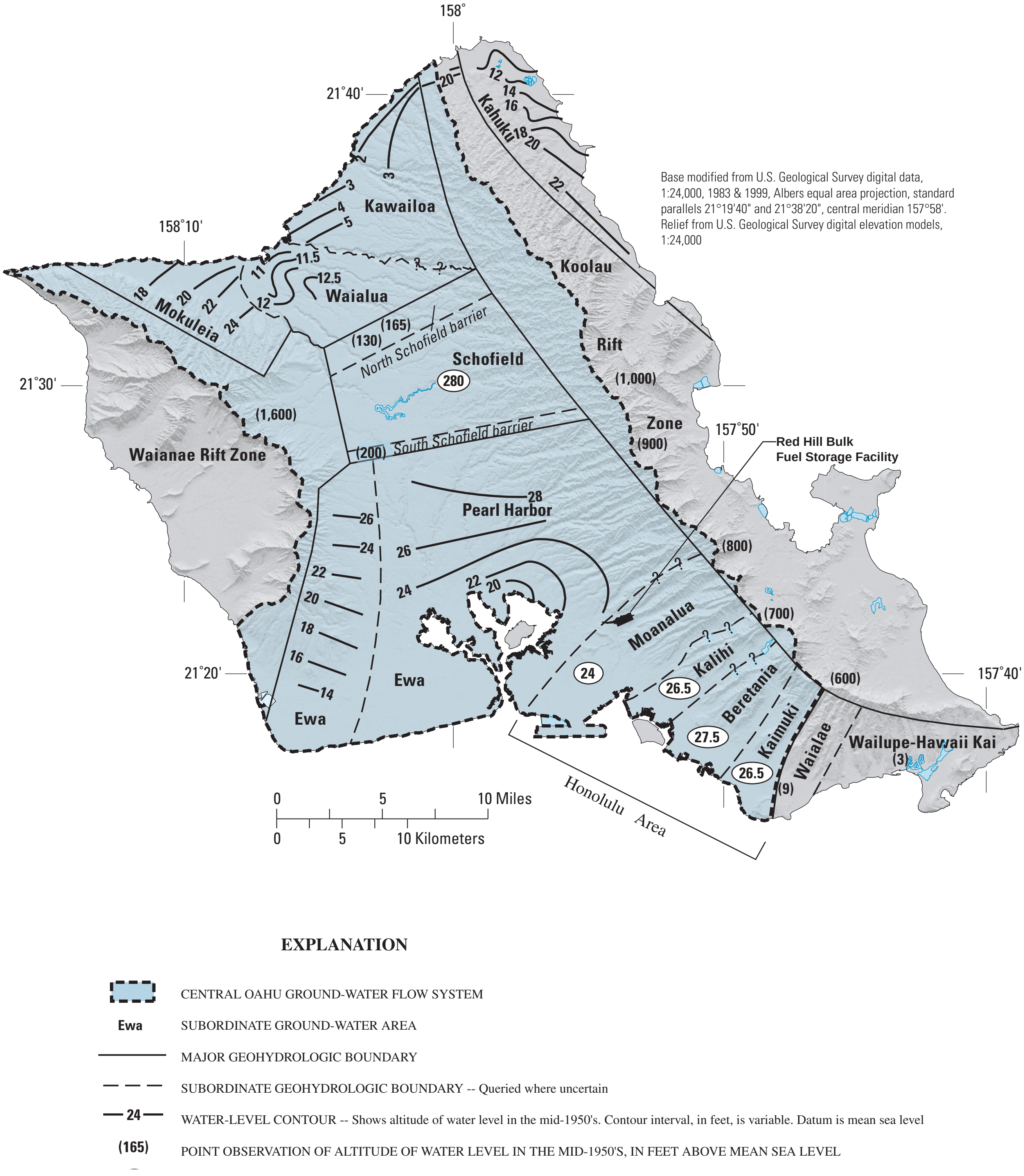
Previous investigators noted that the Red Hill Ridge is not a hydrogeologic boundary, and there are no geochemical or physical attributes that separate the two aquifers at this location (DON 2007). The likely physical boundary between the Moanalua and Waimalu Aquifer systems is the North Hālawa Valley fill to the northwest of the facility, which extends below the water table in the vicinity of the Facility and consists of low-permeability sediments (DON 2007).

The Facility is located upgradient of the Hawai‘i State Underground Injection Control Line, which indicates the border between groundwater that is, and is not, considered a potential source of drinking water. The nearest public drinking water well, the Hālawa Shaft, is located hydraulically cross-gradient of the Facility (DON 2007). This drinking water well is approximately 4,400 ft the northwest of the USTs, and pumps water from the basal aquifer (Figure 1 and Figure 6).

Navy Supply Well 2254-01 is located downgradient of the Facility. This well consists of a pumping station, located in the lower access tunnel approximately 2,700 ft west of the USTs, and an infiltration gallery that extends from the pump station approximately 1,270 ft along the water table, toward the Facility (Figure 1 and Figure 7). The infiltration gallery is located hydraulically downgradient from the Facility and intercepts most of the water that would be affected by releases from the Facility (DON 2007). This well extracts an average of 4 mgd and up to 18 mgd of groundwater.

#### *3.6.2.1 SURFACE WATER*

Surface water bodies in the vicinity of the Facility include the southern segment of the Hālawa Stream (approximately 665 ft to the north) and the northern segment of the Moanalua Stream (approximately 1,760 ft to the south). In the area of Hālawa Valley, streams flow above the basal groundwater table over deeply weathered rock and may exchange water with perched water associated with the alluvial material, known as valley fill. Groundwater that flows beneath the Facility does not intercept surface water inland of the ocean shoreline (DON 2007). Both Hālawa and Moanalua streams are losing streams that lie at significantly higher elevations than the aquifer (Figure 7), and are therefore not likely to be impacted by releases at RHSF.



Base modified from U.S. Geological Survey digital data, 1:24,000, 1983 & 1999, Albers equal area projection, standard parallels 21°19'40" and 21°38'20", central meridian 157°58'. Relief from U.S. Geological Survey digital elevation models, 1:24,000

**Source:**
**Hunt 1996.**

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**Figure 4**
**Groundwater Areas and Potentiometric Surface in the Principal Volcanic-Rock Aquifers, O‘ahu, Hawai‘i**
**WP/SOW**
**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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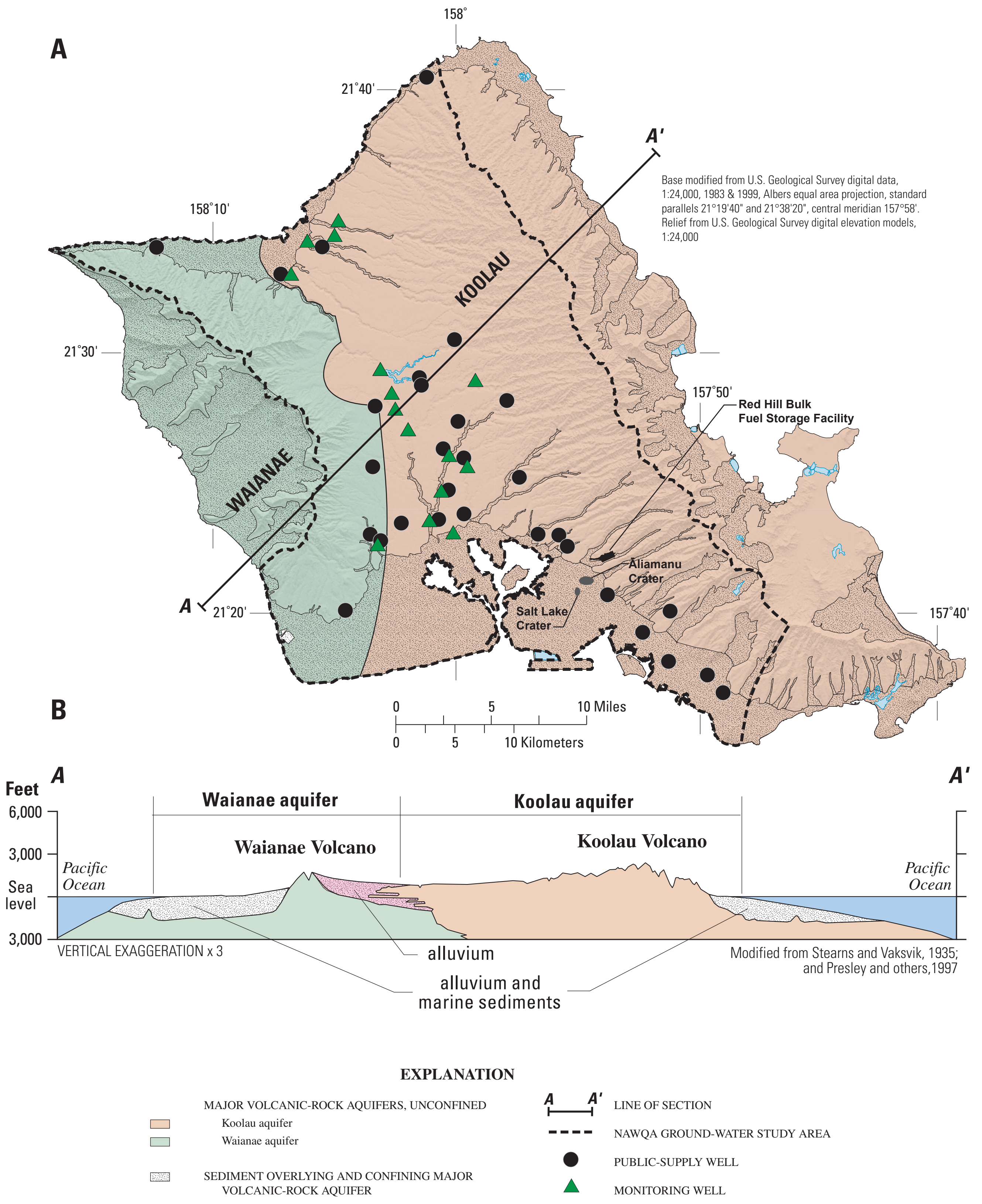


**Note:**

**(A) Areal extent of aquifers within depths tapped by wells (modified from Hunt 1996); (B) aquifers in cross section (modified from Stearns and Vaksvik 1935; Oki et al. 1997; and Presley et al. 1997). Sampled wells are shown for reference.**

**Figure 5**
**Waiʻanae and Koʻolau Volcanic Rock Aquifers, Oʻahu, Hawaiʻi**
**WP/SOW**
**Investigation and Remediation of Releases and Groundwater Protection and Evaluation**
**Red Hill Bulk Fuel Storage Facility**
**JBPHH, Oʻahu, Hawaiʻi**

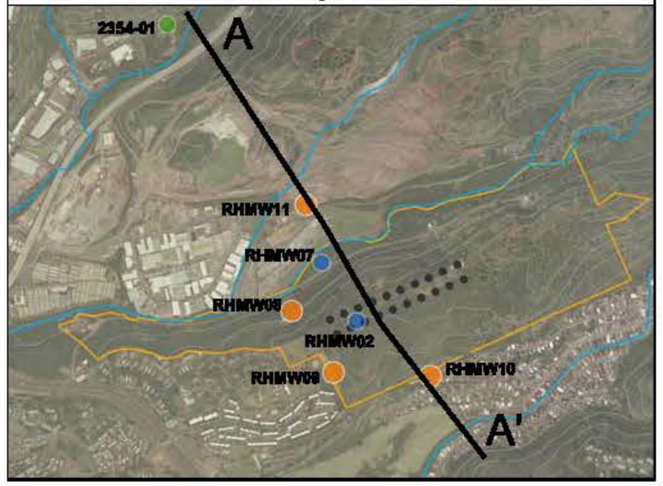
## Legend

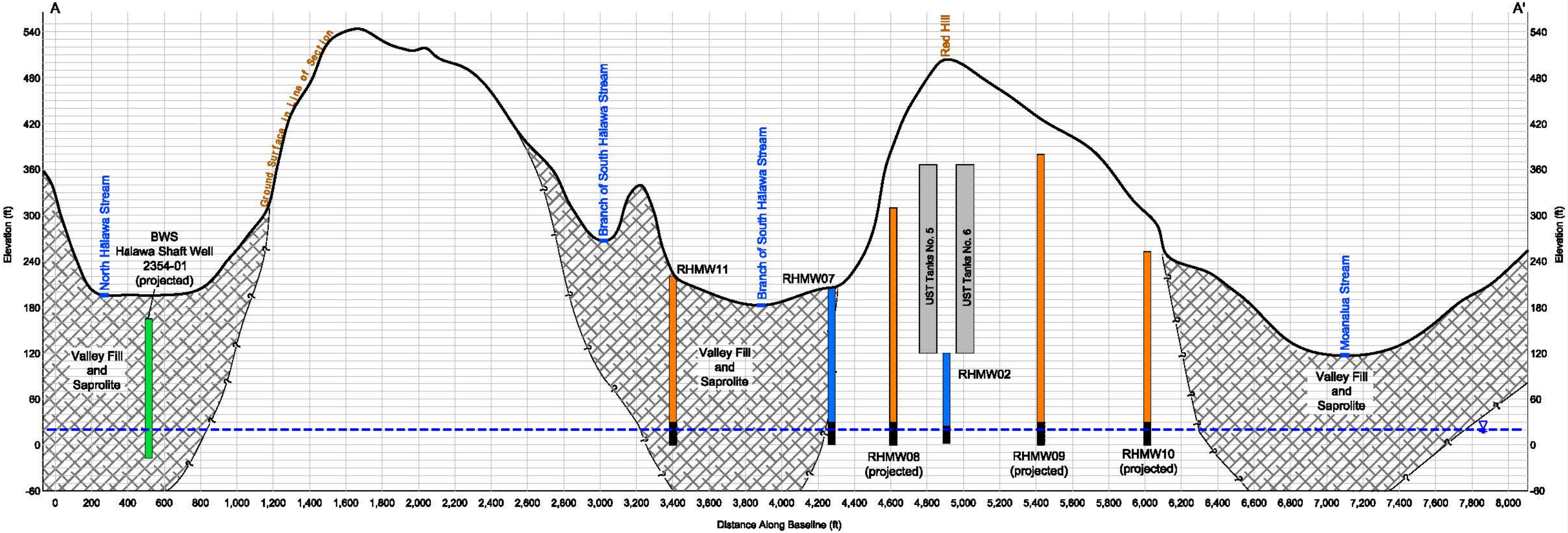
- ‑ ‑▽‑ ‑ Groundwater surface (approximate)
- —?— Assumed approximate boundary between valley fill/saprolite and basalt
- 🟧 Proposed monitoring well screened interval
- 🟦 Existing monitoring well screened interval
- 🟩 Existing Navy water supply well

## Notes

1. Existing well logs show a complex subsurface comprised of alternating pāhoehoe and a'ā lava flow with sporadic clinker zones, fractures, and voids.
2. Acronyms and Abbreviations:
   - ft feet
   - UST Underground Storage Tank
3. Tops of well casing elevations differ from ground surface in line of section due to projection.

## Key Plan





**Note: Vertical exaggeration = 1H : 5V (approximate)**

Figure 6
Geological Cross Section (Transverse)
WP/SOW
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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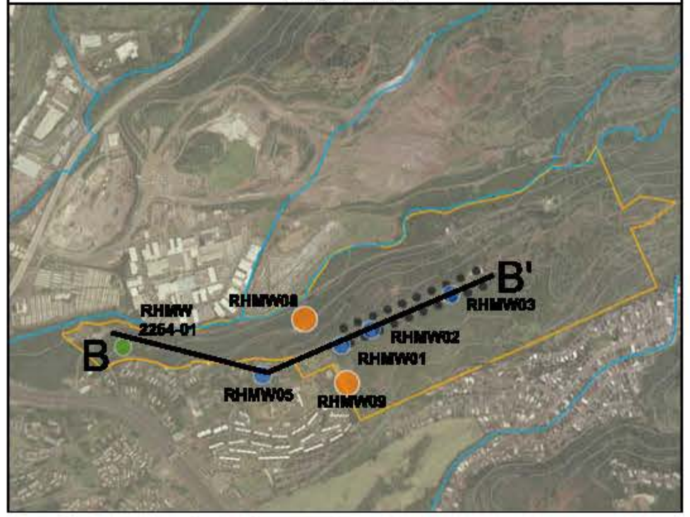
## Legend

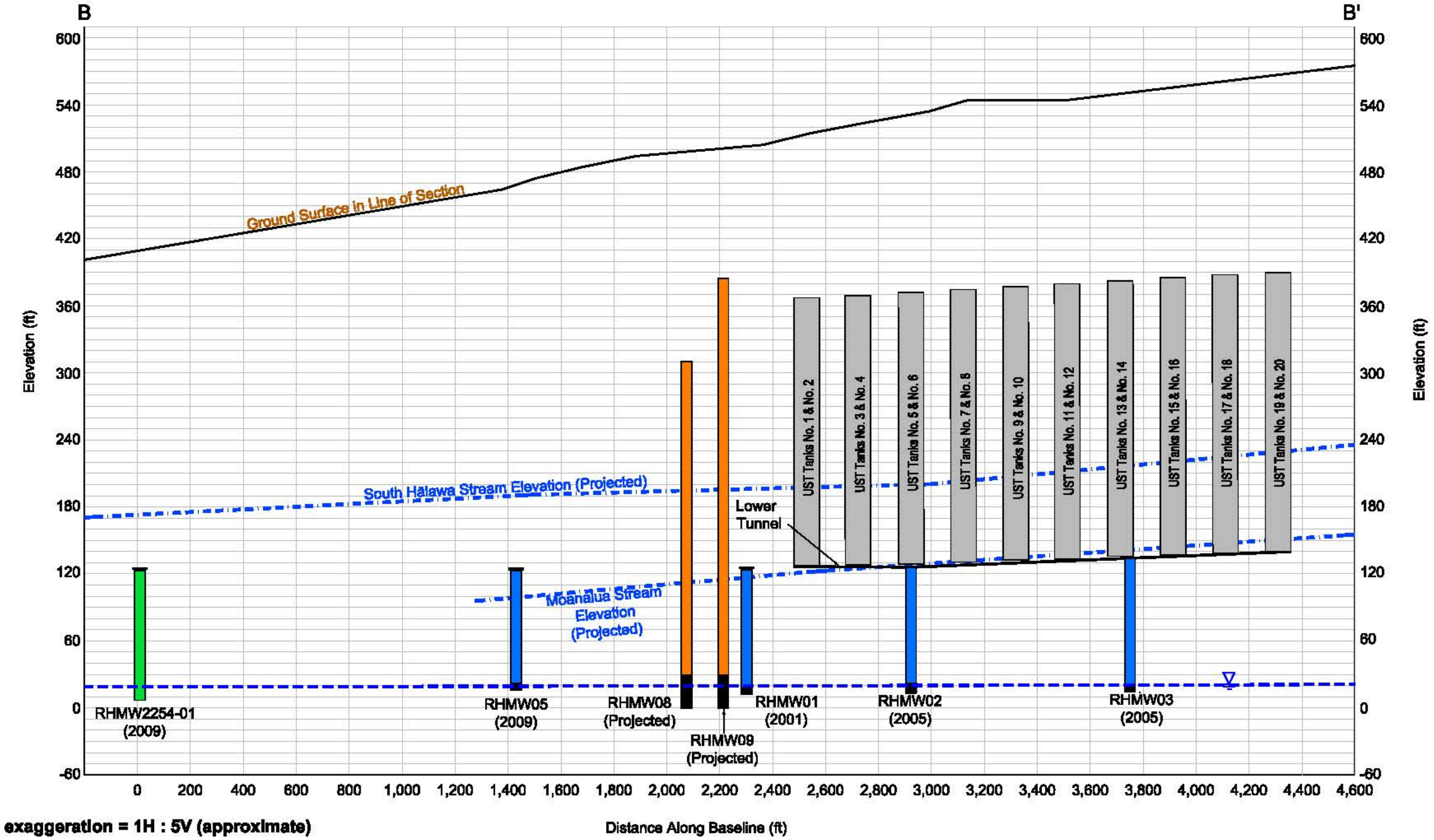
- 🟦 Groundwater surface (approximate)
- ▪ Stream elevation (projected)
- 🟧 Proposed monitoring well screened interval
- 🟦 Existing monitoring well screened interval
- 🟩 Existing Navy water supply well

## Notes

1. Existing well logs show a complex subsurface comprised of alternating pāhoehoe and a'ā lava flow with sporadic clinker zones, fractures, and voids.
2. Acronyms and Abbreviations:
   - ft feet
   - UST Underground Storage Tank
3. Tops of well casing elevations differ from ground surface in line of section due to projection.

## Key Plan





**Note: Vertical exaggeration = 1H : 5V (approximate)**

**Figure 7**
**Geological Cross Section (Longitudinal)**
**WP/SOW**
**Investigation and Remediation of Releases**
**and Groundwater Protection and Evaluation**
**Red Hill Bulk Fuel Storage Facility**
**JBPHH, O'ahu, Hawai'i**

#### *3.6.2.2 GROUNDWATER LEVELS AND HYDRAULIC GRADIENTS*

The permeability (i.e., the hydraulic conductivity) of Hawaiian volcanic rocks is highly variable depending on the type of emplacement (i.e., extrusive [lava flows], intrusive [dikes/sills], or explosive/airfall [pyroclastics]), the presence of interflow zones and voids, and the reduction in permeability by weathering.

- High permeability (often horizontal) commonly occurs in thin pāhoehoe flows (large number of interflow zones), rubbly aʻā flow base and tops (aʻā clinker zones), and highly fractured rocks.
- Low permeability (potential confining layers; often vertical) commonly occurs in dense massive aʻā flows (Figure 8), massive unweathered intrusive rocks (dikes/sills), ash beds, and weathered rocks (saprolite)/soil horizons. The principal (though relatively low) permeability in massive aʻā is along vertical cooling joints. Slight weathering and swelling can seal these joints, resulting in a layer of low vertical permeability.

These conditions result in highly complex and variable matrices with anisotropic conditions, highly variable permeability, and unpredictable and unresolvable flow patterns in the subsurface. Vertical permeability is often orders of magnitude lower than horizontal permeability. Horizontal permeability is also found to be significantly higher in the direction of the original lava flow.

Water levels measured in monitoring wells completed directly beneath the USTs indicate that the water table typically ranges in elevation from 17.0 to 21.9 ft msl. The ground surface at the USTs is approximately 420–560 ft msl, thus the water table lies approximately 400–540 ft bgs. Beneath the USTs, the water table lies approximately 100 ft below the bottom of the tanks. The bottoms of the tanks and the groundwater beneath the Facility are deeper than the adjacent valley floors (the low points of which are indicated by the elevations of the streams projected onto Red Hill as shown on Figure 7).

Groundwater levels near the Facility are strongly influenced by the rate of pumping at Navy Supply Well 2254-01. Groundwater levels measured in May 2006 were re-evaluated in 2010 (DON 2010a) to prepare revised water table potentiometric maps representing pumping and non-pumping conditions. When pumps at Navy Supply Well 2254-01 were operating at normal capacity (approximately 4 mgd), the hydraulic gradients indicated a component of groundwater flow to the west-northwest and another component to the southwest. East of the Facility, the gradient was approximately 0.00028 to the northwest. At the UST Facility, there was a localized gradient of approximately 0.00022 to the southwest. When the pumps in Well 2254-01 were pumping at the maximum sustainable rate for four days (approximately 10 mgd), this increased the drawdown substantially near the pumping well and created a hydraulic capture zone along the infiltration gallery that increased the southwesterly gradient in the area of the Facility.

Farther away to the northwest, the BWS Hālawa Shaft is a major drinking water source for south Oʻahu. Although the Hālawa Shaft is located northwest of the UST Facility, the results from a regional groundwater test in May 2006 did not indicate any hydraulic response in wells on the northern edge of Hālawa Valley during increased pumping of Navy Supply Well 2254-01. However, the other wells monitored near the Red Hill UST Facility did show a clear hydraulic response to pumping by Navy Supply Well 2254-01. Based on those results, it has been suggested that the valley fill sediments in North Hālawa Valley and/or South Hālawa Valley, which likely extend to depths below the water table, may act as a barrier to groundwater flow (DON 2010a).

### 3.6.2.3 HYDRAULIC CONDUCTIVITY

The groundwater flow properties of the principal aquifer in the area of the Facility depend mainly on the volcanic rock type, which has four major forms: lava flows, dikes, pyroclastic deposits, and saprolite. The lava flows are either pāhoehoe or aʻā. Massive, dense aʻā flow beds of low permeability alternate with thin rubbly clinker beds of high permeability that commonly provide preferential flow paths (see Section 3.7).

Dikes are thin, near-vertical sheets of massive, low-permeability rock that intruded existing rocks and cooled beneath the ground surface. Dikes are typically less than 10 ft wide, but can extend vertically and laterally for long distances. They impede the flow of groundwater due to their lower permeability. Within a dike complex, dikes intersect at various angles. Dikes tend to channel groundwater flow parallel to the general trend of the dikes. The number of dikes can exceed 1,000 per mile in the center of the rift zone, but it sharply decreases in the outer part. However, single, widely scattered dikes can extend farther from the designated dike complex (Takasaki and Mink 1985). Pyroclastic rocks include ash, cinder, spatter, welded tuff and larger blocks; they typically have significantly lower permeability and may affect localized groundwater flow directions. Saprolite is a soft, clay-rich, thoroughly weathered volcanic rock that may be from 100 ft to as much as 300 ft thick and has very low hydraulic conductivity (DON 2007).

Sedimentary deposits are also important in influencing groundwater flow in the basal aquifers in some areas, particularly coastal deposits and deep-cut alluvium-filled stream valleys (DON 2007). Following periods of extensive erosion, the larger valleys were deeply incised. Some of these valleys were filled in by marine and terrestrial sediments during periods when the relative sea level was substantially higher than today. The bottoms of the sediments in many stream valleys extend significantly below the water table. Since the fill sediments have lower overall permeability than the underlying lava flows, they act as barriers to groundwater flow (DON 2007, Appendix L). Hydraulic conductivity estimates of the alluvium range from 0.019 to 0.37 ft per day (ft/d) (Wentworth 1938). The U.S. Geological Survey (USGS) groundwater model (Oki 2005) used 0.058 ft/d for both horizontal and vertical hydraulic conductivity in the Pearl Harbor area. In most cases, the lower range of this estimate reflects the effective hydraulic conductivity, which contrasts with that of the surrounding flank lavas, making the valley-fill deposits a barrier to groundwater flow. Underlying the valley fills are layers of highly weathered basalt (saprolite), which are low-permeability units that impede groundwater flow. The hydraulic conductivity of saprolite is generally less than 1 ft/d and can be as low as 0.001 ft/d (Oki et al. 1999).

To the west of the Facility, substantial thicknesses of heterogeneous sediments occur on the coastal plains in southern Oʻahu around Pearl Harbor. These terrestrial and marine sediments and reef limestone deposits form a 1,000-ft-thick wedge, commonly referred to as caprock, and overlie the lava flows of the basaltic aquifer. Overall, the caprock has lower hydraulic conductivity than the basaltic rocks, and it overlies and confines the basal aquifer in the Pearl Harbor and Honolulu areas. The hydraulic conductivity of the caprock spans several orders of magnitude depending on material type (DON 2007). Hydraulic conductivity of the older alluvium, including fine-grained muds and saprolite, ranges from 0.01 to 1 ft/d. Sands have estimated hydraulic conductivities ranging from 1 to 1,000 ft/d. Coral gravels and reef limestone deposits can have hydraulic conductivities of several thousands of ft/d. Although the permeability of the components is diverse, the caprock represents a low-permeability formation and acts as a confining unit that “caps” the basal aquifer near the coastline, as evidenced by artesian groundwater and springs around Pearl Harbor.

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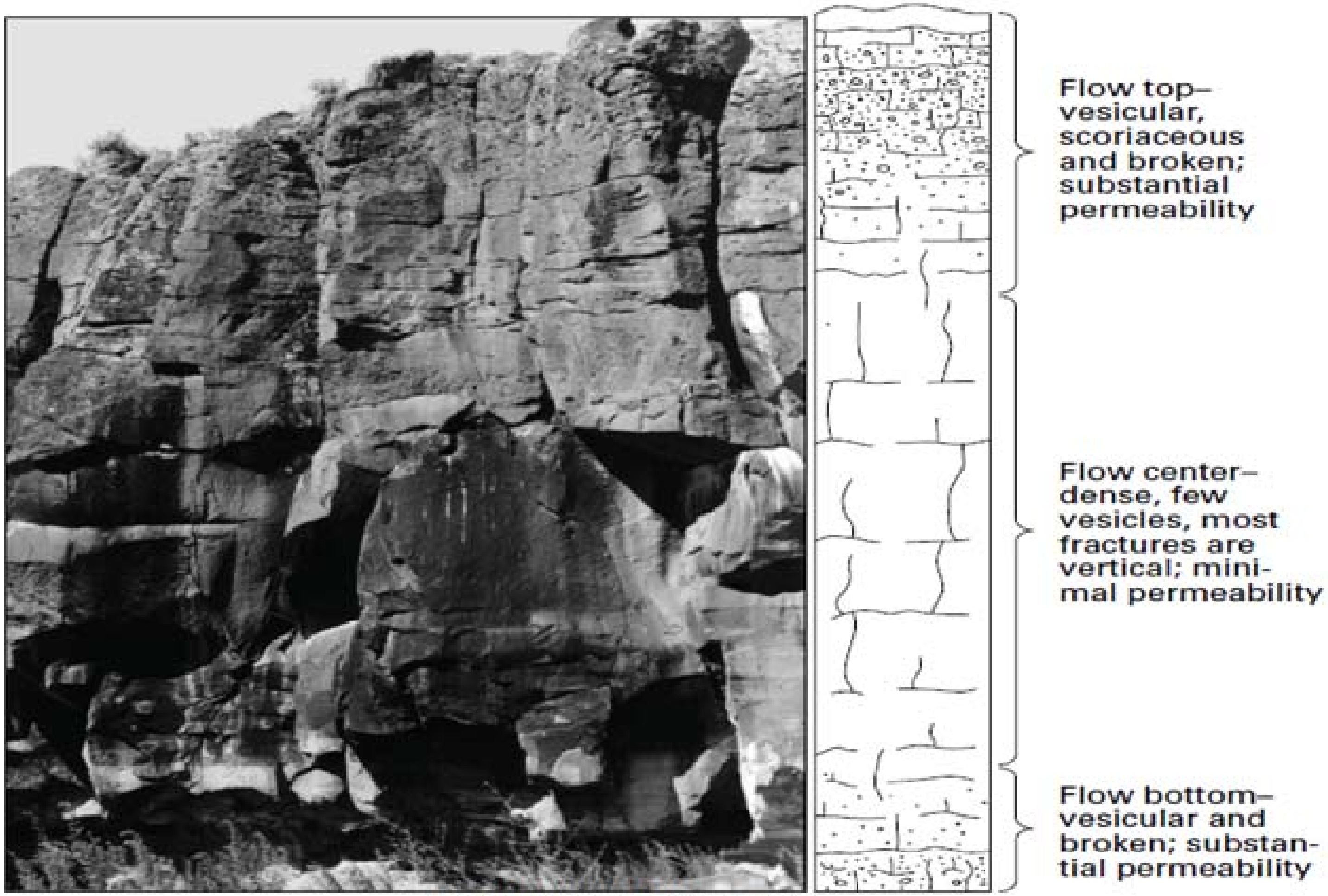

Modified from Whitehead, 1992

**Note:**
**Massive a‘ā flows display highly variable permeability. (Source: USGS 1999)**

**Figure 8**
**A‘ā Permeability**
**WP/SOW**
**Investigation and Remediation of Releases**
**and Groundwater Protection and Evaluation**
**Red Hill Bulk Fuel Storage Facility**
**JBPHH, O‘ahu, Hawai‘i**

The Navy developed a local 3-D numerical groundwater flow model for the Facility area. This local model utilized the DOH SDWB regional Source Water Assessment Program (SWAP) model and the USGS Modular Groundwater Flow Model (MODFLOW) 2000. The local model was set up and calibrated to be consistent with the hydrogeologic information available at that time (DON 2007). Hydraulic parameters of hydraulic conductivity and porosity for three main materials: basalt, valley fill, and caprock were applied, and the model was calibrated to dynamic flow conditions using the results of a regional pump test to estimate values for Specific Storativity and Specific Yield (similar to porosity) for the same materials. Table 2 presents the results of the hydraulic parameter calibration for the numerical model (DON 2007). The model will be updated to incorporate new hydrogeologic information, some of which will address identified data gaps, and applied to address the project objectives, as described in the Groundwater Flow and Contaminant Fate and Transport Modeling WP/SOW (Appendix H).

**Table 2: Hydraulic Parameters Developed from Model Calibration**

| Hydrogeologic Unit | Horizontal, Transversal K [ft/d] | Horizontal, Longitudinal K [ft/d] | Vertical K [ft/d] | Effective Porosity | Specific Storage [ft$^{-1}$] | Specific Yield |
|---|---|---|---|---|---|---|
| Caprock | 115 | 115 | 115 | 0.10 | 3.05 × 10-5 | 0.10 |
| Valley Fill | 0.066 | 0.066 | 0.066 | 0.15 | 1.52 × 10-5 | 0.12 |
| Basalt | 1476 | 4428 | 7.4 | 0.05 | 1.07 × 10-5 | 0.031 |

| | |
|---|---|
| K | hydraulic conductivity |
| ft$^{-1}$ | per foot |

## 3.7 GEOLOGICAL CONCEPTUAL SITE MODEL

The geological CSM provides a framework for assessing the geology and hydrogeology of RHSF and evaluating the feasibility of investigation methodologies and potential remedial alternatives. The proposed work includes updating and refining the CSM by evaluating potential site-specific vadose zone flow mechanisms and degradation of fuel products.

### 3.7.1 Vadose Zone Geology

Volcanic formations in Hawaiʻi can be divided into four groups, all of which may be present at Red Hill: (1) lava flows (extrusive), (2) dikes and sills (intrusive), (3) pyroclastic deposits (extrusive, e.g., volcanic tuff), and (4) weathered rock known as saprolite and associated weathered soil horizons. Each of these groups of rocks has markedly different physical and hydraulic properties. The interbedding of lava flows often result in highly heterogeneous formations that become even more complex with variations in lithology between individual flows, varied areal extent of flows, and the inclusion of dikes and weathered horizons (Figure 9).

#### *3.7.1.1 TYPES OF HAWAIIAN LAVA FLOWS*

There are mainly two types of lava flows, based on physical texture. Pāhoehoe lava flows are characterized as fluid, relatively low-viscosity flows. The cooled rock is vesicular and ropy, and has a smoothly undulating surface (Photo 1) (photos are at the end of this section). Numerous elongate voids can be present that form in the horizontal, longitudinal direction, thereby creating preferential pathways.

Pāhoehoe flows form as relatively rapid-flowing basaltic lavas that tend to spread out laterally and are typically thin. These flows contain voids of various sizes, and are often cracked and collapsed in places. Lava tubes are associated with pāhoehoe lava flows.

A‘ā lava flows are characterized by an interior or core of solid, dense, massive rock with exterior top and bottom coarse rubble or clinker zones (Photo 2). As the higher viscosity lava in the core travels downslope, the clinkers are carried along at the surface. At the leading edge of an a‘ā flow, however, these cooled fragments tumble down the steep front and are buried by the advancing flow. Clinker zones are similar to layers of coarse, well-sorted gravel, where layered sequences of flows can result in widespread beds with high horizontal permeability (Figure 8). The smaller effective porosity of massive a‘ā cores can result in extremely low vertical permeability, especially when the rock is not fractured (Photo 3 – Photo 9). The principal vertical permeability of a massive a‘ā core is imparted by wide regularly spaced cooling joints, which are typically low-permeability features.

The hydraulic conductivity of flank lavas is dependent on such features as thickness of the flows, thickness of clinker zone associated with a‘ā flows, frequency and extension of fractures, and occurrence of lava tubes associated with pāhoehoe flows. Horizontal hydraulic conductivity ranges from several hundred to several thousand ft/d in highly permeable dike-free flank lavas (DON 2007). Rotzoll et al. (2007) analyzed 238 aquifer tests of wells in Central Maui and found that hydraulic conductivity is log-normally distributed and ranges over several orders of magnitude, from 1 to 8,000 ft/d. The arithmetic mean, geometric mean, and median values of hydraulic conductivity for dike-free volcanic rocks were respectively 1,700, 900, and 1,200 ft/d (DON 2007). The USGS groundwater model (Oki 2005) used a value of 1,500 ft/d for horizontal hydraulic conductivity in the Pearl Harbor area. Horizontal hydraulic conductivity tends to be several times greater parallel to the original lava flow direction than perpendicular to the flows (Nichols et al. 1996). Souza and Voss (1987) estimated the ratio of vertical to horizontal hydraulic conductivity to be 0.05.

#### *3.7.1.2 DIKES*

Dikes are thin, typically near-vertical sheets of massive, intrusive rock that are often no more than several feet thick, but can extend vertically thousands of feet and laterally for several miles (Photo 10). Typically, only fractures contribute to porosity and permeability in dikes. Where dikes intrude lava flows, they inhibit groundwater flow principally in the direction perpendicular to the plane of the dike.

Areas with numerous dikes that intersect at various angles are known as dike complexes. Small compartments can form where dikes intersect, thereby lowering overall rock porosity and permeability (Takasaki and Mink 1985).

Marginal dike zones are areas where vertical dikes are subparallel and widely scattered. Such zones can impound water within large compartments of more permeable lavas and tend to channel groundwater flow parallel to the general trend of the dikes (Figure 10) (Hirashima 1962; Takasaki 1971).

Hydraulic conductivity is greater along the strike of the dike than perpendicular to the strike and the average conductivity decreases as the number of dikes increases toward the center of the rift zone. The overall hydraulic conductivity of an entire dike complex can be 0.01 ft/d or even lower (DON 2007).

#### *3.7.1.3 PYROCLASTIC DEPOSITS*

Pyroclastic (airfall) deposits are granular in nature and include ash, cinder, spatter, and larger blocks. Porosity and permeability are similar to that of granular sediments, with similar grain size and degree of sorting (Photo 11). Fine-grained ash is less permeable than coarser pyroclastic deposits, and its permeability may be reduced further by weathering or by compaction. Weathered ash beds can act as thin confining units within lava sequences.

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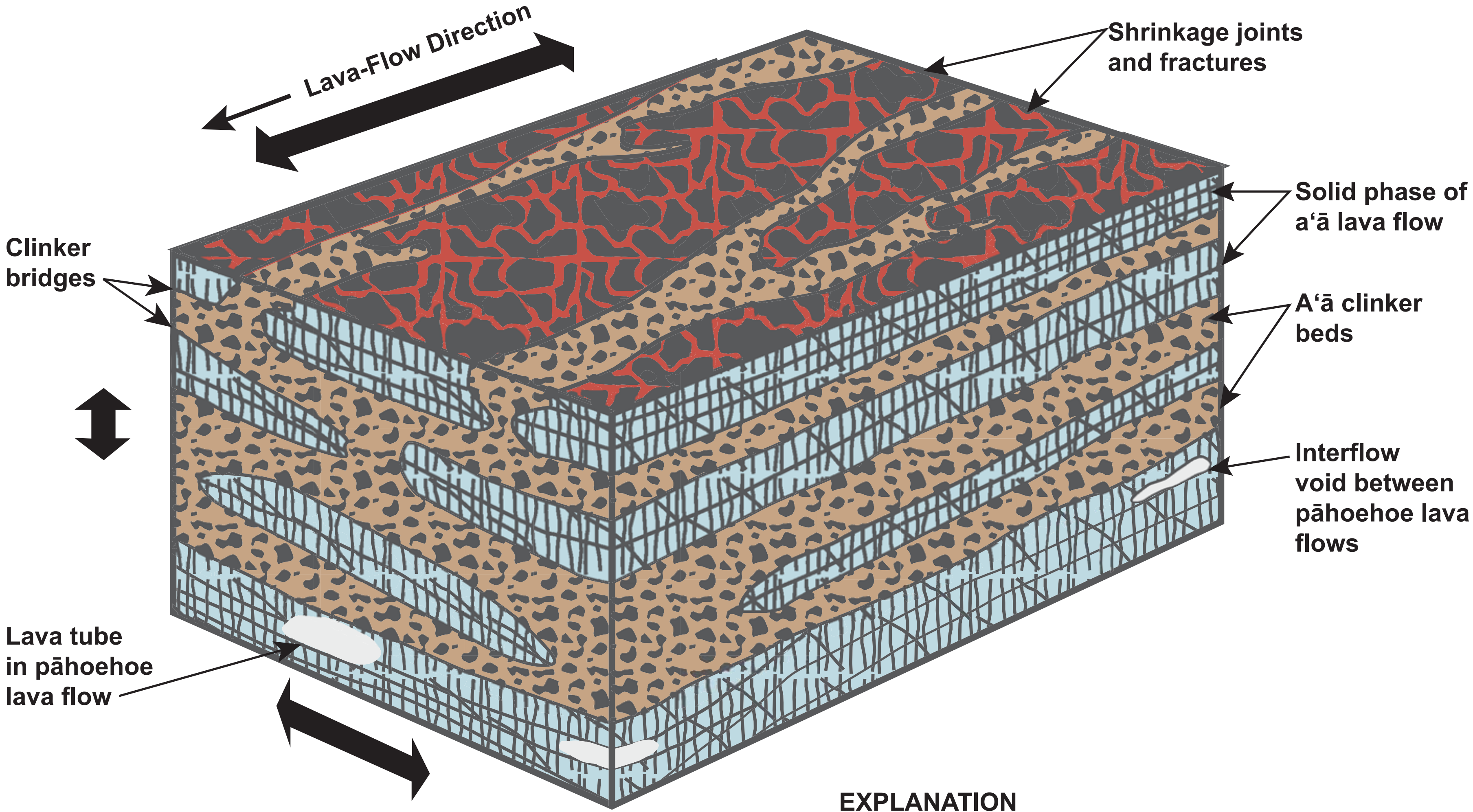

## EXPLANATION

⟺ Arrow Length Denotes Relative Magnitude of Permeability in Direction of Arrows

**Note:**
Successive interbedded pāhoehoe and massive a‘ā often create highly irregular formations with various fractures and voids, intermixed with widespread areas of high horizontal permeability.
(L.C. Schematic only; modified from Takasaki and Valenciano 1969.)

Figure 9
Interbedded Lava Flows
WP/SOW
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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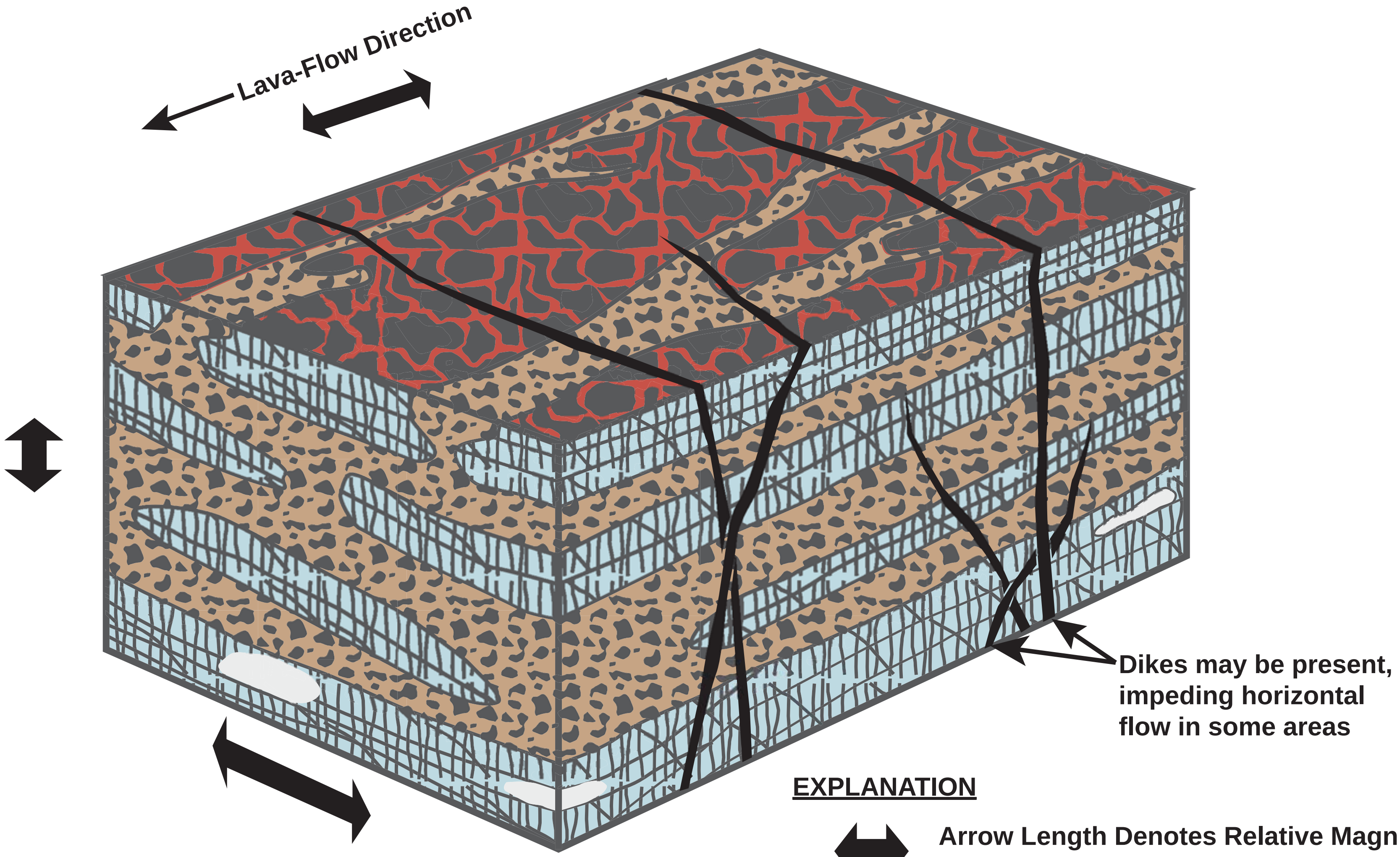

**EXPLANATION**

⟷ Arrow Length Denotes Relative Magnitude of Permeability in Direction of Arrows

**Note:**
Dike complexes can impound water within large compartments of more permeable lavas and tend to channel groundwater flow parallel to the general trend of the dikes. (L.C. Schematic only; modified from Takasaki and Valenciano 1969.)

Figure 10
Dike Complexes
WP/SOW
Investigation and Remediation of Releases
and Groundwater Protection and Evaluation
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, Hawai‘i

Weathering between flow events ("hiatuses") can form weathered soil horizons with lower permeability that can impede vertical flow of water and contaminants to deeper aquifers (Photo 12). Exposed weathering profiles on Oʻahu typically include inches to feet of soil underlain by several feet to several tens of feet of saprolite.

#### *3.7.1.4 SAPROLITE*

Saprolite is weathered rock material that retains textural features of the parent rock (Photo 13). Intense weathering of basaltic rocks can significantly reduce the permeability of the parent rock by transforming igneous minerals to clays and oxides (Hunt 1996). In Hawaiʻi, saprolite zones are typically around 75 ft thick but can be 300 ft thick or greater beneath the valley floors or in areas of high precipitation. Water percolating beneath stream channels in valleys often significantly increases the depth of weathering. Rocks with a high proportion of pore space and surface area, such as ash, cinder, and aʻā clinker, are weathered quickly, while the weathering of dense massive rock proceeds more slowly.

### 3.7.2 Porosity in Volcanic Rocks

The diverse rock textures encompassed by the two types of lava impart a complex porosity distribution to the lavas (Hunt 1996). In a layered sequence of lava flows, several types of primary porosity are present: (a) vesicular – small isolated gas vesicles that form in molten lava (Photo 5–Photo 9); (b) fracture – joints, cracks, and bedding-plane separations (Photo 14); (c) intergranular – fragmental rock, including cinders, rubble, and clinkers (Photo 15A and 13B); and (d) conduits – large openings such as lava tubes and interflow voids (Photo 16).

Vesicles are poorly connected and contribute little to effective porosity. Estimates of the total porosity of various volcanic rocks on Oʻahu range from 5 to 51 percent, with a median value of approximately 43 percent; values of effective porosity may be lower by as much as a factor of 10 (Hunt 1996). Fracture and intergranular porosity can form a pervasive network of small openings that facilitates diffuse groundwater flow. Conduits, such as lava tubes, provide avenues for highly channelized flow (Photo 16).

### 3.7.3 Permeability in Volcanic Rocks

As noted in Section 3.6.2.2, the permeability of Hawaiian volcanic rocks is highly variable depending on the type of emplacement, the presence of interflow zones and voids, and the reduction in permeability by weathering. High permeability commonly occurs in thin pāhoehoe flows (large number of interflow zones), rubbly aʻā flow base and tops (i.e., aʻā clinker zones), and highly fractured rocks.

Low permeability commonly occurs in massive aʻā flows (Figure 8), massive unweathered intrusive rocks (dikes/sills), ash beds, and weathered rocks (saprolite)/soil horizons, which can create potential confining layers that impede vertical flow (see Section 3.6.2.3). Slight weathering and swelling can seal these joints, resulting in a layer of low vertical permeability.

These conditions result in highly complex and variable rock types and fabrics that frequently result in highly variable and anisotropic permeability and unpredictable and unresolvable flow patterns in the subsurface. Vertical permeability is often orders of magnitude lower than horizontal permeability. Horizontal permeability is also found to be significantly higher in the original lava flow direction.

### 3.7.4 Red Hill Vadose Zone

The Red Hill vadose zone is composed a highly heterogeneous and anisotropic formation of interbedded lava flows (see Appendix B). Different types of lava appear to have flowed in different directions at different times, and may have been weathered between flow events, potentially forming weathered horizons and soils. These processes result in the presence of sizable voids and relatively impermeable regions or zones in unpredictable locations and in no repeatable order. As suggested in the preceding sections, volcanic rocks such as those composing the Red Hill vadose zone have a wide range of physical and hydraulic properties. Furthermore, interbedded lava flows become even more complex with variations in lithology between individual flows, varied areal extent of flows, and the inclusion of dikes and weathered horizons. The presence of massive dense a‘ā flows, along with the formation of lava tubes, dikes, sills, weathering, and other factors have likely formed horizontally oriented voids that are not interconnected, resulting in a relatively impermeable condition in the vertical direction.

The heterogeneity and unpredictable properties of the Red Hill vadose zone are evidenced by the water levels measured in the recently installed RHMW07, which has consistently exhibited a groundwater surface elevation approximately 4 ft higher than all of the other wells in the vicinity of Red Hill. These data suggests that groundwater in RHMW07 is not in hydraulic communication with the other Red Hill wells (this will be verified during the proposed synaptic water level measurement study). The data are consistent with the presence of a dike complex that has impeded flow and altered the localized groundwater flow regime. Similar essentially randomly placed features may have also inhibited the flow of LNAPL toward the groundwater, and explain why NAPL has not been detected in measurable quantities in any of the groundwater monitoring or supply wells.

In the neighboring valleys, alluvium is present near the ground surface. Below the alluvium, intense weathering of basaltic rocks reduces the permeability of the parent rock by altering igneous minerals to clays and oxides (saprolite). In Hawai‘i, saprolite zones are typically around 75 ft thick but can be 300 ft thick or greater beneath the valley floors or in areas of high precipitation. Water percolating beneath stream channels in valleys such as Hālawa and Moanalua often significantly increases the depth of weathering. Rocks with a high proportion of pore space and surface area are weathered preferentially; the weathering of massive dense rock (i.e., a‘ā flow cores) proceeds more slowly. These valley fills and underlying saprolitic formations may hinder groundwater flow and contaminant transport north and south of Red Hill.

Although the proposed scope of work includes further evaluating the subsurface geology of the site before drawing any final recommendations (see Section 4.1, Task 1), these site-specific geologic conditions may explain the lack of NAPL observed in the groundwater and suggest the following preliminary, tentative conclusions:

- It is advisable to limit drilling near the tank farm, to avoid penetrating the naturally existing confining layers and creating preferential pathways that could transport NAPL to the groundwater (see Section 4.7 and Appendix F).
- Locating isolated pockets of NAPL via drilling may not be feasible given the highly variable permeability and unpredictable and unresolvable flow patterns in the subsurface.
- Active remediation or removal of NAPL in the vadose zone may prove difficult because the NAPL would first have to be located, the NAPL is expected to be very deep below the surface, access might be limited by the presence of the USTs, and remedial efforts could

result in penetrating the naturally existing confining layers and creating preferential pathways that could transport NAPL to the groundwater (see Section 4.7 and Appendix F).

- The formation (particularly any high-permeability zones where NAPL would be most likely to accumulate) is likely oxygen-rich, promoting natural attenuation of petroleum products and reducing contaminant levels. The recorded dissolved oxygen concentrations in the background well (RHMW04) during the 2015 quarterly monitoring events were between 6 and 9 mg/L, indicating a relatively oxygen-rich environment (DON 2016).
- Due to the highly variable anisotropic and heterogeneous nature of the vadose zone, numerical flow modeling of NAPL in the vadose zone would not be expected to produce meaningful, reliable, or reproducible results. The models developed for porous media or for fractured (mainland) bedrock would not be expected to reflect Hawaiian geology with any reasonable degree of accuracy.

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**Photo 1:** Pāhoehoe flows are characterized by a smoothly undulating surface. Photograph by J. Kauahikaua, USGS, September 10, 2000. Source: http://hvo.wr.usgs.gov/archive/spotlight_images/20000910-0840_JPK.html

**Photo 2:** A'ā flows are characterized by solid massive cores with top and bottom clinker zones. Source: http://hvo.wr.usgs.gov/multimedia/archive/2000/Feb/

**Photo 3:** Thick massive a‘ā flows exposed in outcrop on steep hillside; note widely spaced cooling joints and absence of open fractures in cores of flows. Photograph by Jack Kronen, AECOM, June 2005.

**Photo 4:** Thick massive a‘ā flows in outcrop; note absence of open fractures in a‘ā cores and interbeds of a‘ā clinker and thinner pāhoehoe flows. Photograph by Jack Kronen, AECOM, June 2005.

**Photo 5:** Closeup of massive aʻā core in outcrop; note stretched vesicles and absence of open fractures. Photograph by Jack Kronen, AECOM, January 2016.

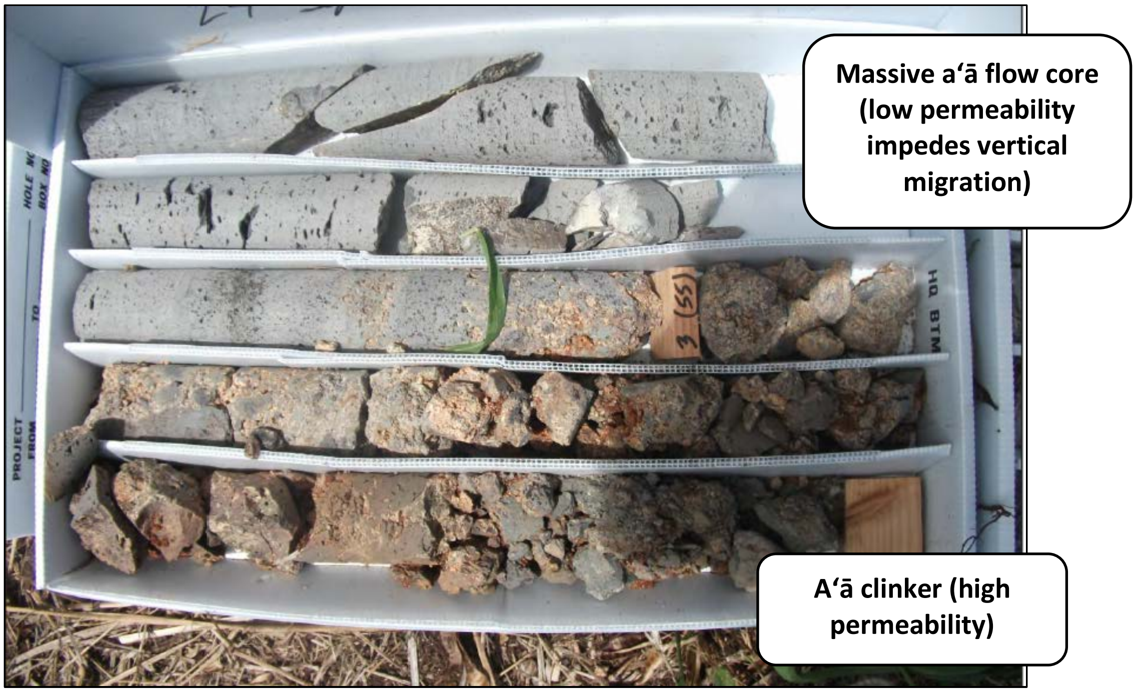

**Photo 6:** Boring at RHMW07 (surface elevation = 216.53 ft msl); core interval 40–50 ft bgs (166.5–176.5 ft msl). Source: DON (2015b).

**Photo 7:** Boring at RHMW07 (surface elevation = 216.53 ft msl); core interval 60–70 ft bgs (146.5–156.5 ft msl). Source: DON (2015b).

**Photo 8:** Boring at RHMW07 (surface elevation = 216.53 ft msl); core interval 160–170 ft bgs (46.5–56.5 ft msl). Source: DON (2015b).

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**Photo 9:** Boring at RHMW07 (surface elevation = 216.53 ft msl); core interval 210–220 ft bgs (-3.5–6.5 ft msl). Source: DON (2015b).

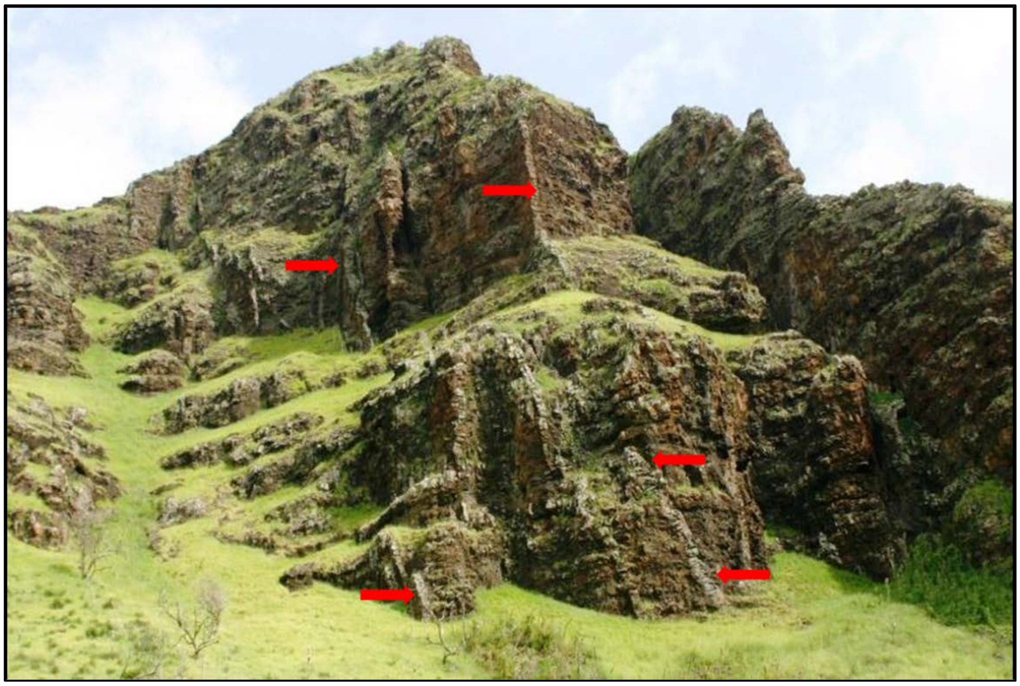

**Photo 10:** Dikes are thin, near-vertical sheets of massive, intrusive rock that are often no more than several feet thick, but can extend thousands of feet vertically and several miles laterally. Photograph by Scot Izuka. Source: http://hi.water.usgs.gov/studies/GWRP/hydrogeology.html

**Photo 11:** Pyroclastic (airfall) granular deposits include ash, cinder, spatter, and larger blocks; porosity and permeability are similar to that of granular sediments with similar grain size and degree of sorting. Permeability of ash may be reduced further by weathering or by compaction to tuff; weathered ash beds can act as thin confining units within lava sequences. Photograph by Jack Kronen, March 2015.

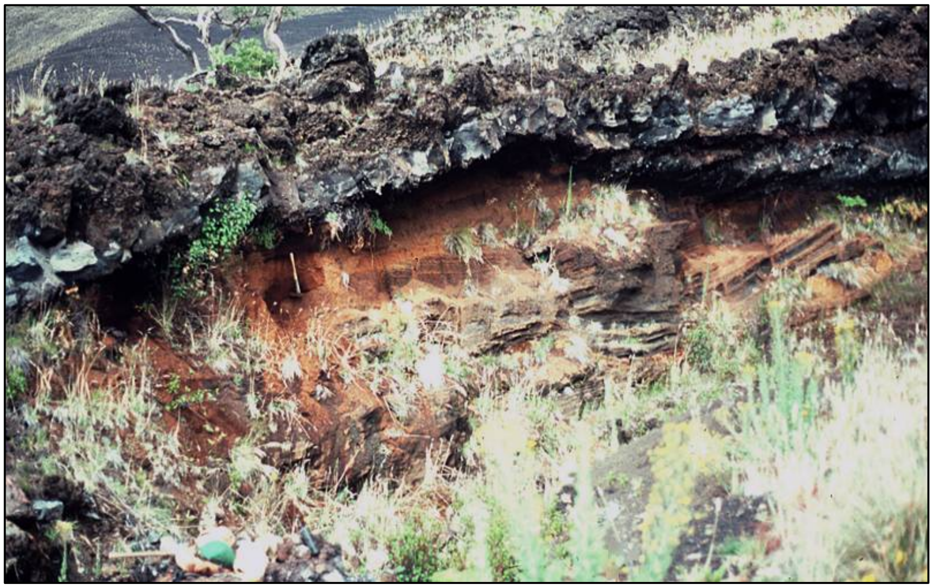

**Photo 12:** Weathering between flow events ("hiatuses") can form weathered soil horizons with lower permeability. Photograph by D. Sherrod. Source: http://hvo.wr.usgs.gov/volcanoes/haleakala/newmapping.html

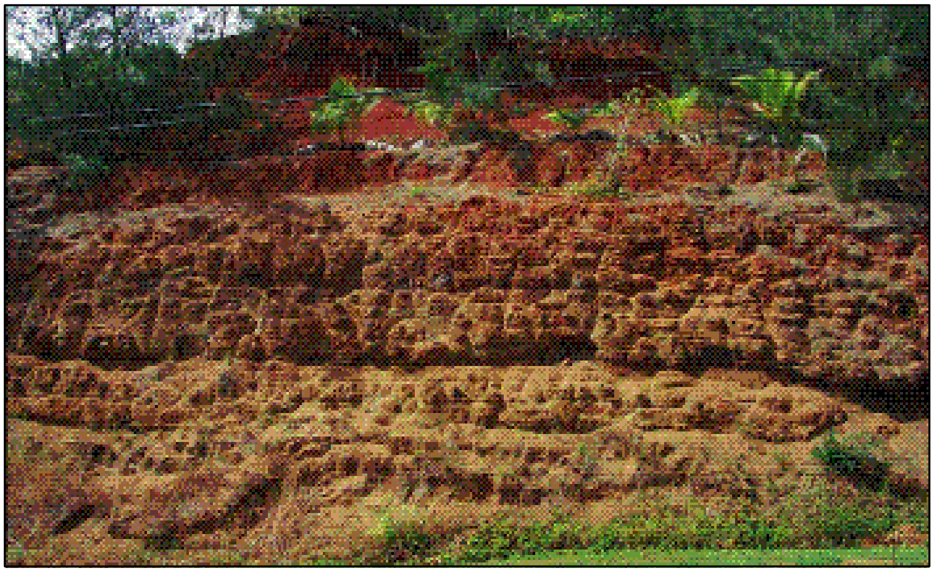

**Photo 13:** Saprolite is weathered material that retains textural features of parent rock. Zones of saprolite can be 300 feet thick. Percolating water beneath stream channels in valleys often significantly increases the depth of weathering. Photograph by S. B. Gingerich, USGS. Source: http://pubs.usgs.gov/ha/ha730/ch_n/gif/N052.gif

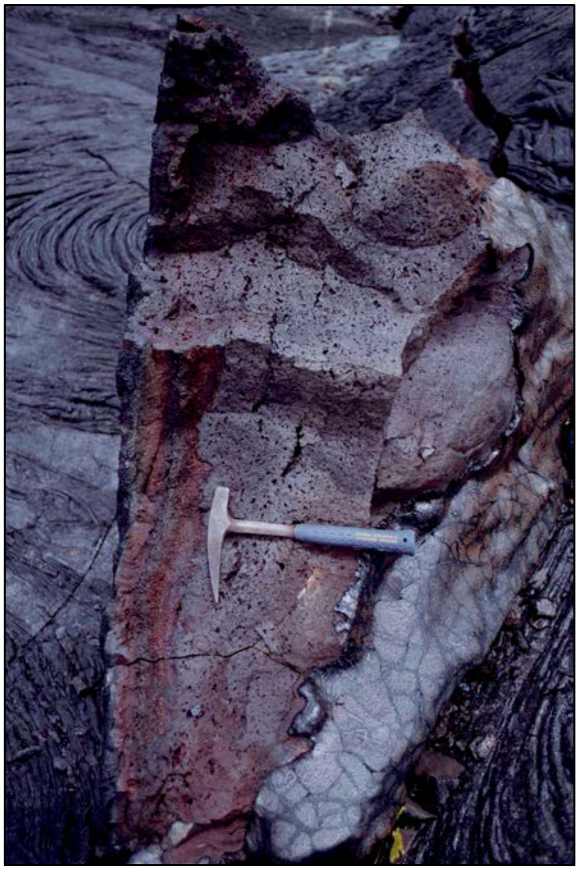

**Photo 14:** Porosity in volcanic rocks: Fracture joints, cracks, and bedding plane separations can form during emplacement or from weathering. Source: http://gallery.usgs.gov

**Photo 15A:** Porosity in volcanic rocks: Scoria/Cinder is composed of highly vesicular lava fragments that are explosively ejected from a vent. Source: http://gallery.usgs.gov

**Photo 15B:** Porosity in volcanic rocks: Rubble and clinkers in an aʻā flow have high porosity and permeability. Source: http://hvo.wr.usgs.gov/multimedia/archive/2001/Apr/20010423-994_DAS_large.jpg

**Photo 16:** Conduits/large opening in volcanic rocks: Lava tubes are naturally formed tunnels in lava flows created by the crusting of lava over the main lava channel and followed by drainage of lava. Lava tubes follow the direction of flow. Interflow (typically horizontal) voids are formed by cooling and expanding lava during emplacement. Photograph by C. Heliker, June 20, 1989. Source: http://hvo.wr.usgs.gov/gallery/kilauea/erupt/2553008_L.jpg

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# 4. Scope of Work

Scoping Meetings between the Parties, their consultants, and the DLNR Commission on Water Resource Management were held to discuss the activities and analyses recommended to achieve the objectives of the AOC Statement of Work Sections 6 and Section 7. The parties agreed that the following seven tasks would constitute the required scope of work:

- *Task 1:* Evaluate subsurface geology
- *Task 2:* Investigate LNAPL
- *Task 3:* Identify COPCs
- *Task 4:* Expand the monitoring network
- *Task 5:* Update the existing groundwater model
- *Task 6:* Update CF&T model and evaluate whether to perform a tracer study
- *Task 7:* Evaluate remedial alternatives

Scoping Meetings for AOC Statement of Work Section 6 and Section 7 were conducted in person in October 2015 and from November 30, 2015 through December 4, 2015, and continued thereafter via email and phone conference. Scoping was completed on February 4, 2016 and resulted in a list of 27 agreed-upon items and 8 action items. The lists of agreed-upon and action items are presented in Appendix A.1. The scoping completion letter issued by the Regulatory Agencies is presented in Appendix A.2, and the Navy’s acknowledgement and response letter is presented in Appendix A.3. The 27 agreed-upon items outline the major preliminary agreements reached by the Parties, which comprise the scope of work required to address AOC Statement of Work Section 6 and Section 7. The February 4, 2016 scoping completion letter affirms the 27 agreed-upon items, and presents Regulatory Agency agreements and recommendations for the groundwater modeling, a list and schedule of deliverables, the revised long-term monitoring (LTM) and AOC analyte list, screening criteria, and additional analyses requested for the investigation. The March 30 Navy response letter provides the Navy’s concurrence on the analyte list and screening criteria, and requests clarifications to and recommends minor modifications to the additional requirements presented in the February 4, 2016 letter, including a modification to the proposed silica gel cleanup analysis (further discussed in Section 4.3).

The eight action items are recommended to inform decisions and activities to address AOC Statement of Work Section 6 and Section 7. Action items 1, 3, 6, 7, and 8 were resolved during the December 10, 2015 teleconference between scoping parties, in the scoping completion letter, and during the records review conducted prior to preparation of this WP/SOW. The remaining action items are related to the groundwater and CF&T models, and will be resolved during the course of the modeling activities.

This WP/SOW details the activities that have been and will be performed to complete the seven tasks identified for AOC Statement of Work Sections 6 and 7 in accordance with the Scoping Meeting agreements. The seven tasks are described in the following sections.

## 4.1 TASK 1: EVALUATE SUBSURFACE GEOLOGY

NAPL was released to the complex geological formations that occur within the vadose zone below the RHSF tanks. However, NAPL has not been observed in measureable quantities in any of the monitoring or supply wells. A better understanding of site geology will contribute to the development of a detailed and site-specific CSM to help identify NAPL fate and transport mechanisms and focus subsequent sampling and analyses.

Previous investigations determined that the principal aquifer beneath RHSF is composed of interbedded zones of high and low horizontal permeability; that low-permeability zones of unfractured basalt and dikes form barriers to groundwater flow; and that fine-grained valley fill sediments form low-permeability flow barriers north and south of Red Hill. Saprolite beneath the valley fill also forms an additional low-permeability flow barrier, which may further impede groundwater flow and contaminant transport north and south of Red Hill.

The following activities will be conducted to provide the data required to refine the geologic CSM for the RHSF area:

- Perform a document and literature search; and review existing and newly acquired geologic literature, maps, photographs, aerial imagery, drilling and boring logs, and rock cores.
- Conduct a field survey to map visible outcrops and evidence of other geologic features such as dikes and large fractures. This may allow for structural mapping to identify the locations of major rock types and features. To the extent possible, measure and plot the dip and strike of bedding, fractures, dikes, faults and potential preferential flow pathways. Measure thicknesses of individual flow units at available rock outcrops. Estimate the trend and plunge of any visible linear features. All mapped features will be surveyed using Global Positioning System (GPS) survey techniques to determine horizontal and vertical coordinates.
- Construct geologic cross sections integrating boring log, rock core, and field data, providing as much detail as possible. Correlate geologic units and bedding across the site, if possible. Integrate available geophysical data into the cross sections.
- Construct subsurface geologic maps of geologic horizons, if appropriate. Integrate available geophysical data into mapping.

Based on the site-specific geological CSM (in accordance with Agreed-Upon Item 3; Appendix A.1):

- Evaluate whether modeling of potential vertical flow to the groundwater aquifer is likely to be accurate, reproducible, or reliable.
- Evaluate whether additional sampling to locate NAPL is likely to be productive and meaningful; if so, suggest feasible locations.

## 4.2 TASK 2: INVESTIGATE LIGHT NON-AQUEOUS-PHASE LIQUID (LNAPL)

As stated in Agreed-Upon Items 2, 7, and 8 (Appendix A.1), the complex geology limits the feasibility of NAPL investigation techniques that could be implemented at the site. Various methods and technologies currently being used in the environmental industry to assess the nature and extent of subsurface NAPL were evaluated for potential feasibility and success if implemented at RHSF for this investigation. The evaluation is presented in Appendix E. While it is not clear that any of the available methodologies would be successful, of 13 technologies evaluated, an electrical resistivity (ER) survey was recommended as the most likely candidate, and retained for further evaluation. Other technologies were not recommended for further evaluation due to the complex nature of the Red Hill subsurface geology, site constraints, and the various technologies' low likelihood of producing actionable data. The proposed ER pilot survey is described in Section 6.2.4.

## 4.3 TASK 3: IDENTIFY CHEMICALS OF POTENTIAL CONCERN

Multiple types of fuel have been stored at RHSF. Each tank has contained at least one of the following fuels: diesel oil (DO), NSFO, Navy Distillate, F-76, AVGAS, MOGAS, JP-5, and JP-8 (DON 2002). Since the early 2000s, the Facility has stored only JP-5, JP-8, and F-76. The Facility has not stored leaded fuels since 1968. Tank 5 contained JP-8, a kerosene-based fuel, when the January 2014 release occurred. The VOC content of the JP-8 released from Tank 5 cannot be accurately determined because there is no standard formula for kerosene, and the levels of benzene and other VOCs in kerosene-based products vary depending on the crude oil source (ATSDR 2016). However, the Occupational Safety and Health Administration’s (OSHA’s) kerosene chemical profile (OSHA 2004) shows that benzene is a very small component of kerosene, which is consistent with the historical groundwater VOC results.

Prior to receipt of the February 4, 2016 regulatory letter (Appendix A.2), the existing LTM program included the analytes listed in Table 9-5 of the DOH-HEER TGM for gasolines and middle distillates (i.e., TPH-g, TPH-d, TPH-o, BTEX, 1-methylnaphthalene, 2-methylnaphthalene, and naphthalene) (DOH 2009), plus additional VOCs, additional PAHs, and lead scavengers. These additional VOCs and PAHs were not related to the fuels currently stored in the tanks, but may have been included in the LTM COPC list because they are part of the analyte list often reported by laboratories for the VOC and PAH analytical methods. Detailed lists of all analytes and summary statistics for each monitoring well are presented in Appendix D.

Following the November–December 2015 Scoping Meeting agreed-upon items (specifically Agreed-Upon Items 9, 10 and 27 in Appendix A.1) and the February 4, 2016 regulatory agencies’ letter on Scoping Meeting completion (Appendix A.2) The provided the revised list of COPCs and screening criteria for the AOC Statement of Work Sections 6 and 7 investigation was agreed upon by the Parties. Table 3 lists the COPCs selected as analytes for specific groundwater monitoring wells and the frequency of analysis. The primary petroleum-based COPCs (listed in the first row of Table 3) were chosen in accordance with the DOH-HEER TGM (DOH 2009), based on their potential presence in fuel stored on site and on past groundwater monitoring results. Table 4 lists the screening criteria for the investigation.

**Table 3: COPC List for AOC Statement of Work Sections 6 and 7 Investigation**

| COPC | Sampling Location | Frequency |
|---|---|---|
| TPH-g, TPH-d, TPH-o, BTEX, 1-methylnaphthalene, 2-methylnaphthalene, naphthalene, and natural attenuation parameters (NAPs) (dissolved oxygen, ferrous iron, sulfate, nitrate, chloride) | RHMW01, RHMW02, RHMW03, RHMW04, RHMW05, RHMW06, RHMW07, RHMW08, RHMW09, RHMW10, RHMW11, RHMW2254-01, HDMW2253-03, and OWDFMW01 | Every investigation groundwater sampling event |
| TPH-d and TPH-o with silica gel cleanup | RHMW01, RHMW02, RHMW03, and RHMW05 | One wet-season and one dry-season investigation sampling event |
| Lead scavengers (1,2-dichloroethane and 1,2-dibromoethane) | RHMW08, RHMW09, RHMW10, and RHMW11 | One year of investigation groundwater sampling; may be dropped from COPC list if results are non-detect. |

**Table 4: Screening Criteria for AOC Statement of Work Sections 6 and 7 Investigation**

| COPC [a] | Screening Criterion (µg/L) |
|---|---|
| TPH-g | 100 |
| TPH-d | 100 |
| TPH-o | 100 |
| Benzene | 5.0 |
| Ethylbenzene | 30 |
| Toluene | 40 |
| Xylenes, total | 20 |
| 1-Methylnaphthalene | 4.7 |
| 2-Methylnaphthalene | 10 |
| Naphthalene | 17 |
| 1,2-Dibromoethane [b] | 0.04 |
| 1,2-Dichloroethane [b] | 0.15 |

Note: COPC screening criteria were provided in the February 4, 2016 scoping completion letter (Appendix A.2).

[a] Screening criterion is not applicable to NAPs.

[b] 1,2-Dibromoethane and 1,2-Dichloroethane (lead scavengers) will be analyzed only in RHMW08, RHMW09, RHMW10, and RHMW11. Lead scavenger analysis can be dropped after 1 year of sampling if results are non-detect.

Samples to be analyzed for TPH-d and TPH-o will also undergo separate silica-gel-cleaned TPH-d and TPH-o analysis for the first two (wet- and dry-season) monitoring events to provide additional information on the degree of weathering of the dissolved-phase fuel found in the groundwater, in accordance with the February 4, 2016 letter (Appendix A.2). Silica gel cleanup can be used to separate hydrocarbons associated with biological sources and by-products of fuel weathering (usually polar) from hydrocarbons associated with fresh petroleum (usually nonpolar). Polar compounds will preferentially adsorb to silica, while non-polar compounds will not. DOH-HEER TGM Section 9.3.1.2, Total Petroleum Hydrocarbons, discusses the use of silica gel cleanup to separate out the polar TPH fraction and the remaining non-polar TPH fraction: “*Comparison of data for groundwater samples tested with and without silica gel cleanup could be useful for assessing the state of natural biodegradation within a plume of petroleum-contaminated groundwater and optimizing remedial and monitoring actions*” (DOH 2009). The silica-gel-cleaned TPH data together with the non-silica-gel-cleaned TPH data can be used to further refine the CSM by helping to identify where biodegradation is likely occurring within the monitoring well network. The silica-gel-cleaned TPH data, taken in conjunction with an analysis of the chromatographs and natural attenuation parameter (NAP) data, can provide compelling evidence that biodegradation is occurring, particularly in regions where the groundwater is not expected to have other TPH constituents that could bind with the silica gel. There is, however, a potential for the silica-gel-cleaned TPH results to be inconsistent with the NAPs. In this case, the silica-gel-cleaned TPH data would support the assumption that biodegradation is occurring, because the silica-gel-cleaned TPH results are direct measurements of non-polar petroleum hydrocarbons (assumed to be petroleum degradation by-products), and that NAPs can be used in conjunction with the petroleum hydrocarbon data to estimate the extent and rate at which biodegradation and other natural attenuation processes are occurring.

Silica gel cleanup is recommended for samples from RHMW01, RHMW02, and RHMW03 because TPH has historically been detected in the groundwater samples from these wells; silica gel cleanup is also recommended for groundwater samples from RHMW05, as this is the downgradient groundwater monitoring well, and it is not expected to have other groundwater chemistry attributes that could interfere with interpretation of silica-gel-cleanup results. Evaluation of the non-polar TPH data reported for these wells may show a pattern of weathering, e.g., weathering may be more prominent in the downgradient wells compared to RHMW02 (well closest to Tank 5).

The February 4, 2016 letter also suggested silica gel cleanup for samples from monitoring well OWDFMW01. Table 4 lists the screening criteria for the investigation. However, silica gel cleanup is not recommended for samples from well OWDFMW01, because it is located at the OWDF, where additional chemical compounds that could interfere with the data analysis may be present in the subsurface. OWDFMW01 is also located downgradient of the previously reported hydrological capture zone (radius of influence) of Navy Supply Well 2254-01, and OWDFMW01 is therefore expected to be impacted by the USTs. This conclusion is supported by the geochemical and COPC data reported for groundwater samples from OWDFMW01, which are significantly different from the data reported from all of the other sampling locations in the LTM well network (as shown by the TPH chromatography results presented in the groundwater monitoring laboratory reports), indicating that groundwater conditions at the OWDF are not the result of petroleum product released from the RHSF tanks. Analysis of groundwater samples from RHMW05 for petroleum hydrocarbons with and without silica gel cleanup, the chromatographs, and NAPs may provide more actionable data (as compared to samples from OWDFMW01) that can be used to characterize the extent and rate of natural attenuation downgradient of the USTs and upgradient of the nearest supply well.

## 4.4 TASK 4: EXPAND THE MONITORING WELL NETWORK

In response to the January 2014 release, the Navy has already installed two new monitoring wells (RHMW06 and RHMW07). As agreed upon during the December Scoping Meetings, four new strategically placed wells will be installed to further expand the monitoring well network. In order to expedite the installation of four new proposed monitoring wells (RHMW08, RHMW09, RHMW10, and RHMW11), a separate RHSF Monitoring Well Installation WP (DON 2016) has been prepared to detail the methods and procedures proposed for installation of four more new monitoring wells to further expand the RHSF monitoring well network (in accordance with Agreed-Upon Items 14 and 15; Appendix A.1). These proposed wells will be installed prior to the refinement of the groundwater model (Tasks 5 and 6 below), and will be an integral part of the investigation proposed in this WP/SOW. The continued use and determination of the six new wells’ adequacy as sentinel wells will be evaluated after completion of the activities proposed herein, and, if warranted, further expansion of the monitoring well network will be discussed with the regulatory agencies. Additional monitoring wells may be installed if necessary to fill data gaps and ensure that the RHSF monitoring well network is adequate to provide early warning of potential impact to the drinking water resource.

The current monitoring well network and the rationale for the locations of the four proposed new monitoring wells are listed below.

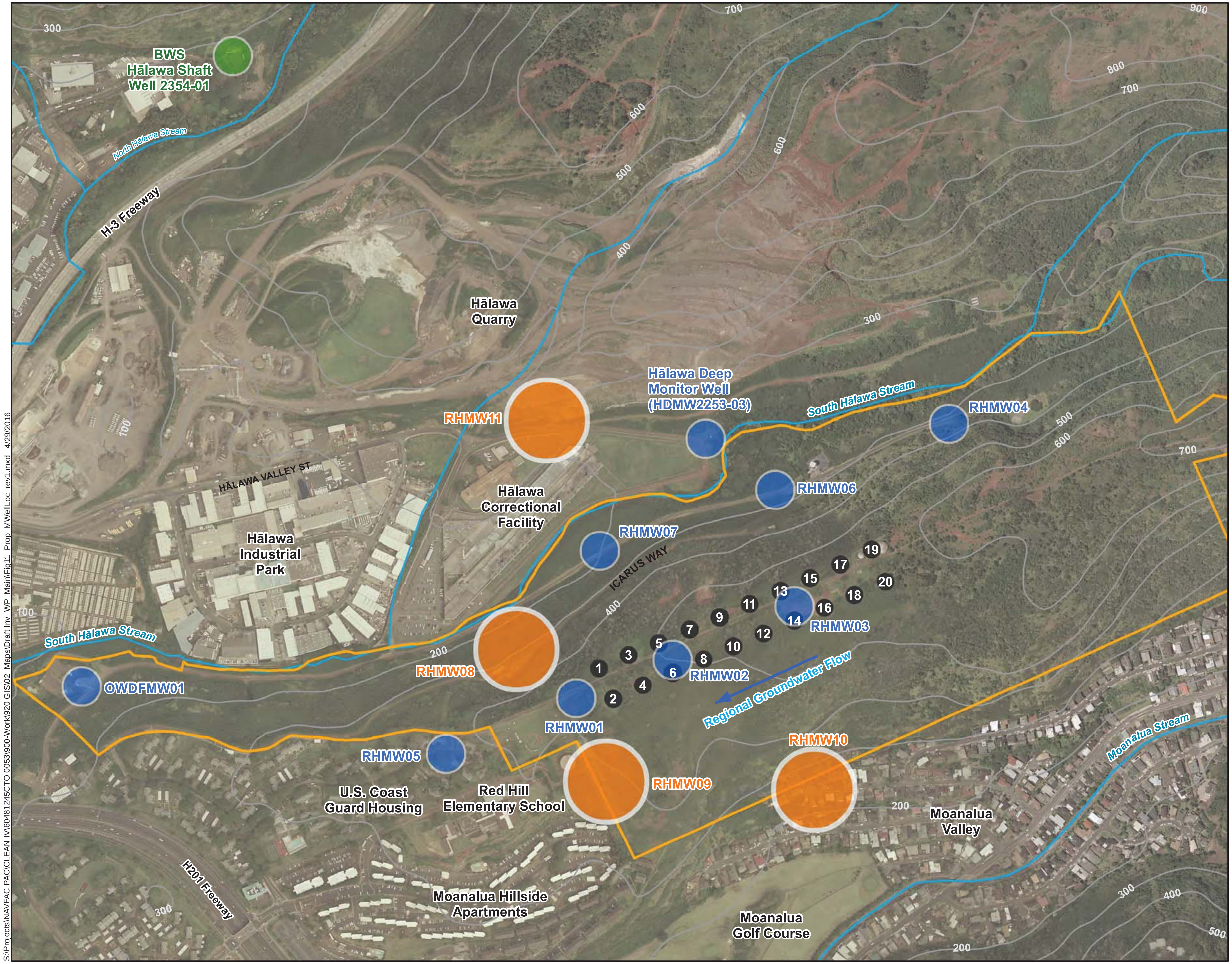
*Current monitoring well network:* The current monitoring well network includes:

- Inside-tunnel groundwater monitoring wells RHMW01 (near Tank 1), RHMW02 (near Tank 5), RHMW03 (near Tank 13), RHMW05 (between the tank farm and the Navy Supply Well 2254-01), and RHMW2254-01 (sampling point located at the infiltration gallery for the Navy Supply Well 2254-01).
- Outside-tunnel groundwater monitoring wells RHMW04 (background well), RHMW06 and RHMW07 (two sentinel wells located between the tank farm and the Hālawa Correctional

Facility), OWDFMW01 (at the Former Oily Waste Disposal Facility), and HDMW2253-03 (the Hālawa Deep Monitor Well located north of the Hālawa Correctional Facility).

*Proposed new wells:* The proposed expansion of the monitoring well network includes four new monitoring wells (locations are shown on Figure 11).

- *RHMW08:* This well will monitor groundwater west of the tanks, in the general area between the tanks and the supply water infiltration gallery. In addition, the well will establish a monitoring point between Red Hill and the Hālawa Correctional Facility and Hālawa Industrial Park that can be used to evaluate the potential for vapor intrusion if contaminated groundwater were to migrate to these areas. It is anticipated that the total well depth will be approximately 320 ft bgs. The well will provide groundwater elevation data to further define groundwater flow patterns in the area (e.g., to evaluate whether there is a northward flow component in the site vicinity). This location was recommended by the State of Hawai‘i DLNR.
- *RHMW09:* This well will monitor groundwater southwest of the tanks, in the general area between the tanks and the water supply infiltration gallery. In addition, this well will establish a monitoring point upgradient of the nearby residential areas to the southwest of Red Hill that can be used to evaluate the potential for vapor intrusion if contaminated groundwater were to migrate to this area. It is anticipated that the total well depth will be approximately 395 ft bgs. The well will provide groundwater elevation data to further define groundwater flow patterns in the general area between the tanks and the water supply infiltration gallery.
- *RHMW10:* This well will provide a monitoring point south of Red Hill and south of existing well RHMW03. It will provide a monitoring point between Red Hill and a nearby residential area in Moanalua Valley that can be used to evaluate groundwater quality to the south and the potential for vapor intrusion if contaminated groundwater were to migrate to this area. It is anticipated that the total well depth will be approximately 265 ft bgs. The well will provide groundwater elevation data to further define groundwater flow patterns downslope and southeast of Red Hill (e.g., to evaluate whether there is a southward flow component in the site vicinity). The location was recommended as a potential monitoring location in previous Navy correspondence, which indicated that it may be the only feasible location (due to inaccessibility of other locations) south of and immediately adjacent to Red Hill. This proposed well is not within the RHSF boundary; therefore, drilling activities can only commence after the Navy receives approval for installation of a monitoring well at this location from the property owner, a process the Navy has already initiated.
- *RHMW11:* This well will provide a monitoring point north of Red Hill and existing well RHMW07. It will provide a monitoring point between Red Hill and the Hālawa Shaft that can be used to evaluate whether groundwater is migrating from Red Hill to this area. It is anticipated that the total well depth will be approximately 235 ft bgs. If bedrock is not encountered at the target depth, drilling may be extended deeper to investigate the extent of valley fill or saprolite. The well will provide groundwater elevation data to further define groundwater flow patterns in the area (e.g., to evaluate whether there is a northward flow component in the site vicinity). It will also provide data to help characterize the geological matrix of Hālawa Valley (e.g., the depth of the valley fill and underlying saprolite, which have been identified as potentially significant impediments to groundwater and contaminant flow to the north. This proposed well is not within the RHSF boundary; therefore, drilling activities can only commence after the Navy receives approval for installation of a monitoring well at this location from the property owner, a process the Navy has already initiated.



## Location Map

## Legend

● Proposed Monitoring Well Location

● Existing Monitoring Well Location

❶ Red Hill UST

— Stream

—400— Topographic Contour
(feet above mean sea level)

▭ Red Hill Installation Boundary

## Notes

1. Map projection: NAD 1983 UTM Zone 4N
2. Base Map: http://hawaii.wr.usgs.gov/oahu/earthdata.html (USGS 1-foot orthoimagery)
3. Acronyms and Abbreviations:
   UST Underground Storage Tank

Figure 11
Proposed Monitoring Well Locations
WP/SOW
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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Table 5 summarizes the rationale and investigation objectives for the proposed new monitoring wells and recently installed wells.

**Table 5: New and Proposed Well and Objectives Matrix**

| Well ID | Objective 1: Sentinels | Objective 2: Characterize Flow | Objective 3: Characterize Chemistry | Objective 4: Characterize Matrix | Objective 5: Other Uses |
|---|---|---|---|---|---|
| **Recently Installed Monitoring Wells** | | | | | |
| RHMW06 | ✓ | ✓ | ✓ | | ✓ |
| RHMW07 | ✓ | | ✓ | | ✓ |
| **Proposed New Monitoring Wells** | | | | | |
| RHMW08 | ✓ | ✓ | ✓ | | ✓ |
| RHMW09 | ✓ | ✓ | ✓ | | ✓ |
| RHMW10 | ✓ | ✓ | ✓ | | ✓ |
| RHMW11 | ✓ | ✓ | ✓ | ✓ | ✓ |

ID identification

Objectives:

*1. Sentinels* – Provide monitoring points between the Red Hill tanks and receptors potentially exposed via the drinking water supply system, and to guard against the potential for vapor intrusion concerns due to constituents in groundwater.

*2. Characterize Flow* – Provide additional groundwater elevation data to evaluate groundwater flow patterns in the vicinity of the Red Hill Facility and refine and calibrate the groundwater flow model.

*3. Characterize Groundwater Chemistry* – Provide water quality data and evaluate COPC concentrations and NAPs.

*4. Characterize Matrix* – Further characterize the stratigraphy and properties of the Valley Fill, caprock, and saprolite layers.

*5. Other Uses* – Provide potential monitoring and access points for other activities, such as a tracer study or augmentation, if warranted upon completion of other field activities.

## 4.5 TASK 5: UPDATE THE EXISTING GROUNDWATER MODEL

The groundwater flow model previously developed for the site will be updated with newly collected data provided by others (potentially including the USGS) and acquired during the activities described in this WP/SOW (in accordance with Agreed-Upon Item 17 and 18). The updated model will be used to support a human health risk assessment and evaluate remedial alternatives. Specifically, the groundwater flow model will be used to improve the understanding of the direction and rate of groundwater flow within the aquifers around the facility. The model will be calibrated to match new groundwater data obtained since 2007, including transient calibration to match available pumping rate and drawdown data. Predictive modeling will be performed to simulate the effects of future water supply well pumping, including increased usage scenarios, and to simulate the effects of different remedial alternatives. Details of the approach proposed to update the model are presented in Appendix H. The following modeling scenarios are anticipated:

- *Existing conditions* – The flow model will be calibrated to match the static hydraulic head data collected from all available wells in the vicinity of RHSF, and further refined and calibrated using data from the planned week-long synoptic monitoring of transducers in up to 20 area wells and all available supply well pumping rates. Model output will include time-series plots comparing water level hydrographs to actual measured levels in monitored wells and contour maps of the water table potentiometric surface, estimated model parameters, and model calibration statistics.
- *Base case conditions* – Based on a review of all available data, the base flow model will be established using representative hydraulic head data under anticipated normal long-term conditions. Model output will include hydraulic heads at specific locations and hydraulic gradients for comparison to the available site measurements.

- *Future Pumping Scenario 1, increased pumping from existing drinking water supply wells* – The calibrated flow model will evaluate groundwater levels, hydraulic gradients, and flow patterns for potential increased pumping rates representing high water demand from existing water supply wells during drought conditions. Model output will include time-series water level hydrographs and a water table potentiometric surface contour map.
- *Future Pumping Scenario 2: increased pumping from a hypothetical new drinking water supply well* – The calibrated flow model will evaluate the hypothetical groundwater levels, hydraulic gradients, and groundwater flow patterns that would exist if a new supply well were to be installed at a particular location and water is extracted at the rate expected under normal demand conditions. Model output will include time-series water level hydrographs and a water table potentiometric surface contour map.
- *Future Pumping Scenario 3: remedial alternative analysis* – The calibrated flow model will evaluate hypothetical groundwater levels, hydraulic gradients, and groundwater flow patterns under different remedial alternative scenarios, which will be identified in the future. Model output will include time-series water level hydrographs and a water table potentiometric surface contour map.

## 4.6 TASK 6: UPDATE THE CONTAMINANT FATE & TRANSPORT (CF&T) MODEL AND EVALUATE WHETHER TO PERFORM A TRACER STUDY

The existing CF&T model will be updated with newly collected data provided by others (potentially including the USGS) and resulting from the activities in this WP/SOW (in accordance with Agreed-Upon Item 12, 23 and 24). The updated model will be used with the groundwater flow model to support a health risk assessment and evaluate remedial alternatives. The updated model will be used to evaluate how close a LNAPL plume could get to the Red Hill Shaft without exceeding the MCLs or EALs. The newly collected data and modeling results will be evaluated and discussed with the Regulatory Agencies to determine whether a tracer study is warranted, feasible, and likely to produce meaningful data. Details regarding the approach proposed to update the model are presented in Appendix H.

## 4.7 TASK 7: EVALUATE REMEDIAL ALTERNATIVES

A preliminary, tentative analysis of various potential in-situ and ex-situ technologies for remediating NAPL in the subsurface and dissolved hydrocarbons in groundwater at the RHSF site is presented in Appendix F (in accordance with Agreed-Upon Item 21). Technologies were evaluated for their general capabilities, proven track record, and the likelihood that they would be effective at sites with subsurface conditions similar to those at Red Hill. Although the technologies have been preliminarily evaluated at this time, detailed and comparative analysis of remedial alternatives will not be conducted until the investigation and modeling efforts (Tasks 1 through 6) are complete.

RHSF is not subject to Comprehensive Environmental Response, Compensation, and Liability Act or Clean Water Act regulatory requirements; therefore, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) is not applicable to response actions for the site. However, the nine NCP criteria for evaluating remedial action alternatives will be considered for detailed and comparative analysis of alternatives:

1. Overall protection of human health and the environment
2. Compliance with all required federal and state laws

3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility, or volume through treatment
5. Short-term effectiveness
6. Implementability
7. Cost
8. Projected Federal and State acceptance
9. Projected community acceptance

# 5. Project and Task Description

## 5.1 FIELD ACTIVITIES

Field activities to be conducted include vegetation clearance, monitoring well installation (performed under a separate RHSF Monitoring Well Installation WP [DON 2016]), geologic mapping, a pilot-scale ER survey to evaluate the feasibility this method for investigating NAPL in the Red Hill vadose zone, groundwater sampling at the wells in the monitoring well network, synoptic groundwater level measurements, topographic survey, and IDW disposal.

## 5.2 FIELD SCHEDULE

It is anticipated that the investigation will be completed within 3 years after government approval of the final version of this WP/SOW. The investigation schedule will include time for field activities (i.e., monitoring well installation, geologic mapping, groundwater sampling, topographic survey, synoptic water level reading, and possibly ER survey), data generation and evaluation, human health risk assessment, groundwater flow modeling, and report writing. The overall schedule is dictated by the AOC Statement of Work, which does not allot additional time for reviews and approvals by the Regulatory Agencies, which could affect the overall completion date.

Mobilization for the installation of proposed groundwater monitoring wells RHMW08, RHMW09, RHMW10, and RHMW11 will occur after the final Monitoring Well Installation WP (DON 2016) has been approved by the Regulatory Agencies. Installation at the four locations may occur concurrently or sequentially, depending on availability of drilling equipment and access to property outside the RHSF site boundary (for wells RHWM10 and RHMW11).

Mobilization for the groundwater sampling will occur after the final version of this WP/SOW has been submitted and approved and at least one new monitoring well has been installed. Sampling will be performed during one wet-season event (October–April) and one dry season (May–September) event, followed by six quarterly sampling events in accordance with the sampling schedule for the existing groundwater long-term monitoring program. Each of the four proposed monitoring wells will be included in the sampling schedule as soon as each well has been completed and developed. The sequence of the wet-season and dry-season sampling events will depend on the timeframe of final WP/SOW approval. It is anticipated that the final version of this WP/SOW will be approved during the middle of the 2016 dry season.

Mobilization for the synoptic groundwater level readings will occur once all four proposed well installations have been completed. It is anticipated that the synoptic groundwater level readings will span 1 week.

The proposed pilot-scale ER survey will be scheduled after approval of the final version of this WP/SOW. The study is anticipated to be completed prior to submittal of the first version of the *Investigation and Remediation of Releases Report*.

The Navy CTO Contracting Officer's Representative (COR) and the AECOM Technical Services, Inc. (AECOM) CTO manager will coordinate activities prior to each mobilization and during all aspects of the field efforts, and keep the Regulatory Agencies apprised of the progress of activities.

## 5.3 REPORT SCHEDULE

During and following the investigation field activities, up to eight reports are anticipated to be submitted to the Navy and Regulatory Agencies.

### 5.3.1 Groundwater Flow Model Progress Reports

In accordance with AOC Statement of Work Section 7.1.2, brief Groundwater Flow Model Progress Reports will be submitted to the Regulatory Agencies every 4 months, to inform the agencies of the progress of the groundwater modeling at RHSF. Other (non-flow-modeling) updates may also be included, as appropriate. The first progress report will be submitted 4 months after approval of the final version of this WP/SOW. The second progress report will be submitted 4 months after the submittal of the first progress report. At least one groundwater sampling event is expected to have been conducted prior to completion of the second progress report. The subsequent three groundwater flow model progress reports will be provided every 4 months after submittal of previous progress reports.

### 5.3.2 Groundwater Flow Model Report

In accordance with AOC Statement of Work Section 7.1.3, a *Groundwater Flow Model Report* will be submitted within 24 months of approval of the final version of this WP/SOW. As detailed in Appendix H, the report will summarize modeling efforts to refine the existing groundwater flow model, improve the understanding of the direction and rate of the groundwater flow within the aquifers around the facility, and evaluate potential exposure routes. The groundwater flow model will utilize numerical flow (MODFLOW), particle tracking (MODPATH), and reactive transport models (RT3D or MT3D).

### 5.3.3 Investigation and Remediation of Releases Report

In accordance with AOC Statement of Work Section 6.3, an *Investigation and Remediation of Releases Report* will be submitted within 24 months of approval of the final version of this WP/SOW. The report will summarize the results of the field investigation, the groundwater sampling, the comprehensive water level elevation survey and groundwater flow evaluation, the human health risk assessment, and the conclusions and recommendations for the site. The report will also re-evaluate assumptions made during the Scoping Meetings, identify data gaps, and make recommendations for future site activities including additional data collection (e.g., whether a tracer study is recommended) and an evaluation of potential remedial options.

### 5.3.4 Contaminant Fate and Transport Model Report

In accordance with AOC Statement of Work Section 7.2.3, a *Contaminant Fate and Transport Model Report* will be submitted within 180 days of the final *Groundwater Flow Model Report.* The *Contaminant Fate and Transport Model Report* will utilize a well-established, state of the practice solute transport modeling code (RT3D or MT3DMS) in conjunction with the updated groundwater flow model. As detailed in Appendix H, the report will include a description of the model setup and calibration, and simulations of transport under the various potential remedial alternatives and hypothetical fuel release scenarios. Preparation of the *Contaminant Fate and Transport Model Report* is expected to commence immediately after Regulatory Agencies' acceptance of the final *Groundwater Flow Model Report*.

## 5.4 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA

The data quality objectives (DQOs) for this investigation are based on Sections 6 and 7 of the AOC Statement of Work, with general consideration of the guidance contained in *Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4* (EPA 2006) and the *Guidance for Data Quality Assessment* (EPA G-9) (EPA 2000).

### 5.4.1 Problem Definition

The project team reviewed AOC Statement of Work Sections 6 and 7, related Scoping Meeting materials and correspondence, historical site information, current site conditions, site groundwater monitoring data, the existing site CF&T model, and the preliminary CSM (Section 5.5) to develop the following problem statements:

- Previously recorded releases of petroleum-related products from the USTs at the Facility to the subsurface have occurred. Dissolved-phase petroleum-related COPCs have been detected in the groundwater aquifer in the site vicinity, upgradient of drinking water supply wells.
- Previous investigation results indicate that human exposure to drinking water from the supply wells is a potentially complete exposure pathway.
- Although previous investigations concluded that vapor intrusion is not a complete exposure pathway, additional groundwater data are needed to verify this conclusion for nearby residences.

### 5.4.2 Study Goals

The goal of this investigation is to achieve the objectives described in AOC Statement of Work Section 6 (Investigation and Remediation of Releases) and Section 7 (Groundwater Protection and Evaluation):

- Section 6: "*The purpose of the deliverables to be developed and the work to be performed under this Section is to determine the feasibility of alternatives for investigating and remediating releases from the Facility.*"
- Section 7: "*The purpose of the deliverables to be developed and the work to be performed under this Section is to monitor and characterize the flow of groundwater around the Facility. Navy and DLA shall update the existing Groundwater Protection Plan 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 in this Section shall be used to inform subsequent changes to the Groundwater Protection Plan. The deliverables and work to be performed under this Section may include the installation of additional monitoring wells as needed.*"

The related principal study questions are therefore:

- What is the general nature of the Red Hill vadose zone, and how does it impact the alternatives for investigating and remediating NAPL that may be present in the vadose zone?
- What is the nature and extent of groundwater contamination?
- What are the groundwater flow patterns in the site vicinity?

- What fate and transport processes affect the petroleum constituents released to groundwater from the facility?
- What are the alternatives for further investigating and remediating any petroleum products that are both present in groundwater and pose unacceptable risk to receptors (if any)?

### 5.4.3 Information Inputs

The CSM (see Section 5.5) was used to assist in determining the following required inputs to the decisions:

- *Records review*. The following documents have been or will be reviewed:
    - Historical reports and records, including planning documents and investigation and monitoring reports for RHSF
    - Water supply well pumping rates and schedules
    - Well construction details for Hālawa Shaft and Red Hill Shaft
    - Well construction and boring logs for wells in the vicinity of RHSF
    - Scoping Meeting materials and correspondences between the Navy and other stakeholders
    - Reports describing the methods used to characterize and remediate other fuel release sites in Hawaiʻi (e.g., Waikakalaua Fuel Storage Annex, Kīpapa Gulch)
- *The DOH-HEER TGM (DOH 2009).* Information on COPCs, silica gel cleanup, and screening criteria. The primary groundwater screening criteria for human health are based on the State of Hawaiʻi Tier 1 EALs (DOH 2011) for sites where groundwater is currently or potentially a drinking water resource and surface water bodies are not located within 150 meters of the release site (TGM Table D-1b). The groundwater data will also be compared to the Tier I EALs for evaluation of potential vapor intrusion hazards (TGM Table C-1a).
- *Geologic mapping.* The site geology will be mapped using existing boring logs and data, aerial imagery, historical documents, and a records search as well as field mapping techniques within the RHSF boundaries and surrounding properties.
- *Review of neighboring properties.* DOH UST, LUST, and SHWB database records of neighboring properties.
- *Analytical results from groundwater samples.* Groundwater samples will be analyzed for the COPCs listed below using EPA Solid Waste (SW)-846 methods at a fixed-base laboratory (see Section 6.3 for the analytical sampling program and Appendix G for the analytical data quality plan). The groundwater data will be used to evaluate potential health risks associated with both the direct contact and vapor intrusion pathways (to verify that vapor intrusion is not a complete exposure pathway for nearby residences).
    - PAHs (1-methylnaphthalene, 2-methylnaphthalene, and naphthalene)
    - VOCs (BTEX)
    - TPH-g, TPH-d, and TPH-o
    - NAPs (dissolved oxygen, methane, ferrous iron, sulfate, nitrate, and chloride)
    - Lead scavengers (1,2-dibromoethane and 1,2-dichloroethane).

- *Subsurface soil and rock core samples from representative lithologies.* In accordance with the Monitoring Well Installation WP (DON 2016), rock cores and subsurface soil samples will be collected to characterize the rock and soil formations underlying the site and evaluate COPC concentrations in potentially contaminated soil (if encountered). The subsurface soil samples, if collected, will be analyzed for BTEX, TPH, and PAHs. Soil samples for geotechnical testing will also be collected if unsaturated zones of unconsolidated material or significant layers of clay or low-permeability zones are encountered. The geotechnical samples will be tested for parameters including Atterberg limits, effective porosity, permeability, moisture content, density, particle size distribution, cation exchange capacity, and total organic carbon to assess the soil characteristics beneath RHSF (see Section 6.3 for the analytical sampling program and Appendix G for the analytical data quality plan).
- *Synoptic groundwater level readings.* The water elevation levels at the current monitoring well network and the four proposed new monitoring wells will be measured to evaluate the hydraulic connection between groundwater beneath RHSF and the Red Hill Shaft, and to confirm that there is no hydraulic connection with the Hālawa Shaft.

### 5.4.4 Boundaries of the Study

The physical boundaries identified for this investigation are defined to the northeast by the Ko‘olau Mountain range, to the southeast by Moanalua Valley, to the southwest by the residential housing, and to the northwest by Hālawa Valley (Figure 1). The modeling domain, however, extends farther, as shown in Appendix H. Data acquired during the investigation will be reviewed to determine whether the study area should be expanded, e.g., additional monitoring wells may be installed at locations outside the current study area boundary if necessary to fill data gaps and ensure that the RHSF monitoring well network is adequate to achieve the project objectives.

The temporal boundaries of the investigation are based on the time required to complete the following investigation activities:

- Installation of four proposed groundwater monitoring wells, each assumed to span a 4-week installation period per well, to begin after approval of the final Monitoring Well Installation WP (DON 2016).
- The investigation and risk evaluation report will include a wet-season and a dry-season groundwater sampling event, which will begin after approval of the final version of this WP/SOW. The seasonal groundwater sampling events may be followed by up to six quarterly groundwater sampling events.
- Synoptic water level monitoring will be conducted over a 1-week period beginning after installation and development of the four proposed new monitoring wells.

### 5.4.5 Procedural Approach

As described in the AOC Statement of Work and the Scoping Meeting minutes, conclusions and recommendations will be presented in the four reports that will be submitted upon completion of the each work item:

- *Investigation and Remediation of Releases Report* (AOC Statement of Work Section 6.3)
- *Groundwater Flow Model Report* (AOC Statement of Work Section 7.1.3)
- *Contaminant Fate and Transport Model Report* (AOC Statement of Work Section 7.2.3)

- *Groundwater Monitoring Well Network Report* (AOC Statement of Work Section 7.3.3)

In accordance with AOC Statement of Work Sections 6.4 and 6.5, within 60 days from the Regulatory Agencies’ approval of the *Investigation and Remediation of Releases Report*, the Parties will attend an Investigation and Remediation of Releases Decision Meeting to evaluate the feasibility of investigating and remediating potential releases from the Facility to the maximum extent practicable. Within 60 days from the decision meeting, the Navy and DLA will submit to the Regulatory Agencies a Decision Document for the Investigation and Remediation of Releases, including a proposed plan and schedule for implementation.

In accordance with AOC Statement of Work Sections 7.3.4 and 7.3.5, within 60 days from the Regulatory Agencies’ approval of the *Groundwater Monitoring Well Network Report*, the Parties will attend a Groundwater Monitoring Well Network Decision Meeting to evaluate subsequent actions for implementing the Groundwater Monitoring Well Network. Within 60 days from the decision meeting, the Navy and DLA will submit to the Regulatory Agencies a Decision Document for the Groundwater Monitoring Well Network, including a proposed plan and schedule for implementation.

### 5.4.6 Performance and Acceptance Criteria

Appendix G presents the COPCs and project action levels (PALs), which the Parties have agreed to. The PALs, based on the EALs, will be used to assist in formulating recommendations for the site. This section describes the following:

- Potential sources of study error (i.e., field error and analytical error).
- Methods for reducing the potential for study errors.
- Methods for minimizing the probability of decision errors.

#### 5.4.6.1 SOURCES OF ERROR

Sources of error in an investigation can be divided into two main categories: sampling design errors and measurement errors. Sampling design error occurs when the design is unable to adequately evaluate the true condition of the groundwater or other environmental media. Measurement error can occur as a result of performance variance from laboratory instrumentation, analytical methods, and operator error. The EPA identifies the combination of all these errors as a “total study error” (EPA 2006). One objective of the investigation is to reduce the total study error so that decision makers can be confident that data generated during the study accurately represent the chemical characteristics of the site.

#### 5.4.6.2 MINIMIZING POTENTIAL ERRORS

The investigation will use decision-error minimization techniques in sampling design, sampling methodologies, and laboratory measurement of COPCs. The sampling design (location, frequency, response to exceedances) is based on the current best understanding of the flow regime and the contaminant distribution model. The investigation will use the following methods to minimize errors potentially associated with sampling design, sampling methodologies, and laboratory analysis of COPCs:

1. Evaluate all of the available historical data to identify COPCs, sampling locations, and site characteristics.

2. Select locations inside and outside site boundaries to install groundwater monitoring wells to further characterize groundwater flow.
3. Apply standardized field sampling methodologies. Sampling activities will be performed in accordance with the *Project Procedures Manual, U.S. Navy Environmental Restoration Program, NAVFAC Pacific* (DON 2015a).
4. Ensure use of applicable EPA SW-846 analytical methods for sample chemistry analysis by a competent analytical laboratory accredited by the U.S. Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP) to reduce measurement errors.
5. Ensure use of applicable American Society for Testing and Materials methods for geotechnical analysis by an accredited geotechnical laboratory to reduce measurement errors.
6. Identify and control potential laboratory error and sampling error through the use of spikes, blanks, and duplicates.

The following sections discuss the methods that will be used to reduce the probability of decision error.

#### *5.4.6.3 SAMPLING DESIGN*

This investigation will minimize the probability of decision error by implementing a systematic sampling approach. The goal of the sampling design is to manage the likelihood of decision errors within a tolerable range. The hypotheses for the sampling design are as follows:

- *Null hypothesis:* COPC concentrations in a potentially contaminated area are higher than the PALs (i.e., area is “dirty”).
- *Alternative hypothesis:* COPC concentrations in a potentially contaminated area are less than or equal to the PALs (i.e., area is “clean”).

In general, two types of decision errors can occur when evaluating the null hypothesis:

1. *Decision Error A (False Negative):* Determining that contamination does not exist when it actually does exist (i.e., a “dirty” area is identified as “clean”). The consequence of this error is that potentially contaminated media will not be further evaluated, that risks to human health may not be evaluated, and that no corrective action will be taken when it may be warranted. Decision Error A is the more severe decision error.
2. *Decision Error B (False Positive):* Determining that contamination does exist when it actually does not exist (i.e., a “clean” area is identified as “dirty”). The consequence of this error is that unnecessary time and resources may be spent on additional sampling, assessment, and possible corrective action when it may not be warranted. The consequence of Decision Error B is less severe than the consequence of Decision Error A.

The sampling strategy developed to minimize the probability of these potential decision errors utilizes the procedures outlined in Procedure I-C-3, *Monitoring Well Sampling* (DON 2015a) for the field effort and in accordance with the DoD *Quality Systems Manual* (QSM) Version 5.0 (DoD 2013) for the laboratory analytical effort. Additionally, the four proposed new monitoring well locations were selected based on review of historical information and previous environmental investigation reports, the location of human health receptors relative to RHSF, the expected groundwater flow directions, and site reconnaissances conducted in January and February 2016. The file review, site reconnaissances, and subsurface geology will be further evaluated to minimize the probability of missing a preferential groundwater flow pathway that may indicate that NAPL and dissolved-phase constituents are migrating toward Navy Supply Well 2254-01, the Hālawa Shaft, or other potential offsite receptors.

Analytical data reported for the groundwater samples will be screened against the PALs (based on the DOH Tier 1 EALs Table D-1b and Table C-1a, EPA MCLs, and SSRBLs) as well as the project limits of detection (LODs) and detection limit goals, which are set below the PALs (discussed in Appendix G). Analytical laboratories will be evaluated for technical capability to meet these laboratory limit goals and PALs. This will minimize the probability of non-detect analytical results exceeding the PALs. The analytical data quality plan is presented in Appendix G.

#### 5.4.7 Optimizing the Design for Obtaining Data

The investigation has been designed to collect data in a manner consistent with the AOC Statement of Work and the existing GWPP, and efficient in terms of both cost and time. The following steps will be taken during the data collection process to reduce error and ensure cost- and time-effectiveness:

- One wet-season and one dry-season groundwater sampling event will be conducted to establish baseline water levels and COPC concentrations, and evaluate seasonal variations in groundwater conditions.
- Following the initial rounds of wet- and dry-season sampling, six rounds sampling will be conducted on a quarterly basis utilizing all available RHSF groundwater sampling locations to evaluate trends and overall site risk. Using the same analytical data for both the investigation and the quarterly groundwater monitoring program will ensure consistency in data quality.

### 5.5 CONCEPTUAL SITE MODEL

A pictorial CSM of the project vicinity is presented on Figure 12.

##### *5.5.1.1 CHEMICAL TRANSPORT AND FATE*

The geological CSM presented in Section 3.7 demonstrated that in Hawaiian volcanic rocks, porosity distribution is complex, permeability is highly variable, and the Red Hill vadose zone is highly heterogeneous and anisotropic. Geologic processes result in the presence of sizable voids and relatively impermeable regions or zones in unpredictable locations and in no repeatable order. Formation of lava tubes, dikes, sills, weathering, and other factors likely resulted in the formation of horizontally oriented voids that are not interconnected and in a relatively impermeable condition in the vertical direction. These observations may explain the lack of NAPL observed in the groundwater at the site. Locating NAPL via drilling would be very difficult given the highly variable permeability and unpredictable and unresolvable flow patterns in the subsurface, and such activity could create pathways through naturally existing confining layers to the groundwater. The relatively oxygen-rich formation at the site (as evidenced by the background monitoring well DO concentrations measured during the quarterly groundwater monitoring events) should promote natural attenuation of petroleum products, thereby decreasing chemical concentrations.

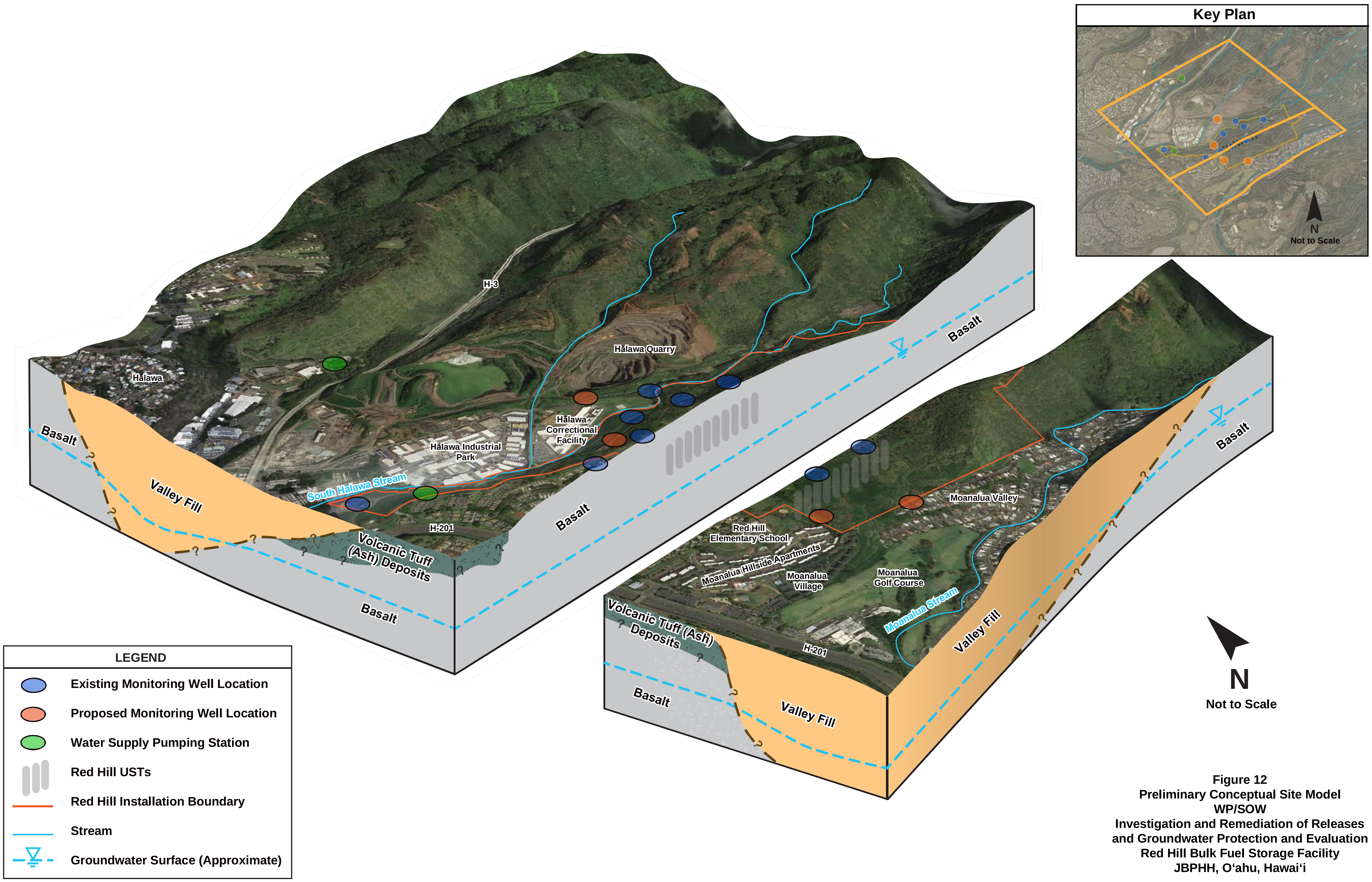

**Figure 12**
**Preliminary Conceptual Site Model**
**WP/SOW**
**Investigation and Remediation of Releases and Groundwater Protection and Evaluation**
**Red Hill Bulk Fuel Storage Facility**
**JBPHH, O'ahu, Hawai'i**

S:\Projects\NAVFAC PAC\CLEAN IV\60481245CTO 0053\900-Work\921 Graphics\CSM Native\Red Hill CSM Layout.ai 03/18/2016

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#### *5.5.1.2 HUMAN RECEPTORS*

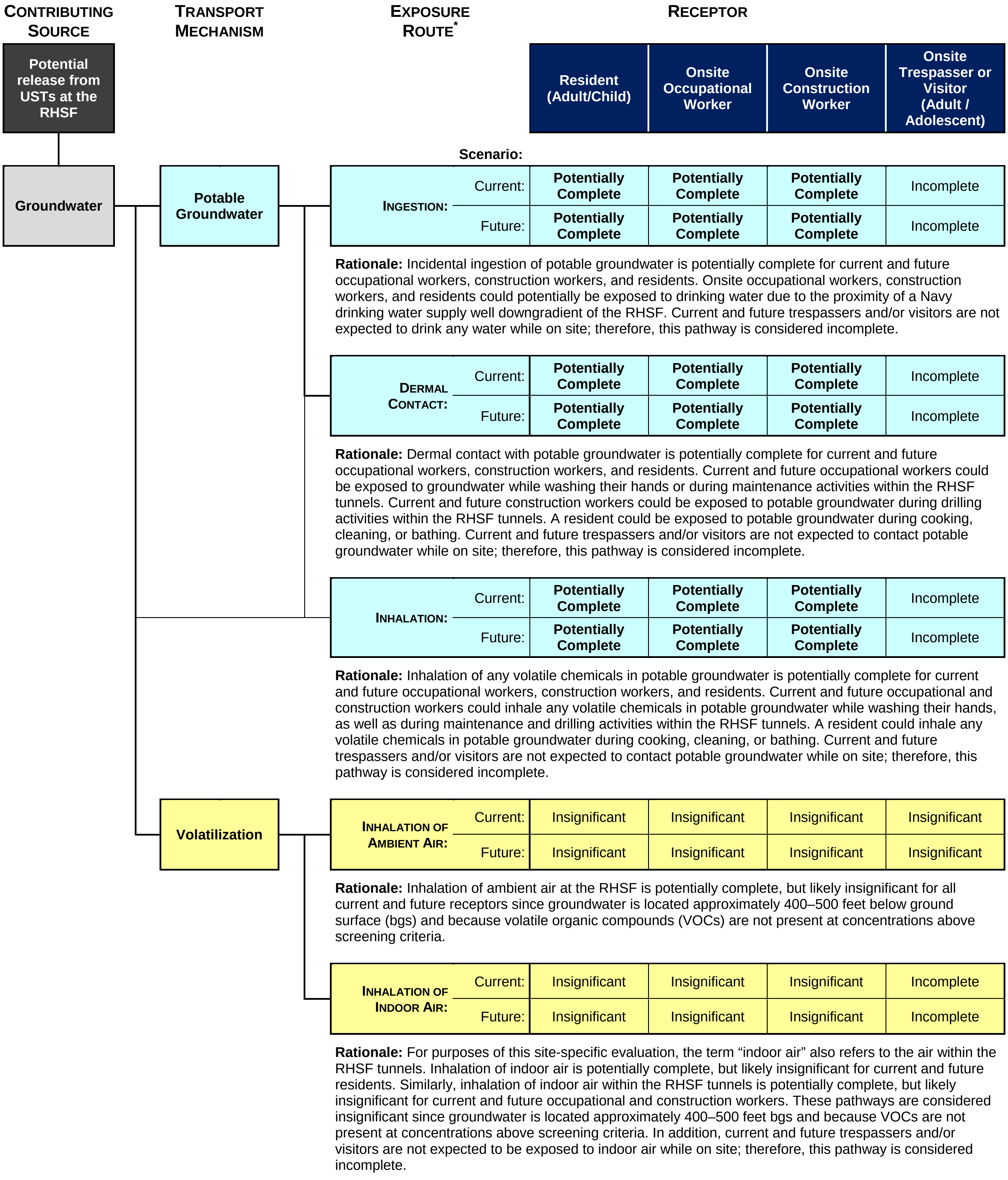
Figure 13 presents the preliminary Human Health Exposure Pathway Evaluation, which will be re-evaluated in the *Investigation and Remediation of Releases Report*. Based on previous investigations and existing data, potable groundwater is considered to present the only potentially complete exposure pathway. Previous investigation results indicated that the vapor intrusion pathway is not complete for onsite receptors (DON 2007); the locations of new monitoring wells RHMW09 and RHMW10 were selected in part in order to verify this conclusion for nearby residential receptors by comparing the groundwater VOC concentrations to the DOH EALs for vapor intrusion (TGM Table C-1a). The current and potential future receptors identified for the onsite and offsite areas are:

- *Current and Future Onsite Workers (Adult):* The primary human receptors are current and future onsite industrial and construction workers.
- *Current and Future Offsite Residents (Adult/Child):* Residential receptors are located in communities surrounding RHSF.

### 5.5.2 Tier III Human Health Risk Assessment

A Tier III human health risk assessment will be performed to evaluate if current site conditions are protective and if COPCs are present at concentrations that could pose adverse effects to human health. Groundwater data collected from the existing sampling locations at RHSF will be evaluated to identify potentially unacceptable risks attributable to the use of groundwater as a drinking water source, and to confirm that intrusion of vapor impacted by VOCs released from the groundwater does not pose unacceptable risks to nearby residents. The Tier III risk assessment will be conducted in accordance with *U.S. Navy Human Health Risk Assessment Guidance* (DON 2008c), the DOH-HEER EHE Guidance (DOH 2011), and the EPA's *Risk Assessment Guidance for Superfund, Volume I* (Parts A, B, E, and F) (EPA 1989, 1991, 2004, 2009), as warranted.

The existing SSRBLs (DON 2014) will be evaluated to confirm that they remain protective of the groundwater resource. If they are found to no longer be protective, new SSRBLs will be proposed. As part of the Tier IA step in the Navy Risk Assessment Process (DON 2008c), COPC concentrations reported for the groundwater samples will be compared to the Tier 1 EALs listed in Table D-1b (DOH 2011), which are presented in the February 4, 2016 scoping completion letter (Appendix A.2), and the Tier 1 EALs listed in Table C-1a (DOH 2011). COPC concentrations that exceed the DOH EALs may be further evaluated in a Tier II baseline risk assessment.



| Exposure Route | Scenario: | Resident (Adult/Child) | Onsite Occupational Worker | Onsite Construction Worker | Onsite Trespasser or Visitor (Adult / Adolescent) |
|---|---|---|---|---|---|
| INGESTION: | Current: | **Potentially Complete** | **Potentially Complete** | **Potentially Complete** | Incomplete |
| | Future: | **Potentially Complete** | **Potentially Complete** | **Potentially Complete** | Incomplete |

**Rationale:** Incidental ingestion of potable groundwater is potentially complete for current and future occupational workers, construction workers, and residents. Onsite occupational workers, construction workers, and residents could potentially be exposed to drinking water due to the proximity of a Navy drinking water supply well downgradient of the RHSF. Current and future trespassers and/or visitors are not expected to drink any water while on site; therefore, this pathway is considered incomplete.

| Exposure Route | Scenario: | Resident (Adult/Child) | Onsite Occupational Worker | Onsite Construction Worker | Onsite Trespasser or Visitor (Adult / Adolescent) |
|---|---|---|---|---|---|
| DERMAL CONTACT: | Current: | **Potentially Complete** | **Potentially Complete** | **Potentially Complete** | Incomplete |
| | Future: | **Potentially Complete** | **Potentially Complete** | **Potentially Complete** | Incomplete |

**Rationale:** Dermal contact with potable groundwater is potentially complete for current and future occupational workers, construction workers, and residents. Current and future occupational workers could be exposed to groundwater while washing their hands or during maintenance activities within the RHSF tunnels. Current and future construction workers could be exposed to potable groundwater during drilling activities within the RHSF tunnels. A resident could be exposed to potable groundwater during cooking, cleaning, or bathing. Current and future trespassers and/or visitors are not expected to contact potable groundwater while on site; therefore, this pathway is considered incomplete.

| Exposure Route | Scenario: | Resident (Adult/Child) | Onsite Occupational Worker | Onsite Construction Worker | Onsite Trespasser or Visitor (Adult / Adolescent) |
|---|---|---|---|---|---|
| INHALATION: | Current: | **Potentially Complete** | **Potentially Complete** | **Potentially Complete** | Incomplete |
| | Future: | **Potentially Complete** | **Potentially Complete** | **Potentially Complete** | Incomplete |

**Rationale:** Inhalation of any volatile chemicals in potable groundwater is potentially complete for current and future occupational workers, construction workers, and residents. Current and future occupational and construction workers could inhale any volatile chemicals in potable groundwater while washing their hands, as well as during maintenance and drilling activities within the RHSF tunnels. A resident could inhale any volatile chemicals in potable groundwater during cooking, cleaning, or bathing. Current and future trespassers and/or visitors are not expected to contact potable groundwater while on site; therefore, this pathway is considered incomplete.

| Exposure Route | Scenario: | Resident (Adult/Child) | Onsite Occupational Worker | Onsite Construction Worker | Onsite Trespasser or Visitor (Adult / Adolescent) |
|---|---|---|---|---|---|
| INHALATION OF AMBIENT AIR: | Current: | Insignificant | Insignificant | Insignificant | Insignificant |
| | Future: | Insignificant | Insignificant | Insignificant | Insignificant |

**Rationale:** Inhalation of ambient air at the RHSF is potentially complete, but likely insignificant for all current and future receptors since groundwater is located approximately 400–500 feet below ground surface (bgs) and because volatile organic compounds (VOCs) are not present at concentrations above screening criteria.

| Exposure Route | Scenario: | Resident (Adult/Child) | Onsite Occupational Worker | Onsite Construction Worker | Onsite Trespasser or Visitor (Adult / Adolescent) |
|---|---|---|---|---|---|
| INHALATION OF INDOOR AIR: | Current: | Insignificant | Insignificant | Insignificant | Incomplete |
| | Future: | Insignificant | Insignificant | Insignificant | Incomplete |

**Rationale:** For purposes of this site-specific evaluation, the term “indoor air” also refers to the air within the RHSF tunnels. Inhalation of indoor air is potentially complete, but likely insignificant for current and future residents. Similarly, inhalation of indoor air within the RHSF tunnels is potentially complete, but likely insignificant for current and future occupational and construction workers. These pathways are considered insignificant since groundwater is located approximately 400–500 feet bgs and because VOCs are not present at concentrations above screening criteria. In addition, current and future trespassers and/or visitors are not expected to be exposed to indoor air while on site; therefore, this pathway is considered incomplete.

*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.

RHSF Red Hill Bulk Fuel Storage Facility
UST underground storage tank

**Figure 13**
**Human Health Exposure Pathway Evaluation**
**WP/SOW**
**Investigation and Remediation of Releases**
**and Groundwater Protection and Evaluation**
**Red Hill Bulk Fuel Storage Facility**
**JBPHH, O‘ahu, Hawai‘i**

# 6. Data Generation and Acquisition

The investigation activities will include the following:

- Further characterizing the site geology though literature review, site reconnaissance, and continuous coring.
- Obtaining subsurface soil chemical and geotechnical data for characterization of contamination and geologic conditions in the vadose zone (completed under the Monitoring Well Installation WP [DON 2016]).
- Conducting geological mapping.
- Obtaining groundwater analytical data for characterization of past releases and current groundwater conditions.
- Topographic surveying.
- Obtaining water level data for characterization of the groundwater flow conditions at the site.
- Conducting IDW disposal activities.
- Conducting the ER pilot study and its associated vegetation and utility clearance and IDW disposal activities.

## 6.1 SAMPLING PROCESS DESIGN

The first two groundwater sampling events will be conducted during the wet and dry seasons to capture seasonal variations in groundwater levels and COPC concentrations.

The analytical parameters and the number of samples to be collected from each groundwater sampling location and analyzed by the offsite, fixed-base laboratory are listed in Table 6. Groundwater samples to be collected for QC purposes are discussed in Section 6.7.1.

**Table 6: Field Sampling Table**

| Sampling Location/ID Number | Matrix | Depth (ft bgs) | Analytical Group | Number of Samples | Sampling SOP Reference (DON 2015a) |
|---|---|---|---|---|---|
| RHMW01, RHMW02, RHMW03, RHMW04, RHMW05, RHMW06, RHMW07, RHMW08, RHMW09, RHMW10, RHMW11, RHMW2254-01, OWDFMW01, and HDMW2253-03 | Groundwater | approx. 80–350 | VOCs, PAHs, TPH, NAPs | 1 primary per event<br>2 duplicate per event<br>1 MS/MSD pair per event<br>3 trip blanks per event [a] | Procedure I-C-3, *Monitoring Well Sampling* |
| RHMW01, RHMW02, RHMW03, and RHMW05 | Groundwater | approx. 80–350 | TPH with Silica Gel Cleanup | 1 primary for one wet-season event<br>1 primary for one dry-season event | Procedure I-C-3, *Monitoring Well Sampling* |
| HDMW2253-03 | Groundwater | 208 | VOCs, PAHs, TPH | 1 field blank [b]<br>1 equipment blank [b] | Procedure I-C-3, *Monitoring Well Sampling* |

| Sampling Location/ID Number | Matrix | Depth (ft bgs) | Analytical Group | Number of Samples | Sampling SOP Reference (DON 2015a) |
|---|---|---|---|---|---|
| RHMW08, RHMW09, RHMW10, and RHMW11 | Groundwater | approx. 100–350 | Lead scavengers | 1 primary per event for 1 year of sampling only<br>1 duplicate per event for 1 year of sampling only<br>1 MS/MSD pair per event for 1 year of sampling only | Procedure I-C-3, *Monitoring Well Sampling* |

ID identification
MS matrix spike
MSD matrix spike duplicate

[a] Assume that each sampling event will span 3 field days, and one trip blank will be collected for each day.

[b] Rental pump equipment will be used during sampling of groundwater monitoring well HDMW2253-03, and field and equipment blanks will be collected during each sampling event at HDMW2253-03. All other monitoring wells have dedicated pumps installed; therefore, no field and equipment blanks will be collected for these wells.

## 6.2 FIELD INVESTIGATION

Where applicable, all field activities will be conducted in accordance with the standard operating procedures (SOPs) presented in the *Project Procedures Manual* (DON 2015a).

A pre-work meeting will be held prior to the start of fieldwork, and the investigation activities will be scheduled as required to minimize disturbance of Navy activities at RHSF. The pre-work meeting will include discussion of the following:

- Obtaining Notification of Possible Disruption to Facilities. Notification will include electronic maps of boring/well locations and a proposed field schedule.
- Methods of communication
- Mobilization
- Health and safety issues
- Site security issues
- IDW storage areas
- Decontamination activities and staging areas
- Traffic control plans

### 6.2.1 Groundwater Sampling

One wet-season and one dry-season round of groundwater sampling and analysis will be conducted at eight existing sampling locations within RHSF (RHMW01, RHMW02, RHMW03, RHMW04, RHMW05, RHMW06, RHMW07, and RHMW2254-01) and two existing sampling locations outside of RHSF (HDMW2253-03 and OWDFMW01). The investigation sampling schedule for these locations will coincide with the quarterly sampling conducted under the current long-term groundwater monitoring program (DON 2014). Groundwater data collected for this investigation will be incorporated into the quarterly long-term groundwater monitoring data set.

Each of the proposed new wells (RHMW08, RHMW09, RHMW10, and RHMW11) installed under the separate Monitoring Well Installation WP (DON 2016) will be incorporated into the investigation sampling schedule as soon as the well has been installed and developed. The proposed wells will be installed concurrently or sequentially depending on availability of drilling equipment and receipt of approval from property owners for offsite wells RHMW10 and RHMW11 (DON 2016). Similar to sampling for the existing wells, sampling of the new wells will also coincide with the quarterly long-term monitoring schedule, and the groundwater data will be incorporated into the quarterly long-term groundwater monitoring data set.

Prior to purging and sampling, the depth to groundwater and the depth to the bottoms of the wells will be measured. Manual water level measurements made during each sampling event will be used to document well drawdown conditions during sampling.

After this step, micropurging will be conducted until water quality indicators stabilize. Groundwater samples will then be collected and submitted to the laboratory for analysis. The monitoring wells will be sampled in accordance with Procedure I-C-3, *Monitoring Well Sampling* (DON 2015a).

Groundwater sampling will include the following activities:

- Measure depth to groundwater from top of casing and assess presence or absence of immiscible phase. The depth to groundwater measurement and the determination of immiscible phase will involve checking the monitoring well head with a PID, to determine if well VOC levels are above ambient conditions, prior to deploying an oil/water interface probe. Groundwater level and immiscible-phase readings will be recorded to the nearest 0.01 ft in the field logbook. Measurements will be made relative to a permanent and clearly identifiable datum point on the top of each well casing.
- Measure well depth to bottom from top of casing.
- Purge static water within the well using dedicated pumps and low-flow sampling techniques. Note: the Hālawa Deep Monitor Well HDMW2253-03 does not have a dedicated pump; therefore, HDMW2253-03 will be purged using a rented bladder pump.
- Monitor groundwater parameters for stabilization. The parameters will be measured with a water quality meter calibrated daily in the field using factory-prepared standards, in accordance with the manufacturer’s instructions. The following field parameters will be measured at regular, timed intervals during well purging:
  - specific conductivity (milliSiemens per centimeter)
  - dissolved oxygen (milligrams per liter)
  - salinity (parts per thousand)
  - temperature (degrees Celsius)
  - redox potential (millivolts)
  - pH
  - turbidity (nephelometric turbidity units)
  - total dissolved solids (grams per liter)
- Obtain groundwater sample.

Purging will be considered complete when two or three consecutive field parameters stabilize within 10 percent or less. Temperature will not be considered for the stability evaluation. Field parameter measurements will be recorded on Monitoring Well Sampling Logs. Groundwater removed from wells during purging will be properly disposed of as IDW in accordance with Procedure I-A-6, *IDW Management* (DON 2015).

### 6.2.2 Topographic Survey

A topographic survey will be completed. A Hawai‘i-licensed surveyor will map monitoring well locations in accordance with Procedure I-I, *Land Surveying* (DON 2015a). The monitoring wells and other pertinent site features will be surveyed and located with respect to an established control point. Each location will be surveyed to provide location coordinates based on the North American Datum of 1983 State Plane Zone 3 coordinate system, and ground surface elevations based on msl. The surveyor will provide the data with an accuracy of ±0.1 ft for horizontal coordinates and ±0.01 ft for elevation. The survey data will be plotted on a topographic base map, along with pertinent site features. The survey data will be placed on site evaluation maps, compiled in a data table, and copies of the field notes will be obtained and placed in the project files.

### 6.2.3 Synoptic Water Level Reading

Water levels will be measured in the wells to provide a synoptic representation of groundwater elevation and flow within and around RHSF and the effects of pumping water supply wells in the area. The effort will consist of collecting synoptic water level data during a period of 1 week using transducers installed in up to 20 available wells. The purpose of the groundwater elevation study is to evaluate groundwater flow gradients, which are complicated due to the complex site geology and the effects of pumping at nearby water supply wells.

The water elevation levels at the current monitoring well network and the four proposed new monitoring wells will be measured to evaluate the hydraulic connection between groundwater beneath RHSF and the Red Hill Shaft, and to confirm that there is no hydraulic connection with the Hālawa Shaft. Data collection will be coordinated with pumping schedules at Hālawa Shaft and Red Hill Shaft, if possible.

In-Situ Aqua TROLL down-hole water quality data loggers (transducers), or equivalent, will be deployed at fixed elevations at the selected monitoring points and programmed to record at 6-minute intervals for a period of 1 week. The data loggers will synchronously record groundwater level (pressure), specific electrical conductivity, and temperature at each well, producing a continuous record of these parameters for a 7-day period. The data loggers will be checked approximately on a daily basis to ensure the loggers are functioning properly and that the groundwater levels are accurate.

### 6.2.4 Proposed Electrical Resistivity Survey

A pilot-scale ER survey will be conducted to evaluate the feasibility of screening the subsurface for anomalous zones that may indicate the presence of NAPL, potential preferential flow pathways, and geologic mapping. The pilot-scale ER survey will include nine transects in the lower tunnel and lower adit plus one transect on the ground surface at the top of the Red Hill Ridge above the tank farm along Icarus Way. Approval for access to the ER survey locations will be arranged and permission to drill 0.5-inch-diameter holes to depths of up to 1 ft in the concrete floor of the tunnel and adit will be obtained. Prior to drilling into the concrete floor, a review will be conducted to ensure that no utility lines or other structures that could be damaged by the drilling exist within the upper 1 ft of concrete. The holes will be patched with concrete following completion of the survey.

Each transect is anticipated to be spaced according to the electrode spacing and survey line distances listed in Table 7 (actual electrode spacing and survey line distances may be adjusted to accommodate field conditions).

**Table 7: Proposed ER Survey Transect Spacing, Length, and Image Depths**

| Proposed Location/Use | Electrode Spacing (ft) | Survey Line (ft) | Corresponding Image Depth (ft) |
|---|---|---|---|
| Within lower tunnel for sensitivity testing and higher resolution imaging | 5 | 271 | 54 |
| Within tunnel or adit for deep geologic mapping | 13 | 722 | 147 |
| On ground surface | 36 | 1,984 | 400 |

Note: Electrode spacing and survey line distances will be adjusted based on field conditions.

Typically, ER surveys are conducted in conjunction with targeted confirmation drilling and sampling to improve the interpretation of data and calibrate electrical imagery to subsurface geology and the presence or absence of NAPL and bioactivity. Due to restrictions associated with drilling within the Red Hill tunnels, the boring logs and core data from the previous and proposed new monitoring wells will be used for this purpose.

## 6.3 FIELD AND ANALYTICAL SAMPLING PROGRAM

Analytical data generated during this investigation will include field parameter and analytical chemistry data. Field parameters will include water level measurements, observations (e.g., weather conditions during sampling, water clarity and condition, evidence of free product), dissolved oxygen measurements, ferrous iron field test results, and groundwater sampling parameters (e.g., turbidity, specific conductance, oxidation reduction potential [ORP], pH).

The analytical data listed in Table 8 (with the exception of the dissolved oxygen, which is a field parameter) will be generated by a DoD ELAP-certified analytical chemistry laboratory. Lead scavengers will be analyzed only for RHMW08, RHMW09, RHMW10, and RHMW11 for at least 1 year of sampling. Analysis for lead scavengers can be discontinued after 1 year of sampling if sample results are below the groundwater action levels established by DOH in the February 4, 2016 scoping completion letter (Appendix A.2). The expected maximum number of field samples to be collected during each groundwater sampling event is presented in Table 9.

**Table 8: Analysis and Monitoring Well Summary Table**

| | | | Sampling Location | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | Analyte(s) | Analytical Method | RHMW01 | RHMW02 | RHMW03 | RHMW04 | RHMW05 | RHMW06 | RHMW07 | RHMW08 | RHMW09 | RHMW10 | RHMW11 | RHMW2254-01 | HDMW2253-03 | OWDFMW01 |
| TPH | TPH-g, TPH-d, TPH-o | EPA SW-846 8015 | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| TPH with Silica Gel Cleanup [a] | TPH-d, TPH-o | EPA SW-846 3630/ 8015 | x | x | x | | x | | | | | | | | | |
| VOCs | benzene, toluene, ethylbenzene, total xylenes | EPA SW-846 8260 | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| PAHs | naphthalene,<br>1-methylnaphthalene,<br>2-methylnaphthalene | EPA SW-846 8270 SIM | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| NAPs | dissolved oxygen | Field parameter | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| | ferrous iron | SM 3500-Fe | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| | methane | RSK 175M | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| | nitrate, sulfate, chloride | EPA 300.0 | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Lead Scavengers [b] | 1,2-dibromoethane,<br>1,2-dichloroethane | SW-846 8260 | | | | | | | | x | x | x | x | | | |

SIM selective ion monitoring

[a] Samples for TPH with silica gel cleanup will be collected from RHMW01, RHMW02, RHMW03, and RHMW05 for the first two seasonal groundwater sampling events only.

[b] Lead scavengers will be collected from RHMW08, RHMW09, RHMW10, and RHMW11 for at least 1 year of sampling, and may be discontinued if sample results are below the groundwater action levels established by DOH in the February 4, 2016 letter (Appendix A.2).

**Table 9: Expected Maximum Number of Field Samples per Groundwater Sampling Event**

| Analytical Group | No. of Sampling Locations | No. of Field Duplicates | No. of MS/MSD Pairs [a] | No. of Field Blanks | No. of Equipment Blanks | No. of VOA Trip Blanks | Total No. of Samples |
|---|---|---|---|---|---|---|---|
| VOCs (BTEX) and TPH-g | 14 | 2 | 1 | 1 | 1 | 3 | 23 |
| TPH-d, TPH-o, and PAHs (1-methylnaphthalene, 2-methylnaphthalene, naphthalene) | 14 | 2 | 1 | 1 | 1 | — | 20 |
| Lead scavengers (1,2-dibromoethane, 1,2-dichloroethane) | 4 | 1 | 1 | — | — | — | 7 |
| NAPs (dissolved oxygen, methane, ferrous iron, nitrate, sulfate, chloride) | 14 | — | — | — | — | — | 14 |

VOA volatile organic analysis

[a] MS and MSD pairs count as two samples.

Groundwater sample volumes collected for TPH-d and TPH-o analysis will undergo silica gel cleanup during one wet-season and one dry-season sampling event. Silica gel cleanup is relatively well established for pesticide analyses when hydrocarbons may interfere, and for removing polar compounds (associated with biogenic sources) of total recoverable hydrocarbons that may interfere with analysis of non-polar petroleum-related (or petrogenic) hydrocarbons (TPH). The silica gel cleanup data may also indicate the extent to which petroleum may have degraded at the site by comparing the relative fraction of polar and non-polar compounds that may be associated with the petroleum weathering process. This may provide a useful line of evidence for the investigation, but would need to be considered in conjunction with other data, such as the chromatography and the NAPs that will be measured during the investigation. To minimize sample variability effects, both analyses (TPH and silica-gel-cleaned TPH) will be analyzed sequentially on the same sample. Silica gel cleanup will be performed on samples from RHMW01, RHMW02, RHMW03, and RHMW05 because the hydrocarbon data reported for these wells in conjunction with NAP data may be useful to characterize natural attenuation processes beneath the tank farm and in the area immediately upgradient of the nearest supply well.

## 6.4 SAMPLE CONTAINERS

Groundwater samples for chemical analyses will be placed in the sample containers listed in Table 10, preserved as indicated, and analyzed within the required holding times. These containers, preservatives, and holding times are specified in the respective EPA SW-846 methods. The analytical laboratories selected for the project will supply the required sample containers. Appendix G discusses the analytical chemistry quality plan for the investigation.

**Table 10: Sample Containers, Preservatives, and Holding Times**

| SW-846 Parameter | Number/Type of Containers per Sample | Preservative | Holding Time |
|---|---|---|---|
| **TPH** | | | |
| TPH-g | 2 × 40-mL vials, Teflon-lined septum caps | No headspace, cool to ≤6°C and adjust to pH <2 with HCl | Maximum holding time is 7 days if pH >2 or 14 days if pH <2. |
| TPH-d, TPH-o (without and with silica gel cleanup) | 3 × 1-L amber glass, Teflon-lined lid | Cool to ≤6°C | 7 days/40 days [a] |
| **PAHs** | | | |
| 1-Methylnaphthalene, 2-Methylnaphthalene, and Naphthalene | 2 × 1-L amber glass, Teflon-lined lid | Cool to ≤6°C | 7 days/40 days [a] |
| **VOCs** | | | |
| Benzene, Toluene, Ethylbenzene, and Total Xylenes | 2 × 40-mL vials, Teflon-lined septum caps | No headspace, cool to ≤6°C and adjust to pH <2 with $H_2SO_4$, HCl, or solid $NaHSO_4$ | Maximum holding time is 7 days if pH >2 or 14 days if pH <2. |
| **Lead Scavengers** | | | |
| 1,2-dibromoethane and 1,2-dichloroethane | 2 × 40-mL vials, Teflon-lined septum caps | No headspace, cool to ≤6°C and adjust to pH <2 with $H_2SO_4$, HCl, or solid $NaHSO_4$ | Maximum holding time is 7 days if pH >2 or 14 days if pH <2. |
| **NAPs** | | | |
| Chloride, sulfate | 1 × 125 mL plastic | Cool to ≤6°C | 7 days |
| Nitrate | 1 × 125 mL plastic | Cool to ≤6°C | 48 hours |
| Ferrous iron | 2 × 250 mL amber glass | Cool to ≤6°C, no headspace | 7 days |
| Methane | 2 × 40-mL vials, rubber-lined septum caps | No headspace, cool to ≤6°C and adjust to pH <2 with HCl | Maximum holding time is 7 days if pH >2 or 14 days if pH <2. |

°C degree Celsius
mL milliliter
[a] x days/y days = *x* days from sample collection to extraction/*y* days for analysis of extracts following extraction.

## 6.5 SAMPLE LABELING

Each sample will be assigned a chain-of-custody (COC) sample identification (ID) number and a descriptive ID number in accordance with Procedure I-A-8, *Sample Naming* (DON 2015a). All sample ID numbers will be recorded in the field logbook in accordance with Procedure III-D, *Logbooks* (DON 2015a). The COC sample ID number (the only ID number submitted to the analytical laboratory) is used to facilitate data tracking and storage. The COC sample ID number allows all samples to be submitted to the laboratory without providing information on the sample type or source. The descriptive ID number is linked to the COC sample ID number, which provides information regarding sample type, origin, and source.

### 6.5.1 COC Sample Identification Number

A COC sample ID number will be assigned to each sample as follows, to facilitate data tracking and storage:

**ESzzz**

Where:

**ES =** Designating the samples for RHSF Groundwater Long-Term Monitoring program

**zzz =** Chronological number, starting with next consecutive number (will be determined prior to field work and is dependent on the last number used in the most recent quarterly monitoring event)

QC samples will be included in the chronological sequence.

### 6.5.2 Descriptive Sample Identification Number

A descriptive ID number (for internal use only) will identify the sampling location, type, sequence, matrix, and depth. The descriptive ID number is used to provide sample-specific information (e.g., location, sequence, and matrix). The descriptive identifier is not revealed to the analytical laboratory. The descriptive ID number for all samples is assigned as follows:

**Aaaaaa-bb-d-gggggg**

Where:

**Aaaaaa** = Site Area Identifier (see Table 11)

**bb** = Sample Type and Matrix Identifier (see Table 12)

**d** = Field QC Sample Type Identifier (see Table 13)

**gggggg** = Month, date and year of collection (e.g., 021716 to designate February 17, 2016).

For example, the sample number RHMW08-GW-S-060116 would indicate that the sample is the primary groundwater sample collected from RHMW08 on June 1, 2016. The duplicate sample would be designated as RHMW08-GW-D-060116. These characters will establish a unique descriptive identifier that will be used during data evaluation.

**Table 11: Site Area Identifiers**

| Identifier | Site Area |
|---|---|
| RHMW01 | Inside-tunnel groundwater monitoring well RHMW01 |
| RHMW02 | Inside-tunnel groundwater monitoring well RHMW02 |
| RHMW03 | Inside-tunnel groundwater monitoring well RHMW03 |
| RHMW04 | Background groundwater monitoring well RHMW04 |
| RHMW05 | Inside-tunnel groundwater monitoring well RHMW05 |
| RHMW06 | Outside-tunnel groundwater monitoring well RHMW06 |
| RHMW07 | Outside-tunnel groundwater monitoring well RHMW07 |
| RHMW08 | Outside-tunnel groundwater monitoring well RHMW08 |
| RHMW09 | Outside-tunnel groundwater monitoring well RHMW09 |
| RHMW10 | Outside-tunnel groundwater monitoring well RHMW10 |
| RHMW11 | Outside-tunnel groundwater monitoring well RHMW11 |
| RHMW2254 | Inside-tunnel groundwater sampling point RHMW2254-01; infiltration gallery |
| OWDFMW01 | Oily Waste Disposal Facility monitoring well OWDFMW01 |
| HDMW2253 | Hālawa Deep Monitor Well HDMW2253-03 located at the Hālawa Correctional Facility |

**Table 12: Sample Type and Matrix Identifiers**

| Identifier | Sample Type | Matrix |
|---|---|---|
| GW | Groundwater | Water |
| WQ | Water Blanks | Water |

**Table 13: Field QC Sample Type Identifiers**

| Identifier | Field or QC Sample Type | Description |
|---|---|---|
| S | Primary Sample | All field samples, except QC samples |
| D | Duplicate | Replicate for water |
| E | Equipment Blank | Water QC |
| B | Field Blank | Water QC |
| T | Trip Blank | Water QC |
| IDW | IDW Sample | All IDW samples |

**Handling, Shipping, and Custody**

All samples collected for analysis will be recorded in the field logbook in accordance with Procedure III-D, *Logbooks* (DON 2015a). All samples will be labeled and recorded on COC forms in accordance with Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody Procedures* (DON 2015a). Samples will be handled, stored, and shipped in accordance with Procedure III-F, *Sample Handling, Storage, and Shipping* (DON 2015a). All samples collected on this project will be shipped to the analytical laboratory via overnight airfreight.

All samples received at the analytical laboratory will be managed in accordance with laboratory SOPs for receiving samples, archiving data, and sample disposal and waste collection, as well as, storage and disposal per Section 5.8, “Handling of Samples” of the DoD QSM (DoD 2013).

## 6.6 LABORATORY ANALYTICAL METHODS

Groundwater samples will be analyzed by a DoD ELAP-certified laboratory using the analytical method specified for each analytical group. The various laboratory analytical methods, number of analytical samples to be analyzed, duplicate samples, for each location site are presented in Appendix G.

Analytical laboratory chemistry data will include:

- TPH-g, TPH-d, and TPH-o by EPA SW-846 method 8015
- Silica-gel-cleaned TPH-g, TPH-d, and TPH-o by EPA SW-846 method 3630 and 8015
- PAHs (1-methylnaphthalene, 2-methylnaphthalene, and naphthalene) by EPA SW-846 method 8270 SIM
- VOCs (benzene, ethylbenzene, toluene, and total xylenes) by EPA SW-846 method 8260
- Lead scavengers (1,2-dichloroethane, 1,2-dibromoethane) by EPA SW-846 method 8260
- NAPs (excluding dissolved oxygen, which is a field parameter):
  - Methane by method RSK 175M
  - Ferrous iron by method SM 3500-Fe
  - Nitrate, sulfate, and chloride by method EPA 300.0

## 6.7 QUALITY CONTROL

Field and laboratory QC measures are described below. In addition to the laboratory requirements presented in this section, the laboratory will follow the analytical chemistry quality plan in Appendix G.

### 6.7.1 Field QC

Field QC samples including field blanks, trip blanks, equipment rinsate and duplicate samples will be collected according to the procedures described in Procedure III-B, *Field QC Samples (Water, Soil)* (DON 2015a). A summary of the number of field QC samples is presented in Table 14.

**Table 14: Summary of Field Quality Control Samples**

| Analytical Group | No. of Sampling Locations (per event) | No. of Field Duplicates (per event) | No. of MS/MSD Pairs (per event) | No. of Field Blanks (per event) | No. of Equipment Blanks (per event) | No. of VOA Trip Blanks (per event) |
|---|---|---|---|---|---|---|
| VOCs (BTEX), TPH-g | 14 | 2 | 1 | 1 | 1 | 3 |
| TPH-d, TPH-o, PAHs (1-methylnaphthalene, 2-methylnaphthalene, naphthalene) | 14 | 2 | 1 | 1 | 1 | — |
| Lead scavengers (1,2-dibromoethane, 1,2-dichloroethane) | 4 | 1 | 1 | — | — | — |
| NAPs (dissolved oxygen, methane, ferrous iron, nitrate, sulfate, chloride) | 14 | — | — | — | — | — |

All monitoring wells in the sampling program except well HDMW2253-03 have dedicated pumps. As such, field and equipment blank samples will be collected only in association with the rental sampling equipment to be used during groundwater collection at HDMW2253-03.

### 6.7.2 Laboratory QC

Laboratory QC samples will include method blanks, laboratory control samples, matrix spikes/matrix spike duplicates (MS/MSDs), and duplicates as described in the DoD QSM Version 5.0 (DoD 2013).

### 6.7.3 Corrective Actions

Corrective actions will be implemented when control limits for field or laboratory QC measurements are not met as described in Appendix G.

### 6.7.4 Data Quality Parameters

Data quality is quantitatively and qualitatively evaluated by assessing parameters of precision, accuracy, representativeness, comparability, and completeness as described in Appendix G.

## 6.8 LABORATORY ANALYTICAL DETECTION LIMITS

Prior to procuring the analytical laboratory, proposals will be submitted to multiple laboratories to determine their ability to perform the specified analytical methods and QC and their ability to achieve the required detection and quantitation limits (see Appendix G). The laboratories will be required to show that their analytical instruments are capable of achieving limits of quantitation (LOQs) that do not exceed the LOQ goals set for each COPC (see Appendix G). To minimize the chances of generating non-detect results that exceed the screening criteria, the laboratories' LODs and LOQs will be reviewed prior to procurement of the laboratory and before any samples are submitted for analysis. If necessary, the laboratory may be required to use a different method or modify the method as needed to achieve the required LOQ and LOD goals (see Appendix G).

## 6.9 EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

### 6.9.1 Field Equipment

During the field investigation, field equipment used to measure VOCs (i.e., PID and four gas meters), temperature, pH, specific conductivity, dissolved oxygen, ORP, turbidity, salinity, and total dissolved solids will be inspected and maintained as recommended by the manufacturer and through a visual inspection of damage.

### 6.9.2 Laboratory Equipment

The analytical laboratory is responsible for inspecting and maintaining laboratory equipment as described in their laboratory quality assurance (QA) plan (as specified by the analytical method used), and as described in Appendix G.

## 6.10 INSTRUMENT CALIBRATION AND FREQUENCY

### 6.10.1 Field Equipment Calibration

Field measurements of temperature, pH, specific conductivity, dissolved oxygen, ORP, turbidity, salinity, and total dissolved solids will be taken during groundwater sampling. Field instruments used to take these measurements will be calibrated as recommended by the manufacturer.

### 6.10.2 Laboratory Equipment Calibration

The analytical laboratory is responsible for calibrating laboratory equipment as specified by the analytical method used and as described in Appendix G.

## 6.11 DOCUMENTS AND RECORDS

In accordance with Procedure III-D, *Logbooks* (DON 2015a), a bound field notebook with consecutively numbered, water-repellent pages will be maintained. The logbook will be clearly identified with the name of the activity, the person assigned responsibility for maintaining the logbook, and the beginning and ending dates of the entries. The logbook will serve as the primary record of field activities. Logbooks will allow a reviewer to reconstruct applicable events by having entries made in chronological order and in sufficient detail. The following information is to be included in the logbook:

- Data maintained in other logs or data sheets will be referenced.
- Entry records will be corrected by drawing a single line through the incorrect entry, then initialing and dating the change. An explanation is to be included if more than a simple mistake was made.
- Entries will be signed or initialed by the individual making the entry at the end of each day.
- Page numbers will be entered on each logbook page.

## 6.12 RECORD KEEPING

Data records will be retained for at least 10 years and as described in Appendix G.

## 6.13 SAMPLING EQUIPMENT DECONTAMINATION

Equipment will be decontaminated in accordance with Procedure I-F, *Equipment Decontamination* (DON 2015a). All sampling equipment will be cleaned before and after use. A staging and decontamination area will be established near the proposed well locations. Liquid wastes generated during monitoring activities will be captured, containerized in properly labeled U.S. Department of Transportation approved 55-gallon drums or other suitable temporary containers, and managed as IDW.

## 6.14 INVESTIGATION-DERIVED WASTE

Green waste generated during vegetation clearance for the proposed ER survey will be processed in accordance with the most recent Navy directive on green waste disposal to prevent the spread of the coconut rhinoceros beetle (JBPHH Green Waste Disposal Direction; the April 29, 2015 version is reproduced in Appendix C). AECOM will coordinate with the Navy CTO COR to ensure that the most current guidance is obtained and followed. Cleared vegetation less than 2 inches in diameter will be chipped on site, and larger green waste will be cut in 5- to 6-ft lengths for deciduous and evergreen materials, or 3-ft lengths for palmaceous materials. Processed green waste will be collected each day and will be transported to and disposed of at the designated disposal facility no more than 24 hours from time of generation.

IDW will also include well purge water and decontamination liquids. Labels with the required information will be placed on the IDW containers as they are moved to a staging area located on RHSF property for temporary storage prior to disposal. The labels will identify the contents of each drum and list Navy contact information, the site/project name, and date of generation. IDW generated will be collected at the end of each day. The IDW will be evaluated based on the corresponding groundwater sampling data and IDW sampling data to select appropriate disposal methods. IDW will be stored in U.S. Department of Transportation-approved 55-gallon steel drums containers, placed on pallets, covered with tarps, and temporarily stored in a secure, Navy-designated staging area at RHSF. The IDW will be handled, stored, and labeled in accordance with Procedure I-A-6, *Investigation-Derived Waste Management* (DON 2015b). The drums will be segregated according to source and matrix, and at least one representative composite IDW sample will be collected from each grouping for waste characterization in accordance with Procedure I-D-1, *Drum Sampling* (DON 2015a). IDW characterization samples will be submitted to a DoD ELAP–certified laboratory for analysis. Waste profile forms will be prepared and submitted to potential disposal facilities for approval. The IDW will be kept at the staging area until the IDW analytical data are received and associated waste profile forms are approved by the disposal facilities. The IDW will then be removed from the staging area, transported, and disposed of at the approved disposal facilities. IDW will be disposed of within 90 calendar days of the generation date. Disposable personal protective equipment and disposable sampling equipment will be collected in plastic trash bags and disposed of as municipal solid waste.

# 7. Assessment and Oversight

## 7.1 ASSESSMENT AND RESPONSE ACTIONS

Project assessment for this investigation will consist of field and laboratory activity assessments as described below and summarized in Table 15. Corrective action responses are summarized in Table 16.

### 7.1.1 Field Activity Assessment

The AECOM field manager will be responsible for periodic internal reviews to verify that field sampling procedures, instrument calibrations, and other relevant activities are performed in accordance with the WP/SOW. A bound field logbook will be used to document deviations in the proposed field activities, changes in sampling locations, samples types and other relevant issues.

The data verification process will include onsite data review against the WP/SOW requirements for completeness and accuracy. The COC records and field QC logbook will be examined for traceability of data from sample collection to the planned and requested analyses for environmental field and field QC samples.

### 7.1.2 Laboratory Activity and Data Assessment

Laboratory activity and data assessment are summarized in this section, and discussed in detail in Appendix G.

#### *7.1.2.1 PROJECT CHEMIST OVERSIGHT AND COMMUNICATION*

The project chemist will oversee the procured laboratory to ensure, to the maximum extent practicable, that the reported laboratory limits are below the screening criteria. The project chemist will assess laboratory analytical capabilities prior to laboratory procurement and again prior to the start of field work. The project chemist will also oversee and review work done by the laboratory, and the laboratory and project chemist will ensure frequent communications. Upon receipt from the designated analytical laboratory, electronic data will be assessed for proper reporting format with respect to data fields and content.

#### *7.1.2.2 MATRIX INTERFERENCE*

Even if a laboratory is capable of achieving the LODs and LOQs required for a project, factors such as “matrix interference” and dilution can result in non-detect values that exceed the associated screening criteria.

Matrix interference can occur when a sample contains relatively high concentrations of non-target analytes that interfere with the detection of the target analytes (e.g., high levels of biogenic hydrocarbons in a sample analyzed for petroleum constituents, or samples with high concentrations of polychlorinated biphenyls masking smaller concentrations of pesticides). In order to manage matrix interference, laboratories may be required to modify sample preparation procedures or perform cleanup procedures on the sample extract to minimize the effect of non-target analyte and prevent the matrix interference from fouling the analytical instrument. However, in some cases cleanup procedures and/or modifying sample preparation procedures are not recommended or are insufficient to remove the matrix interference, which can lead to the laboratory being unable to detect or accurately quantify the target analyte. Additionally, the laboratory may need to dilute the sample extract to minimize the matrix interference from fouling the instrument (see further discussion on dilution below). In both of these cases, the laboratory may report a non-detect value that exceeds the LOQ and LOD goals.

#### 7.1.2.3 DILUTION

Analysis of samples containing high concentrations of a target analyte can also foul the analytical instrument, resulting in costly maintenance, analytical data report delays, and potentially resulting in elevated LODs for subsequent analyses. To prevent instrument fouling, historical data for the sample location will be reviewed and the procured laboratory will be informed of the concentrations of target analytes expected from the samples. If the laboratory’s dilution is too high (i.e., yields a non-detect result of the target analyte), then re-analysis of the sample at a lower or no dilution must be required to achieve the lowest non-detect result (“< LOD U”) below the screening criteria as much as possible.

In addition, dilution, which may be required for samples that contain high concentrations of a target analyte, will increase the LOD and LOQ. For example, if a 5-fold dilution is required, the LOD and LOQ will both increase by a factor of 5. For analyses that have multiple target analytes (e.g., PAHs, VOCs), it may be necessary for the laboratory to analyze the sample at multiple dilutions to achieve the lowest LODs for each of the target analytes. For example, in a VOC analysis with target analytes benzene and toluene, if a sample has high concentrations of benzene and low concentrations of toluene, it may be necessary for the laboratory to analyze for benzene at a 2-fold or higher dilution, then re-analyze the sample for toluene at a lower dilution factor or at no dilution (as long as this does not result in instrument fouling). Multiple dilutions, if required, may require additional laboratory costs.

#### 7.1.2.4 INTERPRETING EXCEEDANCES OF SCREENING CRITERIA

Reported data that exceed the screening criteria are evaluated and discussed in the data usability assessment and in the risk assessment. Generally:

1. For U-flagged results (non-detect):
   a) Non-detects below the screening criteria are considered “Definitive Data,” and can be interpreted to indicate that the analyte does not present any risk.
   b) Non-detects above the screening criteria do not allow the drawing of any conclusions. The analyte may or may not be present, and may or may not exceed the screening level. Other lines of evidence (e.g., historical data, analytical results of the whole site, field observations) may be necessary to determine any conclusions for that sample location, and are typically discussed in the sensitivity sections of the data usability assessment and in the uncertainty section of the risk assessment.
2. For detected results with a J-flag (present but not quantitative):
   a) If a J-flagged result (detected result < LOQ) marginally exceeds the screening criteria, the analyte is probably present, but it cannot be said with certainty whether or not the reported numerical result reflects the actual concentration. Therefore, the actual concentration may or may not exceed the screening criteria. It is very likely, however, that the actual concentration lies between the detection limit (DL) and the LOQ; therefore, these numbers can be compared to the screening level.

        i) It is worth noting that Hawai‘i DOH EALs are set conservatively, much lower than the EPA’s MCLs. While EALs are important, ultimately, MCLs are the enforceable limits for drinking water.

    b) Despite the uncertainty in the precise numerical value of J-flagged data, the J flag does not mean the results are significantly inaccurate, and these values are routinely used in risk assessment calculations and in comparisons to screening levels.

    c) If J-flagged results produce an unacceptable level of uncertainty for a site-specific risk assessment, it may be necessary to re-analyze the sample using a different or modified analytical method to provide the required level of data quality.

3. Non-flagged numerical results are considered “Definitive Data” and may be directly compared to screening levels and used in risk assessment calculations.

#### *7.1.2.5 LABORATORY DATA VALIDATION*

All data will be validated by a third-party data validation firm. The project chemist will be the laboratory data activities assessor, with the authority to issue corrective response actions. The scope of work for laboratory assessment includes assessing electronic and hardcopy data upon receipt to ensure comparability and proper reporting format. The assessment will consist of reviewing both types of data to verify that data were delivered in proper fields and that all required fields are populated correctly. The laboratory and the CTO manager will be notified of any nonconformance discovered.

## 7.2 QUALITY REPORTS TO MANAGEMENT

Quality reports to management will consist of submittals (e.g., field logbooks, COC, hardcopy, and electronic laboratory results) to the project chemist and CLEAN CTO manager (see Table 17). In the event that significant corrective actions are required, appropriate documentation will be provided to the CTO manager for assessment and evaluation into the project report.

1 **Table 15: Planned Project Assessments Table**

| Assessment Type | Frequency | Internal or External | Organization Performing Assessment | Person(s) Responsible for Performing Assessment | Person(s) Responsible for Responding to Assessment Findings | Person(s) Responsible for Identifying and Implementing Corrective Action | Person(s) Responsible for Monitoring Effectiveness of Corrective Action |
|---|---|---|---|---|---|---|---|
| Review of field procedures | Daily | Internal | AECOM | Field Manager (AECOM) | Field Team Members (AECOM) | Field Manager (AECOM) | CTO Project Manager (AECOM) |
| Review of field notes/logbook | Weekly | Internal | AECOM | Field Manager / Field QC Coordinator (AECOM) | Field Team Members (AECOM) | Field Manager (AECOM) | CTO Project Manager (AECOM) |
| Review of field instrument calibration sheets | Daily | Internal | AECOM | Field Manager (AECOM) | Field Team Members (AECOM) | Field Manager (AECOM) | CTO Project Manager (AECOM) |
| Review of COC forms | Daily | Internal | AECOM | Project Chemist (AECOM) | Field QC Coordinator (AECOM) | Field Manager / Field QC Coordinator (AECOM) | CTO Project Manager (AECOM) |
| Field audit | Once | Internal | AECOM | Quality Assurance Manager (AECOM) | CTO Project Manager/ Field Manager (AECOM) | Field Manager (AECOM) | CTO Project Manager/Field Manager (AECOM) |
| Laboratory data assessment | Once per SDG | External/ Internal | TBD/AECOM | Third-Party Data Validator (TBD) / Project Chemist (AECOM) | Laboratory Project Manager (TBD) | Laboratory Project Manager (TBD) | Third-Party Data Validator (TBD) / Project Chemist (AECOM) |

2 SDG sample delivery group

1 **Table 16: Assessment Findings and Corrective Action Responses**

| Assessment Type | Nature of Deficiencies Documentation | Individual(s) Notified of Findings | Timeframe of Notification | Nature of Corrective Action Response Documentation | Individual(s) Receiving Corrective Action Response [a] | Timeframe for Response |
|---|---|---|---|---|---|---|
| Review of field procedures | Verbal communication/logbook record | CTO Project Manager (AECOM) | Immediate | Logbook entry | CTO Project Manager (AECOM) | 24 hours after notification |
| Review of field notes/logbook | Logbook record | CTO Project Manager (AECOM) | Immediate | Logbook entry | CTO Project Manager (AECOM) | 24 hours after notification |
| Review of field instrument calibration sheets | Logbook record | CTO Project Manager (AECOM) | Immediate | Logbook entry | CTO Project Manager (AECOM) | 24 hours after notification |
| Review of COC forms | Logbook record | Field Manager (AECOM) | Immediate | E-mail | QC Coordinator / Field Manager (AECOM) | 24 hours after notification |
| Field audit | Written audit report | CTO Project Manager/ Field Manager (AECOM) | 72 hours after audit | Letter | Quality Assurance Manager (Navy Contractor) | 24 hours after notification |
| Laboratory data assessment | Verbal communication or e-mail | CTO Project Manager (AECOM) / Laboratory Project Manager (TBD) | 24 hours after notification | Letter or e-mail | Third-Party Data Validator (TBD) / Project Chemist (AECOM) | 24 hours after notification |

2 [a] Copies of all assessment findings and corrective action responses will be provided to the NAVFAC Hawaii CTO COR.

**Table 17: Quality Assurance Management Reports**

| Type of Report | Frequency | Projected Delivery Date(s) | Person(s) Responsible for Report Preparation | Report Recipient(s) |
|---|---|---|---|---|
| Third-Party Data Validation Report | Once, after submission of each sampling delivery group from the analytical laboratory | 21 days after receipt of laboratory SDG data package | Third-Party Data Validator (TBD) | CTO Project Manager (AECOM) and CTO COR (NAVFAC Hawaii) |
| Third-Party DQA Report | Once, after all data are generated | 21 days after receipt of final laboratory data package | Third-Party Data Validator (TBD) | CTO Project Manager (AECOM) and CTO COR (NAVFAC Hawaii) |
| Field Audit Report | Once, during the initial 3 weeks of the field work | 21 days after audit (if performed) | QA Manager (AECOM) | CTO Project Manager (AECOM), CTO Field Manager (AECOM), and QA Manager (NAVFAC Hawaii) |

DQA data quality assessment

# 8. Data Validation, Management, and Usability

Review of laboratory analytical data will be performed as described in Appendix G.

## 8.1 DATA REVIEW, VERIFICATION, AND VALIDATION

All analytical laboratory data will be validated by a third-party data validation firm. Third-party data validation will consist of standard validation (90 percent) and full validation (10 percent). The first 10 percent of project field data (COPCs) generated by the laboratory will be validated at full validation to establish a baseline, ensuring the laboratory has complied with the requirements outlined in both the analytical methods and the DoD QSM (DoD 2013). In addition, data quality checks (i.e., evaluating the precision and accuracy) will be performed once the analytical data are received from the laboratory. AECOM will verify the data against the specified limits of quantitation and LODs in Appendix G. All documents produced for the project will be kept in a secured facility for the life of the project. Upon closure of the project, laboratory documents will be archived with the project report in the administration record file at NAVFAC Pacific.

In addition, all project analytical data will be validated by a third-party data validation firm in accordance with the following NAVFAC Pacific Environmental Restoration Program Data Validation Procedures (DON 2015a):

1. Procedure II-B, *Standard and Full Data Validation Procedure for GC/MS Volatile Organics by SW-846 8260B*
2. Procedure II-C, *Standard and Full Data Validation Procedure for GC/MS Semivolatile Organics by SW-846 8270C* (Full Scan and SIM)
3. Procedure II-H, *Standard and Full Data Validation Procedure for Extractable Total Fuel Hydrocarbons by SW-846 8015B*
4. Procedure II-R, *Standard and Full Data Validation Procedures for Wet Chemistry Analyses*

For analyses that have no applicable Data Validation Procedures (DON 2015a), data will be validated in accordance with the analytical methods and the DoD QSM (DoD 2013).

## 8.2 DATA MANAGEMENT

All analytical data, field notes, data sheets, and other data necessary to support the project will be maintained in an AECOM electronic database. All hard copies of analytical data, field notes, data sheets, and other data necessary to support the project will be maintained in the AECOM Honolulu office. Data received from the validation firm will be uploaded into AECOM’s Microsoft SQL server 2005, which is managed via EQuIS (Environmental Data Management Software). Formats for the electronic data deliverable (EDD) and requirements for hard copy analytical data packages are provided in Appendix G.

### 8.2.1 Laboratory Subcontractor Requirements

The laboratory will verify, reduce, and report analytical data as specified in their laboratory QA plan and in Appendix G. Calculation of results is documented in the laboratory SOPs and is required to be consistent with the referenced, published method. Reporting units will be consistent with and comparable to applicable regulatory and decision thresholds.

Both laboratory sample data and QC data will be reported in the printed and EDD Level 4 QC deliverables. The hard copy, printed report, and EDD format are specified in Appendix G. Turnaround time for deliverables will typically be 21 days from date of sample receipt.

### 8.2.2 Validation Subcontractor Requirements

Validator deliverables will include validated data, validation reports, and data quality assessment (DQA) reports. Validated data will consist of EQuIS format data validation assistant forms with associated qualifiers and qualification codes. Hard copy validation reports will include a case narrative describing any discrepancies or anomalies in the data and the validated data themselves. Validation deliverables will also include a DQA report that lists all QC analyses performed, the results of the comparison with established standards, and an estimate of the potential effect of out-of-control events on the usability of the data.

### 8.2.3 Data Recording

Data recording activities will be performed on the electronic data. EDDs will be loaded into a project database and checked for completeness and errors. If errors are encountered or data are incomplete, the laboratory will be notified and data will be resubmitted. If only minor errors or omissions are encountered, data management personnel will correct the data manually, and the laboratory will be notified and made aware of the errors or problems, to avoid making them in future projects. Once in the database, the records will be made accessible to project personnel.

Electronic data will be manually verified against hard copy data for the entire project. Final data tables will be compared with the database to verify the output.

Computer files will be backed up daily to avoid losing information. Hard copy data will be stored in secure areas, while electronic data will be stored in password-protected files, with read-only access to users not authorized to edit the data. The data will be stored for 10 years as described in Appendix G.

### 8.2.4 Data Evaluation

Data evaluation will primarily consist of developing presentations of results and conclusions. Data evaluation may include summary data tables, figures showing detected analytes or significant chemical concentrations, and text to supplement the tables and figures. Additional evaluation may be required, depending on the findings of the sampling events.

### 8.2.5 Data Reporting

Complete data tables will be appended to the report for this investigation. Reduced data (e.g., data summary tables) will be presented in the main portion of the report. Corresponding text will focus on temporal trends, spatial patterns, and relation of analytes to contaminant sources.

A summary of the overall data quality relative to the project DQOs will be provided. Data validation results will be summarized in the Data Quality section of the report, and the effect of the validation qualifiers on the conclusions of the report will also be presented. Any limitation associated with the data will be discussed in detail in the report. The project chemist will summarize the DQA report in relation to the decisions to be made at the site and will evaluate the usability of the data for the purposes intended. Field logs and field measurements will be appended to the report. Finally, a summary of the results of laboratory, field system, and performance assessments will be included in the final project files.

### 8.3 RECONCILIATION WITH USER REQUIREMENTS

Data that have undergone review as discussed in Section 7.1.2 and in Section 8.1 will be evaluated against DQOs and PALs. Any limitations associated with the data will be discussed in detail in the reporting document.

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# Appendix A:
# Red Hill AOC Scoping Meeting Summary, Regulator's Completion of Scoping Letter, and Navy Response to Regulatory Agencies' Letter

# Appendix A.1
# Red Hill AOC Scoping Meeting Summary

## Red Hill Administrative Order of Consent Scoping Meetings

## Red Hill SOW Sections 6 & 7 – Investigation & Remediation of Release, Groundwater Protection and Evaluation Scoping Meeting Summary

## 11/30 – 12/4/2015

[Items Revised per Outcome of Teleconference Held on December 10, 2015]

ATTENDEES:
Navy/DLA:

- NAVFAC PAC: Kris Saboda, Bruce Tsutsui
- NAVFAC HI: CDR Vogel, Jimmy Miyamoto, Aaron Poentis, June Shimabuku, Janice Fukumoto, Joel Narusawa, Tracy Saguibo, Raelynn Kishaba, Brian Fukuda,
- AECOM: Frank Cioffi, Jeff Johnson, John Thackston, Margie Thach, Jack Kronen
- DLA: Amanda Mano‘i
- Moderator: Bharti Ujjani

EPA: Tom Huetteman, Bob Pallarino, Don Bussey
DOH: Rich Takaba, Robert Whittier, Shunsheng Fu, Joanna Seto, Mark Frazier
DOH Consultant/UH: Donald Thomas
DLNR/CWRM: Patrick Casey (11/30), Robert Chenet (11/30)

The following are the major preliminary agreements and action items from scoping meetings held during the week of November 30, 2015 and on Thursday, December 10, 2015 among the Parities identified in the AOC to discuss requirements to fulfill SOW Section 6 (Investigation and Remediation of Releases) and SOW Section 7 (Groundwater Protection and Evaluation) of the AOC. A Preliminary Work Plan/Statement of Work Task List for AOC SOW Section 6 and Section 7 was preliminarily agreed upon and is presented in Attachment 1. In some cases, the details of tasks presented in the attached Preliminary Work Plan/Statement of Work Task List for AOC SOW Section 6 and Section 7 were modified from their original description as presented in Attachment 2, “Red Hill Bulk Fuel Storage Facility AOC SOW Section 6 and Section 7”. Presentation slides with additional information were used in scoping sessions during the week of November 30, 2015 and are presented in Attachment 2.

**Agreed-Upon Items:** Agreed-upon items were reviewed and discussed further among the Parties in a teleconference on Thursday, December 10, 2015 from 1100 to 1300.

1. Key objective is the protection of the groundwater resource.
2. The complex geology of Red Hill presents limitations on the practical options for investigation and removal of NAPL.
3. In addition to performing Task 1, Geological Mapping, use existing site data and previous investigations to refine the existing conceptual site model and to focus future work.
4. Combine Sections 6 and 7 Work Plan/SOW and complete within 90 days from determination of final scoping meeting. Revise schedule per AOC Section 8.
5. The Work Plan/SOW will include a section that provides a detailed summary of the site background and history.
6. Potential offsite contaminant sources utilizing DOH’s information repository will be identified in the Work Plan; however, the Navy is not responsible for investigating or cleanup of other non-Navy, point sources.
7. The Work Plan/SOW will provide a detailed justification/evaluation of potential NAPL investigation methodologies, and document why those are not being pursued at this time. None of the methods discussed for investigating NAPL are currently recommended due to

the complexity of the subsurface geology, site constraints, and the low likelihood of producing actionable data.

8. Additional drilling and intrusive work for the purposes of locating NAPL at the tank farm is not proposed at this time.
9. Chemical analyses of the groundwater for this investigation will use SW-846 methods (consistent with methods used in the long-term groundwater monitoring program).
10. The following natural attenuation parameters will be analyzed at the laboratory or in the field, as specified in the Work Plan/SOW: sulfate, nitrate, ferrous ion, dissolved oxygen, methane, and chloride.
11. The Work Plan/SOW and Report will evaluate the existing soil vapor data. No new soil vapor data collection for the current investigation is proposed. At this time, no changes to the existing soil vapor monitoring program are proposed. This task will be coordinated with the AOC SOW Section 4 team for further evaluation.
12. Based on currently available data it is anticipated that the following chemicals of potential concern (COPCs) may be evaluated in the modeling: TPH-G, TPH-D, TPH-O, Naphthalene, 1-Methylnaphthalene, and 2-Methylnaphthalene.
13. The final report will reevaluate the appropriateness of all the assumptions and whether they still hold true upon completion of Work Plan/SOW activities.
14. The general locations proposed by the Navy for the four new monitoring wells (i.e., RHMW08 through RHMW11) are acceptable. These monitoring wells will be installed as part of the current investigations, and their continued use and a determination of their adequacy as sentinel wells will be evaluated in the final report.
15. The proposed wells will be installed prior to the refinement of the groundwater model. The final report will evaluate whether additional wells are needed to fill data gaps. Specifically, the following will be evaluated:
    a. Whether an additional well is recommended between proposed well RHMW-08 and the Red Hill Shaft
    b. Whether RHMW07 is appropriate for retention in the monitoring grid
    c. Whether RHMW04 provides groundwater quality data representative of ambient background conditions, and whether or not a new monitoring well should be established to collect data that more accurately represent ambient background conditions.
16. Continuous core logging will be performed for all newly proposed monitoring wells.
17. The Navy intends to cooperate with the University of Hawaii on data collection efforts from Navy monitoring wells for their regional groundwater studies which may provide additional data that could supplement the existing CSM developed for Red Hill.
18. The existing groundwater flow model prepared in 2007 will be updated utilizing the same software platform (i.e., MODFLOW) incorporating historic, current, and future data. As part of the update, a sensitivity analysis will include evaluating the potential effects of hydraulic barriers associated with the caprock formation and other lower permeability volcanics (i.e., Honolulu Volcanic Series, saprolite, valley fill), and various hypothetical pumping rate scenarios.
19. Communication during the model development will be performed at regular intervals in addition to the deliverables specified in the AOC SOW (i.e., progress reports) to ensure the model is being developed for its intended purpose.
20. EPA to provide additional information on the Desktop Catchment Water Model as a potential resource/tool.
21. Preliminary remedial alternatives will be identified in the Work Plan/SOW, and discussed and evaluated in the final report. Future potential releases will also be considered (e.g., response to catastrophic releases). Coordinate with Section 8 team.

22. Final report will include an initial screening of alternatives followed by a more detailed evaluation of select remedial alternatives.
23. Conceptual site model to evaluate potential vadose zone flow mechanisms and degradation.
24. Contaminant fate and transport modeling to be performed as presented during the scoping meeting (e.g., based on the existing fate and transport model).
25. The seven tasks presented in the scoping meetings are sufficient for the Work Plan/SOW.
26. There are progress report deliverables under AOC SOW Section 7.1.2 for the groundwater flow model to be provided to regulatory agencies every four months following approval of the Sections 6 and 7 Work Plan/SOW. An evaluation of whether to perform a tracer study will be included in a progress report deliverable following monitoring well installation and receipt of initial groundwater gradient and chemical data.
27. Navy will propose a new target analyte list and sampling schedule for the AOC SOW Section 6 and Section 7 investigation in the Work Plan/SOW for regulatory review. Any revisions to the current groundwater long-term monitoring program will be proposed and evaluated in the Groundwater Monitoring Network Report (Section 7.3.3 of the AOC SOW).

**Action Items:** Action items were discussed further among the Parties in a teleconference on Thursday, December 10, 2015 from 1100 to 1300.

1. Navy to consult Counsel to ensure that the scoping meeting materials are appropriate for distribution (e.g. do not contain procurement sensitive information, critical infrastructure information, etc.).
2. Regulatory agencies, in coordination with the Navy, to contact Board of Water Supply to obtain information regarding plans for future drinking water source well(s) in the vicinity of Red Hill, specifically location and pump demand (i.e., production rate).
3. Project coordinators to take steps to modify the AOC SOW schedule to reflect one Work Plan/SOW covering both Section 6 and 7 delivered within 90 days of determination of final scoping meeting.
4. Regulatory agencies, in coordination with the Navy, to request Halawa Shaft pumping rates to provide additional data for the groundwater model.
5. The Navy, with regulatory agency assistance, will request from the Water Commission well construction information on the Halawa Shaft and Red Hill Shaft.
6. The Navy will follow up with DOH on additional LUST and well log information for Halawa Prison and Hawaiian Cement.
7. Regarding all proposed tasks to be included in the Work Plan/SOW, Navy will estimate and evaluate task durations for AOC schedule feasibility.
8. Propose a preliminary scope of work schedule. Example, determine whether to complete the geologic mapping prior to advancing the wells.

# Appendix A.2
# Regulator's Completion of Scoping and COPC List Letter
# (February 4, 2016)

**UNITED STATES ENVIRONMENTAL
PROTECTION AGENCY
REGION IX**
**75 Hawthorne Street
San Francisco, CA 94105**

**STATE OF HAWAII
DEPARTMENT OF HEALTH**
P. O. BOX 3378
HONOLULU, HI 96801-3378

FEB 04 2016

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

Dear Mr. Miyamoto,

This letter serves two purposes. The first is to declare that the Scoping for Sections 6 & 7 of the Red Hill Administrative Order on Consent Statement of Work (AOC SOW) is now complete. The second purpose is to respond to the recommended list of chemicals of potential concern (COPC) submitted to the Regulatory Agencies for approval via email by Ms. June Shimabuku, NAVFAC Hawaii on January 12, 2016.

**Final Scoping for AOC SOW Sections 6 and 7**

The U.S. Environmental Protection Agency ("EPA") and Hawaii Department of Health ("DOH"), collectively the "Regulatory Agencies" have reviewed the revised meeting minutes from our in-person meeting held November 30 – December 3, 2015 (submitted via email on January 22, 2016), as well as the Preliminary Work Plan/Statement of Work Task List (submitted via email on December 18, 2015) and agree that they correctly capture what was agreed to at the meetings.

One issue not explicitly reflected in the Agreed Upon Items List is that the Navy will incorporate appropriate catastrophic releases scenarios in its Fate and Transport Modeling. Similar to the linkage reflected in #21 of the Agreed Upon items, the Risk/Vulnerability Assessment being performed under Section 8 of the AOC SOW will provide information that can be used in the Fate and Transport Models to determine the threat that a large scale fuel release poses to drinking water wells in the vicinity of Red Hill.

Per Sections 6.2, 7.1.2, 7.2.2, and 7.3.2 of the AOC SOW, the Navy will develop the following Scopes of Work for approval by the Regulatory Agencies: the Investigation and Remediation of Releases Scope of Work, the Groundwater Flow Model Report Scope of Work, the Contaminant Fate and Transport Model Report Scope of Work, and the Groundwater Monitoring Well Network Scope of Work. These will all be included in a single Work Plan/Scope of Work that will be submitted to the Regulatory Agencies within 90 days of the

Final Scoping Meeting, which is the date of this letter. While Section 6.2 of the AOC SOW states that the Investigation and Remediation of Releases Scope of Work is due 60 days after the final scoping meeting, the Navy requested that the deadline be extended to 90 days. The Regulatory Agencies approved this request on January 20, 2016.

## Navy's Proposed Chemical of Potential Concern (COPC) Recommendations

The Regulatory Agencies have reviewed the Navy's proposed list of COPCs and for the most part agree with the proposal. While we agree with the list of COPCs, there are some additional requirements the Navy must meet in order for us to have confidence in the data submitted. We are willing to have further discussions about the specifics of these requirements, however, any further discussions on this subject does not suspend the 90 day deadline for submittal of the AOC SOW Section 6 & 7 Workplan/Scope of Work.

All samples taken from existing groundwater monitoring wells, designated as RHMW01, RHMW02, RHMW03, RHMW04, RHMW05, RHMW06, RHMW07, RHMW2254-01, HDMW2253, and OWDFMW01, will be analyzed for the approved list of COPCs. All samples taken from any new groundwater monitoring wells installed by the Navy will also be analyzed for the approved list of COPCs as well as for lead scavengers 1,2 dichloroethane and 1,2 dibromoethane. Analysis for lead scavengers will be conducted for one year's worth of sampling and can be discontinued if the analyses show levels of these contaminants are below the groundwater action levels established by the Hawaii Department of Health (DOH).

The analytes and the appropriate action levels are summarized in Tables 1, 2 and 3 in Enclosure A to this letter.

The following are additional requirements the Navy shall meet in conducting groundwater and soil vapor sampling. These requirements are to be implemented in a timely manner and shall also be addressed in the Sampling and Analysis Plan to be developed under Task #3 of the Navy's Scope of Work for Sections 6 & 7 of the Administrative Order on Consent Statement of Work.

- Laboratory analysis of all samples shall be able to achieve quantification limits lower than DOH environmental action levels.
- All groundwater samples should be analyzed without dilution whenever possible to avoid laboratory "D" flags.
- Over the next year split samples for TPH in groundwater shall be taken at RHMW01, RHMW02, RHMW03, and OWDFM01 to run a silica gel prep before analysis. These split sampling events should be performed twice over the year, one during the dry season and one during the wet season. This should be done in order to show the ratio of polar (degraded) TPH in the samples without silica gel prep. This can provide a valuable measure of degradation of TPH at the site.
- Two or more consecutive months of soil vapor samples shall be analyzed with Methods TO-15 and/or TO-17 to obtain carbon ranges from C5 to C18 (see Hawaii Department of Health Hazard Evaluation and Emergency Response Technical Guidance Manual, Section 7.8.2) at all Soil Vapor monitoring locations.

- The Navy shall modify the quarterly groundwater sampling procedure at groundwater monitoring well HDMW2253-03. Sampling at this well shall use a low-flow groundwater sample collection method at bottom of casing in this well. Due to a lack of an appropriate screen in the well casing, this well, as currently constructed, does not meet DOH guidance which would qualify it to provide groundwater samples for assessing contamination.

Thank you for your cooperative efforts to develop this Scope of Work outline. We look forward to continuing the progress of implementing the work outlined in the Red Hill AOC. Please contact us with any questions or concerns.

Sincerely,

| | |
|---|---|
| Bob Pallarino, EPA Region 9<br>EPA Red Hill Project Coordinator | Steven Chang, DOH<br>DOH Red Hill Project Coordinator |

Enclosure

cc: Aaron Poentis, NAVFAC Hawaii
June Shimabuku, NAVFAC Hawaii

# ENCLOSURE A
# ANALYTES AND ACTION LEVELS

## TABLE 1
## ANALYTES AND ACTION LEVELS FOR RED HILL MONITORING WELLS RHMW01, RHMW02, AND RHMW03

| ANALYTE | Environmental Action Level µg/L | SSRBL µg/L |
|---|---|---|
| TPH-g | 100 | NA |
| TPH-d | 100 | 4500 |
| TPH-o | 100 | NA |
| Benzene | 5 | 750 |
| Ethylbenzene | 30 | NA |
| Toluene | 40 | NA |
| Total Xylenes | 20 | NA |
| Naphthalene | 17 | NA |
| 1-Methylnaphthalene | 4.7 | NA |
| 2-Methylnaphthalene | 10 | NA |

**NA – Not Applicable**

## TABLE 2
## ANALYTES AND ACTION LEVELS FOR RED HILL MONITORING WELLS RHMW04, RHMW05, RHMW06, RHMW07, RHMW2254-01, HDMW2253, AND OWDFMW01

| ANALYTE | Environmental Action Level µg/L |
|---|---|
| TPH-g | 100 |
| TPH-d | 100 |
| TPH-o | 100 |
| Benzene | 5.0 |
| Ethylbenzene | 30 |
| Toulene | 40 |
| Total Xylenes | 20 |
| Naphthalene | 17 |
| 1-Methylnaphthalene | 4.7 |
| 2-Methylnaphthalene | 10 |

## ENCLOSURE A
## ANALYTES AND ACTION LEVELS

### TABLE 3
### ANALYTES AND ACTION LEVELS FOR FUTURE RED HILL MONITORING WELLS RHMW08, RHMW09, RHMW10, AND RHMW11

| **ANALYTE** | **Environmental Action Level µg/L** |
|---|---|
| TPH-g | 100.0 |
| TPH-d | 100.0 |
| TPH-o | 100.0 |
| Benzene | 5.0 |
| Ethylbenzene | 30.0 |
| Toulene | 40.0 |
| Total Xylenes | 20.0 |
| Naphthalene | 17.0 |
| 1-Methylnaphthalene | 4.7 |
| 2-Methylnaphthalene | 10.0 |
| 1,2 Dichloroethane* | 5.0 |
| 1,2 Dibromoethane* | 0.04 |

*Lead Scavengers can be discontinued after one year of sampling if all samples result in non-detection.

# Appendix A.3

# Navy Response to Regulatory Agencies' February 4, 2016 Letter on Chemicals of Potential Concern

(March 30, 2016)

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DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

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

5750
Ser N4/0495
March 30, 2016

**CERTIFIED NO: 7015 0640 0002 4677 5628**

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

Mr. Steven Y.K. Chang, P.E., Chief
State of Hawaii Department of Health
Environmental Management Division
Solid and Hazardous Waste Branch
919 Ala Moana Boulevard, Room 210
Honolulu, HI 96814

Dear Mr. Pallarino and Mr. Chang:

SUBJECT: NAVY RESPONSE TO REGULATORY ANGENCIES' FEBRUARY 4, 2016 LETTER ON CHEMICALS OF POTENTIAL CONCERN

We appreciate the time and effort the Environmental Protection Agency (EPA) and the State of Hawaii Department of Health (DOH) (herein referred to as the "Regulatory Agencies") have invested into the evaluation of our recommended list of chemicals of potential concern (COPCs) for Red Hill. The purpose of this correspondence is to provide the following recommendations and clarifications regarding four specific items listed in your February 4, 2016 response letter:

a. In regards to the statements related to the catastrophic release scenarios to be evaluated under Section 8 of the Administrative Order on Consent (AOC) Statement of Work (SOW) and subsequent scenario inputs for the Contaminant Fate and Transport (CF&T) Model for this evaluation:

It is anticipated that the CF&T Modeling will evaluate release scenarios at the groundwater table, analogous to the scenarios investigated and assessed in 2007 and 2010. As discussed and noted during the Scoping Meetings, we do not anticipate modeling flow through the complex, highly heterogenic vadose zone. In the event particular catastrophic release scenarios are timely developed under Section 8, the suitability of those release scenarios for inclusion in the CF&T Model will be evaluated and determined with the Regulatory Agencies at that time.

b. In regards to the comments concerning laboratory analysis of samples achieving quantification limits lower than environmental action levels, and no dilutions whenever possible of groundwater samples to avoid laboratory "D" flags:

During the competitive procurement of analytical laboratory services, analytical laboratory selection will be based on the requirements to achieve specific performance criteria, including the listed reporting levels shown in Table 1, Table 2, and Table 3 of the February 4, 2016 response letter. Project chemists will oversee, communicate frequently, and work closely with the analytical laboratory to minimize dilutions and elevated detection limits as much as possible. However, in some cases, dilutions and elevated detection levels may be unavoidable if factors such as matrix interference and potentially elevated COPC concentrations (if present) are encountered in samples. We will inform and discuss such instances with the Regulatory Agencies when or if they occur.

c. In regards to the request to split samples for total petroleum hydrocarbons (TPH) in groundwater over the next sampling year (one wet season and one dry season) at RHMW01, RHMW02, RHMW03, and OWDFMW01 to run a silica gel preparation before analysis for a valuable measure of TPH degradation at the site:

We would like to clarify our understanding of the capabilities and limitations of this method, and request further information regarding how any results from this method will be used in decision-making for the site.

Silica gel cleanup is relatively well established for pesticide analyses when polychlorinated biphenyls (PCBs) may interfere, and for removing polar compounds (i.e., biogenic sources) of total recoverable hydrocarbons (TRH) that may interfere with analysis of non-polar petroleum-related (or petrogenic) hydrocarbons (TPH). We also understand that silica gel cleanup may potentially help indicate the extent to which petroleum may have degraded at a site by comparing the relative fraction of polar and non-polar compounds that may be associated with the petroleum weathering process. This may provide a useful line of evidence for Red Hill; however, these results would need to be considered in conjunction with other data, such as the chromatography and the natural attenuation parameters (NAPs) that will be measured during the investigation. We respectfully request feedback as to whether the Regulatory Agencies may consider using petrogenic TPH data rather than TRH data in screening, risk assessment, and site decision-making. Additionally, we have two recommendations if this method is utilized. First, in order to minimize sample variability effects, we recommend running both analyses (TRH and silica gel prepared TPH) sequentially on the same sample rather than using split samples. Second, we strongly recommend analyzing a sample from *RHMW05* instead of OWDFMW01. OWDFMW01 is a monitoring well in an existing environmental site previously addressed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). A sample from that down gradient, existing CERCLA site (Oily Waste Disposal Facility) potentially contains additional chemical compounds that may interfere with the preparation method and analysis. We believe samples from RHMW05, including analysis of NAPs, may provide far more useful and productive data to characterize natural attenuation occurring in the vicinity of the site, including up gradient of the nearest supply well.

d. In regards to the request to collect two or more consecutive months of soil vapor samples via the EPA TO-15 and/or TO-17 methods in order to obtain carbon range data (e.g., C5 to C18) at all soil vapor monitoring locations:

As agreed to during the Scoping Meetings (see Agreed Upon Item #11), the work conducted in pursuit of Section 6 and 7 of the AOC SOW will include evaluation of historical soil vapor data; however, it will not include the collection of any new soil vapor data as it is not anticipated to add any actionable data for the work conducted under Section 6 and 7 of the AOC SOW. Further discussion on this item is respectfully requested of the Regulatory Agencies to better define the COPC list, requirements, and intent of the collection and analysis of soil vapor data via EPA TO-15 and TO-17 methods in the current long-term monitoring program.

We will revise our target COPC list as outlined in the February 4, 2016 response letter as soon as possible. We will be contacting you to discuss the recommendations and requested items detailed in this letter.

If you have any questions, please contact Aaron Y. Poentis, Regional Environmental Department, at (808) 471-1171, extension 226.

Sincerely,

D. A. TUFTS
Captain, CEC, U.S. Navy
Regional Engineer
By direction of the
Commander

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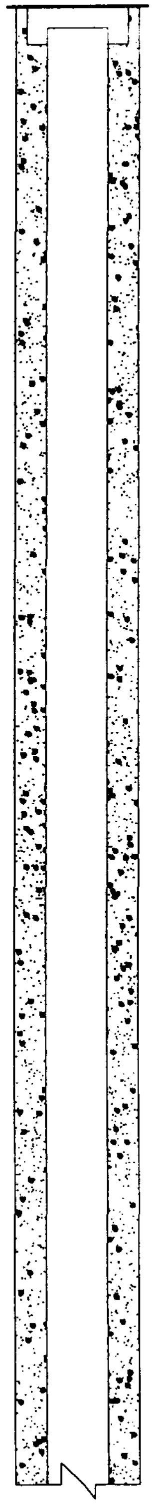
# Appendix B:
# Borehole Logs and Core Photos
# (on CD-ROM at end of document)

**PROJECT:** Red Hill Bulk Storage Facility
**CLIENT:** PACNAVFACENGCOM

**Boring/Monitoring Well No.** B-V1D
**Project No.** CTO 0229

| | | | |
|---|---|---|---|
| LOCATION: V1D - Basal Aquifer | ELEVATION: 102.56 | | |
| DRILLER: Salisbury & Associates, Inc. | DATE DRILLED: 2/13/01 | LOGGED BY: Lance Williams | |
| RILL RIG: SAITECH EH5, Portable Core Drill | DEPTH TO WATER> | FIRST: 86.0 | COMPL.: 86.1 |
| ORING ANGLE: 90 | WELL DIAMETER (inch): 1" | | |

| Corrected Elevation/ Boring Length (ft) | | Core Run Number | PID Reading (ppm) | Sample Number | Core Recovery % | Graphic Log | SOIL DESCRIPTION | WELL CONSTRUCTION |
|---|---|---|---|---|---|---|---|---|
| 102.56 | 0 | 1 | NM | | 100 | | Concrete 0-2' over fine to coarse sand with fine gravel and silt 2-2.5; basalt 2.5'; no odor | |
| 102.06 | | 2 | 172 | | 83 | | | |
| 98.56 | | 3 | NM<br>NM<br>99.2 | | 71 | | Small to large vesicles; no odor; 10YR 3/1<br>Small to medium vesicles; no odor; 10YR 3/1 to 2/1 | |
| 95.36 | | 4 | NM | | 0 | | Small vesicles; no odor; 5YR 3/2 to 10YR 2/2 | |
| 94.16 | | 5 | NM | | 33 | | Small to medium vesicles; no odor; 5YR 3/2 to 10YR 2/2 | |
| 93.66 | | 6 | | | 100 | | | |
| 91.76 | 10 | 7 | 124 | | 105 | | Small to large vesicles; no odor; 10YR 2/2 | |
| | | 8 | | | 93 | | Small to large vesicles; no odor; 10YR 2/2 to 3/2 | |
| 86.06 | | 9 | NM | | 96 | | Primarily small to medium vesicles; no odor; 10YR 2/2 | |
| 81.66 | 20 | 10 | NM | | 100 | | Small to primarily large vesicles; no odor; 10YR 2/2 to 5YR 3/2 to 10YR 3/1 | |
| 76.26 | | 11 | 3.2 | | 100 | | Small to large vesicles; no odor; 10YR 3/1 to 5YR 3/2 | |
| 71.26 | 30 | 12 | 10.8 | | 100 | | Small to medium vesicles; no odor; 5YR 3/2 to 10YR 3/1 | |
| 66.16 | | 13 | NM | | 102 | | Small to large vesicles; no odor; 5YR 3/2 to 10YR 3/1 | |
| 60.96 | 40 | 14 | NM | | 100 | | Small to large vesicles; no odor; 10YR 2/2 to 5YR 3/2 | |
| 57.26<br>56.91 | | 15 | NM | | 98 | | Small to medium vesicles; no odor; 10YR 2/2 to 5YR 3/2<br>Void | |
| 53.06 | 50 | 16 | NM | | 98 | | Small to medium vesicles; no odor; 10YR 2/2 to 5YR 3/2 | |
| 48.06 | | 17 | 1.0 | | 89 | | Small to medium vesicles; no odor; 10YR 2/2 to 5YR 3/2 | |
| 43.36 | 60 | 18 | 6.9 | | 100 | | Small to large vesicles; no odor; 10YR 3/1 to 2/2 to 5YR 3/2 | |
| 38.36 | | 19 | 1.8 | | 83 | | Small to large vesicles; no odor; 10YR 2/5 to 5YR 3/2 | |
| 34.26 | 70 | 20 | 0.0 | | 92 | | Small to medium vesicles; no odor; 10YR 2/1 to 2/2 tp 5YR 3/2 | |
| 29.16 | | 21 | 0.0 | RH-BR-V1D-S01 | 102 | | Small vesicles; no odor; 10YR 2/1 | |



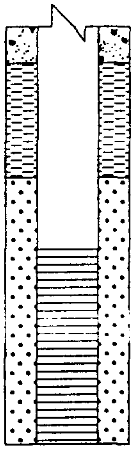
This information pertains only to this boring and sh

not be interpreted as being indicitive of the site.

Corrected elevations are provided for angle borings.

| | | | |
|---|---|---|---|
| **PROJECT:** Red Hill Bulk Storage Facility<br>**CLIENT:** PACNAVFACENGCOM | | **Boring/Monitoring Well No.** B-V1D<br>**Project No.** CTO 0229 | |
| LOCATION: V1D - Basal Aquifer | ELEVATION: 102.56 | | |
| DRILLER: Salisbury & Associates, Inc. | DATE DRILLED: 2/13/01 | LOGGED BY: Lance Williams | |
| ›RILL RIG: SAITECH EH5, Portable Core Drill | DEPTH TO WATER> | FIRST: 86.0 | COMPL.: 86.1 |
| ›ORING ANGLE: 90 | WELL DIAMETER (inch): 1" | | |

| Corrected Elevation/ Boring Length (ft) | | Core Run Number | PID Reading (ppm) | Sample Number | Core Recovery % | Graphic Log | SOIL DESCRIPTION | WELL CONSTRUCTION |
|---|---|---|---|---|---|---|---|---|
| 24.06 | 80 | 22 | 0 | | 100 | | Medium vesicles; no odor; 10YR 2/2 | |
| 18.86 | | 23 | 0.0 | RH-BR-V1D-S02 | 106 | | Medium vesicles; no odor; 10YR 2/2 | |
| 15.66 | | 24 | 0.0 | | 96 | | Large vesicles; no odor; 10YR 2/1 | |
| 10.16 | 90 | | | | | | | |
| 9.56 | | 25 | 0.0 | | 86 | | Small vesicles; no odor; 10YR 2/2 | |
| | | | | | | | Clinker zone 93-100' | |
| 6.56 | | | | | | | | |
| 4.96 | | 26 | 0.0 | | 56 | | Medium vesicles; clinker zone; no odor; 10YR 2/1 | |
| 4.96 | | 27 | 0.0 | RH-BR-V1D-S03 | 50 | | Medium vesicles; clinker zone; no odor; 10YR 2/2 | |
| 2.56 | 100 | | | | | | Clinker zone | |
| | | | | | | | B-V1D terminated at 100.0' | |
| | 110 | | | | | | | |
| | 120 | | | | | | | |
| | 130 | | | | | | | |
| | 140 | | | | | | | |
| | 150 | | | | | | | |

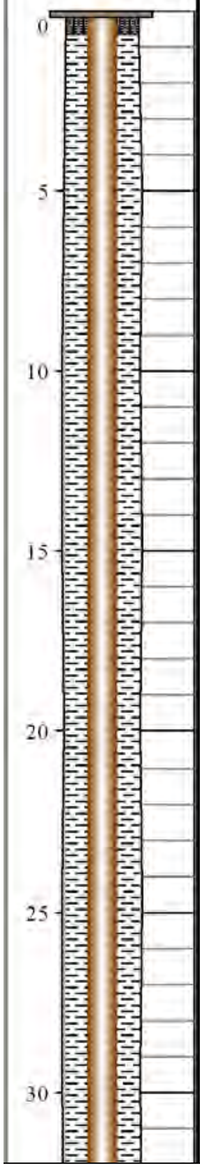


This information pertains only to this boring and sh ot be interpreted as being indicative of the site.

Corrected elevations are provided for angle borings.

# GEOLOGIC BOREHOLE LOG

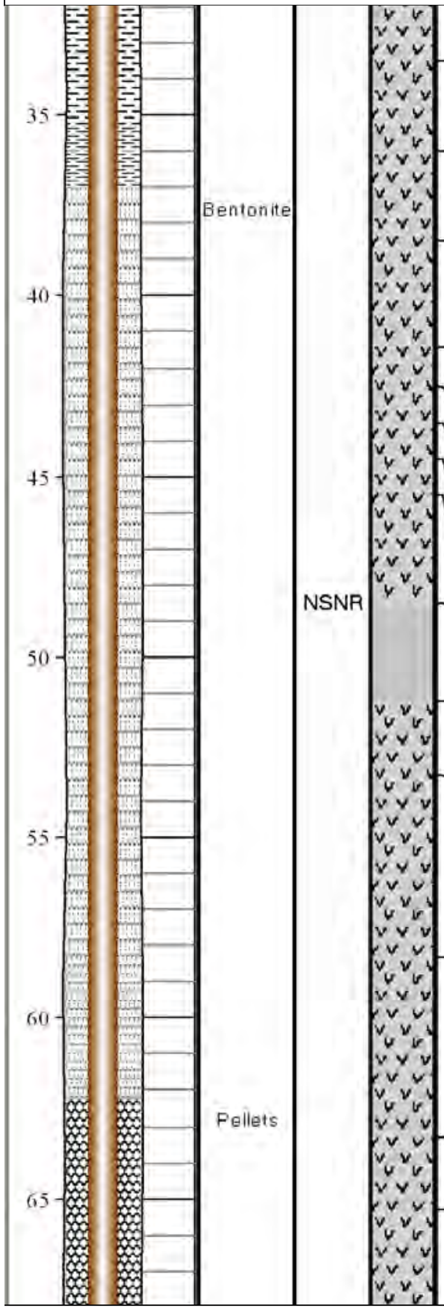
| | | |
|---|---|---|
| Location: **RHSF** | Station Name: **RHMW02** | Location Type: **Monitoring Well** |
| Location Description: **lower access tunnel, N of Tank 6** | Establishing Company: **TEC Inc.** | |
| Drilling Foreman: **Dean McLure** | Drilling Company: **Valley Well Drilling** | |
| Geologist: **N. Griffin/S. MacMillan** | Ground Surface Elevation (ft): **106.57** | Datum: **MSL** |
| Drilling Sampling Method: **Rock Coring** | Borehole Diameter (in): **5** | |
| Total Depth (ft): **103.5** | Date Drilling Started: **27 July 2005** | Date Drilling Ended: **28 July 2005** |
| Remarks: | | |



| Well Construction | Well Fill | USCS | | Soil Description | Soil Sample |
|---|---|---|---|---|---|
| | Cement Grout | CON | | Concrete - gray. | |
| | | FILL | | Sand base. | |
| | | IE | | Basalt boulders. | |
| | | CON | | Concrete - Rate = 5/ 10.5. | |
| | | | | Basalt - brownish black (5YR 2/ 1), RQD = 68.3%, 60% vesicles: 3mm - 7mm, 100% recovery, no odor, PID sample head space: 0 ppm. | |
| | | | | Basalt - brownish black (5YR 2/ 1), Rate = 1/ 4, RQD = 69.4%, 40% vesicles: 5mm - 1cm, 69% recovery, no odor, PID sample head space: 0 ppm. | |
| | | | | Basalt - brownish black (5YR 2/ 1), Rate = 5/ 15, RQD = 100%, 10% vesicles: 0.5cm - 1cm, 100% recovery. | |
| | | | | Basalt - brownish black (5YR 2/ 1), Rate = 5/ 10, RQD = 86.7%, 10% vesicles: 2mm - 4mm, 100% recovery, no odor, PID sample head space: 0 ppm. | |
| | | | | Basalt - brownish black (5YR 2/ 1), Rate = 5/ 5, RQD = 80.8%, 80% vesicles: 1mm - 2mm, 100% recovery. | |
| | | | | Basalt - brownish black (5YR 2/ 1), Rate = 5/ 5, RQD = 80.8%, 60% vesicles: 5mm, 100% recovery, verticle fractures present - possible shearing from drill. | |
| | | | | Basalt - brownish black (5YR 2/ 1), RQD = 43.3%, 75% vesicles: 3mm - 5mm, 100% recovery. | |
| | | | | Basalt - red, RQD = 43.3%, 80% vesicles: 2mm, 100% recovery. | |
| | | IE | | Basalt - dusky brown (5YR 2/ 2), Rate = 5/ 5, RQD = 46.7%, 60% vesicles: 2mm - 3mm, 100% recovery, no odor. | |

# GEOLOGIC BOREHOLE LOG

| | | |
|---|---|---|
| Location: **RHSF** | Station Name: **RHMW02** | Location Type: **Monitoring Well** |
| Location Description: **lower access tunnel, N of Tank 6** | Establishing Company: **TEC Inc.** | |
| Drilling Foreman: **Dean McLure** | Drilling Company: **Valley Well Drilling** | |
| Geologist: **N. Griffin/S. MacMillan** | Ground Surface Elevation (ft): **106.57** | Datum: **MSL** |
| Drilling Sampling Method: **Rock Coring** | Borehole Diameter (in): **5** | |
| Total Depth (ft): **103.5** | Date Drilling Started: **27 July 2005** | Date Drilling Ended: **28 July 2005** |
| Remarks: | | |



Basalt - grayish black (N2). Rate = 5/5. RQD = 81.7%. 40% vesicles: 3mm - 5mm. 100% recovery, no odor, PID sample head space: 0 ppm.

Basalt - grayish black (N2). Rate = 5/5. RQD = 81.7%. 40% vesicles: 3mm - 5mm. 100% recovery, no odor, PID sample head space: 0 ppm.

Basalt - grayish black (N2). Rate = 8/5. RQD = 66.7%. 60% vesicles: 4mm - 10mm. 100% recovery, no odor.

Basalt - grayish black to moderate brown (N2 to 5YR 4/4). Rate = 8/5. RQD = 66.7%. 70% vesicles: 1mm - 4mm. 100% recovery, no odor.

Basalt - grayish black (N2). Rate = 8/5. RQD = 66.7%. 60% vesicles. 100% recovery, no odor.

Basalt - greyish black (N2). Rate = 8/5. RQD = 43.3%. 70% vesicles: 2mm - 4mm. 90% recovery.

Basalt - grayish black (N2). Rate = 8/5. RQD = 43.3%. 50% vesicles: 5mm - 10mm. 90% recovery.

Basalt - grayish black (N2). Rate = 8/5. RQD = 43.3%. 50-70% vesicles: 4mm - 10mm. 90% recovery.

0% recovery.

Basalt - moderate brown to dusky yellowish brown (5YR 4/4 to 10YR 2/2). Rate = 5/10. RQD = 0%. 70-80% vesicles: 2mm - 3mm. 20% recovery, no odor, PID sample head space: 0 ppm, soft drilling.

Basalt - grayish black to blackish red (N2 to 5R 2/2). Rate = 5/10. RQD = 0%. 10% vesicles: 1mm - 5mm. 25% recovery. PID sample head space: 0.4 ppm. clinker zone.

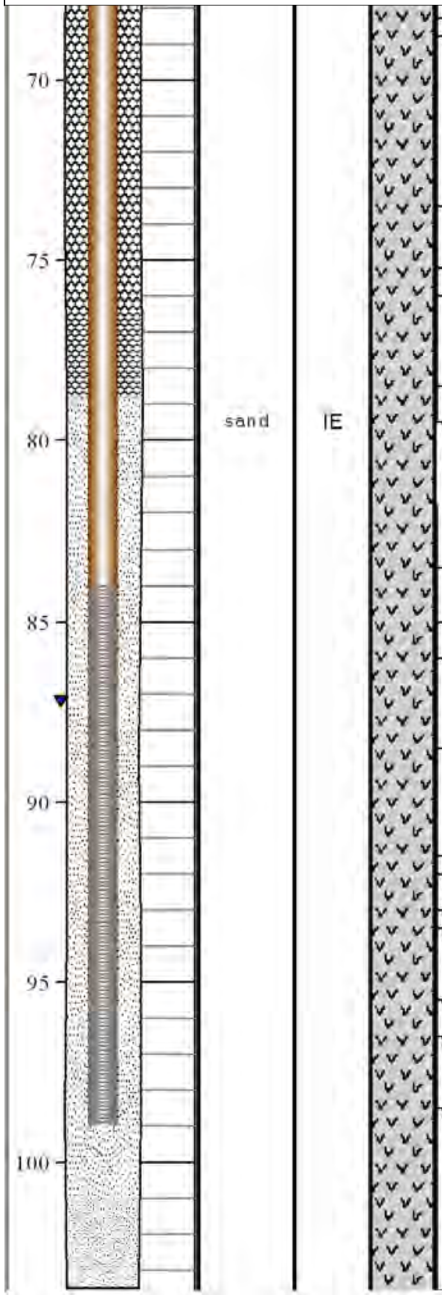
Basalt - grayish black to blackish red (N2 to 5R 2/2). Rate = 5/10. RQD = 0%. 25% vesicles: 1mm - 5mm. 25% recovery. PID sample head space: 0 ppm, clinker zone.

Basalt - grayish black to blackish red (N2 to 5R 2/2). Rate = 8/5. RQD = 40%. 1mm - 5mm. 90% recovery.

Basalt - dark gray (N3). Rate = 8/5. RQD = 40%. 1mm. 90% recovery. PID sample head space: 0 ppm, blue rock.

# GEOLOGIC BOREHOLE LOG

Location: **RHSF**
Station Name: **RHMW02**
Location Type: **Monitoring Well**
Location Description: **lower access tunnel, N of Tank 6**
Establishing Company: **TEC Inc.**
Drilling Foreman: **Dean McLure**
Drilling Company: **Valley Well Drilling**
Geologist: **N. Griffin/S. MacMillan**
Ground Surface Elevation (ft): **106.57**
Datum: **MSL**
Drilling Sampling Method: **Rock Coring**
Borehole Diameter (in): **5**
Total Depth (ft): **103.5**
Date Drilling Started: **27 July 2005**
Date Drilling Ended: **28 July 2005**
Remarks:



Basalt - moderate brown (5YR 3/4), Rate = 5/10, RQD = 63.3%, weathered.

Basalt - medium gray (N5), Rate = 5/10, RQD = 63.3%, 10-20% vesicles: 1mm - 3mm, 100% recovery, core barrel and rods stuck.

Basalt - dark gray (N4), Rate = 15/3, RQD = 16.7%, <10% vesicles: 4mm - 1mm, 75% recovery, blue rock.

Basalt - Has possible natural horizontal fractures, approx. 0.5 - 1" thick.

Basalt - moderate brown (5YR 3/4), Rate = 15/3, RQD = 16.7%, weathered, possible weak zone.

Basalt - moderate brown to grayish brown (5YR 3/4 to 5YR 3/2), Rate = 15/5, RQD = 96.7%.

Basalt - Rate = 15/5, RQD = 96.7%, 80% vesicles. 1st 3 clinker 0.5 diameter subround pieces, grades to vesicular basalt.

Basalt - grayish black (N2), Rate = 15/5, RQD = 96.7%, 2 clinker at 83'2, cream colored center.

Basalt - dark gray (N3), Rate = 15/5, RQD = 63.3%, 80% vesicles: 1mm - 5mm, 100% recovery, no odor, PID sample head space: 2 ppm.

RHMW02S01

Basalt - moderate brown (5YR 3/4), Rate = 15/5, RQD = 63.3%, 90% vesicles: 1mm - 2mm, 100% recovery, no odor, PID sample head space: 2 ppm.

Basalt - dark gray (N2), Rate = 15/5, RQD = 63.3%, 80% vesicles: 1mm - 5mm, 100% recovery, no odor, PID sample head space: 2 ppm.

Basalt - dark gray (N3), Rate = 15/5, RQD = 65%, 90% vesicles: 1mm - 4mm, 100% recovery, no odor, PID sample head space: 0 ppm.

Basalt - moderate brown (5YR 3/4), Rate = 15/5, RQD = 65%, 85% vesicles: 1mm - 3mm, 100% recovery, no odor, PID sample head space: 0 ppm.

Basalt - dark gray (N3), Rate = 15/5, RQD = 65%, 85% vesicles: 1mm - 5mm, 100% recovery, no odor, PID sample head space: 0 ppm.

Basalt - moderate brown to light brown (5YR 3/4 to 5YR 8/6), Rate = 15/5, RQD = 65%, 90% vesicles: 1mm - 3mm, 100% recovery, no odor, PID sample head space: 0 ppm.

Basalt - dark gray to grayish black (N3 to N2), Rate = 15/5, RQD = 60%, 80% vesicles: 1mm - 5mm, 98% recovery, no odor, PID sample head space: 0 ppm.

Basalt - dark gray to grayish black (N3 to N2), Rate = 15/5, RQD = 60%, 65% vesicles: 5mm - 10mm, 98% recovery, no odor, PID sample head space: 0 ppm.

Basalt - dark gray to grayish black (N3 to N2), Rate = 15/5, RQD = 60%, 80% vesicles: 1mm - 5mm, 98% recovery, no odor, PID sample head space: 0 ppm.

Basalt - grayish brown to dark gray (5YR 3/2 to N3), Rate = 20/5, RQD = 63%, 30 - 50% vesicles: 2 mm - 5mm, 11.25% recovery, highly weathered - fractured.

# Well Construction Log

| | | | |
|---|---|---|---|
| **Location:** Red Hill BFSF | **Station ID:** | **Station Name:** RHMW02 | **Date:** 7/27/2005 |
| **Sys_Samp_Code:** | **Elevation:** | **TD:** 103.5' | **Time** **Start:** |
| **Driller:** Dean | **CO.:** VWD | **Date Finished:** 7/28/2005 | **Finish:** |

## Drilling Protocol

| | | | |
|---|---|---|---|
| **Hole Diameter:** 5" | **Drilling Method:** Coring | **Inclination:** 90° | **Azimuth:** n/a |

## Casing

| | | | | |
|---|---|---|---|---|
| **Material:** PVC Sch 80 | **Diameter** | **ID:** 1.939 | **From:** 0' | |
| | | **OD:** 2.375 | **To:** 84' | |

## Screen

| | | | | |
|---|---|---|---|---|
| **Material:** PVC Sch 80 | **Diameter** | **ID:** 1.939 | **From:** 84' | **Slot #:** 0.02 |
| | | **OD:** 2.375 | **To:** 99' | |

## Annular Fill

| | | | | | |
|---|---|---|---|---|---|
| **Sand:** | Monterey #3 **Type** | **Bentonite** | **Chips:** 12 **Bags** | **Grout:** 0 **Bags** | |
| | 4 **Bags** | | **Pellets:** 2 **Bkts** | **Cement:** 10 **Bags** | |

## Surface Casing

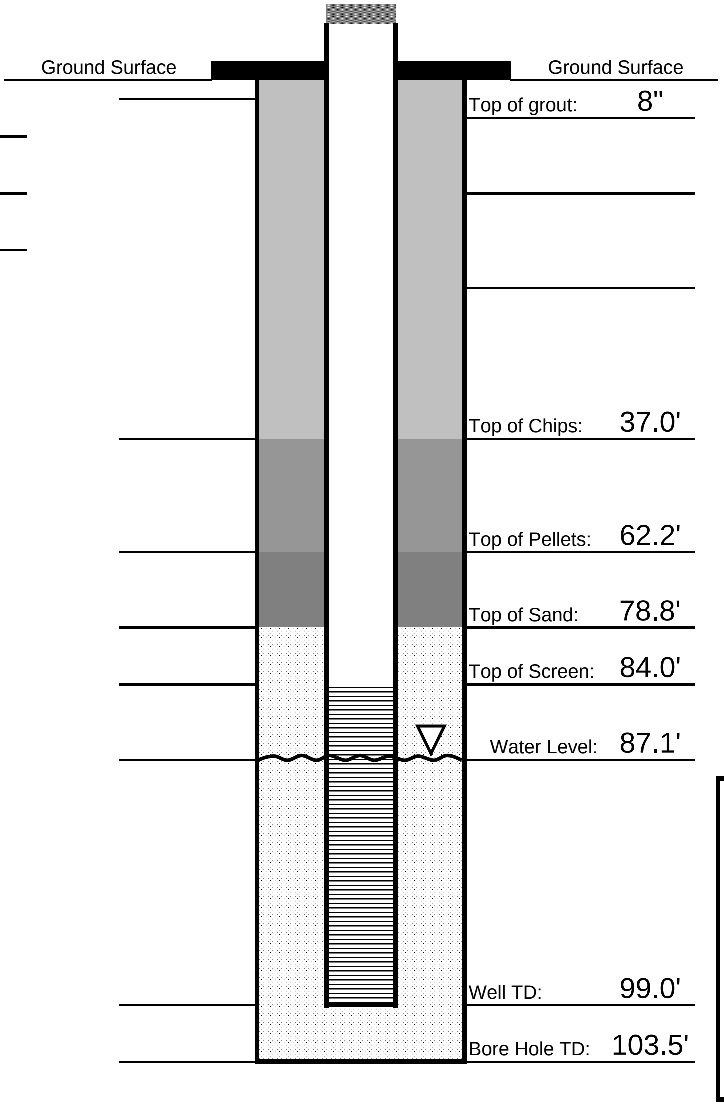
Type: Traffic Cover

Diameter: 12"

Length: 12"

**Estimated Construction**

**Actual Construction**



Top of grout: 8"

Top of Chips: 37.0'

Top of Pellets: 62.2'

Top of Sand: 78.8'

Top of Screen: 84.0'

Water Level: 87.1'

Well TD: 99.0'

Bore Hole TD: 103.5'

Notes:

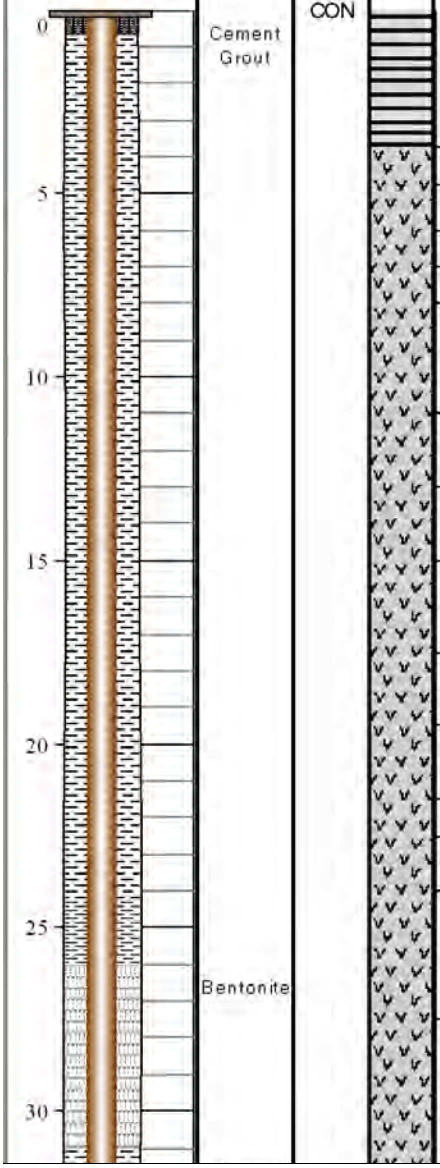
Borehole caved in to 99'

■ Cement
▒ Grout
▒ B. Chips
▓ B. Pellets
░ Sand

# GEOLOGIC BOREHOLE LOG

| | | |
|---|---|---|
| Location: **RHFSF** | Station Name: **RHMW03** | Location Type: **Monitoring Well** |
| Location Description: **lower access tunnel, N of Tank 14** | Establishing Company: **TEC Inc.** | |
| Drilling Foreman: **Tim Robertson** | Drilling Company: **Valley Well Drilling** | |
| Geologist: **N. Griffin/S. MacMillan** | Ground Surface Elevation (ft): **122.11** | Datum: **MSL** |
| Drilling Sampling Method: **Rock Coring** | Borehole Diameter (in): **5** | |
| Total Depth (ft): **118** | Date Drilling Started: **2 September 2005** | Date Drilling Ended: **7 September 2005** |
| Remarks: | | |

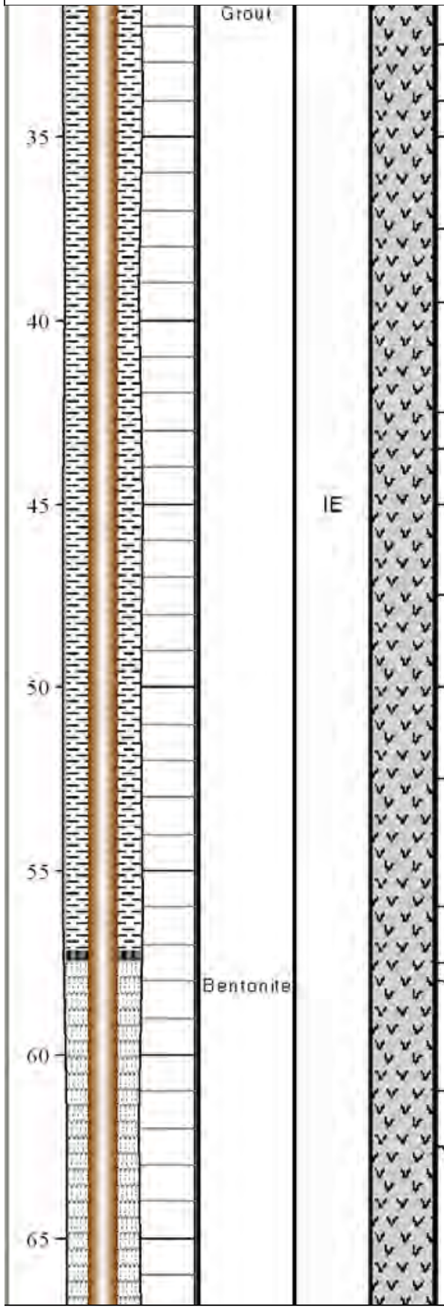
Well Construction | Well Fill | USCS



| Soil Description | Soil Sample |
|---|---|
| Concrete. | |
| Basalt - dark gray to grayish brown (N3 to 5YR 3/2), Rate = 1/30, RQD = 33%, 80% vesicles: 1mm - 2mm, 100% recovery, PID sample head space: 0 ppm. | |
| Basalt - grayish black (N2), Rate = 3/10, RQD = 73%, 70 - 90% vesicles: 1mm - 2mm, 100% recovery, PID sample head space: 0 ppm. | |
| Basalt - moderate brown (5YR 3/4), Rate = 3/10, RQD = 73%, 70 - 90% vesicles: 1mm - 2mm, 100% recovery, PID sample head space: 0 ppm. | |
| Basalt - dark gray (N3), Rate = 3/10, RQD = 73%, 30 - 80% vesicles: 1 mm - 10mm, 100% recovery, PID sample head space: 0 ppm. | |
| Basalt - dark gray (N3), Rate = 3/10, RQD = 90%, 30 - 80% vesicles: 1 mm - 10mm, 100% recovery, PID sample head space: 0 ppm. | |
| Basalt - moderate brown (5YR 3/4), Rate = 3/10, RQD = 90%, 70 - 90% vesicles: 1 mm - 5mm, 100% recovery, PID sample head space: 0 ppm. | |
| Basalt - light brown (5YR 5/6), Rate = 4.5/12, RQD = 11%, 75 - 95% vesicles: 1 mm - 3mm, 66% recovery, PID sample head space: 0 ppm. | |
| Basalt - dark gray (N3), Rate = 4.5/12, RQD = 11%, 80 - 90% vesicles: 1 mm - 5mm, 66% recovery, PID sample head space: 0 ppm. | |
| Basalt - soft gray, Rate = 1/3, RQD = 42%, highly vessicular, 100% recovery. | |
| Basalt - soft gray, Rate = 1/3, RQD = 42%, 100% recovery. | |
| Basalt - soft gray, Rate = 1/3, RQD = 42%, highly vessicular, soft - fractured, 100% recovery. | |
| Basalt - red to soft gray, Rate = 5/18, RQD = 48%, vessicular, 100% recovery. | |
| Basalt - red, Rate = 5/18, RQD = 48%, vessicular, soft - fractured, 100% recovery. | |
| Basalt - red to soft gray, vessicular, fractured, poor recovery, clinker zone. | |

# GEOLOGIC BOREHOLE LOG

| | | |
|---|---|---|
| Location: **RHFSF** | Station Name: **RHMW03** | Location Type: **Monitoring Well** |
| Location Description: **lower access tunnel, N of Tank 14** | Establishing Company: **TEC Inc.** | |
| Drilling Foreman: **Tim Robertson** | Drilling Company: **Valley Well Drilling** | |
| Geologist: **N. Griffin/S. MacMillan** | Ground Surface Elevation (ft): **122.11** | Datum: **MSL** |
| Drilling Sampling Method: **Rock Coring** | Borehole Diameter (in): **5** | |
| Total Depth (ft): **118** | Date Drilling Started: **2 September 2005** | Date Drilling Ended: **7 September 2005** |
| Remarks: | | |



Basalt - gray to red. Rate = 5/10. RQD = 50%, poor recovery, clinker zone.

Basalt - gray to red. Rate = 5/10. RQD = 50%, vessicular. 75% recovery.

Basalt - gray to red. Rate = 5/10. RQD = 50%, vessicular. 75% recovery.

Basalt - Rate = 5/11. Clinker.

Basalt - gray to red. Rate = 5/11. RQD = 60%, very vessicular. 80% recovery.

Basalt - gray to red. Rate = 5/10. RQD = 70%, 83% recovery.

Basalt - red to gray. Rate = 5/10. RQD = 70%, poor recovery, clinker.

Basalt - red to gray. Rate = 5/10. RQD = 70%, soft. 83% recovery.

Basalt - gray, RQD = 50%, glassy, 50% recovery, PID sample head space: 0 ppm.

Basalt - no recovery, clinker.

Basalt - hard fragmented material, very poor recovery, slow drilling, started in clinker.

Basalt - gray, hard.

Basalt - hard drilling, rubble zone.

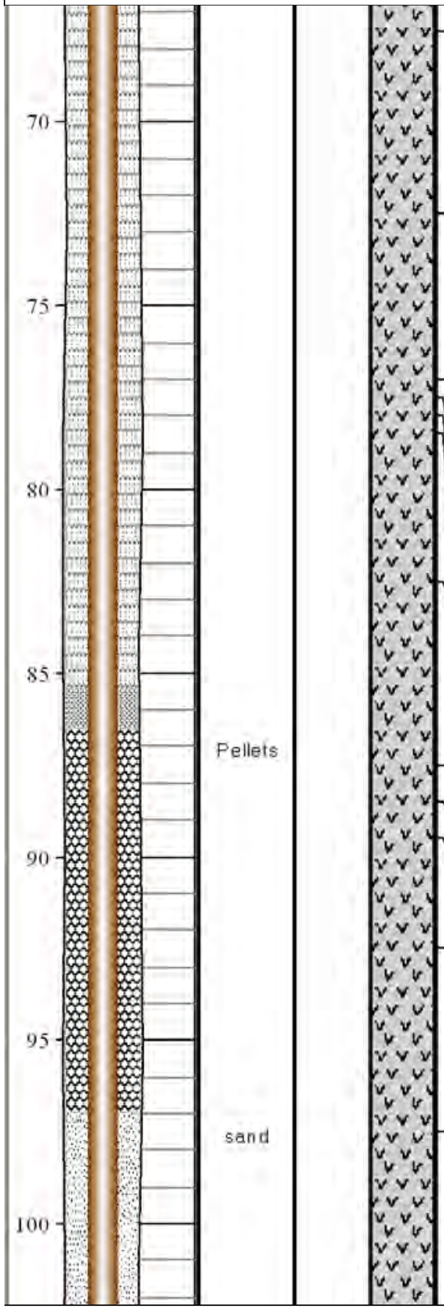
Basalt - medium dark gray (N4). Rate = 3/63. RQD = 0%. 30 - 50% vesicles: 3 mm - 8 mm. 50% recovery. PID sample head space: 0 ppm.

Basalt - grayish black (N2). Rate = 1.5/30. RQD = 0%. 5% vesicles: 2 mm - 3 mm. 100% recovery, no odor. PID sample head space: 0 ppm, mechanically fractured blue stone, rubble at last 2 on top.

Basalt - grayish black (N2). Rate = 3/30, RQD = 18%, 5 - 10% vesicles: 2 mm - 3 mm, 60% recovery, no odor, PID sample head space: 0 ppm, mechanically fractured blue stone.

# GEOLOGIC BOREHOLE LOG

| | | |
|---|---|---|
| Location: **RHFSF** | Station Name: **RHMW03** | Location Type: **Monitoring Well** |
| Location Description: **lower access tunnel, N of Tank 14** | Establishing Company: **TEC Inc.** | |
| Drilling Foreman: **Tim Robertson** | Drilling Company: **Valley Well Drilling** | |
| Geologist: **N. Griffin/S. MacMillan** | Ground Surface Elevation (ft): **122.11** | Datum: **MSL** |
| Drilling Sampling Method: **Rock Coring** | Borehole Diameter (in): **5** | |
| Total Depth (ft): **118** | Date Drilling Started: **2 September 2005** | Date Drilling Ended: **7 September 2005** |
| Remarks: | | |



Basalt - grayish black (N2). Rate = 5/30. RQD = 10%. 5 - 10% vesicles: 2 mm - 3 mm. 60% recovery. no odor. PID sample head space: 0 ppm. mechanically fractured blue stone.

Basalt - grayish black (N2). Rate = 5/26. RQD = 0%. 5 - 10% vesicles: 1 mm - 5mm. 80% recovery. no odor. PID sample head space: 0 ppm. mechanically fractured blue stone.

Basalt - grayish black (N2). Rate = 5/26. RQD = 0%. 1% vesicles: 2 mm. 80% recovery. no odor. PID sample head space: 0 ppm. mechanically fractured blue stone.

Basalt - dusky yellowish brown (10YR 3/2). Rate = 5/25. RQD = 0%. 30% vesicles: 1 mm. 60% recovery. no odor.

Basalt - light brown (5YR 5/6). Rate = 5/25. RQD = 0%. 30% vesicles: 1 mm. 60% recovery. no odor.

Basalt - grayish black (N2). Rate = 5/25. RQD = 0%. 3 - 5% vesicles: 1 mm - 2 mm. 60% recovery. no odor.

Basalt - medium dark gray (N4). Rate = 5/25. RQD = 33%. 60% vesicles: 1 mm. 67% recovery. no odor.

Basalt - grayish black (N2). Rate = 5/19. RQD = 45%. 75% vesicles: 1 mm. 87% recovery.

Basalt - grayish black (N2). Rate = 5/19. RQD = 45%. 75% vesicles: 1 mm. 87% recovery.

Basalt - brownish gray (5YR 4/1). Rate = 5/19. RQD = 45%. 80% vesicles: 1 mm. 87% recovery. highly fractured softer basalt.

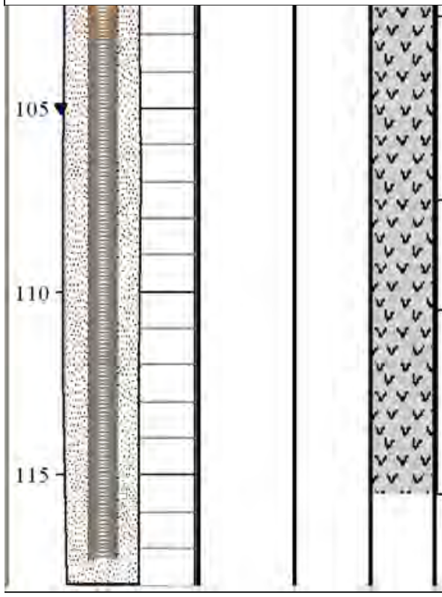
Basalt - dark gray w/ some light brown clay (N3 w/ 5YR 5/6). Rate = 5/40. RQD = 8.3%. 50 - 60% vesicles: 1 mm - 10 mm. 68% recovery. no odor. PID sample head space: 0 ppm.

RHMW03S01

Basalt - dark gray (N3). Rate = 5/20. RQD = 15%. 40 - 60% vesicles: 1 mm - 10 mm. 35% recovery. poor recovery. possible void - noted quick drop while drilling approx. 6.

# GEOLOGIC BOREHOLE LOG

| | | |
|---|---|---|
| Location: **RHFSF** | Station Name: **RHMW03** | Location Type: **Monitoring Well** |
| Location Description: **lower access tunnel, N of Tank 14** | Establishing Company: **TEC Inc.** | |
| Drilling Foreman: **Tim Robertson** | Drilling Company: **Valley Well Drilling** | |
| Geologist: **N. Griffin/S. MacMillan** | Ground Surface Elevation (ft): **122.11** | Datum: **MSL** |
| Drilling Sampling Method: **Rock Coring** | Borehole Diameter (in): **5** | |
| Total Depth (ft): **118** | Date Drilling Started: **2 September 2005** | Date Drilling Ended: **7 September 2005** |
| Remarks: | | |



Basalt - dark gray (N3). Rate = 5/ 20. RQD = 28%. 40 - 50% vesicles: 1 mm - 8 mm, 85% recovery, no odor. PID sample head space: 0 ppm.

Basalt - dark gray (N3). Rate = 5/ 20. no recovery. one small piece of basalt. some med. grained sand pieces.

Basalt - dark gray (N3). Rate = 5/ 13. RQD = 0%. 40% vesicles: 1 mm - 5 mm. 10% recovery. poor recovery.

# Well Construction Log

Page 1 of 1

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Location:** | Red Hill BFSF | **Station ID:** | | **Station Name:** | RHMW03 | **Date:** | 9/2/2005 |
| **Sys_Samp_Code:** | | **Elevation:** | | **TD:** | 118.0' | **Time** | **Start:** |
| **Driller:** | Tim | **CO.:** | VWD | **Date Finished:** | 9/7/2005 | | **Finish:** |

### Drilling Protocol

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Hole Diameter:** | 5" | **Drilling Method:** | Coring | **Inclination:** | 90° | **Azimuth:** | n/a |

### Casing

| | | | | | | |
|---|---|---|---|---|---|---|
| **Material:** | PVC Sch 80 | **Diameter** | **ID:** | 1.939" | **From:** | 0' |
| | | | **OD:** | 2.375" | **To:** | 102.3' |

### Screen

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Material:** | PVC Sch 80 | **Diameter** | **ID:** | 1.939" | **From:** | 102.3' | **Slot #:** | 0.02 |
| | | | **OD:** | 2.375" | **To:** | 117.3' | | |

### Annular Fill

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sand:** | Monterey #3 | **Type** | **Bentonite** | **Chips:** | 8 | **Bags** | **Grout:** | 0.5 | **Bags** | |
| | 2 | **Bags** | | **Pellets:** | 1.5 | **Bkts** | **Cement:** | 9 | **Bags** | |

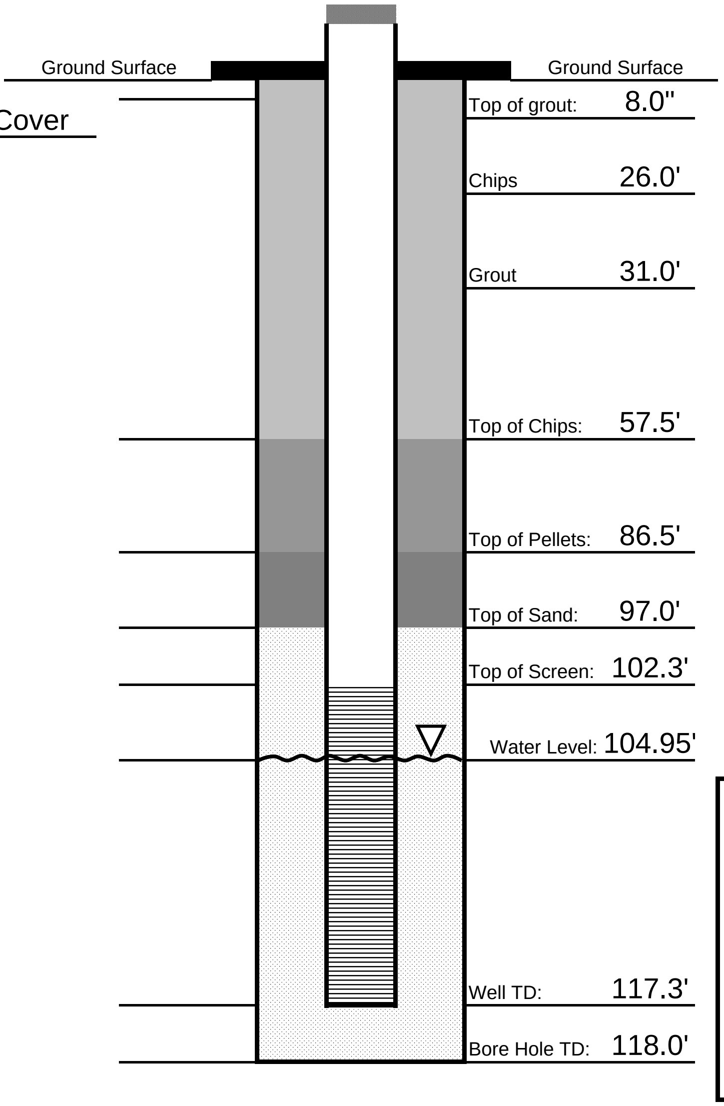
**Estimated Construction** **Actual Construction**

## Surface Casing

Type: Flush Traffic Cover

Diameter: 12"

Length: 12"



Top of grout: 8.0"

Chips 26.0'

Grout 31.0'

Top of Chips: 57.5'

Top of Pellets: 86.5'

Top of Sand: 97.0'

Top of Screen: 102.3'

Water Level: 104.95'

Well TD: 117.3'

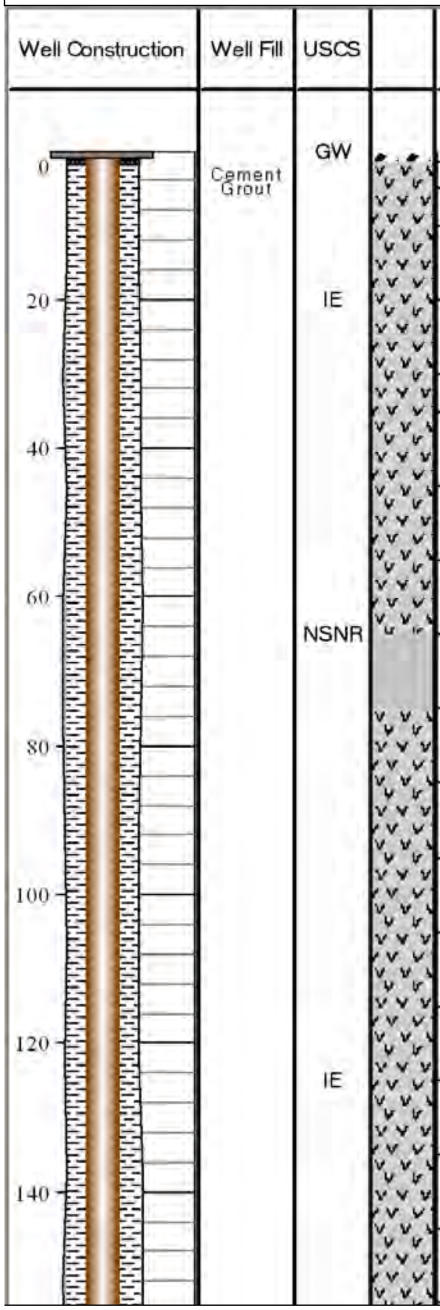
Bore Hole TD: 118.0'

Notes:

- ■ Cement
- ▨ Grout
- ▨ B. Chips
- ▨ B. Pellets
- ░ Sand

# GEOLOGIC BOREHOLE LOG

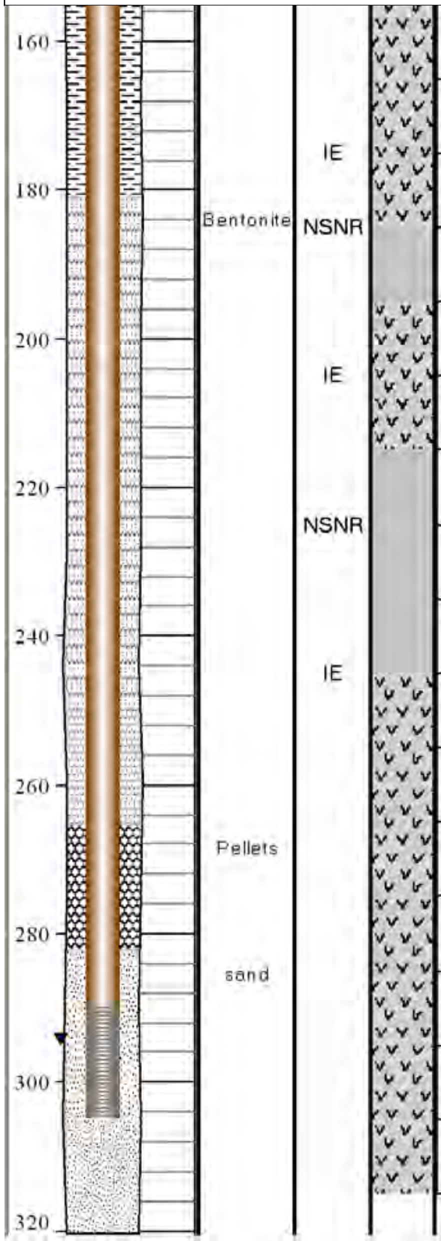
| | | |
|---|---|---|
| Location: **RHFSF** | Station Name: **RHMW04** | Location Type: **Monitoring Well** |
| Location Description: **west. access rd., S of Navy Firing Range** | Establishing Company: **TEC Inc.** | |
| Drilling Foreman: **Tomas Fernandez** | Drilling Company: **Valley Well Drilling** | |
| Geologist: **N. Griffin/S. MacMillan** | Ground Surface Elevation (ft): **313.03** | Datum: **MSL** |
| Drilling Sampling Method: **Rock Coring** | Borehole Diameter (in): **8** | |
| Total Depth (ft): **320.5** | Date Drilling Started: **22 July 2005** | Date Drilling Ended: **26 July 2005** |
| Remarks: | | |



| Soil Description | Soil Sample |
|---|---|
| Well-graded gravel with sand - dark reddish brown (5YR 2.5/2), medium stiff, moist, 80% gravel, 15% fines, 5% fines, road base. | RHMW04S02 |
| Basalt bedrock. | |
| Basalt - moderate brown (5YR 3/4), Rate = 5/5, 50 - 80% vesicles. | |
| Basalt - dark gray (blue rock) (N3), Rate = 5/10, massive, 5% small crystals. | |
| Basalt - dark gray (N3), Rate = 5/10, 70 - 90% vesicles:small. | |
| Basalt - dark gray (N3), Rate = 5/7, massive. | |
| Basalt - dark gray (N3), Rate = 5/10, 70 - 90% vesicles. | |
| Basalt - dark gray (N3), Rate = 5/10, vesicles. | |
| Basalt - dark gray (N3), Rate = 5/10, vesicles. | |
| Basalt - dark gray (N3), Rate = 5/12, vesicles. | |
| Rate = 5/18, no recovery. | |
| Basalt - moderate brown to dark gray (5YR 3/4 to N3), Rate = 5/12, vesicles. | |
| Basalt - dark gray (N3), Rate = 5/16, vesicles with min. deposits, Perched water encountered - to approx. 130 feet. | |
| Basalt - dark gray (N3), Rate = 5/15, massive. | |
| Basalt - dark reddish brown to dark gray (10YR 3/4 to N3), Rate = 5/20, vesicles. | |
| Basalt - medium dark gray to dark gray (N4 to N3), Rate = 5/15, vesicles. | |
| Basalt - dark reddish brown to dark gray (10YR 3/4 to N3), Rate = 5/15, massive and vesicles. | |
| Basalt - dark reddish brown (10YR 3/4), Rate = 5/10, vesicles. | |
| Basalt - dark gray (N3), Rate = 5/12, vesicles. | |

# GEOLOGIC BOREHOLE LOG

| | | |
|---|---|---|
| Location: **RHFSF** | Station Name: **RHMW04** | Location Type: **Monitoring Well** |
| Location Description: **west. access rd., S of Navy Firing Range** | Establishing Company: **TEC Inc.** | |
| Drilling Foreman: **Tomas Fernandez** | Drilling Company: **Valley Well Drilling** | |
| Geologist: **N. Griffin/S. MacMillan** | Ground Surface Elevation (ft): **313.03** | Datum: **MSL** |
| Drilling Sampling Method: **Rock Coring** | Borehole Diameter (in): **8** | |
| Total Depth (ft): **320.5** | Date Drilling Started: **22 July 2005** | Date Drilling Ended: **26 July 2005** |
| Remarks: | | |



Basalt - dark gray (N3). Rate = 5/5. vesicles.

Basalt - dark gray (N3). Rate = 5/15. vesicles.

Basalt - dark gray (N3). Rate = 5/30. vesicles.

Rate = 5/14. No recovery.

Basalt - dark gray (N3). Rate = 5/10. vesicles.

Basalt - dark gray (N3). Rate = 5/13. vesicles.

Rate = 5/10. No recovery.

Rate = 5/15. No recovery.

Rate = 5/12. No recovery.

Basalt - dark gray (N3). Rate = 5/12. vesicles.

Basalt - medium dark gray (N4). Rate = 5/10. vesicles.

Basalt - medium dark gray (N4). Rate = 5/10. vesicles.

Basalt - medium dark gray (N4). Rate = 5/10. vesicles.

Basalt - dark gray (N3). Rate = 5/10. vesicles.

Basalt - dark gray (N3). Rate = 5/10. vesicles.

Basalt - dark gray to blackish red (N3 to 5R 2/2). Rate = 5/8. vesicles. water at 311'.

# Well Construction Log

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Location:** | Red Hill BFSF | **Station ID:** | | **Station Name:** | RHMW04 | **Date:** | 7/22/2005 |
| **Sys_Samp_Code:** | | **Elevation:** | | **TD:** | 320.5' | **Time** **Start:** | |
| **Driller:** | Tomas | **CO.:** | VWD | **Date Finished:** | 7/26/2005 | **Finish:** | |

## Drilling Protocol

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Hole Diameter:** | 8" | **Drilling Method:** | Air Rotary | **Inclination:** | 90° | **Azimuth:** | n/a |

## Casing

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Material:** | PCV Sch 80 | **Diameter** | **ID:** | 3.826" | **From:** | 0' | |
| | | | **OD:** | 4.5" | **To:** | 290' | |

## Screen

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Material:** | PCV Sch 80 | **Diameter** | **ID:** | 3.826" | **From:** | 290' | **Slot #:** | 0.02 |
| | | | **OD:** | 4.5" | **To:** | 305' | | |

## Annular Fill

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Sand:** | Monterey #3 | **Type** | **Bentonite** | **Chips:** | 16 | **Bags** | **Grout:** | 2 | **Bags** | |
| | 6 | **Bags** | | **Pellets:** | 6 | **Bkts** | **Cement:** | 40 | **Bags** | |

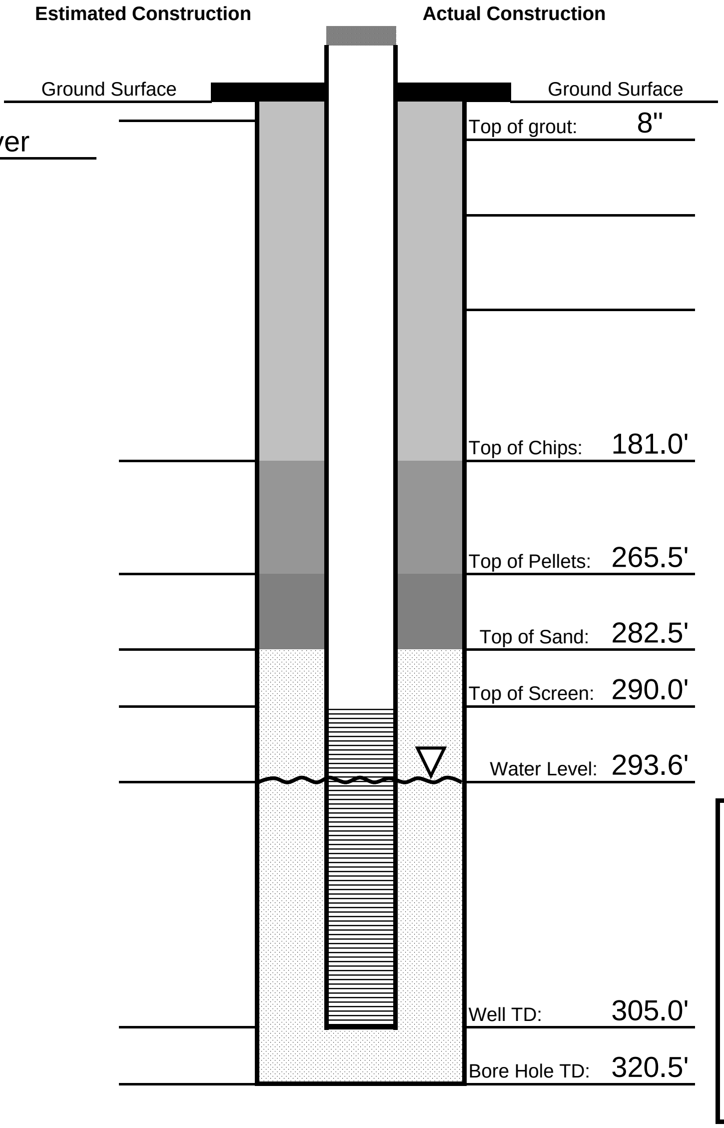
### Surface Casing

Type: Traffic Cover

Diameter: 12"

Length: 12"

Pad: 3X3

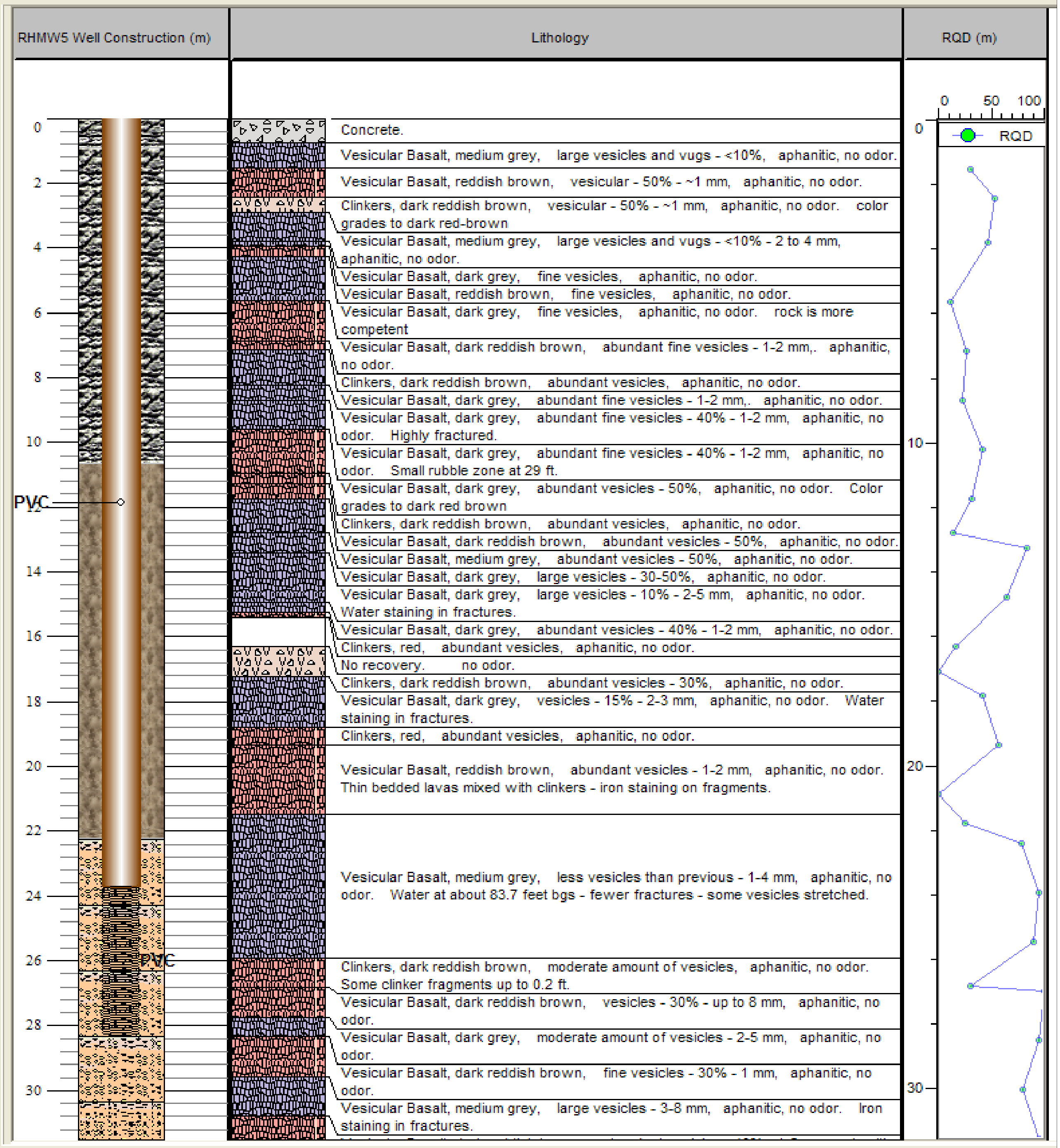


| | |
|---|---|
| ■ | Cement |
| ▒ | Grout |
| ▒ | B. Chips |
| ▓ | B. Pellets |
| ░ | Sand |

Notes:

| | | | |
|---|---|---|---|
| **Project Name:** | Red Hill Bulk Fuel Storage Facility, LTM 2009 | | |
| **Contract No:** | N47408-04-D-8514, T.O. 54 | **Location:** | At Bend in Lower Tunnel Between Adit 3 and Adit 5 |
| **Well Identifier:** | RHMW05 | **Drilling Technique:** | Air Rotary Coring |
| **Start Date:** | April 10, 2009 | **Bit Type/Size:** | Diamond Core /4.8-inches diam |
| **End Date:** | April 24, 2009 | **Filter Pack:** | 1 mm,<br>silica sand |
| **Completion Type:** | Flush Mounted | | |
| **Riser Material:** | 2-inch, Schedule 80 PVC, flush threaded | **Annular Seal:** | Bentonite Chips/Pellets |
| **Screen Material:** | 2-inch, Schedule 80 PVC, 0.02 slot size | **Groundwater Elevation** | |
| **Screened Interval:** | 78 ft to 93 ft below ground surface | **Range between 7/14/2009 and 3/25/2010** | |

| **Coordinates (m):** | Northing | Easting | Elevation | |
|---|---|---|---|---|
| NAD 83, HI State Plane, Zone 3, FIPS 5103 | 22,461 | 510,317 | 31 | 83.09 to 83.96 ft below top of casing |



Concrete.

Vesicular Basalt, medium grey, large vesicles and vugs - <10%, aphanitic, no odor.

Vesicular Basalt, reddish brown, vesicular - 50% - ~1 mm, aphanitic, no odor.

Clinkers, dark reddish brown, vesicular - 50% - ~1 mm, aphanitic, no odor. color grades to dark red-brown

Vesicular Basalt, medium grey, large vesicles and vugs - <10% - 2 to 4 mm, aphanitic, no odor.

Vesicular Basalt, dark grey, fine vesicles, aphanitic, no odor.

Vesicular Basalt, reddish brown, fine vesicles, aphanitic, no odor.

Vesicular Basalt, dark grey, fine vesicles, aphanitic, no odor. rock is more competent

Vesicular Basalt, dark reddish brown, abundant fine vesicles - 1-2 mm,. aphanitic, no odor.

Clinkers, dark reddish brown, abundant vesicles, aphanitic, no odor.

Vesicular Basalt, dark grey, abundant fine vesicles - 1-2 mm,. aphanitic, no odor.

Vesicular Basalt, dark grey, abundant fine vesicles - 40% - 1-2 mm, aphanitic, no odor. Highly fractured.

Vesicular Basalt, dark grey, abundant fine vesicles - 40% - 1-2 mm, aphanitic, no odor. Small rubble zone at 29 ft.

Vesicular Basalt, dark grey, abundant vesicles - 50%, aphanitic, no odor. Color grades to dark red brown

Clinkers, dark reddish brown, abundant vesicles, aphanitic, no odor.

Vesicular Basalt, dark reddish brown, abundant vesicles - 50%, aphanitic, no odor.

Vesicular Basalt, medium grey, abundant vesicles - 50%, aphanitic, no odor.

Vesicular Basalt, dark grey, large vesicles - 30-50%, aphanitic, no odor.

Vesicular Basalt, dark grey, large vesicles - 10% - 2-5 mm, aphanitic, no odor. Water staining in fractures.

Vesicular Basalt, dark grey, abundant vesicles - 40% - 1-2 mm, aphanitic, no odor.

Clinkers, red, abundant vesicles, aphanitic, no odor.

No recovery. no odor.

Clinkers, dark reddish brown, abundant vesicles - 30%, aphanitic, no odor.

Vesicular Basalt, dark grey, vesicles - 15% - 2-3 mm, aphanitic, no odor. Water staining in fractures.

Clinkers, red, abundant vesicles, aphanitic, no odor.

Vesicular Basalt, reddish brown, abundant vesicles - 1-2 mm, aphanitic, no odor. Thin bedded lavas mixed with clinkers - iron staining on fragments.

Vesicular Basalt, medium grey, less vesicles than previous - 1-4 mm, aphanitic, no odor. Water at about 83.7 feet bgs - fewer fractures - some vesicles stretched.

Clinkers, dark reddish brown, moderate amount of vesicles, aphanitic, no odor. Some clinker fragments up to 0.2 ft.

Vesicular Basalt, dark reddish brown, vesicles - 30% - up to 8 mm, aphanitic, no odor.

Vesicular Basalt, dark grey, moderate amount of vesicles - 2-5 mm, aphanitic, no odor.

Vesicular Basalt, dark reddish brown, fine vesicles - 30% - 1 mm, aphanitic, no odor.

Vesicular Basalt, medium grey, large vesicles - 3-8 mm, aphanitic, no odor. Iron staining in fractures.

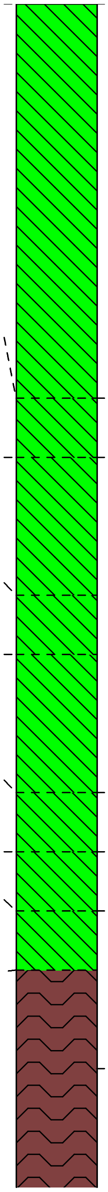
**TEC Representative :** Robert Whittier, P.G.

**Driller:** Tomas Fernandez; Valley Well Drilling, Inc.

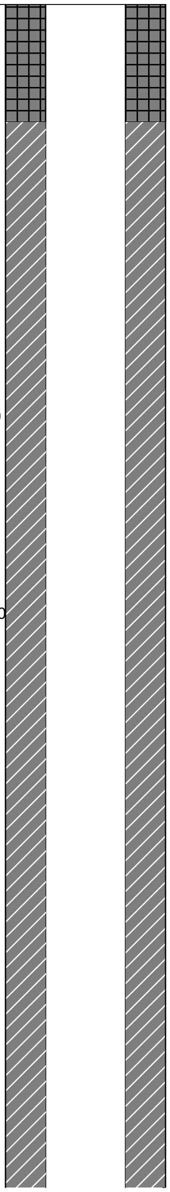
| | | | |
|---|---|---|---|
| **GEOLOGIC LOG** | DATE STARTED: 28-Aug-14<br>DATE COMPLETED: 17-Sept-14 | LOGGER: TM Jensen<br>WEATHER: 90 degrees Fahrenheit | PAGE 1 OF 10<br>WELL NO.: RHMW06 |
| COMPANY NAME: **PARSONS** | | DRILLING SUBCONTRACTOR: Valley Well Drilling | SURFACE ELEV.: 255.81 ft amsl |
| OFFICE LOCATION: South Jordan, Utah | | DRILL RIG TYPE: Mobile B-59 and B-90 | SOUNDING TUBE ELEV.: 259.01 ft |
| PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01 | | DRILLING METHOD: Auger, HQ core, Air Rotary | NORTHING: 75327.83 |
| LOCATION: Red Hill BFSF, HI | JOB NUMBER: 749435 | BOREHOLE DIAMETER: 6 & 12"Auger, 4" Core, 8" Air | EASTING: 1676274.17 |

| DEPTH (ft bgs) | DESCRIPTION OF MATERIALS | ERPIMS LITHO-LOGIC CODE | PID HS, ppmv (DEPTH, ft bgs) | BLOW COUNT/ RQD |
|---|---|---|---|---|
| 0<br>5 | (0.0, 10.0) Clay | CLAY | | |
| 10 | (10.0, 11.5) Clay: dark brown, CL, little silt, plastic, small rounded pebbles, poor recovery, Note: basalt cobbles and boulders within clay are present from ground surface to the saprolite contact | CLAY | 0.0 | 12/19/19 |
| | (11.5, 15.0) Clay | CLAY | | |
| 15 | (15.0, 16.5) Clay: dark yellowish brown, CH, stiff, plastic, small angular rock fragments, poor recovery | | | 21/25/100 for 4" |
| | (16.5, 20.0) Clay | | | |
| 20 | (20.0, 21.5) Clay: dark yellowish brown to gray, friable, dry | CLAY | 0.0 | |
| | (21.5, 23.0) Clay | CLAY | 0.0 | |
| | (23.0, 24.5) Clay: gray basalt in tip, cobble (?), only tip recovery | SAPR | 0.0 | |
| 25<br>30 | (24.5, 35.0) Saprolite: start coring, in and out of weathered basalt and saprolite, mottled yellowish to dark yellowish brown saprolite, thin bands of gray vesicular basalt, solid rock contact at about 35 feet bgs, NOTE: THE GSA ROCK COLOR CHART (1991) WAS USED FOR THE FOLLOWIING WET COLOR DESCRIPTIONS | VLBA | 0.0 | |

GRAPHIC LOG



WELL CONSTRUCTION (ft bgs)



WELL CONSTRUCTION INFORMATION

SURFACE COMPLETION: 3.5' x 3.5' x 2' concrete pad w/ 8" above-ground steel casing

WELL CASING:

| | |
|---|---|
| Material: | SCH. 80 PVC |
| Diameter: | 4" |
| Interval: | +3.2-230 bgs |

WELL SCREEN:

| | |
|---|---|
| Material: | SCH. 80 PVC |
| Screen Opening: | 0.020 |
| Diameter: | 4" |
| Interval: | 230-260 bgs |

CONDUCTOR CASING:

| | |
|---|---|
| Material: | PVC |
| Diameter: | 10" |
| Interval: | 0-40 bgs |

DEPTH INTERVAL:

| | |
|---|---|
| Concrete: | 0-3 |
| Cement Grout: | 3-40 bgs |
| Bentonite Chips: | 40-215 bgs |
| Bentonite Seal: | 215-223 bgs |
| Sand Pack: | 223-269 bgs |
| Hole Cuttings: | 269-270 bgs |

**NOTE:** All intervals are measured from ground surface.

amsl - Above Mean Sea Level
bgs - Below Ground Surface
ft - feet
mm - millimeter(s)
N/A - Not Applicable
NS - Not Sampled
PID - Photoionization Detector
ppmv - Parts per Million, Volume per Volume
SAA - Same as Above
Horizontal Survey System: NAD 83 Epoch 2010.0
Elevations: Local Mean Sea Level (feet)

DP - Direct Push
HSA - Hollow Stem Auger
SSA - Solid Stem Auger
TD - Total Depth
HS - Head Space
ERPIMS CODE DESCRIPTIONS:
ASPT - Asphalt
CLAY - Clay
CLGV - Clay and Gravel
CLSD - Clay and Sand
CLSL - Clay and Silt

CN - Concrete
COBL - Cobble or Boulder
CORL - Coral
FILL - Fill or other Man-Made Deposits
GVL - Gravel
GVLP - Gravel, predominantly pebble-sized
GVSL - Gravel and Silt
NDPS - No Description Provided, Problems in Sampling
NSNR - No Sample or No Recovery Obtained
PTHM - Peat, Humus, and other Organic Material
SAPR - Saprolite

SD - Sand
SDSL - Sand and Silt
SDGR - Sand and Gravel
SEDU - Sedimentary (Undifferentiated)
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SLGV - Silt and Gravel
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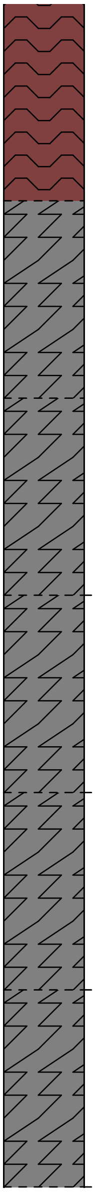
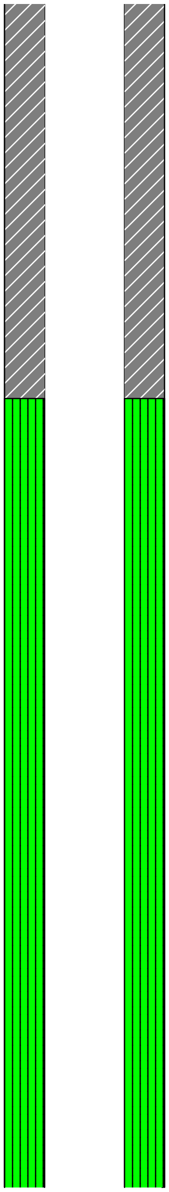
VLBA - Basalt, Lava
VLTF - Volcanic Tuff

| | | | |
|---|---|---|---|
| **GEOLOGIC LOG** | DATE STARTED: 28-Aug-14<br>DATE COMPLETED: 17-Sept-14 | LOGGER: TM Jensen<br>WEATHER: 90 degrees Fahrenheit | PAGE 2 OF 10<br>WELL NO.: RHMW06 |
| COMPANY NAME: **PARSONS**<br>OFFICE LOCATION: South Jordan, Utah | | DRILLING SUBCONTRACTOR: Valley Well Drilling<br>DRILL RIG TYPE: Mobile B-59 and B-90 | SURFACE ELEV.: 255.81 ft amsl<br>SOUNDING TUBE ELEV.: 259.01 ft |
| PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01<br>LOCATION: Red Hill BFSF, HI | JOB NUMBER: 749435 | DRILLING METHOD: Auger, HQ core, Air Rotary<br>BOREHOLE DIAMETER: 6 & 12"Auger, 4" Core, 8" Air | NORTHING: 75327.83<br>EASTING: 1676274.17 |

| DEPTH (ft bgs) | DESCRIPTION OF MATERIALS | GRAPHIC LOG | ERPIMS LITHO-LOGIC CODE | PID HS, ppmv (DEPTH, ft bgs) | BLOW COUNT/ RQD | WELL CONSTRUCTION (ft bgs) | WELL CONSTRUCTION INFORMATION |
|---|---|---|---|---|---|---|---|
| 30 | | | | | | | |
| 35 | (35.0, 40.0) Basalt: olive gray, 5Y 4/1, pumice-like vesicular with small semi-round voids, vertical fracture at 37 ft with iron stained and weathered surfaces, 3 ft. recovery | | | | 75% | | |
| 40 | (40.0, 45.0) Basalt : SAA, vesicular with 30% small and round voids, competent, infilled voids near bottom at 44 ft. | | | | 90% | | |
| 45 | (45.0, 50.0) Basalt: SAA, vesicular with up to 35% voids, variable size and shape voids-some larger than 5 mm., moderate strength w/ mechanical fractures | | VLBA | 0.0 | 80% | | |
| 50 | (50.0, 55.0) Basalt: olive gray to greenish gray, dense, 10% voids, oblique fractures w/ weathered surfaces, drilling water return | | VLBA | 0.0 | 50% | | |
| 55 | (55.0, 60.0) Basalt: greenish gray and dense from 55-57, up to 1 in. vugs w/ some secondary infilling, transitions back to olive gray vesicular basalt | | VLBA | 0.0 | NA | | |
| 60 | | | | | | | |





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SDGR - Sand and Gravel
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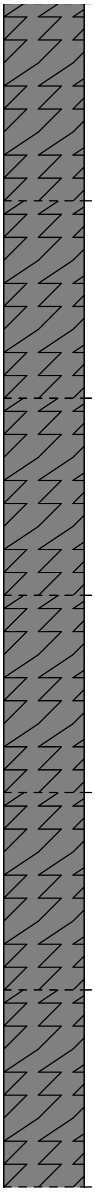
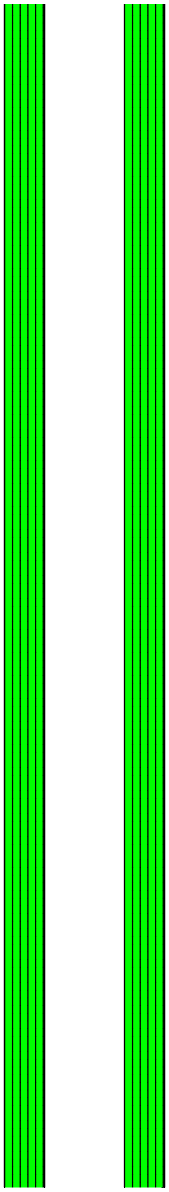
SLCL - Silt and Clay
SLGV - Silt and Gravel
SLSD - Silt and Sand
VLBA - Basalt, Lava
VLTF - Volcanic Tuff

# GEOLOGIC LOG

| | | | |
|---|---|---|---|
| DATE STARTED: 28-Aug-14 | LOGGER: TM Jensen | PAGE 3 OF 10 | |
| DATE COMPLETED: 17-Sept-14 | WEATHER: 90 degrees Fahrenheit | WELL NO.: RHMW06 | |
| COMPANY NAME: **PARSONS** | DRILLING SUBCONTRACTOR: Valley Well Drilling | SURFACE ELEV.: 255.81 ft amsl | |
| OFFICE LOCATION: South Jordan, Utah | DRILL RIG TYPE: Mobile B-59 and B-90 | SOUNDING TUBE ELEV.: 259.01 ft | |
| PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01 | DRILLING METHOD: Auger, HQ core, Air Rotary | NORTHING: 75327.83 | |
| LOCATION: Red Hill BFSF, HI — JOB NUMBER: 749435 | BOREHOLE DIAMETER: 6 & 12"Auger, 4" Core, 8" Air | EASTING: 1676274.17 | |

| DEPTH (ft bgs) | DESCRIPTION OF MATERIALS | GRAPHIC LOG | ERPIMS LITHO-LOGIC CODE | PID HS, ppmv (DEPTH, ft bgs) | BLOW COUNT/ RQD | WELL CONSTRUCTION (ft bgs) | WELL CONSTRUCTION INFORMATION |
|---|---|---|---|---|---|---|---|
| 60 | (60.0, 65.0) Basalt: olive gray, vesicular w/ 30% small round voids, iron-stained voids and natural fractures from 63-65 ft. | | VLBA | 0.0 | 75% | | |
| 65 | (65.0, 70.0) Basalt: SAA, large angled fracture at 67.5 ft., voids infilled with white mineral, grades to non-vesicular and more dense at 69 ft. | | VLBA | 0.0 | 80% | | |
| 70 | (70.0, 75.0) Basalt: lost core, trip out, recover 2 ft. of gray vesicular basalt | | VLBA | 0.0 | NA | | |
| 75 | (75.0, 80.0) Basalt: brownish black 5YR 2/1, vesicular, grades to brownish gray 5YR 4/1 with larger voids at 76 ft., some secondary infilling of voids from 76-77 ft, some fractures | | VLBA | 0.0 | 75% | | |
| 80 | (80.0, 85.0) Basalt: grayish black (N2), dense, vugs with pristine "needle-like" zeolite cyrstals, light coating of white to bluish gray amporphous silica within voids indicative of the movement of water, large fracture at 82 ft. with secondary rust colored mineralization | | VLBA | 0.0 | 80% | | |
| 85 | (85.0, 90.0) Basalt: dark gray (N3), hard, dense, competent, 10% open voids, as large as 5 mm., some infilling of voids with amorphous quartz or zeolite, 10% slightly weathered olivine phenocrysts, Note: first occurrence of phenocrysts, rock above is aphanitic w/ very few phenocryts | | VLBA | 0.0 | 80% | | |
| 90 | | | | | | | |





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ppmv - Parts per Million, Volume per Volume
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Elevations: Local Mean Sea Level (feet)

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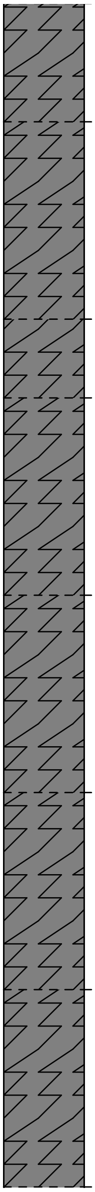
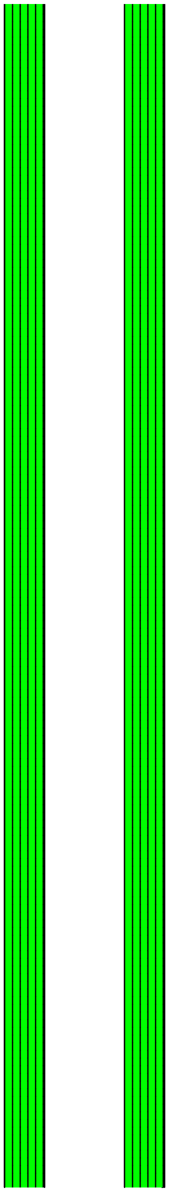
| | | | |
|---|---|---|---|
| **GEOLOGIC LOG** | DATE STARTED: 28-Aug-14<br>DATE COMPLETED: 17-Sept-14 | LOGGER: TM Jensen<br>WEATHER: 90 degrees Fahrenheit | PAGE 4 OF 10<br>WELL NO.: RHMW06 |
| COMPANY NAME: **PARSONS**<br>OFFICE LOCATION: South Jordan, Utah | | DRILLING SUBCONTRACTOR: Valley Well Drilling<br>DRILL RIG TYPE: Mobile B-59 and B-90 | SURFACE ELEV.: 255.81 ft amsl<br>SOUNDING TUBE ELEV.: 259.01 ft |
| PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01<br>LOCATION: Red Hill BFSF, HI | JOB NUMBER: 749435 | DRILLING METHOD: Auger, HQ core, Air Rotary<br>BOREHOLE DIAMETER: 6 & 12"Auger, 4" Core, 8" Air | NORTHING: 75327.83<br>EASTING: 1676274.17 |





| DEPTH (ft bgs) | DESCRIPTION OF MATERIALS | GRAPHIC LOG | ERPIMS LITHO-LOGIC CODE | PID HS, ppmv (DEPTH, ft bgs) | BLOW COUNT/ RQD | WELL CONSTRUCTION (ft bgs) | WELL CONSTRUCTION INFORMATION |
|---|---|---|---|---|---|---|---|
| 90 | (90.0, 93.0) Basalt: partial run, SAA, transitions to as much as 35% voids, zones where voids are infilled with reddish orange clay-like soft silica, large infilled fracture at 90-91 ft. | | VLBA | 0.0 | 80% | | |
| 95 | (93.0, 98.0) Basalt: SAA, 25 % voids, range from 1 mm. to 8 mm., zones w/ infilling of voids, few fractures | | VLBA | 0.0 | 90% | | |
| | (98.0, 100.0) Basalt: SAA, few healed or infilled fracture zones | | VLBA | | 60% | | |
| 100 | (100.0, 105.0) Basalt: SAA, grades dense, competent, and unweathered at 104 ft., cyrstalline texture, few olivine phenocrysts, lost circulation, switched over to all water and no air | | VLBA | 0.0 | 75% | | |
| 105 | (105.0, 110.0) Basalt: SAA, grades from dense and hard to low density and weak pumice-like vesicular w/ 50% small and round voids at 109 ft. | | VLBA | 0.0 | 85% | | |
| 110 | (110.0, 115.0) Basalt: SAA, dark gray vesicular, zones with reddish orange soft silica along fractures and in voids, 6 in. clay zone at 114 ft., possibly a weathered zone between flows | | VLBA | 0.0 | 50% | | |
| 115 | (115.0, 120.0) Basalt: SAA, dark gray, variable void percentage througout, mechanical breaks, reddish orange soft silica where weathered | | VLBA | 0.0 | 60% | | |
| 120 | | | | | | | |

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Horizontal Survey System: NAD 83 Epoch 2010.0
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VLBA - Basalt, Lava
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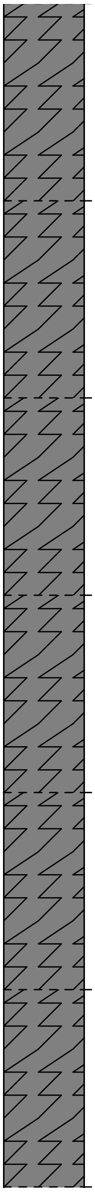
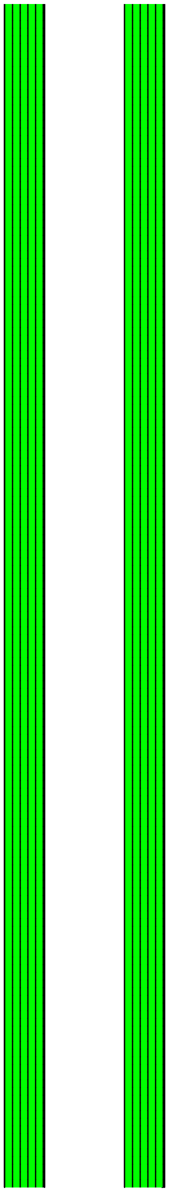
| | | | |
|---|---|---|---|
| **GEOLOGIC LOG** | DATE STARTED: 28-Aug-14<br>DATE COMPLETED: 17-Sept-14 | LOGGER: TM Jensen<br>WEATHER: 90 degrees Fahrenheit | PAGE 5 OF 10<br>WELL NO.: RHMW06 |
| COMPANY NAME: **PARSONS**<br>OFFICE LOCATION: South Jordan, Utah | | DRILLING SUBCONTRACTOR: Valley Well Drilling<br>DRILL RIG TYPE: Mobile B-59 and B-90 | SURFACE ELEV.: 255.81 ft amsl<br>SOUNDING TUBE ELEV.: 259.01 ft |
| PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01<br>LOCATION: Red Hill BFSF, HI | JOB NUMBER: 749435 | DRILLING METHOD: Auger, HQ core, Air Rotary<br>BOREHOLE DIAMETER: 6 & 12"Auger, 4" Core, 8" Air | NORTHING: 75327.83<br>EASTING: 1676274.17 |

| DEPTH (ft bgs) | DESCRIPTION OF MATERIALS | GRAPHIC LOG | ERPIMS LITHO-LOGIC CODE | PID HS, ppmv (DEPTH, ft bgs) | BLOW COUNT/ RQD | WELL CONSTRUCTION (ft bgs) | WELL CONSTRUCTION INFORMATION |
|---|---|---|---|---|---|---|---|
| 120 | (120.0, 125.0) Basalt: SAA, washout from 123-124 ft., 60% recovery | | VLBA | 0.0 | 50% | | |
| 125 | (125.0, 130.0) Basalt: dark gray (N3), stronger rock, 25% voids, large irregular voids up to 10 mm., fresh high-angle fracture at 128.5 ft., minor infilling of voids at 129 ft. w/ reddish orange soft silica, mechanical breaks | | VLBA | 0.0 | 85% | | |
| 130 | (130.0, 135.0) Basalt: dark gray (N3), overall brown from oxidation, looks like broken up rubble zone at top of flow, lava inclusions, secondary infilling in weak zones | | VLBA | 0.0 | 40% | | |
| 135 | (135.0, 140.0) Basalt: dark gray (N3), harder and dense, vesicular basalt, 20% voids, two high-angle fractures at 139 ft., coated fracture surfaces and some infilling of voids | | VLBA | 0.0 | 85% | | |
| 140 | (140.0, 145.0) Basalt: SAA, aphanitic-crystalline texture, dense, irregular voids, a few fresh fractures w/light iron-oxide staining | | VLBA | 0.0 | 80% | | |
| 145 | (145.0, 150.0) Basalt: dark gray, compentent, moderate strength, mechanical breaks, not much infilling of voids | | VLBA | 0.0 | 90% | | |
| 150 | | | | | | | |





| | | | |
|---|---|---|---|
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| N/A - Not Applicable | HS - Head Space | GVL - Gravel | SLCL - Silt and Clay |
| NS - Not Sampled | ERPIMS CODE DESCRIPTIONS: | GVLP - Gravel, predominantly pebble-sized | SLGV - Silt and Gravel |
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| SAA - Same as Above | CLGV - Clay and Gravel | NSNR - No Sample or No Recovery Obtained | VLTF - Volcanic Tuff |
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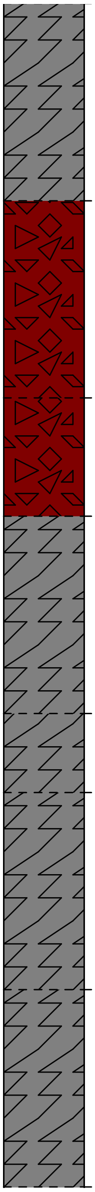
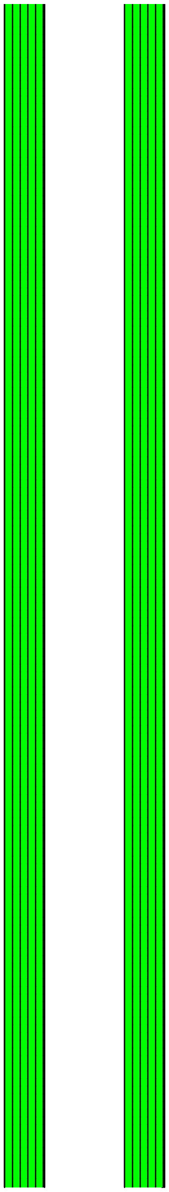
| Elevations: Local Mean Sea Level (feet) | CLSL - Clay and Silt | SAPR - Saprolite | |

# GEOLOGIC LOG

| | | | |
|---|---|---|---|
| **GEOLOGIC LOG** | DATE STARTED: 28-Aug-14<br>DATE COMPLETED: 17-Sept-14 | LOGGER: TM Jensen<br>WEATHER: 90 degrees Fahrenheit | PAGE 6 OF 10<br>WELL NO.: RHMW06 |
| COMPANY NAME: **PARSONS** | | DRILLING SUBCONTRACTOR: Valley Well Drilling | SURFACE ELEV.: 255.81 ft amsl |
| OFFICE LOCATION: South Jordan, Utah | | DRILL RIG TYPE: Mobile B-59 and B-90 | SOUNDING TUBE ELEV.: 259.01 ft |
| PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01 | | DRILLING METHOD: Auger, HQ core, Air Rotary | NORTHING: 75327.83 |
| LOCATION: Red Hill BFSF, HI | JOB NUMBER: 749435 | BOREHOLE DIAMETER: 6 & 12"Auger, 4" Core, 8" Air | EASTING: 1676274.17 |





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|---|---|---|---|---|---|---|---|
| 150 | (150.0, 155.0) Basalt: dark gray, crystalline, dense, some olivine, 5% voids, mechanical breaks | | VLBA | 0.0 | 80% | | |
| 155 | (155.0, 160.0) Clinker: switched bits and went to air, poor recovery, bad core resulting from air coring, rounded, red rock possibly clinker | | VLBA | 0.0 | NA | | |
| 160 | (160.0, 163.0) Clinker: grayish red 10R 4/2 clinker, lost water circulation, diesel odor in ambient air from apparent venting of tanks | | VLBA | BG=1.5 | NA | | |
| 165 | (163.0, 168.0) Basalt: dark gray, hard, dense, crystalline texture, some quartz, 10% voids, trace secondary black mineral coating, fresh fractures w/ little secondary mineralization on surfaces, PID interference from background fumes in ambient air | | VLB | BG=27 | 90% | | |
| | (168.0, 170.0) Basalt: SAA, finish run, silica-coated vertical fracture, some mechanical breaks | | VLBA | 0.0 | | | |
| 170 | (170.0, 175.0) Basalt: SAA, dark gray, two healed fractures from 170-171, grades to rubbly broken zone, weathered rock and mud from 172-175, poor recovery | | VLBA | 0.0 | NA | | |
| 175 | (175.0, 180.0) Basalt: dark gray and less compentent pumice-like vesicular w/ about 30% small round voids, few thin broken zones, several healed fractures | | VLBA | 0.0 | 50% | | |
| 180 | | | | | | | |

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| | | | |
|---|---|---|---|
| **GEOLOGIC LOG** | DATE STARTED: 28-Aug-14<br>DATE COMPLETED: 17-Sept-14 | LOGGER: TM Jensen<br>WEATHER: 90 degrees Fahrenheit | PAGE 7 OF 10<br>WELL NO.: RHMW06 |

COMPANY NAME: **PARSONS**
OFFICE LOCATION: South Jordan, Utah
PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01
LOCATION: Red Hill BFSF, HI
JOB NUMBER: 749435

DRILLING SUBCONTRACTOR: Valley Well Drilling
DRILL RIG TYPE: Mobile B-59 and B-90
DRILLING METHOD: Auger, HQ core, Air Rotary
BOREHOLE DIAMETER: 6 & 12"Auger, 4" Core, 8" Air

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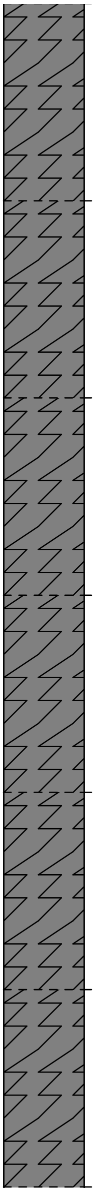
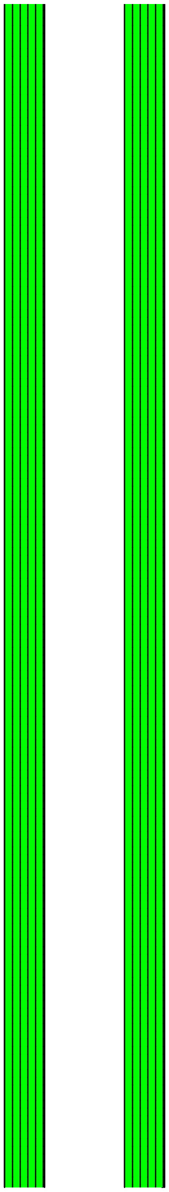
NORTHING: 75327.83
EASTING: 1676274.17

| DEPTH (ft bgs) | DESCRIPTION OF MATERIALS | GRAPHIC LOG | ERPIMS LITHO-LOGIC CODE | PID HS, ppmv (DEPTH, ft bgs) | BLOW COUNT/ RQD | WELL CONSTRUCTION (ft bgs) | WELL CONSTRUCTION INFORMATION |
|---|---|---|---|---|---|---|---|
| 180 | (180.0, 185.0) Basalt: dark gray vesicular, variable void percentage, broken zone from 181-183 ft., fractures and voids infilled with reddish orange soft silica | | VLBA | 0.0 | 50% | | |
| 185 | (185.0, 190.0) Basalt: SAA, grades to brownish gray then back to dark gray, less voids from 190-192 ft, fractured w/ gouged slickenside surfaces at 193 ft., infilling of voids with soft silica | | VLBA | 0.0 | 70% | | |
| 190 | (190.0, 195.0) Basalt: dark gray (N3), vesicular, variable void size, shape, and percentage, more compentent, fractures at 194 ft., coated fracture surface with reddish orange silica and black oxides and infilling of voids below fractures, mechanical breaks, | | VLBA | 0.0 | 70% | | |
| 195 | (195.0, 200.0) Basalt: dark gray, vesicular, larger connected voids, dense, light olive brown coating in voids indicative of the movement of water, some olivine, few horizontal fractures | | VLBA | 0.0 | 50% | | |
| 200 | (200.0, 205.0) Basalt: dark gray (N3), cyrstalline texture, compentent and consistent core, subtle flow layering w/ stretched voids, horizontal fractures from 200-201 feet, secondary black oxides | | VLBA | 0.0 | 90% | | |
| 205 | (205.0, 210.0) Basalt: dark gray, weathered w/ secondary infilling, broken zones | | VLBA | 0.0 | 50% | | |
| 210 | | | | | | | |





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bgs - Below Ground Surface
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mm - millimeter(s)
N/A - Not Applicable
NS - Not Sampled
PID - Photoionization Detector
ppmv - Parts per Million, Volume per Volume
SAA - Same as Above
Horizontal Survey System: NAD 83 Epoch 2010.0
Elevations: Local Mean Sea Level (feet)

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# GEOLOGIC LOG

DATE STARTED: 28-Aug-14
DATE COMPLETED: 17-Sept-14

LOGGER: TM Jensen
WEATHER: 90 degrees Fahrenheit

WELL NO.: RHMW06

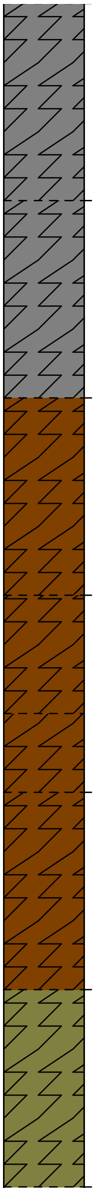
COMPANY NAME: **PARSONS**
OFFICE LOCATION: South Jordan, Utah
PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01
LOCATION: Red Hill BFSF, HI
JOB NUMBER: 749435

DRILLING SUBCONTRACTOR: Valley Well Drilling
DRILL RIG TYPE: Mobile B-59 and B-90
DRILLING METHOD: Auger, HQ core, Air Rotary
BOREHOLE DIAMETER: 6 & 12"Auger, 4" Core, 8" Air

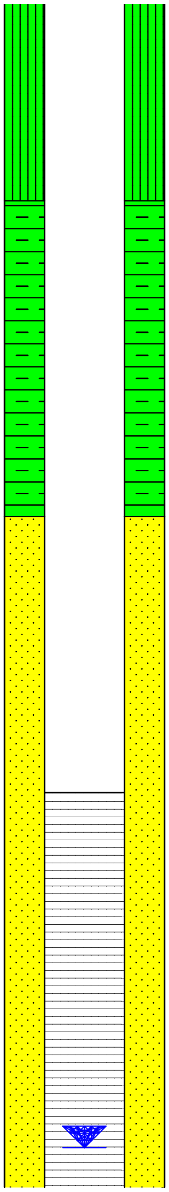
SURFACE ELEV.: 255.81 ft amsl
SOUNDING TUBE ELEV.: 259.01 ft
NORTHING: 75327.83
EASTING: 1676274.17

| DEPTH (ft bgs) | DESCRIPTION OF MATERIALS | ERPIMS LITHO-LOGIC CODE | PID HS, ppmv (DEPTH, ft bgs) | BLOW COUNT/ RQD | WELL CONSTRUCTION INFORMATION |
|---|---|---|---|---|---|
| 210 | (210.0, 215.0) Basalt: brownish gray 5YR 4/1, 30% voids, less dense, broken w/ soft silica infillling, dark reddish brown non-vesicular bands, grades to dark gray at 214 ft. | VLBA | 0.0 | | |
| 215 | (215.0, 220.0) Basalt: brownish gray 5YR 4/1, w/ dark yellowish brown bands, less competent, moderate strength, broken zone from 218-219 w/ secondary infilling, olive gray w/ 10% voids from 219-220 ft. | VLBA | 0.0 | | |
| 220 | (220.0, 225.0) Basalt: grayish red 10R 4/2, low density and weak, weathered matrix, | VLBA | 0.0 | 75% | |
| 225 | (225.0, 230.0) Basalt: SAA, alternating with dark gray vesicular, olive gray basalt w/ 30% voids at 229 ft., irregular voids up to 1 in., light silica coating in voids indicative of the movement of water | VLBA | 0.0 | | |
| 230 | (230.0, 235.0) Basalt: SAA, but more competent, up to 30% irregular voids, increase in void percentage near bottom of run, black oxide secondary mineralization in some voids and surfaces | VLBA | 0.0 | 90% | |
| 235 | (235.0, 240.0) Basalt: dark brown to dark yellowish brown to olive to greenish black, possible alteration to serpentine or chlorite in places, friable in places, non-competent, weathered to clay | VLBA | 0.0 | 25% | |
| 240 | | | | | |

GRAPHIC LOG



WELL CONSTRUCTION (ft bgs)



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Elevations: Local Mean Sea Level (feet)

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# GEOLOGIC LOG

DATE STARTED: 28-Aug-14
DATE COMPLETED: 17-Sept-14

LOGGER: TM Jensen
WEATHER: 90 degrees Fahrenheit

WELL NO.: RHMW06

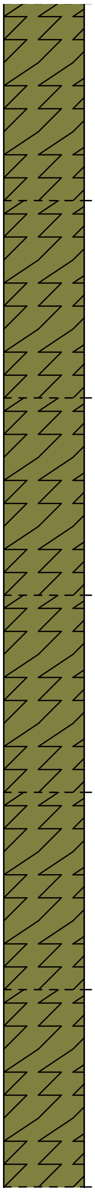
COMPANY NAME: **PARSONS**
OFFICE LOCATION: South Jordan, Utah

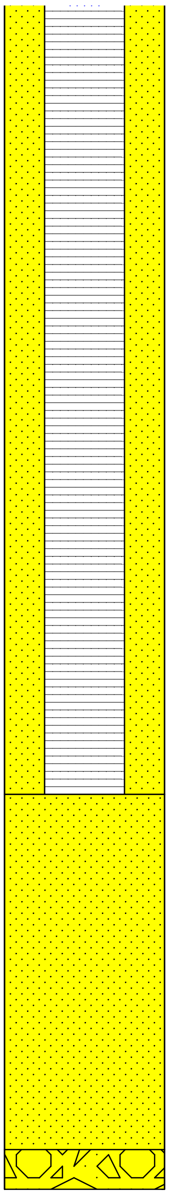
PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01
LOCATION: Red Hill BFSF, HI JOB NUMBER: 749435

DRILLING SUBCONTRACTOR: Valley Well Drilling
DRILL RIG TYPE: Mobile B-59 and B-90
DRILLING METHOD: Auger, HQ core, Air Rotary
BOREHOLE DIAMETER: 6 & 12"Auger, 4" Core, 8" Air

SURFACE ELEV.: 255.81 ft amsl
SOUNDING TUBE ELEV.: 259.01 ft
NORTHING: 75327.83
EASTING: 1676274.17

| DEPTH (ft bgs) | DESCRIPTION OF MATERIALS | GRAPHIC LOG | ERPIMS LITHO-LOGIC CODE | PID HS, ppmv (DEPTH, ft bgs) | BLOW COUNT/ RQD | WELL CONSTRUCTION (ft bgs) | WELL CONSTRUCTION INFORMATION |
|---|---|---|---|---|---|---|---|
| 240 | (240.0, 245.0) Basalt: brownish gray, moderate density and strength, low void percentage, grades to olive gray vesicular basalt that is low density and weak, zones of infilling with clay-like pinkish gray soft silica | | VLBA | 0.0 | 60% | | |
| 245 | (245.0, 250.0) Basalt: olive gray, 3-foot partial run, blocked off, variable void percentage, moderate density and strength, large and irregular open voids that are lightly coated with secondary amporphous silica indicative of water saturated conditions, finish 2-foot run, SAA, <10% voids, voids infilled with white mineral | | VLBA | 0.0 | 75% | | |
| 250 | (250.0, 255.0) Basalt: SAA, from 250-253, more infilling of voids, grades to olive black 5YR 2/1 basalt, shows slickenlines along fracture plane and possible serpentine or talc-like secondary alteration on fracture surfaces | | VLBA | 0.0 | 70% | | |
| 255 | (255.0, 260.0) Basalt: SAA, olive black, light density and weak, pumice-like vesicular, 30% small and round voids, some infilled, grades to olive gray and more dense basalt w/ larger voids, slickenlines on fracture surfaces | | VLBA | 0.0 | 50% | | |
| 260 | (260.0, 265.0) Basalt: SAA from 260-262 ft., grades back to olive black light density vesicular basalt, 3 in. band of white silica at 263 ft., weak rock and strongly oxidized at 264 ft., lost water pressure during coring at 263 feet | | VLBA | 0.0 | 50% | | Well TD = 260 ft bgs |
| 265 | (265.0, 270.0) Basalt: SAA, poor recovery, weak and broken rock | | VLBA | 0.0 | NA | | |
| 270 | | | | | | | |





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VLTF - Volcanic Tuff

| | | | |
|---|---|---|---|
| **GEOLOGIC LOG** | DATE STARTED: 28-Aug-14<br>DATE COMPLETED: 17-Sept-14 | LOGGER: TM Jensen<br>WEATHER: 90 degrees Fahrenheit | PAGE 10 OF 10<br>WELL NO.: RHMW06 |
| COMPANY NAME: **PARSONS** | | DRILLING SUBCONTRACTOR: Valley Well Drilling | SURFACE ELEV.: 255.81 ft amsl |
| OFFICE LOCATION: South Jordan, Utah | | DRILL RIG TYPE: Mobile B-59 and B-90 | SOUNDING TUBE ELEV.: 259.01 ft |
| PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01 | | DRILLING METHOD: Auger, HQ core, Air Rotary | NORTHING: 75327.83 |
| LOCATION: Red Hill BFSF, HI | JOB NUMBER: 749435 | BOREHOLE DIAMETER: 6 & 12"Auger, 4" Core, 8" Air | EASTING: 1676274.17 |

| DEPTH (ft bgs) | DESCRIPTION OF MATERIALS | GRAPHIC LOG | ERPIMS LITHO-LOGIC CODE | PID HS, ppmv (DEPTH, ft bgs) | BLOW COUNT/ RQD | WELL CONSTRUCTION (ft bgs) | WELL CONSTRUCTION INFORMATION |
|---|---|---|---|---|---|---|---|
| 270 | (270.0, 275.0) Basalt: olive gray, large open voids coated with silica and black oxides from 270-272 ft., grades to more dense and fractured, back to brownish gray at the bottom | ▨ | VLBA | 0.0 | 75% | ▨ | |
| 275 | (275.0, 280.0) Basalt: SAA, grades back to olive gray, zone w/ large coated open voids, some infilling w/ white mineral in smaller voids, few vertical fractures w/ slickenlines on fresh fracture surfaces | ▨ | VLBA | 0.0 | 75% | ▨ | |
| 280 | | | | | | | |

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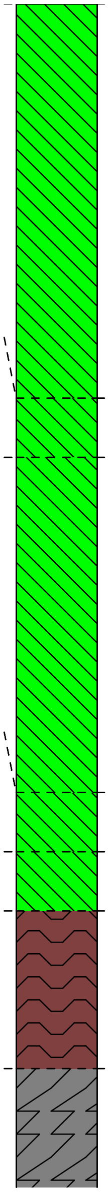
# GEOLOGIC LOG

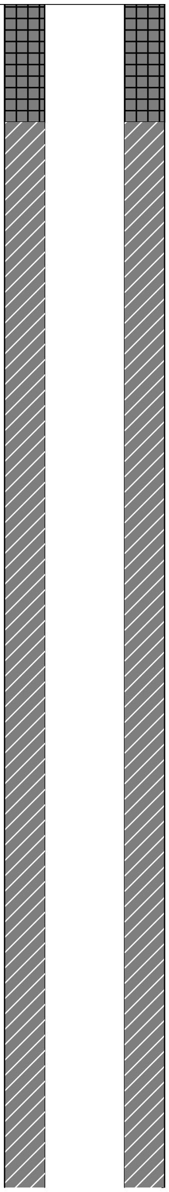
| | | | |
|---|---|---|---|
| DATE STARTED: 19-Sept-14 | LOGGER: TM Jensen | PAGE 1 OF 8 | |
| DATE COMPLETED: 6-Oct-14 | WEATHER: 90 degrees Fahrenheit | WELL NO.: RHMW07 | |
| COMPANY NAME: **PARSONS** | DRILLING SUBCONTRACTOR: Valley Well Drilling | SURFACE ELEV.: 216.53 ft amsl | |
| OFFICE LOCATION: South Jordan, Utah | DRILL RIG TYPE: Mobile B-59 and B-90 | SOUNDING TUBE ELEV.: 220.29 ft | |
| PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01 | DRILLING METHOD: Ream, HQ core, Air Rotary | NORTHING: 74964.96 | |
| LOCATION: Red Hill BFSF, HI | JOB NUMBER: 749435 | BOREHOLE DIAMETER: 12" Ream, 4" Core, 8" Air | EASTING: 1675189.52 |

| DEPTH (ft bgs) | DESCRIPTION OF MATERIALS | ERPIMS LITHO-LOGIC CODE | PID HS, ppmv (DEPTH, ft bgs) | BLOW COUNT/ RQD |
|---|---|---|---|---|
| 0<br>5 | (0.0, 10.0) Clay | CLAY | | |
| 10 | (10.0, 11.5) Clay: dusky yellowish brown (10YR 2/2), CH, stiff, plastic, slightly moist, Note: basalt cobbles and boulders within clay were contacted from ground surface to the saprolite contact | CLAY | 0.0 | 35/50 for 12" |
| 15 | (11.5, 20.0) Clay | CLAY | | |
| 20 | (20.0, 21.5) Clay: pulverized rock and sand, probably a cobble at this depth broken up by air hammer bit, Note: dry clay from 10 to 20 feet with some sand | CLAY | 0.0 | 100 for 3" |
| | (21.5, 23.0) Clay | CLAY | 0.0 | |
| 25 | (23.0, 27.0) Saprolite: no split spoon recovery at 24 ft, reddish brown cuttings, likely saprolite | SAPR | 0.0 | |
| 30 | (27.0, 45.0) Basalt: gray with vesicles, cuttings from air hammer to 42 feet, then rock core from 40 to 45 feet with description as follows: 2 feet of cement grout (from conductor casing), dark gray (N3) | VLBA | 0.0 | |

GRAPHIC LOG



WELL CONSTRUCTION (ft bgs)



WELL CONSTRUCTION INFORMATION

SURFACE COMPLETION: 3.5' x 3.5 'x 2' concrete pad w/ 8" above-ground steel casing

WELL CASING:
Material: SCH. 80 PVC
Diameter: 4"
Interval: +3.76-184 bgs

WELL SCREEN:
Material: SCH. 80 PVC
Screen Opening: 0.020
Diameter: 4"
Interval: 184-214 bgs

CONDUCTOR CASING:
Material: PVC
Diameter: 10"
Interval: 0-40 bgs

DEPTH INTERVAL:
Concrete: 0-3
Cement Grout: 3-40 bgs
Bentonite Chips: 40-176 bgs
Bentonite Seal: 176-179 bgs
Sand Pack: 179-230 bgs
Hole Cuttings: 230-235 bgs

**NOTE:** All intervals are measured from ground surface.

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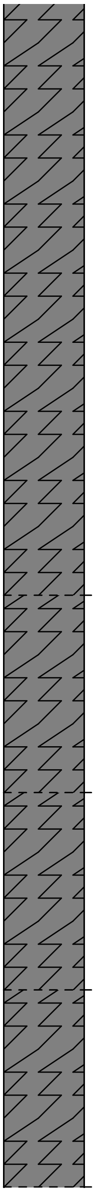
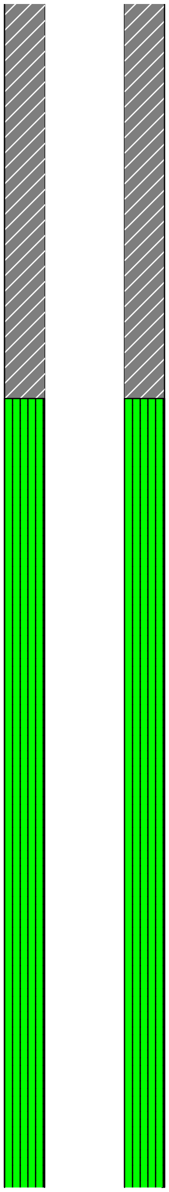
## GEOLOGIC LOG

| | | | |
|---|---|---|---|
| DATE STARTED: 19-Sept-14 | LOGGER: TM Jensen | PAGE 2 OF 8 | |
| DATE COMPLETED: 6-Oct-14 | WEATHER: 90 degrees Fahrenheit | WELL NO.: RHMW07 | |
| COMPANY NAME: **PARSONS** | DRILLING SUBCONTRACTOR: Valley Well Drilling | SURFACE ELEV.: 216.53 ft amsl | |
| OFFICE LOCATION: South Jordan, Utah | DRILL RIG TYPE: Mobile B-59 and B-90 | SOUNDING TUBE ELEV.: 220.29 ftl | |
| PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01 | DRILLING METHOD: Ream, HQ core, Air Rotary | NORTHING: 74964.96 | |
| LOCATION: Red Hill BFSF, HI | JOB NUMBER: 749435 | BOREHOLE DIAMETER: 12" Ream, 4" Core, 8" Air | EASTING: 1675189.52 |





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|---|---|---|---|---|---|
| 30 | basalt, broken and rubbly zones with secondary pinkish to reddish orange soft silica or zeolite infilling spaces between rock fragments, few voids, moderate strength, one oblique fracture at 43 feet, NOTE: THE GSA ROCK COLOR CHART (1991) WAS USED FOR WET COLOR DESCRIPTIONS | | | | |
| 35 | | | | | |
| 40 | | | | | |
| 45 | (45.0, 50.0) Basalt: broken or rubbly zone from 45-49 ft, top of flow, weak rock, irrregular fractures and voids infilled with secondary pink to orange to red soft silica, dark gray basalt at 49 ft. | VLBA | 0.0 | <50% | |
| 50 | (50.0, 55.0) Basalt: dark gray (N3), aphanitic texture, trace phenocrysts, hard, dense, variable 5% to 20% voids that are horizontally stretched, subhorizontal to subvertical fractures w/ soft silica and seconday black oxide mineralization along thinly parted fracture planes, 100% recovery | VLBA | 0.0 | 80% | |
| 55 | (55.0, 60.0) Basalt: broken and rubbly similar to 45-50 ft., highly weathered with copious amounts of red to brown soft silica in voids and open space between rock fragments, very weak | VLBA | 0.0 | 40% | |
| 60 | | | | | |

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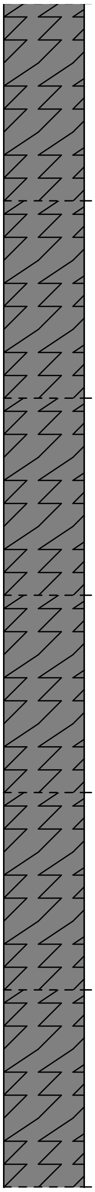
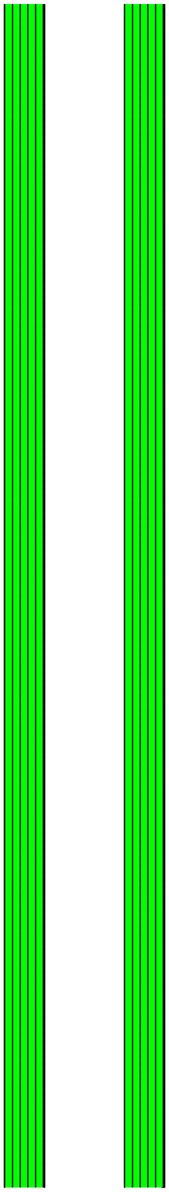
| | | | |
|---|---|---|---|
| **GEOLOGIC LOG** | DATE STARTED: 19-Sept-14<br>DATE COMPLETED: 6-Oct-14 | LOGGER: TM Jensen<br>WEATHER: 90 degrees Fahrenheit | PAGE 3 OF 8<br>WELL NO.: RHMW07 |
| COMPANY NAME: **PARSONS**<br>OFFICE LOCATION: South Jordan, Utah | DRILLING SUBCONTRACTOR: Valley Well Drilling<br>DRILL RIG TYPE: Mobile B-59 and B-90 | | SURFACE ELEV.: 216.53 ft amsl<br>SOUNDING TUBE ELEV.: 220.29 ftl |
| PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01<br>LOCATION: Red Hill BFSF, HI JOB NUMBER: 749435 | DRILLING METHOD: Ream, HQ core, Air Rotary<br>BOREHOLE DIAMETER: 12" Ream, 4" Core, 8" Air | | NORTHING: 74964.96<br>EASTING: 1675189.52 |





| DEPTH (ft bgs) | DESCRIPTION OF MATERIALS | GRAPHIC LOG | ERPIMS LITHO-LOGIC CODE | PID HS, ppmv (DEPTH, ft bgs) | BLOW COUNT/ RQD | WELL CONSTRUCTION (ft bgs) | WELL CONSTRUCTION INFORMATION |
|---|---|---|---|---|---|---|---|
| 60 | (60.0, 65.0) Basalt: consolidated and cemented grayish red clinker from 60-62 ft, then dark gray (N3) basalt, aphanitic, harder, 10% voids, irregular fractures bottom with red to orange soft silica | | VLBA | 0.0 | 60% | | |
| 65 | (65.0, 70.0) Basalt: dark gray (N3), aphanitic, hard, strong, slight flow layering with stretched voids, few thinly parted fractures, rubbly at bottom with lava inclusions | | VLBA | 0.0 | 80% | | |
| 70 | (70.0, 75.0) Basalt: dense medium bluish gray (5B 5/1) mixed with dark gray to grayish red, grades to loose to consolidated clinker-like zone from 72.5-75 ft. | | VLBA | 0.0 | 90% | | |
| 75 | (75.0, 80.0) Basalt: dark gray to grayish black (N2), broken rock, black cinder inclusions, 20% to 30% voids, overall weak rock, looks permeable but does not appear to contain water, red to orange soft silica and harder tan silica in voids and cracks, lost water circulation after this run | | VLBA | 0.0 | 40% | | |
| 80 | (80.0, 85.0) Basalt: grayish black (N2), pumice-like vesicular, small-spherical voids up to 40%, some infilling of voids with soft silica, few angled fractures with soft reddish orange silica, moderate strength and density, porous and could transmit water | | VLBA | 0.0 | 60% | | |
| 85 | (85.0, 90.0) Basalt: SAA, vesicular, slight lower void percentage, few fractures with silica coating | | VLBA | 0.0 | 80% | | |
| 90 | | | | | | | |

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SAA - Same as Above
Horizontal Survey System: NAD 83 Epoch 2010.0
Elevations: Local Mean Sea Level (feet)

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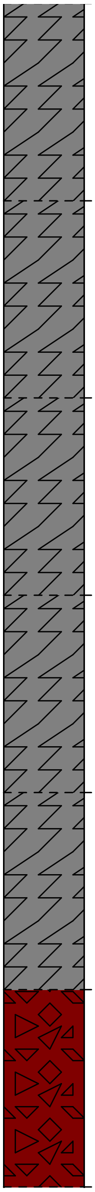
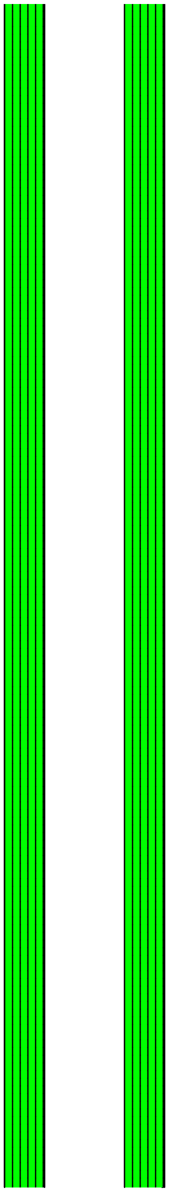
VLTF - Volcanic Tuff

|  |  |  |  |
|---|---|---|---|
| **GEOLOGIC LOG** | DATE STARTED: 19-Sept-14<br>DATE COMPLETED: 6-Oct-14 | LOGGER: TM Jensen<br>WEATHER: 90 degrees Fahrenheit | PAGE 4 OF 8<br>WELL NO.: RHMW07 |
| COMPANY NAME: **PARSONS**<br>OFFICE LOCATION: South Jordan, Utah | | DRILLING SUBCONTRACTOR: Valley Well Drilling<br>DRILL RIG TYPE: Mobile B-59 and B-90 | SURFACE ELEV.: 216.53 ft amsl<br>SOUNDING TUBE ELEV.: 220.29 ftl |
| PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01<br>LOCATION: Red Hill BFSF, HI | JOB NUMBER: 749435 | DRILLING METHOD: Ream, HQ core, Air Rotary<br>BOREHOLE DIAMETER: 12" Ream, 4" Core, 8" Air | NORTHING: 74964.96<br>EASTING: 1675189.52 |

| DEPTH (ft bgs) | DESCRIPTION OF MATERIALS | GRAPHIC LOG | ERPIMS LITHO-LOGIC CODE | PID HS, ppmv (DEPTH, ft bgs) | BLOW COUNT/ RQD | WELL CONSTRUCTION (ft bgs) | WELL CONSTRUCTION INFORMATION |
|---|---|---|---|---|---|---|---|
| 90 | (90.0, 95.0) Basalt: SAA, some larger connected voids up to 5 mm., some fractures and voids with soft silica infilling, moderate strength and density, | | VLBA | 0.0 | >80% | | |
| 95 | (95.0, 100.0) Basalt: SAA, but more variable void shape and density, good RQD, i.e., limited fractures | | VLBA | 0.0 | 80% | | |
| 100 | (100.0, 105.0) Basalt: SAA, variable void percentage up to 30%, porous, few horizontal fractures | | VLBA | 0.0 | 90% | | |
| 105 | (105.0, 110.0) Basalt: SAA, with color change to lighter gray (N4), 6 in. grayish red band at 108 ft., weaker rock, some secondary infilling of voids, one high-angle fracture with soft silica on fracture surfaces | | VLBA | 0.0 | 60% | | |
| 110 | (110.0, 115.0) Basalt: possible large void, bit dropped from 110-111.5 ft., only 1.5 feet of recovery, olive gray basalt, zone of loose or broken rock | | VLBA | 0.0 | | | |
| 115 | (115.0, 120.0) Clinker: SAA, poor recovery, loose or broken rock, possible clinker zone | | VLBA | 0.0 | 40% | | |
| 120 | | | | | | | |





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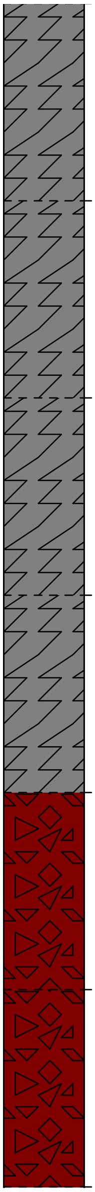
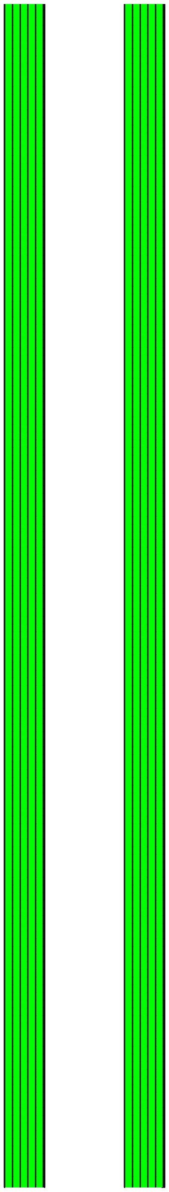
# GEOLOGIC LOG

| | | | |
|---|---|---|---|
| DATE STARTED: 19-Sept-14 | LOGGER: TM Jensen | PAGE 5 OF 8 | |
| DATE COMPLETED: 6-Oct-14 | WEATHER: 90 degrees Fahrenheit | WELL NO.: RHMW07 | |

| | | |
|---|---|---|
| COMPANY NAME: **PARSONS** | DRILLING SUBCONTRACTOR: Valley Well Drilling | SURFACE ELEV.: 216.53 ft amsl |
| OFFICE LOCATION: South Jordan, Utah | DRILL RIG TYPE: Mobile B-59 and B-90 | SOUNDING TUBE ELEV.: 220.29 ftl |
| PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01 | DRILLING METHOD: Ream, HQ core, Air Rotary | NORTHING: 74964.96 |
| LOCATION: Red Hill BFSF, HI JOB NUMBER: 749435 | BOREHOLE DIAMETER: 12" Ream, 4" Core, 8" Air | EASTING: 1675189.52 |





| DEPTH (ft bgs) | DESCRIPTION OF MATERIALS | GRAPHIC LOG | ERPIMS LITHO-LOGIC CODE | PID HS, ppmv (DEPTH, ft bgs) | BLOW COUNT/ RQD | WELL CONSTRUCTION (ft bgs) | WELL CONSTRUCTION INFORMATION |
|---|---|---|---|---|---|---|---|
| 120 | (120.0, 125.0) Basalt: SAA from 120-122 ft., grades to dark reddish brown (10R 3/4) basalt, 20% to 30% irregular voids infilled with soft silica and black oxides, 50% infilled, some olivine phenocrysts in aphantic matrix, flow layering | | VLBA | 0.0 | 40% | | |
| 125 | (125.0, 130.0) Basalt: SAA, grades back to gray, small voids that grade larger (up to 5 mm,) from 128-130 ft., fractures and voids with secondary silica and dark oxide mineralization indicative of water percolation | | VLBA | 0.0 | 60% | | |
| 130 | (130.0, 135.0) Basalt: SAA to 132 ft., 20% large and mostly open voids, grades to hard and dense non-vesicular gray basalt, some partially weathered olivine, overall crystalline texture | | VLBA | 0.0 | 80% | | |
| 135 | (135.0, 140.0) Basalt: SAA, grades to large open voids (15%), then to increasingly smaller and more numerous small voids (30%), fractures and infilled voids at 133.5 ft. | | VLBA | 0.0 | 80% | | |
| 140 | (140.0, 145.0) Clinker: consolidated clinker-like fragments loosely held together by reddish soft sillica, overall conglomeritic appearance | | VLBA | 0.0 | 25% | | |
| 145 | (145.0, 150.0) Clinker: SAA, poor recovery | | VLBA | 0.0 | 25% | | |
| 150 | | | | | | | |

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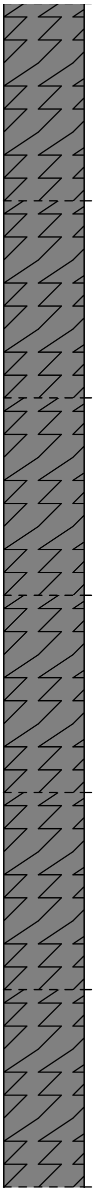
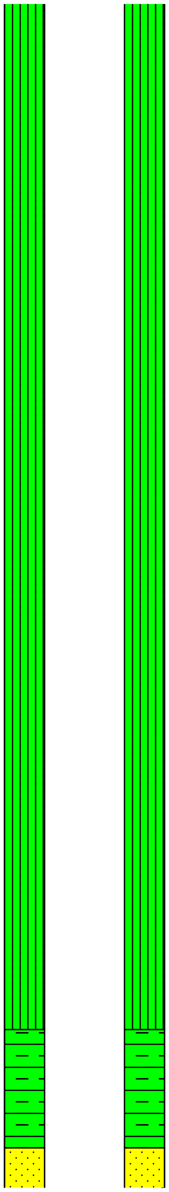
## GEOLOGIC LOG

| | | | |
|---|---|---|---|
| DATE STARTED: 19-Sept-14 | LOGGER: TM Jensen | PAGE 6 OF 8 |
| DATE COMPLETED: 6-Oct-14 | WEATHER: 90 degrees Fahrenheit | WELL NO.: RHMW07 |
| COMPANY NAME: **PARSONS** | DRILLING SUBCONTRACTOR: Valley Well Drilling | SURFACE ELEV.: 216.53 ft amsl |
| OFFICE LOCATION: South Jordan, Utah | DRILL RIG TYPE: Mobile B-59 and B-90 | SOUNDING TUBE ELEV.: 220.29 ftl |
| PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01 | DRILLING METHOD: Ream, HQ core, Air Rotary | NORTHING: 74964.96 |
| LOCATION: Red Hill BFSF, HI JOB NUMBER: 749435 | BOREHOLE DIAMETER: 12" Ream, 4" Core, 8" Air | EASTING: 1675189.52 |

| DEPTH (ft bgs) | DESCRIPTION OF MATERIALS | GRAPHIC LOG | ERPIMS LITHO-LOGIC CODE | PID HS, ppmv (DEPTH, ft bgs) | BLOW COUNT/ RQD | WELL CONSTRUCTION (ft bgs) | WELL CONSTRUCTION INFORMATION |
|---|---|---|---|---|---|---|---|
| 150 | (150.0, 155.0) Basalt: med gray (N4), flow layering w/ horizontallly stretched voids (10%), secondary black oxide mineral, volcanic lava inclusions, two horizontal fractures | | VLBA | 0.0 | | | |
| 155 | (155.0, 160.0) Basalt: SAA, highly fractured at 157 ft., parallel fractures w/ slate-like parting causing rock to block off in core tube, fewer voids | | VLBA | 0.0 | | | |
| 160 | (160.0, 165.0) Basalt: fractured to 161 ft., then vesicular basalt w/ stretched voids (10% to 15%), more competent | | VLBA | 0.0 | 70% | | |
| 165 | (165.0, 170.0) Basalt: SAA to 169 ft., compentent, few voids and fractures, bottom 1 foot is loose w/ soft silica | | VLBA | 0.0 | 90% | | |
| 170 | (170.0, 175.0) Basalt: SAA, continuous from above, overall weak rock, zones that are more competent with 1 in. voids, volcanic lava inclusions some that are reddish brown, capable of transmitting water | | VLBA | 0.0 | 40% | | |
| 175 | (175.0, 180.0) Basalt: dark gray, zones of healed high-angle fractures at 177 ft. and 179 ft., large open voids, 10% to 15% voids | | VLBA | 0.0 | 40% | | |
| 180 | | | | | | | |





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## GEOLOGIC LOG

DATE STARTED: 19-Sept-14
DATE COMPLETED: 6-Oct-14

LOGGER: TM Jensen
WEATHER: 90 degrees Fahrenheit

PAGE 7 OF 8

WELL NO.: RHMW07

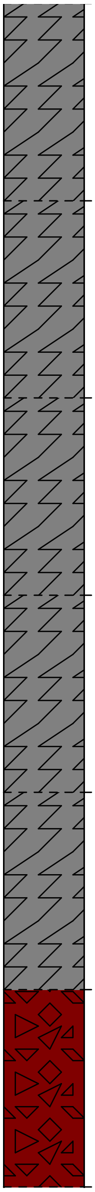
COMPANY NAME: **PARSONS**
OFFICE LOCATION: South Jordan, Utah
PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01
LOCATION: Red Hill BFSF, HI
JOB NUMBER: 749435

DRILLING SUBCONTRACTOR: Valley Well Drilling
DRILL RIG TYPE: Mobile B-59 and B-90
DRILLING METHOD: Ream, HQ core, Air Rotary
BOREHOLE DIAMETER: 12" Ream, 4" Core, 8" Air

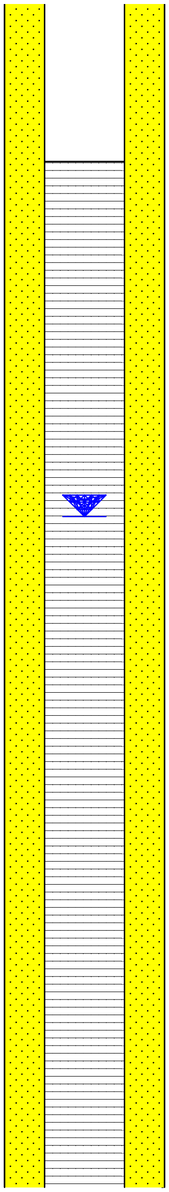
SURFACE ELEV.: 216.53 ft amsl
SOUNDING TUBE ELEV.: 220.29 ftl
NORTHING: 74964.96
EASTING: 1675189.52

| DEPTH (ft bgs) | DESCRIPTION OF MATERIALS | ERPIMS LITHO-LOGIC CODE | PID HS, ppmv (DEPTH, ft bgs) | BLOW COUNT/ RQD |
|---|---|---|---|---|
| 180 | (180.0, 185.0) Basalt: dark gray to black w/ lava inclusions, grades to gray to grayish red vesicular basalt, low-angle fractures, alot of soft red silica, 10% to 20% voids, some infilled, moderate strength | VLBA | 0.0 | 50% |
| 185 | (185.0, 190.0) Basalt: dark gray to olive black, vesicular, 20% voids-large and open, some olivine, few fractures, large void from 188-189 no core, some white amorphous quartz silica or zeolite infilling voids at 190 ft | VLBA | 0.0 | |
| 190 | (190.0, 195.0) Basalt: SAA, grades to smaller voids, healed fractures, moderate strength, core may be saturated, thin coating of secondary mineralization on void surfaces indicative of saturated or below water table conditions | VLBA | 0.0 | 80% |
| 195 | (195.0, 200.0) Basalt: dark gray, vesicular, larger connected voids, dense, light olive brown coating in voids indicative of below water saturated conditions, some olivine, few horizontal fractures | VLBA | 0.0 | 80% |
| 200 | (200.0, 205.0) Basalt: SAA, to 203 ft., grades to olive gray non-vesicular basalt with lava inclusions, weak- mechanical breaks from coring process, secondary black oxide and reddish soft silica | VLBA | 0.0 | 60% |
| 205 | (205.0, 210.0) Clinker: rubbly and loose, pebbly fragments held loosely by soft reddish silica, partial run | VLBA | 0.0 | 20% |
| 210 | | | | |

GRAPHIC LOG



WELL CONSTRUCTION (ft bgs)



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# GEOLOGIC LOG

| | | | |
|---|---|---|---|
| DATE STARTED: 19-Sept-14 | LOGGER: TM Jensen | PAGE 8 OF 8 |
| DATE COMPLETED: 6-Oct-14 | WEATHER: 90 degrees Fahrenheit | WELL NO.: RHMW07 |

| | | |
|---|---|---|
| COMPANY NAME: **PARSONS** | DRILLING SUBCONTRACTOR: Valley Well Drilling | SURFACE ELEV.: 216.53 ft amsl |
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| PROJECT: Monitoring Well Installation N62583-11-D-0515, TO KB01 | DRILLING METHOD: Ream, HQ core, Air Rotary | NORTHING: 74964.96 |
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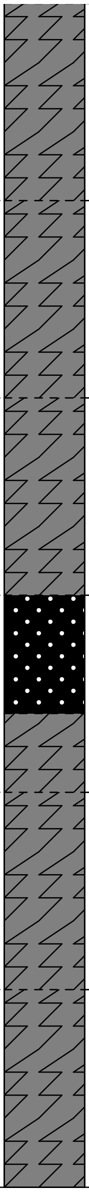
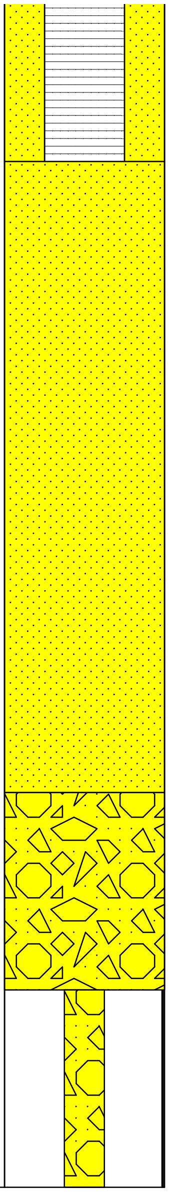
| DEPTH (ft bgs) | DESCRIPTION OF MATERIALS | ERPIMS LITHO-LOGIC CODE | PID HS, ppmv (DEPTH, ft bgs) | BLOW COUNT/ RQD |
|---|---|---|---|---|
| 210 | (210.0, 215.0) Basalt: med. dark gray, hard, dense, stronger rock, few voids, few thinly parted high angle fractures w/ limited secondary mineralization | VLBA | 0.0 | 80% |
| 215 | (215.0, 220.0) Basalt: SAA, hard and dense, few thinly parted and healed fractures- vertical to high angle, does not appear saturated | VLBA | 0.0 | 80% |
| 220 | (220.0, 225.0) Basalt: SAA, but voids are horizontally stretched, bottom 2 feet weak and broken, core saturated in zones of weakness | VLBA | 0.0 | 60% |
| 225 | (225.0, 230.0) Sand: medium to coarse moderately well sorted black sand (SW-SP), contains grains of weathered basalt and light grains of quartz, olivine, carbonate(?), angular to semi-rounded, probably a beach sand deposited between flows, deposited on grayish red fractured basalt that is present at bottom 2 feet of run | VLBA | 0.0 | NA |
| 230 | (230.0, 235.0) Basalt: SAA, grayish red, few zones of broken fragments, thin clay zones, grades to gray basalt at bottom, poor recovery and RQD | VLBA | 0.0 | <50% |
| 235 | (235.0, 240.0) Basalt: medium gray, vesicular, open voids with grayish coating, 20% voids, some black oxide and white (zeolite ?) mineralization, abundant green olivine (20%), olivine is mostly unweathered, looks permeable | VLBA | 0.0 | 100% |
| 240 | | | | |

GRAPHIC LOG



WELL CONSTRUCTION (ft bgs)



WELL CONSTRUCTION INFORMATION

Well TD = 214 ft bgs

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# RHMW06 CORE PHOTOGRAPHS

Core Interval 35 – 45 ft bgs

Core Interval 45 – 55 ft bgs

# RHMW06 CORE PHOTOGRAPHS

Core Interval 55 – 65ft bgs

Core Interval 65 – 75 ft bgs

# RHMW06 CORE PHOTOGRAPHS

Core Interval 75 – 85 ft bgs

Core Interval 85 – 93 ft bgs

# RHMW06 CORE PHOTOGRAPHS

Core Interval 93 – 100 ft bgs

Core Interval 100 – 110 ft bgs

# RHMW06 CORE PHOTOGRAPHS

Core Interval 110 – 120 ft bgs

Core Interval 120 – 130 ft bgs

# RHMW06 CORE PHOTOGRAPHS

Core Interval 130 – 140 ft bgs

Core Interval 140 – 150 ft bgs

# RHMW06 CORE PHOTOGRAPHS

Core Interval 150 – 160 ft bgs

Core Interval 160 – 170 ft bgs

# RHMW06 CORE PHOTOGRAPHS

Core Interval 170 – 180 ft bgs

Core Interval 180 – 190 ft bgs

# RHMW06 CORE PHOTOGRAPHS

Core Interval 190 – 200 ft bgs

Core Interval 200 – 210 ft bgs

# RHMW06 CORE PHOTOGRAPHS

Core Interval 210 – 220 ft bgs

Core Interval 220 – 230 ft bgs

# RHMW06 CORE PHOTOGRAPHS

Core Interval 230 – 240 ft bgs

Core Interval 240 – 250 ft bgs

# RHMW06 CORE PHOTOGRAPHS

Core Interval 250 – 260 ft bgs

Core Interval 260 – 270 ft bgs

# RHMW06 CORE PHOTOGRAPHS

Core Interval 270 – 280 ft bgs

Core Interval 280 – 285 ft bgs

# RHMW07 CORE PHOTOGRAPHS

Core Interval 40 – 50 ft bgs

Core Interval 50 – 60ft bgs

# RHMW07 CORE PHOTOGRAPHS

Core Interval 60 – 70 ft bgs

Core Interval 70 – 80 ft bgs

# RHMW07 CORE PHOTOGRAPHS

Core Interval 80 – 90 ft bgs

Core Interval 90 – 100 ft bgs

# RHMW07 CORE PHOTOGRAPHS

Core Interval 100 – 110 ft bgs

Core Interval 110 – 120 ft bgs

# RHMW07 CORE PHOTOGRAPHS

Core Interval 120 – 130 ft bgs

Core Interval 130 – 140 ft bgs

# RHMW07 CORE PHOTOGRAPHS

Core Interval 140 – 150 ft bgs

Core Interval 150 – 160 ft bgs

# RHMW07 CORE PHOTOGRAPHS

Core Interval 160 – 170 ft bgs

Core Interval 170 – 180 ft bgs

# RHMW07 CORE PHOTOGRAPHS

Core Interval 180 – 190 ft bgs

Core Interval 190 – 200 ft bgs

# RHMW07 CORE PHOTOGRAPHS

Core Interval 200 – 210 ft bgs

Core Interval 210 – 220 ft bgs

# RHMW07 CORE PHOTOGRAPHS

Core Interval 220 – 230 ft bgs

Core Interval 230 – 240 ft bgs

# Appendix C:
# NAVFAC Pacific Standard Operating Procedures and JBPHH Green Waste Disposal Direction
(on CD-ROM at end of document)

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- Procedure I-A, *Planning*
  - Procedure I-A-5, *Utility Clearance*
  - Procedure I-A-6, *Investigation-Derived Waste Management*
  - Procedure I-A-7, *Analytical Data Validation Planning and Coordination*
  - Procedure I-A-8, *Sample Naming*
- Procedure I-B Sampling
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  - Procedure I-C-3, *Monitoring Well Sampling*
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# II. Data Validation Procedures

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- Procedure III-F, *Sample Handling, Storage, and Shipping*

# Utility Clearance

## 1. Purpose

This standard operating procedure describes the process for determining the presence of subsurface utilities and other cultural features at locations where planned site activities involve the physical disturbance of subsurface materials. The procedure applies to the following activities: soil gas surveying, excavating, trenching, drilling of borings and installation of monitoring and extraction wells, use of soil recovery or slide-hammer hand augers, and all other intrusive sampling activities. The primary purpose of the procedure is to minimize the potential for damage to underground utilities and other subsurface features, which could result in physical injury, disruption of utility service, or disturbance of other subsurface cultural features.

## 2. Scope

This procedure applies to all United States Navy Environmental Restoration (ER) Program projects performed in the Naval Facilities Engineering Command, Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

## 3. Definitions

### 3.1 UTILITY

For this procedure, a utility is defined as a manmade underground line or conduit, cable, pipe, vault or tank that is, or was, used for the transmission of material or energy (e.g., gas, electrical, telephone, steam, water or sewage, product transfer lines, or underground storage tanks).

### 3.2 AS-BUILT PLANS

As-built plans are plans or blueprints depicting the locations of structures and associated utilities on a property.

### 3.3 ONE-CALL

The Utility Notification Center is the one-call agency for Oregon, Washington, Montana, and Hawaii. The Utility Notification Center is open 24 hours a day, and accepts calls from anyone planning to dig in. The phone number for the Hawaii One Call Center is 1-866-423-7287 (or 811). Additional information can be found at http://www.callbeforeyoudig.org/hawaii/index.asp.

Calling before you dig ensures that any publicly owned underground lines will be marked, so that you can dig around them safely. Having the utility lines marked not only prevents accidental damage to the lines, but prevents property damage and personal injuries that could result in breaking a line.

The following information will need to be provided when a request is placed to One-Call:

- Your name, phone number, company name (if applicable), and mailing address.
- What type or work is being done. This should be a description of the specific reason for the work, not the method used.
- Who the work is being done for.
- The county and city the work is taking place in.
- The address or the street where the work is taking place.
- Marking instructions, (specific instructions as to where the work is taking place).

Under normal circumstances it takes between 2 days to 5 days from the time you call (not counting weekends or holidays) to have the underground lines marked. Because these laws vary from state to state, exactly how long it will take depends on where your worksite is located. You will be given an exact start time and date when your locate request is completed, which will comply with the laws in your area.

In the event of an emergency (any situation causing damage to life or property, or a service outage), lines can be marked sooner than the original given time if requested, but must be handled via voice contact with One-Call.

### 3.4 TONING

Toning is the process of surveying an area utilizing one or more surface geophysical methods to determine the presence or absence of underground utilities. Typically, toning is conducted after identifying the general location of utilities and carefully examining all available site utility plans. Each location is marked according to the type of utility being identified. In addition, areas cleared by toning are flagged or staked to indicate that all identified utilities in a given area have been toned.

## 4. Responsibilities

The prime contractor CTO Manager is responsible for verifying that these utility locating procedures are performed prior to the initiation of active subsurface exploration. The CTO Manager is responsible for ensuring that all personnel involved in sampling and/or testing shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The onsite Field Manager (FM) and Site Safety and Health Officer (SSHO) are responsible for planning utility clearance and for locating and marking underground utilities according to this procedure.

Field personnel are responsible for the implementation of this procedure.

## 5. Procedures

Follow the following steps at all sites where subsurface exploration will include excavations, drilling, or any other subsurface investigative method that could damage utilities at a site. In addition to the steps outlined below, always exercise caution while conducting subsurface exploratory work.

### 5.1 PREPARE PRELIMINARY SITE PLAN

Prepare a preliminary, scaled site plan depicting the proposed exploratory locations as part of the work plan. Include as many of the cultural and natural features as practical in this plan.

### 5.2 REVIEW BACKGROUND INFORMATION

Search existing plan files to review the as-built plans and available geographic information system databases to identify the known location of utilities at the site. In addition, the contractor should contact the Navy RPM to obtain the most updated GIS layers. Plot the locations of utilities identified onto a preliminary, scaled site plan. Inform the CTO Manager if utilities lie within close proximity to a proposed exploration or excavation location. The CTO Manager will determine if it is necessary to relocate proposed sampling or excavation locations.

Include the utility location information gathered during investigation (e.g., remedial investigation or remedial site evaluation) work in the project design documents for removal or remedial actions. In this manner, information regarding utility locations collected during implementation of a CTO can be shared with the other contractors during implementation of a particular task order. In many instances, this will help to reduce the amount of additional geophysical surveying work the other contractor may have to perform.

Conduct interviews with onsite and facility personnel familiar with the site to obtain additional information regarding the known and suspected locations of underground utilities. In addition, if appropriate, contact shall be made with local utility companies to request their help in locating underground lines. Pencil in the dimensions, orientation, and depth of utilities, other than those identified on the as-built plans, at their approximate locations on the preliminary plans. Enter the type of utility, the personnel who provided the information, and the date the information was provided into the field log.

During the pre-fieldwork interviewing process, the interviewer will determine which site personnel should be notified in the event of an incident involving damage to existing utilities. Record this information in the field logbook with the corresponding telephone numbers and addresses.

### 5.3 DIG PERMIT

Prior to all activities requiring excavation work that may disrupt utility services, vehicular or aircraft traffic flow, protection provided by fire and intrusion alarm systems, or routine activities at Navy bases (including Joint Base Pearl Harbor-Hickam and Naval Base Guam), as well as intrusive work at Marine Corps Base Hawaii, current procedures shall be followed. The dig permit process tries to identify, as much as practical, any known, potentially hazardous work condition related to excavation activities and is intended to prevent accidents. It also informs key Navy personnel of the digging work and coordinates the required work with these activities to minimize inconveniences (JBPHH 2013).

### 5.4 SITE VISIT – LOCATE UTILITIES – TONING

Prior to the initiation of field activities, the field task manager or similarly qualified staff personnel shall visit the site and note existing structures and evidence of associated utilities, such as fire hydrants, irrigation systems, manhole and vault box covers, standpipes, telephone switch boxes, free-standing light poles, gas or electric meters, pavement cuts, and linear depression. Compare notes of the actual site configuration to the preliminary site plan. Note deviations in the field logbook and on the preliminary site plan. Accurately locate or survey and clearly mark with stakes, pins, flags, paint, or other suitable devices all areas where subsurface exploration is proposed. These areas shall correspond with the locations drawn on the preliminary site plan.

Following the initial site visit by the FM, a trained utility locator will locate, identify, and tone all utilities depicted on the preliminary site plan. The locator should use appropriate sensing equipment to attempt to locate utilities that might not have appeared on the as-built plans. This may involve the use of surface geophysical methods (Procedure I-B-2, *Geophysical Testing*). At a minimum, use a utility locator, metal detector, and/or magnetometer; however, it is important to consider the possibility that non-metallic utilities or tanks might be present at the site. Use other appropriate surface geophysical methods, such as Ground Penetrating Radar, if non-metallic cultural features are likely to be present at the site. Clear proposed exploration areas of all utilities in the immediate area where subsurface exploration is proposed. Clearly tone all anomalous areas. Clearly identify all toned areas on the preliminary site plan. After toning the site and plotting all known or suspected buried utilities on the preliminary site plan, the utility locator shall provide the FM with a copy of the completed preliminary site plan. Alternatively, the FM or designee shall document the results of the survey on the preliminary site plan.

Report to the FM anomalous areas detected and toned that are in close proximity to the exploration or excavation areas. The FM shall determine the safe distance to maintain from the known or suspected utility. It may be necessary to relocate proposed exploration or excavation areas. If this is required, the FM or a similarly qualified individual shall relocate them and clearly mark them using the methods described above. Completely remove the markings at the prior location. Plot the new locations on the site plan and delete the prior locations from the plan. In some instances, such as in areas extremely congested with subsurface utilities, it may be necessary to dig by hand to determine the location of the utilities.

### 5.5 PREPARE SITE PLAN

Prior to the initiation of field activities, draft a final site plan that indicates the location of subsurface exploration areas and all known or suspected utilities present at the site. Provide copies of this site plan to the Contracting Officer’s Representative (COR), the CTO Manager, and the subcontractor who is to conduct the subsurface exploration/excavation work. Review the site plan with the COR to verify its accuracy prior to initiating subsurface sampling activities.

## 6. Records

Keep a bound field logbook detailing all activities conducted during the utility locating procedure. The logbook will describe any changes and modifications made to the original exploration plan. The trained utility locator shall prepare a report and keep it in the project file. Also keep a copy of the final site plan on file.

## 7. Health and Safety

Field personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

## 8. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Joint Base Pearl Harbor-Hickam (JBPHH). 2013. *Dig Permit Requests*. JBPHH Instruction 11013.1. 15 March 2013.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual*. EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-B-2, *Geophysical Testing.*

## 9. Attachments

None.

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# Investigation-Derived Waste Management

## 1. Purpose

This standard operating procedure describes the activities and responsibilities of the United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific with regard to management of investigation-derived waste (IDW). The purpose of this procedure is to provide guidance for the minimization, handling, labeling, temporary storage, inventory, classification, and disposal of IDW generated under the ER Program. This procedure will also apply to personal protective equipment (PPE), sampling equipment, decontamination fluids, non-IDW trash, non-indigenous IDW, and hazardous waste generated during implementation of removal or remedial actions. The information presented will be used to prepare and implement work plans (WPs) for IDW-related field activities. The results from implementation of WPs will then be used to develop and implement final IDW disposal plans.

## 2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

This procedure focuses on the requirements for minimizing, segregating, handling, labeling, storing, and inventorying IDW in the field. Certain drum inventory requirements related to the screening, sampling, classification, and disposal of IDW are also noted in this procedure.

## 3. Definitions

### 3.1 IDW

IDW consists of all materials generated during site investigations that might be contaminated with chemicals of concern. IDW might consist of many types of potentially contaminated materials, including but not limited to, PPE, disposable sampling and decontamination equipment, investigation-derived soil, sludge, and sediment, well development and purge water, and decontamination fluids.

### 3.2 PPE

PPE, as defined in this procedure, refers to all disposable materials used to protect personnel from contact with potentially contaminated site media, such as inner and outer gloves, Tyvek suits and overboots, and disposable respirator cartridges. Non-consumable items, such as steel-toe boots, respirators, and hard hats are not included in this procedure.

### 3.3 DISPOSABLE SAMPLING EQUIPMENT

Disposable sampling equipment consists of all single-use equipment that might have come in contact with potentially contaminated site media, including sample bailers, Draeger air monitoring tubes, used soil sampling trowels and spatulas, plastic drop cloths, plastic bags and bucket liners, and sample containers from field analytical test kits.

### 3.4 INVESTIGATION-DERIVED SOIL, SLUDGE, AND SEDIMENT

Investigation-derived soil consists of all potentially contaminated soil that is disturbed as part of site investigation activities. The most commonly encountered form of IDW soil is drill cuttings brought to the ground surface by drilling. Other forms of disturbed soil, including trenching spoils and excess soil remaining from surface sampling, should not be stored as IDW. Excavated soil should be returned to its source if site conditions permit.

Investigation-derived sludge consists of all potentially contaminated sludge materials generated or disturbed during site investigation activities. Generated sludge might consist of drilling mud used or created during intrusive activities. Other sludge might include solvents or petroleum-based materials encountered at the bottom of storage tanks and grease traps.

Investigation-derived sediment consists of all potentially contaminated sediments that are generated or disturbed during site investigation activities. Generated sediments might include solids that settle out of suspension from well development, purge, or decontamination water (see Definitions 3.5 and 3.6) while stored in 55-gallon drums or during sample filtration. Disturbed sediments might also consist of catch basin sediments or excess sediment from surface water activities.

### 3.5 WELL DEVELOPMENT AND PURGE WATER

Development water consists of groundwater withdrawn from newly installed monitoring wells in preparation for well purging or pump testing. Monitoring well development methods are discussed in Procedure I-C-2, *Monitoring Well Development*.

Purge water consists of groundwater that is removed from monitoring wells immediately prior to sampling. Well purging methods are discussed in Procedure I-C-3, *Monitoring Well Sampling*. Groundwater derived during aquifer testing shall be addressed on a site-specific basis. Procedures for handling groundwater generated during aquifer testing shall be included in the WP or equivalent document for the CTO.

### 3.6 DECONTAMINATION FLUIDS

Decontamination fluids consist of all fluids used in decontamination procedures conducted during site investigation activities. These fluids consist of wash water, rinse water, and solvents used for the decontamination of non-consumable PPE, sampling equipment, and drilling equipment. Decontamination procedures are discussed in Procedure I-F, *Equipment Decontamination*.

### 3.7 NON-IDW TRASH

Non-IDW trash is all waste materials, such as waste paper, drink containers, food, and packaging, generated in the support zone that have not come in contact with potentially contaminated site media.

## 3.8 NON-INDIGENOUS IDW

Non-indigenous IDW consists of all waste materials from offsite sources that are generated in the transition or contamination reduction zones and have not come in contact with potentially contaminated site media. Non-indigenous IDW includes materials, such as PPE from "clean" field activities (e.g., field blank generation, water sampling events) and refuse from monitoring well installation (e.g., unused sections of well casing, used bentonite buckets, sand bags, and cement bags).

Non-indigenous waste does not include material/waste that is abandoned at the ER site (including the IDW waste storage area) by other parties not associated with the ER work. Disposal of abandoned material/waste in the vicinity of IDW is the responsibility of the property owner (e.g., Navy Region Hawaii) or party responsible for abandoning the material/waste. The ER contractor shall notify the Contracting Officer's Representative (COR) of the situation as soon as possible so that recovery actions can be coordinated by the Government.

## 3.9 RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) HAZARDOUS WASTE

Under the RCRA, a solid waste that is not excluded from regulation is defined as hazardous if it:

- Is "listed" as a hazardous waste in Chapter 40, Code of Federal Regulations (CFR), Parts 261.31 through 261.33
- Exhibits any of four hazardous "characteristics"—ignitability, corrosivity, reactivity, or toxicity (as determined using the Toxicity Characteristic Leachate Procedure [TCLP]) (40 CFR 261.20-24)
- Is subject to certain "mixture" or "derived-from" rules (40 CFR 261.3).

Under certain circumstances, petroleum- or polychlorinated biphenyl (PCB)-contaminated wastes are not considered RCRA hazardous when they only exhibit toxicity characteristic (40 CFR 261.4(b)(10) and 261.8). If IDW is determined to be RCRA hazardous waste, then RCRA storage, transport, and disposal requirements shall apply unless exempt.

## 3.10 RCRA LAND DISPOSAL RESTRICTIONS (LDR)

Land disposal, as defined in RCRA, is any placement of RCRA hazardous waste on the land in a waste pile, landfill, impoundment, well, land treatment area, etc. LDRs are regulatory restrictions placed on land disposal, including pre-treatment standards, engineered containment, capacity constraints, and reporting and permitting requirements.

## 3.11 AREA OF CONTAMINATION (AOC)

The U.S. Environmental Protection Agency (EPA) considers the RCRA AOC to be a single land-based disposal unit, usually a "landfill," and includes non-discrete land areas in which there is generally dispersed contamination. Storing IDW in a container (i.e., portable storage devices, such as drums and tanks) within the AOC and returning it to its source, whether RCRA hazardous or not, does not trigger RCRA LDRs. In addition, sampling and direct replacement of wastes within an AOC do *not* constitute land disposal.

## 3.12 CERCLA HAZARDOUS SUBSTANCES

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) hazardous substances are listed in 40 CFR Table 302.4 and include substances regulated by the RCRA Subtitle C, Clean Water Act (CWA), Clean Air Act (CAA), and Toxic Substances Control Act (TSCA). The CFR is updated annually; therefore, the most recent CFR should be referenced for the CERCLA hazardous waste list.

CERCLA hazardous substances are defined independent of their concentration level (i.e., any detection of a listed CERCLA constituent is considered a "CERCLA hazardous substance"). "Reportable quantities" identified for chemicals in 40 CFR Table 302.4 concern only CERCLA and RCRA requirements for notification to EPA when a release has occurred; they do not dictate whether a chemical is a hazardous substance.

The definition of CERCLA hazardous substances excludes "petroleum, including crude oil or any fraction thereof;" natural gas; natural gas liquids; liquefied natural gas; and synthetic gas usable for fuel, unless specifically listed or designated under the act. Excluded fractions of crude oil contain hazardous substances, such as benzene, that are indigenous in those petroleum substances or that are normally mixed with or added to petroleum during the refining process. However, hazardous substances that are (1) added to petroleum after the refining process, (2) increase in concentration as a result of contamination of the petroleum during use, or (3) commingled with petroleum after a release to the environment, are not considered part of the petroleum exclusion provision, and therefore, are regulated under CERCLA. In addition, some waste oils are regulated under CERCLA because they are specifically listed.

The scope of CERCLA hazardous substances includes the smaller subsets of RCRA hazardous wastes, PCB Aroclors, and other constituents. Therefore, a RCRA hazardous waste is always considered a CERCLA hazardous substance for a CERCLA-driven response action; however, a CERCLA hazardous substance is not always a RCRA hazardous waste.

CERCLA only regulates releases or threats of releases of hazardous substances into the environment. If there is no evidence that (1) a release has occurred (based on site history, visual observations, background metals evaluation), (2) there is a threat of release (as from abandoned, discarded, or non-maintained chemical receptacles), or (3) the release has entered the environment (as defined below), then CERCLA does not regulate the constituent even though it is identified on the CERCLA hazardous substance list.

### 3.12.1 CERCLA Hazardous Substances: TSCA/PCBs

PCBs are a CERCLA hazardous substance. PCBs belong to a broad family of man-made organic chemicals known as chlorinated hydrocarbons. PCBs were domestically manufactured from 1929 until their manufacture was banned in 1979. They have a range of toxicity and vary in consistency from thin, light-colored liquids to yellow or black waxy solids. Due to their non-flammability, chemical stability, high boiling point, and electrical insulating properties, PCBs were used in hundreds of industrial and commercial applications including electrical, heat transfer, and hydraulic equipment; as plasticizers in paints, plastics, and rubber products; in pigments, dyes, and carbonless copy paper; and many other industrial applications. Although no longer commercially produced in the United States, PCBs may be present in products and materials produced before the 1979 PCB ban.

If PCBs are detected at concentrations equal to or greater than 50 parts per million (ppm), the sample is considered TSCA-regulated. Current PCB regulations can be found in the CFR at 40 761. The EPA Q and A Manual (EPA 2009), referring to CFR 761.61 explains PCB remediation waste must be managed and disposed of based on the concentration at which the PCBs are found. It is unacceptable to dilute the as-found concentration of the contaminated soil by mixing it with clean soil during excavation or other IDW management activities.

### 3.13 ENVIRONMENT

Environment means navigable waters, ocean waters, surface water, groundwater, drinking water supply, land surface or subsurface strata, and ambient air, within the U.S. or under federal jurisdiction (see Section 101(8) of CERCLA or 40 CFR 300.5 for complete definition).

### 3.14 ONSITE AREA

The CERCLA onsite area is defined in 40 CFR 300.400(e)(1) as an area that includes:

- AOC
- All suitable areas in very close proximity to the contamination that are necessary for the implementation of the response action

The delineation of the onsite area is further discussed in Volume 55 Federal Register (FR) Page 8688 and EPA guidance.

Neither CERCLA, the National Oil and Hazardous Substances Pollution Contingency Plan, nor RCRA define the terms “area of contamination” or “contamination.” However, the area of contamination is interpreted as containing “varying types and concentrations of contaminants” (55 FR 8760) that may or may not pose a risk to human health or the environment.

The onsite area may also include several noncontiguous aerial extents of contaminations if they share a common nexus (55 FR 8690).

### 3.15 OFFSITE AREA

The offsite area consists of all areas outside the onsite area.

### 3.16 CERCLA OFFSITE RULE

The CERCLA offsite rule (400 CFR 300.440) states that IDW containing CERCLA hazardous substances (at any concentration) must be stored, treated, or disposed of offsite only at facilities having current EPA approval to accept such CERCLA wastes. RCRA-permitted facilities (Subtitle C and D) must also have specific EPA approval to accept waste generated at a CERCLA site (even if the waste is RCRA hazardous).

With some restrictions, the offsite rule does not apply to the following:

- Wastes generated during non-CERCLA actions
- Treatability study samples

- Wastes generated during emergency response actions
- Laboratory samples

CERCLA allows IDW to be managed, stored, and disposed of onsite within or near the AOC without the need for EPA approval (i.e., CERCLA facility approval) or RCRA permits. If IDW is to be stored or disposed of on site, the onsite area (and the AOC) should be delineated on a figure in the project field book and revised, based on best professional judgment, as site data become available.

# 4. Responsibilities

The prime contractor CTO Manager is responsible for preparing WPs and IDW disposal plans and reports in compliance with this procedure, and is responsible for documenting instances of noncompliance. The CTO Manager is responsible for ensuring that all personnel involved in sampling and/or testing shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for implementing this IDW procedure and ensuring that all project field staff follow these procedures.

Field personnel are responsible for the implementation of this procedure.

# 5. IDW Management Procedures

The procedures for IDW management in the field are described below.

## 5.1 PLANNING FOR IDW MANAGEMENT

The project team should begin planning for IDW issues early in the site investigation planning stage. The proper management of IDW involves all of the following tasks:

- Obtain Navy approval for a designated IDW storage area prior to commencement of field work
  - Complete Navy form, including IDW Tracking Sheet and provide to remedial project manager (RPM) for processing
- Waste generation and minimization
- Chemical screening and characterization of the waste
- Waste handling, storage, and associated maintenance in compliance with all regulations (prepare an IDW drum inventory, ensure storage areas are compliant with type of waste [double containment, TSCA requirements, etc.] maintain condition of drum and labeling, maintain safety and assess controls, comply with permit requirements [for offsite storage])
- Waste transport and disposal within required holding times
- Waste tracking, documentation, record keeping, and reporting

As part of IDW planning, the CTO Manager should consult with the COR and environmental regulatory agencies to clearly identify the primary federal or state regulatory authority that is driving the site investigation. This authority may be CERCLA, RCRA (Subtitle C), RCRA (subtitle I), TSCA, CWA, or an equivalent state program. The primary investigation authority and regulations promulgated under this authority set forth requirements for IDW management. These requirements may differ under the various response authorities. For CERCLA-driven actions, IDW storage and disposal should comply with all applicable or relevant and appropriate requirements (ARARs) and to-be-considered (TBC) criteria to the extent practicable.

Lastly, the CTO Manager should consider the disposal criteria of the anticipated disposal facility when developing the sampling and analysis plan (SAP). Some offsite facilities do not accept waste that is characterized by association with samples collected from the investigation site or they may require analytical data for chemicals that are not of potential concern at the site. Facility disposal criteria may dictate laboratory reporting limits.

If unknown waste is observed onsite, notify the project RPM and COR for further instructions.

### 5.2 IDW MINIMIZATION

Field managers (FMs) and their designates shall minimize the generation of onsite IDW to reduce the need for special storage or disposal requirements that might result in substantial additional costs and provide little or no reduction in site risks (EPA 1992b). Reduce the volume of IDW by applying minimization practices throughout the course of site investigation activities. These minimization strategies include substitution of biodegradable raw materials; using low-volume IDW-generating drilling techniques; where possible, returning excess material to the source location; using disposable sampling equipment versus generating more decontamination fluids from reusable sampling equipment; using bucket and drum liners; and separating trash from IDW.

Material substitution consists of selecting materials that degrade readily or have reduced potential for chemical impacts to the site and the environment. An example of this practice is the use of biodegradable detergents (e.g., Alconox or non-phosphate detergents) for decontamination of non-consumable PPE and sampling equipment. In addition, field equipment decontamination can be conducted using isopropyl alcohol rather than hexane or other solvents (for most analytes of concern) to reduce the potential onsite chemical impacts of the decontamination solvent. Select decontamination solvents carefully so that the solvents, and their known decomposition products, are *not* potentially RCRA hazardous waste, unless absolutely necessary.

Give priority to drilling methods that minimize potential IDW generation. Select hollow-stem auger and air rotary methods, where feasible, over mud rotary methods. Mud rotary drilling produces waste drilling mud, while hollow stem and air rotary drilling methods produce relatively low volumes of soil waste. Use small-diameter borings and cores when soil is the only matrix to be sampled at the boring location; however, the installation of monitoring wells requires the use of larger-diameter borings.

If possible, return soil, sludge, or sediment removed from borings, containment areas, and shallow test trenches to the source immediately after sampling and/or geological logging of the soils (EPA 1991, 1992b). Immediate replacement of solid waste in the source location during investigation activities avoids RCRA LDRs, which permit movement of IDW within the same AOC without considering land disposal to have occurred, even if the IDW is later determined to contain RCRA hazardous material (EPA 1991). Place soil IDW from borings and trenches on polyethylene sheeting (e.g., Visqueen) during excavation and segregate it by approximate depth and any apparent contamination (i.e., visible staining). Following excavation, replace the soil IDW from above the saturated layer into the boring or trench and compact it, if possible. Efforts should be made to return the waste to the approximate depth from which it was generated. Soil and sludge IDW generated at or below the saturated layer of a boring or trench should be placed in drums and not returned to the source area. Suspected contaminated soil and sludge IDW generated above the saturated layer of a boring or trench should not be returned below the saturated layer."

Often monitoring wells are constructed outside the area of concern for soil contamination to sample for potential groundwater contamination or collect characteristic background data. At these locations, soil cuttings generated from above the saturation zone may be immediately disposed of near the wellhead in a shallow pit covered with natural topsoil from the site, and compacted. Contain soil and sludge IDW generated at or below the saturated layer in drums.

Reduce the quantity of decontamination rinse water generated by using dedicated and disposable sampling equipment, such as plastic bailers, trowels, and drum thieves that do not require decontamination. In general, decontamination fluids, and well development and purge water should not be minimized because the integrity of the associated analytical data might be affected.

Minimize the storage of visibly soiled PPE and disposable sampling equipment IDW by implementing decontamination procedures. If, based upon the best professional judgment of the FM, the PPE and disposable sampling equipment can be rendered non-contaminated after decontamination, then double-bag the PPE and disposable sampling equipment and dispose of it off site at a (RCRA Subtitle D) municipal solid waste disposal facility at the end of each work day (EPA 1991, 1992b). Since the decontaminated waste does not contain CERCLA hazardous substances, it need not be disposed of at a CERCLA-approved disposal facility in accordance with the CERCLA offsite rule.

Bucket liners can be used in the decontamination program to reduce the volume of solid IDW generated, and reduce costs on larger projects. The plastic bucket liners can be crushed into a smaller volume than the buckets, and only a small number of plastic decontamination buckets are required for the entire project. The larger, heavy-duty, 55-gallon drum liners can be used for heavily contaminated IDW to provide secondary containment, and reduce the costs of disposal and drum recycling. Drum liners may extend the containment life of the drums in severe climates and will reduce the costs of cleaning out the drums prior to recycling.

All waste materials generated in the support zone are considered non-IDW trash. To minimize the total volume of IDW, separate all trash from IDW, seal it in garbage bags, and properly dispose of it off site as municipal waste at the end of each work day.

Keep excess cement, sand, and bentonite grout prepared for monitoring well construction to a minimum. FMs shall observe well construction to ensure that a sufficient, but not excessive, volume of grout is prepared. Some excess grout may be produced. Unused grout (that should not come in contact with potentially contaminated soil or groundwater) shall be considered non-hazardous trash, and the drilling subcontractor shall dispose of it off site. Surplus materials from monitoring well installation, such as scrap plastic sections, used bentonite buckets, and cement/sand bags that do not come in contact with potentially contaminated soil, shall be considered non-IDW trash, the drilling subcontractor shall dispose of it off site.

Following proper segregation procedures, as discussed in the next section, can minimize the quantity of contaminated IDW generated.

### 5.3 SEGREGATION OF IDW BY MATRIX AND LOCATION

It is necessary to properly segregate IDW in order to:

- Avoid commingling contaminated waste with clean waste, thereby creating a larger volume of waste that must be treated as contaminated
- Facilitate the sampling, screening, classification, and disposal of waste that may require different management methods

Take efforts to segregate IDW even when these activities will increase storage container and storage space requirements. These efforts will drastically reduce the sampling and documentation required for characterizing the waste and their associated costs.

In general, segregate IDW by matrix and source location and depth at the time it is generated. IDW from only one matrix shall be stored in a single drum (e.g., soil, sediment, water or PPE shall *not* be mixed in one drum). Groundwater and decontamination water should not be commingled; however, development and purge water from the same well may be stored together.

In general, IDW from separate sources should not be combined in a single drum or stockpile. Take efforts to segregate waste by increments of depth below ground surface. Most importantly, segregate soil IDW generated at or from below the saturated zone from soil generated above this zone (soil below this zone might be impacted by contaminated groundwater, whereas soil above the zone may be “clean”). Similarly, segregate soil above and below an underground storage tank (UST). Label each drum of soil to indicate the approximate depth range from which it was generated; this task may require cuttings to be segregated on plastic sheeting as they are generated or drums to be filled during the trenching or boring operation if this can be done in a safe manner.

It is possible that monitoring well development and purge water will contain suspended solids, which will settle to the bottom of the storage drum as sediment. Include significant observations on the turbidity or sediment load of the development or purge water in the logbook see Procedure III-D, *Logbooks* and Section 5.5). To avoid mixed matrices in a single drum (i.e., sediment and water), it may be necessary to decant the liquids into a separate drum after the sediments have settled out. This segregation may be accomplished during subsequent IDW sampling activities or during consolidation in a holding tank prior to disposal.

Place potentially contaminated well construction materials in a separate drum. No soil, sediment, sludge, or liquid IDW shall be placed in drums with potentially contaminated waste well construction materials. In addition, potentially contaminated well construction materials from separate monitoring wells shall not be commingled.

Store potentially contaminated PPE and disposable sampling equipment in drums separate from other IDW. Segregate PPE from generally clean field activities, such as water sampling, from visibly soiled PPE, double-bag it, and dispose of it off site as municipal waste. Disposable sampling equipment from activities, such as soil, sediment, and sludge sampling, includes plastic sheeting used as liner material in containment areas around drilling rigs and waste storage areas, disposable sampling equipment, and soiled decontamination equipment. If, according to the Field Manager's best professional judgment, the visibly soiled PPE can be decontaminated and rendered non-hazardous, then double-bag the decontaminated PPE and disposed of it off site as municipal waste (EPA 1991, 1992b). PPE and disposable sampling equipment generated on separate days in the field may be combined in a single drum, provided clean and visibly soiled IDW are segregated as discussed above.

IDW generated from the use of field analytical test kits consists of those parts of the kit that have come into contact with potentially contaminated site media, and used or excess extracting solvents and other reagents. Contain potentially contaminated solid test kit IDW in plastic bags and store it with contaminated PPE or disposable sampling equipment IDW from the same source area as soil material used for the analyses. Segregate the small volumes of waste solvents, reagents, and water samples used in field test kits, and dispose of it accordingly (based upon the characteristics of the solvents as described in this procedure). Most other test kit materials should be considered non-IDW trash, and be disposed of as municipal waste.

Store decontamination fluids in drums separate from groundwater and other IDW. If practical, decontamination fluids generated from different sources should not be stored in the same drum. If decontamination fluids generated over several days or from different sources are stored in a single drum, record information about the dates and IDW sources represented in the drum. Note this information in the field notebook, on the drum label (Section 5.4.3), and in the drum inventory (Section 5.5).

The FM and designated personnel should separate the liquid and sediment portions of the equipment decontamination fluid present in the containment unit used by the drilling or excavation field crew. The contents of this unit normally consist of turbid decontamination fluid above a layer of predominantly coarse-grained sediment. When the contents of the containment unit are to be removed for storage in IDW drums, the FM shall instruct the field crew to place as much of the liquid into drums as possible and transfer the remaining solids into separate drums. Note observations of the turbidity and sediment load of the liquid IDW in the field notebook, on the drum label (Section 5.4.3), and in attachments to the drum inventory (Section 5.5). It is likely that decontamination fluids will contain minor amounts of suspended solids that will settle out of suspension to become sediment at the bottom of IDW storage drums. As noted above, it may be necessary to segregate the drummed water from sediment during subsequent IDW sampling or disposal activities.

Documentation for waste storage containers should include IDW source and segregation information and be maintained as follows:

1. Field logbook should be updated, at least weekly, with all IDW drum additions – update storage area location map to include new drum position and drum number.

2. External drum log (hard copy and electronic copy) should be updated with each IDW drum addition (drum numbers, source, and generation date) and closure of drum (fill date).

## 5.4 DRUM FILLING, HANDLING, AND LABELING, AND INVENTORYING

Drum handling consists of those actions necessary to prepare an IDW drum for labeling. Drum labeling consists of those actions required to legibly and permanently identify the contents of an IDW drum.

### 5.4.1 Drum Filling

Each drum of solid IDW shall be completely filled, when possible. For liquid IDW, drums should be left with headspace of approximately 5 percent by volume to allow for expansion of the liquid and potential volatile contaminants.

### 5.4.2 Drum Handling

IDW shall be containerized using U.S. Department of Transportation-(DOT) approved drums. The drums shall be made of steel or plastic, have a 55-gallon capacity, be completely painted or opaque, and have removable lids (i.e., United Nations Code 1A2 or 1H2). Drums having removable lids with bung holes are preferred to facilitate verification of drum contents. Typically 55-gallon drums are used, however small drums may be used depending on the amount of waste generated. New steel drums are preferred over recycled drums. Recycled drums should not be used for hazardous waste, PCBs or other regulated shipments. For short-term storage of liquid IDW prior to discharge, double-walled bulk steel or plastic storage tanks may be used. For this scenario, consider the scheduling and cost-effectiveness of this type of bulk storage, treatment, and discharge system versus longer-term drum storage.

The Guam Environmental Protection Agency may require double-walled drums or other secondary containment for the storage of liquid IDW. For long-term IDW storage at other project locations, the DOT-approved drums with removable lids are recommended. Verify the integrity of the foam or rubber sealing ring located on the underside of some drum lids prior to sealing drums containing IDW liquids. If the ring is only partially attached to the drum lid, or if a portion of the ring is missing, select another drum lid with a sealing ring that is in sound condition.

To prepare IDW drums for labeling, wipe clean the outer wall surfaces and drum lids of all material that might prevent legible and permanent labeling. If potentially contaminated material adheres to the outer surface of a drum, wipe that material from the drum, and segregate the paper towel or rag used to remove the material with visibly soiled PPE and disposable sampling equipment. Label all IDW drums and place them on appropriate pallets prior to storage.

### 5.4.3 Drum Labeling

Proper labeling of IDW drums is essential to the success and cost-effectiveness of subsequent waste screening and disposal activities (see Attachment I-A-6-1 and Attachment I-A-6-2). Labels shall be permanent and descriptive to facilitate correlation of field analytical data with the contents of individual IDW drums. Label all IDW drums using the **three distinct labeling methods** described below to ensure durability of the information. These three methods are completing and affixing preprinted NAVFAC Pacific ER Program labels; marking information on drum surfaces with paint; and, affixing aluminum tags to the drum. **Use of the preprinted labels, painted labeling, and aluminum tags is *mandatory***. These methods are described below.

### *5.4.3.1 PREPRINTED LABELS*

Complete **two** preprinted NAVFAC Pacific ER Program drum labels as described below and presented in Attachment I-A-6-1. Seal both labels in separate heavy-duty, clear plastic bags, or use permanent markers on weatherproof stickers, to prevent moisture damage.

1. Place one label on the outside of the drum with the label data facing outward. Affix the bag/sticker to the drum at the midpoint of the drum height using a sufficient quantity of adhesive tape (e.g., duct tape, packing/strapping tape) so the bag will remain on the drum as long as possible during storage.

2. Affix the second label (sealed as mentioned above) to the underside of the drum lid, sealing it inside the drum when the lid is replaced.

The use of two or more preprinted labels for outer IDW drum identification purposes should be considered as a short-term backup to the information on the aluminum tags discussed below.

Print the requested information legibly on the drum labels in black, indelible ink. Instructions for entering the required drum-specific information for each label field are presented below:

*CTO:* Enter the four-digit number of the CTO for the project during which the IDW was generated. Include any initial zeroes in the CTO number (e.g., CTO 0047).

*Activity-Site:* Enter the name of the Navy activity responsible for the project site (e.g., Naval Supply Center, Naval Facilities Engineering Command Hawaii) and the name of the site where the project is taking place (e.g., Orote, Landfill, Building [Bldg.] 18).

Drum#: Enter the drum identification number according to the convention described below.

(xxxx-AA-DMzzz);

Where:

| | |
|---|---|
| xxxx | represents the four-digit CTO number |
| AA | represents the unique site identifier assigned by the CTO Manager for multiple site CTOs (e.g., for CTO 0047, OW denotes Old Westpac, OR denotes Orote) |
| DM | represents a *drum* identification number |
| zzz | the sequential drum number for the site, beginning with 001 |

*Date Collected:* Enter the date the IDW was generated and placed in the drum. If IDW was generated over a number of days, enter the start and end dates for the period.

*Contents:* Record the source identification number on the label. Enter a "√" in the box corresponding to the type of IDW placed in the drum. For "Soil" and "Water," use the line provided to record observations on the condition of the drum contents (e.g., diesel odor, high turbidity, specific liquid IDW type). Check "Solid Waste" for PPE and indicate that PPE is present in the drum. Check

"Other" for disposable sampling equipment and potentially contaminated monitoring well construction materials, and indicate the type of waste on the line provided.

*Project Type:* Enter a "√" in the box corresponding to the type of investigation. Choices are Remedial Investigation, RCRA Facility Inspection, UST, and Other. If "Other" is specified, indicate the type of project in the "Comments" area, as described below.

*Comments:* Enter any additional information regarding the drum contents that will assist individuals who will characterize and dispose of the contents of the drum. "Other" project types include Site Inspection, Feasibility Study, Removal/Remedial Action, and Emergency Response activity. In addition, use this space on the label to complete any descriptions that were too large to fit in preceding label fields, such as the turbidity of decontamination water or the site activities from which the PPE was generated.

*For Information Contact:* Enter the project COR activity / code, address, and phone number.

It is essential that all relevant information recorded on individual drum labels be repeated in the field notebook for later development of the drum inventory database (see Section 5.5 and Procedure III-D, *Logbooks*).

#### *5.4.3.2 PAINTED LABELS*

The second method for labeling drums is to paint label information directly on the outer surface of the drum. At a minimum, the information placed on the drum shall include the CTO number, the drum number (following the numbering convention given above), the source identification number and type, the generation date(s), and the telephone number provided at the bottom of the preprinted label appropriate for the project location. The drum surface shall be dry and free of material that could prevent legible labeling. Confine label information to the upper two-thirds of the total drum height. The top surface of the drum lid may be used as an additional labeling area, but this area should only be used *in addition* to the upper two-thirds of the sides of the drum. The printing on the drum shall be large enough to be easily legible. Yellow, white, black, or red paint markers (oil-based enamel paint) that are non-photodegradable are recommended to provide maximum durability and contrast with the drum surface.

#### *5.4.3.3 ALUMINUM TAGS*

The third method for labeling drums is to affix an aluminum tag to the drum with neatly printed information that shall consist of the **CTO number**, the **drum identification number**, the **type of contents**, the **generation date(s)**, the **source** identification number and type, and the **telephone number** provided at the bottom of the appropriate preprinted label. Attachment I-A-6-2 to this procedure presents an example of the aluminum tag, which shall measure approximately 1 inch by 3 inches, or larger. When a ballpoint pen is used to fill out the aluminum tag, the information is permanently recorded as indentations on the tag. A fine ballpoint pen shall be used, and block-printed lettering is required for legibility. Indentations on the tag shall be sufficiently deep to be legible after the label has been exposed to weathering for an extended period.

Complete aluminum tags after the drum has been sealed. Affix the tags to the drum using a wire, which passes through predrilled holes in the label and shall be wrapped around the bolt used to seal the drum lid. The wire is the most likely part of the aluminum tag to decay during exposure. Use of plastic insulated, copper-core electrical wire of appropriate diameter is recommended if long-term exposure to severe weathering is anticipated.

#### *5.4.3.4 WASTE LABELS*

Standard green and white non-hazardous and/or other hazardous waste stickers may be used in conjunction with, but not in lieu of, the above labeling procedures.

## 5.5 DRUM INVENTORY

Accurate preparation of an IDW drum inventory is essential to all subsequent activities associated with IDW drum tracking and disposal. Prepare an inventory for each project in which IDW is generated, stored, and disposed of. This information provided in the inventory report constitutes the results of preparing and implementing an IDW sampling, screening, characterization, and disposal program for each site.

The drum inventory information shall include 10 elements that identify drum contents and indicate their outcome. These elements are discussed in Sections 5.5.1 through 5.5.10.

### 5.5.1 Navy Activity (Generator)/Site Name

Inventory data shall include the Navy activity and the site name where the IDW was generated (e.g., Fleet Industrial Supply Center Pearl/Red Hill, Naval Magazine Headquarters/USTs).

### 5.5.2 CTO Number

Inventory data shall include the four-digit CTO number associated with each drum (e.g., 0089) and contract number as necessary.

### 5.5.3 Drum Number

Include the drum number assigned to each drum in the inventory database. Drum numbers shall adhere to the numbering convention presented in Section 5.4.3.1 (e.g., 0091-LF-DM006).

### 5.5.4 Storage Location Prior to Disposal

Include the storage location of each drum prior to disposal in the inventory database (e.g., Bldg. 394 Battery Disassembly Area, or Adjacent to West end of Bldg. 54). As part of the weekly inventory, a site visit to the IDW storage location shall be performed to observe the condition of the drums and covers. Drums and covers are considered acceptable when the integrity of the drums and covers are structurally intact, drum identification is legible, and the location of the drum storage is secure. An unacceptable classification will require recommendations to remedy the unacceptable classification.

### 5.5.5 Origin of Contents

Specify the source identification of the contents of each IDW drum in the inventory database (e.g., soil boring number, monitoring well number, sediment sampling location, or the multiple sources for PPE- or rinse water-generating activities).

### 5.5.6 IDW Type

Inventory data shall include the type of IDW in each drum (e.g., soil, PPE, disposable sampling equipment, sludge, sediment, development water, steam cleaning water, decontamination rinse water).

### 5.5.7 Waste Volume

Specify the amount of waste in each drum in the inventory database as a percentage of the total drum volume or an estimated percentage-filled level (e.g., 95 percent maximum for liquid IDW).

### 5.5.8 Generation Date

Inventory data shall include the date IDW was placed in each drum. If a drum contains IDW generated over more than one day, the start date for the period shall be specified in dd-mmm-yy format. This date is *not* to be confused with a RCRA hazardous waste accumulation date (40 CFR 262).

### 5.5.9 Expected Disposal Date

Specify the date each drum is expected to be disposed of as part of the inventory in mmm-yy format. This date is for the Navy's information only and shall not be considered contractually binding.

### 5.5.10 Actual Disposal Date

The actual drum disposal date occurs at the time of onsite disposal, or acceptance by the offsite treatment or disposal facility. Enter this date in the drum inventory data base only when such a date is available in dd-mmm-yy format.

Information required to complete all 10 of the inventory elements for the monthly inventory report described above and summarized in Attachment I-A-6-3, will be located on the IDW labels or provided by the CTO Manager.

Actual disposition of the IDW drum contents will be provided to the Navy.

## 5.6 IDW CLASSIFICATION

In general, the CTO Manager should follow IDW classification guidance contained in the *Generic IDW Disposal Plans* for Hawaii and Guam (Ogden 1994, 1995) and EPA guidance (EPA 1991, 1992a). The IDW classification process consists of chemical screening and characterization of the waste.

Various federal and state laws and guidance contain requirements for IDW management (handling, storage, transport, disposal, and recordkeeping) based on the type(s) and concentrations of chemicals present in the waste. To ensure that IDW is managed in compliance with these requirements and to evaluate disposal options, the CTO Manager should

- Directly sample and analyze the IDW or associate it with historical data, observed site conditions, and/or samples collected on site at the source of the waste
- Screen the waste to identify the maximum concentrations of individual chemicals in, or associated with, the waste

- Screen waste constituents against chemical background data, if available
- Characterize the waste based on regulated groups of chemical constituents present in the waste
- Screen waste constituents against risk-based health criteria, ARARs, and TBC criteria for onsite disposal, or disposal facility criteria for offsite disposal

Each of the above steps is distinct and should be performed separately to avoid potential mistakes in the IDW classification process. The following subsections discuss these steps in greater detail.

### 5.6.1 IDW Sampling and Chemical Screening

IDW should be screened to identify chemicals present in the waste and their maximum concentrations. Screening may be facilitated by (1) directly sampling the waste, (2) associating the waste with analytical results from samples collected at the source of the IDW (e.g., a well boring), (3) visual observation of the waste, (4) historical activity data from the site, or (5) a combination of these methods (e.g., association with limited sampling). Composite sampling may be required if the unit volume of IDW is non-homogeneous. Data from samples collected directly from the IDW should take precedence over associated site sample data when making waste management decisions. Procedure I-D-1, *Drum Sampling* discusses methods for drum sampling.

Typically, IDW is screened for chemicals of potential concern at the site and against background data if available. If IDW is generated from outside the suspected AOC (e.g., soil cuttings from the installation of a background monitoring well), assume it is clean, and dispose of it accordingly.

The CTO Manager should consider the disposal criteria of any offsite disposal facility anticipated to be used when developing the SAP. Some offsite facilities do not accept waste that is characterized by association with samples collected from the investigation site or they may require analytical data for chemicals that are not of potential concern at the site. Direct sampling and analysis of the waste may be required for these other constituents. Some disposal facilities prefer to collect and analyze the samples themselves. In addition, disposal facility criteria may dictate laboratory reporting limits. When possible, the CTO Manager should coordinate sampling and data requirements with the disposal subcontractor and anticipated disposal facility. Such efforts may allow IDW sampling to be conducted while the field team is mobilized for the site investigation, rather than conducting a separate IDW sampling event later.

### 5.6.2 IDW Characterization

Various federal and state laws and guidance contain requirements for IDW management (handling, storage, transport, disposal, and recordkeeping) based on the particular constituent or *group(s) of chemical constituents* present in the waste. Therefore, to ensure that IDW is managed in compliance with these requirements, characterize IDW based on the chemical screening results to determine whether any of the following regulated constituents are present in the waste:

- Petroleum hydrocarbons (regulated by RCRA Subtitle I when released from a UST; see 40 CFR Part 280)
- Hazardous wastes (regulated by RCRA Subtitle C; see 40 CFR 261-299)
- Non-hazardous, solid wastes (regulated by RCRA Subtitle D; see 40 CFR 257-258)

- Hazardous substances and commingled petroleum (regulated by CERCLA; see 40 CFR 300.400 and 302.4)
- PCBs (regulated by TSCA; see 40 CFR 700)
- Asbestos (regulated by CAA for disposal; see 40 CFR 61, Subpart M)
- Radioactive wastes (regulated by the Nuclear Regulatory Commission; see 10 CFR [various parts], 40 CFR, Subchapter F, and other applicable laws)

EPA regulations and guidance do not require IDW to be tested to properly characterize it. Instead waste may be characterized based on historical site data, site observations, analytical data from the source of the IDW, and professional judgment (EPA 1991). Specifically, the EPA has indicated that IDW may be assumed not to be “listed” wastes under RCRA unless available information about the site suggests otherwise (53 FR 51444). Similarly, RCRA procedures for determining whether waste exhibits RCRA hazardous characteristics do not require testing if the decision can be made by “applying knowledge of the hazard characteristic in light of the materials or process used” (40 CFR 262.11(c); EPA 1991). If applicable, the disposal plans and reports should state, “there is no evidence based on site data and observations that the IDW contains listed RCRA wastes or exhibits RCRA characteristics.”

For soil IDW, the potential for exhibiting toxicity may be determined by comparing constituent concentrations in the waste against screening values that are 20 times the TCLP criteria as specified in Section 1.2 of EPA Method Solid Waste-846 1311 *Toxicity Characteristic Leaching Procedure* (EPA 2007). Otherwise, samples associated with the soil can be tested using the TCLP.

## 5.7 IDW STORAGE

In general, the CTO Manager should follow IDW storage guidance contained in the *Generic IDW Disposal Plans* for Hawaii and Guam (Ogden 1994, 1995) and EPA guidance (EPA 1990, 1991, 1992a).

Always store IDW in a manner that is secure, protected from weather, and protective of human health and the environment. It is preferable to store IDW within the AOC(s) or on site; however, the Navy may assign a specific IDW storage area away from the project site.

If the IDW is determined to be RCRA hazardous, then RCRA storage, transport, and disposal requirements may apply, including a limited **90-day** storage permit exemption period prior to required disposal. If onsite disposal is an option, store RCRA waste within the AOC so that RCRA LDRs will not apply in the future. LDRs may be triggered if the waste is stored within the onsite area, but outside of the AOC or if the waste is removed from and later returned to the AOC for disposal. The AOC concept does not affect the approach for managing IDW that did not come from the AOC, such as PPE, decontamination equipment and fluids, and groundwater. If RCRA hazardous, these wastes must be managed under RCRA and drummed and disposed of off site (EPA 1991).

RCRA waste should not be stored within the AOC prior to disposal when professional judgment suggests the IDW might pose an immediate or permanent public endangerment (EPA 1991b).

Offsite storage of CERCLA waste must comply with the CERCLA offsite rule (40 CFR 300.440).

If the IDW is determined to be TSCA-regulated, then TSCA storage requirements as described in CFR 764.65, transport, and disposal requirements apply, including a limited **30-day** storage period prior to required disposal. Storage requirements are as follows:

1. Storage facilities must provide an adequate roof and walls to prevent rain water from reaching the stored PCBs.

2. Storage facilities must provide an adequate floor that has continuous curbing with a minimum 6-inch-high curb.

3. Storage facilities must contain no drain valves, floor drains, expansion joints, sewer lines, or other openings that would permit liquids to flow from the curbed area.

4. Storage facilities must provide floors and curbing constructed of continuous smooth and impervious materials to minimize penetration of PCBs.

5. Storage facilities must not be located at a site that is below the 100-year flood water elevation.

6. PCBs in concentrations of 50 ppm or greater must be disposed of within 1 year after being placed in storage.

PCB waste can also be stored in a RCRA-approved waste storage area for 30 days from date of generation.

NAVFAC Pacific requires that all CERCLA, RCRA, and other types of waste be removed from JBPHH areas within 90 days of its generation, particularly within the shipyard area, and 30 days of generation for TSCA waste. Efforts should also be made to dispose of IDW within the 30- and 90-day periods at other Navy installations, unless the IDW will be managed with remediation waste to be generated during a cleanup action in the near future. The Navy may approve extensions of the storage time limit for wastes that are non-hazardous on a project-specific basis.

### 5.7.1 Drum Storage

Implement drum storage procedures to minimize potential human contact with the stored IDW and prevent extreme weathering of the stored drums. Place all IDW drums upright on pallets before the drums are stored. RCRA storage requirements include the following: containers shall be in good condition and closed during storage; wastes shall be compatible with containers; storage areas shall have a containment system; and spills or leaks shall be removed as necessary.

Place all IDW drums generated during field activities at a single AOC or designated IDW storage area together in a secure, fenced onsite area to prevent access to the drums by unauthorized personnel. When a secure area is not available, place drums in an area of the site with the least volume of human traffic. At a minimum, place plastic sheeting (or individual drum covers) around the stored drums. Post signage at the IDW storage area stating that drums should not be removed from the area without first contacting the Navy COR.

Liquid IDW drums must be stored under secondary containment (either secondary containment pallets or handmade plastic sheeting/polyvinyl chloride frame containment) and all IDW drums (soil and water) must utilize secondary containment when stored within 15 feet of a surface water body or storm drain inlet.

Drums from projects involving multiple AOCs shall remain at the respective source areas where the IDW was generated. IDW should not be transferred off site for storage elsewhere, except under rare circumstances, such as the lack of a secure onsite storage area.

Implement proper drum storage practices to minimize damage to the drums from weathering and possible human exposure to the environment. When possible, store drums in dry, shaded areas and cover them with impervious plastic sheeting or tarpaulin material. Make every effort to protect the preprinted drum labels from direct exposure to sunlight, which causes ink on the labels to fade. In addition, store drums in areas that are not prone to flooding. Secure the impervious drum covers appropriately to prevent dislodging by the wind. It may be possible to obtain impervious plastic covers designed to fit over individual drums; nonetheless, repeat the labeling information on the outside of these opaque covers.

Drums in storage shall be placed with sufficient space between rows of drum pallets and shall not be stacked, such that authorized personnel may access all drums for inspection. Proper placement will also render subsequent IDW screening, sampling, and disposal more efficient when individual drum removal is necessary. It is recommended that IDW drums be segregated in separate rows/areas by matrix (i.e., soil, liquid or PPE/other).

If repeated visits are made to the project site, inspect the IDW drums to clear encroaching vegetation, check the condition and integrity of each drum, secondary containment if applicable, check and replace aluminum tags as necessary, and replace or restore the tarpaulin covers.

### 5.7.2 IDW Stockpiles

Consider IDW stockpiling only when a very large quantity of IDW will be generated. Segregate stockpiled IDW, and inventory it by source location and depth to the extent practicable. Stockpiling and media mixing should not be used as methods to dilute chemical concentrations in the waste. Line stockpiles on the bottom, cover it with sturdy plastic, and locate it in areas where weather elements (e.g., wind, rainfall runoff) will not cause migration of the waste. Never dispose of liquid IDW on a stockpile; drum or store liquid waste in other appropriate containers. Follow applicable regulation and guidance when sampling stockpiled waste for characterization purposes.

## 5.8 IDW DISPOSAL

Various methods and requirements for onsite and offsite disposal of IDW are discussed in the *Generic IDW Disposal Plans* for Hawaii and Guam (Ogden 1994, 1995) and EPA guidance (EPA 1990, 1991, 1992b). This section explains the disposal evaluation process and highlights some of the more important requirements for onsite and offsite IDW disposal options.

IDW sampling, characterization, and disposal analysis, particularly for onsite disposal, can be unexpectedly complex and require compliance with many different laws (that act as ARARs for IDW management and disposal). Before preparing the IDW disposal plan, compare estimated costs for onsite vs. offsite disposal. Offsite disposal may be more cost effective than devising and documenting the justification for onsite disposal when the quantity of IDW is small (less than 10 drums) and/or the waste fails the initial conservative screening against conservative risk-based criteria. Also weigh cost savings against the policy preference of the EPA and State of Hawaii Department of Health to manage and dispose of IDW on site, when possible.

### 5.8.1 Onsite Disposal

In general, the EPA preference is to dispose of IDW on site when the disposal action:

- Does not pose an unacceptable long-term risk to human health and the environment
- Is in accordance with chemical-, location- and action-specific ARARs “to the extent practicable” (40 CFR 300.415(i); 55 FR 8756)
- Does not introduce contaminants into clean soil or other site media
- Does not mobilize or significantly increase concentrations of any hazardous constituents already present in the environment
- Is consistent with the final remedy planned for the site
- Takes into account any community concerns regarding waste storage and the disposal method

Base onsite disposal options on best professional judgment and available site-specific data. For some projects, it may be prudent to store the waste temporarily until additional site data become available (e.g., sample analytical data, preliminary risk-assessment results, AOC delineation, and establishment of background values). Factors to consider include, but are not limited to the following:

- The detected or suspected contaminants, their concentrations, and total volume of IDW
- Media potentially affected (e.g., groundwater drinking source)
- Background metals data for site media
- Site access, conditions, and potential receptors
- Current and future land use
- Public perceptions (especially if drum storage and/or disposal takes place in open view)
- Time limits for IDW storage
- Potential requirements to treat waste before disposing of it on site
- Lack of unpaved areas to disposed of waste on site
- Potential wind, erosion, runoff, or flood conditions that might cause offsite migration of disposed waste
- Proximity to the ocean, surface water, or environmentally sensitive habitats
- Natural attenuation processes
- Need for additional utility survey before excavating to backfill waste
- Need for land use controls required to limit exposure pathways (e.g., backfill waste, provide permanent security around site, replant site to prevent erosion)

Protection of human health can be evaluated by comparing chemical concentrations in the waste to the more conservative of EPA residential regional screening levels), environmental action levels, and chemical-specific ARARs and TBC criteria. Ecological receptors can be protected by screening the IDW against EPA ecological soil screening levels. Onsite disposal of surface and groundwater IDW can be evaluated by initially screening against EPA tap-water PRGs, State Safe Drinking Water Standards (maximum contaminant levels and non-zero maximum contaminant level goals), and/or State Surface Water Quality Standards. These criteria are not always ARARs for the disposal method or site conditions; however, they may be useful to affirmatively show that the disposal is protective. Alternatively, the IDW may be associated with human-health and eco-risk assessment results for the site if the onsite placement of IDW is consistent with exposure pathway assumptions made during the risk assessment (e.g., contaminated soil might not present an unacceptable health risk at depth, but could pose such a risk if disposed of at the ground surface).

In general, return IDW consisting of environmental media to or near its source, and return waste generated from depth to its original depth, if possible and approved by NAVFAC in advance. Bury all contaminated soil and water IDW to be disposed of on site below grade at a depth of at least 3 feet and cover it with clean soil to reduce the potential for future exposure to human and ecological receptors.

Dispose of non-indigenous IDW and contaminated decontamination fluids off site. The cleaning detergent Alconox, often used in the decontamination process, is itself non-hazardous and biodegradable. Small quantities of clean decontamination water containing Alconox may be disposed of to clean areas on site. If onsite disposal is appropriate for RCRA IDW, this waste should be disposed of within the AOC to avoid the need to comply with LDRs.

IDW from several non-contiguous onsite areas may be consolidated and disposed of at one of the areas, provided a nexus exists between the wastes generated and response projects (55 FR 8690-8691).

IDW may also be temporarily disposed of back to the AOC without detailed analysis or documentation if the waste will be addressed with other site contamination during a future response action and will not present a significant short-term threat to human health and the environment.

### 5.8.2 Offsite Disposal

If onsite disposal is not a viable option, dispose of the IDW at an appropriate offsite treatment and/or disposal facility. Offsite transport and disposal of IDW must comply with all applicable laws and criteria specific to the chosen disposal facility. These requirements may include, but are not limited to the following:

- RCRA LDRs
- RCRA waste storage permits and time limits
- National Pollutant Discharge Elimination System and sewer disposal criteria
- CERCLA offsite rule
- TSCA treatment requirements
- DOT hazardous material transport packaging, manifesting, and security provisions

- International Maritime Organization ocean transport rules
- Certifications and training for waste transport contractors
- State notification requirements when importing certain types of waste

The CERCLA offsite rule (40 CFR 300.440) requires that CERCLA waste be disposed of only at facilities specifically approved by the EPA to receive such waste for treatment, storage, or disposal. The acceptability status of a disposal facility can change quickly (e.g., if there is a release at the facility); therefore, the CTO Manager should contact the EPA Region 9 CERCLA Offsite Rule Coordinator no more than 60 days prior to disposal of the IDW to verify the facility's approval status. The offsite rule applies to any CERCLA-driven remedial or removal action involving the offsite transfer of waste containing hazardous substances regardless of the concentrations present.

RCRA hazardous waste manifests must always be signed by authorized Navy personnel. In some cases, the Navy may authorize contractors to sign non-hazardous manifests. Navy authorization to allow contractor signature of non-hazardous manifests shall be based upon a Navy review of the contractor's RCRA and DOT training records. In addition, the Navy shall always be allowed the opportunity to review/approve non-hazardous manifests and waste profiles prior to waste disposal efforts.

Disposal of liquid IDW into the Navy sanitary sewer shall occur only if first approved by the Navy. Requests for disposal to Navy facilities should be coordinated through the COR. Discharge to the public sewer system is discouraged and should occur only if approved by state and local government agencies.

## 5.9 RECORDS

The CTO Manager is responsible for completing and updating the site-specific IDW drum inventory spreadsheet and submitting it as needed, and reviewing the IDW disposal plan (IDW disposal paperwork).

FMs and designates are responsible for documenting all IDW-related field activities in the field notebook including most elements of the IDW drum inventory spreadsheet. The correct methods for developing and maintaining a field notebook are presented in Procedure III-D, *Logbooks*.

Guidance related to preparing an IDW disposal plan (if required) is presented in the *Generic IDW Disposal Plans* for Hawaii and Guam (Ogden 1994, 1995).

### 5.9.1 IDW Disposal Documentation

Upon receipt of analytical data from the investigation or from IDW-specific analytical data, the generator information request form will be completed and provided to the IDW subcontractor to begin IDW characterization. Completed IDW disposal paperwork received from the IDW subcontractor should be reviewed for accuracy prior to submitting for Navy review.

The CTO Manager is responsible for submitting backup documentation (actual site or drum sampling results) along with the IDW disposal paperwork to the Navy.

Navy-approved contractor personnel may sign non-hazardous waste IDW documentation. Hazardous waste IDW documentation must be signed by an authorized Navy Environmental Coordinator.

All manifests (non-hazardous and hazardous) must be tracked, and if completed manifests (signed by disposal facility) are not received within 30 days of initial transportation, then contractor must notify the RPM weekly of the shipping status (e-mail is acceptable). Hazardous waste must be disposed of within 45 days of initial transportation. If not, specific IDW transportation details must be supplied to the Navy in order to prepare and file an exception report.

TSCA-regulated waste must be physically destroyed and or buried within 1 year of generation (date placed in IDW drum). Disposal certificates should be provided by the waste facility to the IDW subcontractor and Navy contractor.

Following disposal of IDW, the CTO Manager should prepare a short IDW disposal report summarizing the disposal operation and appending any associated records (e.g., final drum log, waste profiles, transport manifests, bills of lading, disposal facility certifications). Minimal topics to include in the report:

- IDW inventory and storage
- IDW chemical screening and characterization
- IDW transport and disposal
- Manifests
- Drum storage photographs
- Site figure

## 6. Health and Safety

Field Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

## 7. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

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———. 1995. Generic IDW Screening, Sampling, Analysis, and Disposal Plan for Various Hawaii Naval Installations. Pearl Harbor, HI: Pacific Division, Naval Facilities Engineering Command. April.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual.* EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-C-2, *Monitoring Well Development*.

Procedure I-C-3, *Monitoring Well Sampling*.

Procedure I-D-1, *Drum Sampling.*

Procedure I-F, *Equipment Decontamination.*

Procedure III-D, *Logbooks.*

## 8. Attachments

Attachment I-A-6-1: IDW Drum Label

Attachment I-A-6-2: Drum Label – Aluminum Tag

Attachment I-A-6-3: Monthly IDW Drum Inventory Updates

# Attachment I-A-6-1
# IDW Drum Label

**IDW Drum Label**

Contract #:

CTO #: ____________________

ACTIVITY SITE: ________________________________

(_ _ _ _ - _ _ - D M _ _ _)
DRUM #
DATE COLLECTED

CONTENTS: (please ✓ and explain)

☐ Soil ________________________________

☐ Water ________________________________

☐ Solid Waste ________________________________

☐ Other ________________________________

PROJECT TYPE

☐ RI ☐ RFI ☐ UST ☐ Other

COMMENTS: ________________________________

________________________________________________

________________________________________________

________________________________________________

________________________________________________

FOR INFORMATION CONTACT:

COR Activity/ Code:

Address:

Telephone:

# Attachment I-A-6-2
# Drum Label - Aluminum Tag

**Drum Label - Aluminum Tag**

# Attachment I-A-6-3
# Monthly IDW Drum Inventory Updates

**Table I-A-6-1: Monthly IDW Drum Inventory Updates**

| Navy Activity / Site Name (Generator Site) | CTO Number (0bbb) | Drum Number (xxxx-AA-DMzzz) | Drum Storage Location | Origin of Contents (Source ID #) | IDW Type | Waste Volume (Fill level %) | Waste Generation Date (dd-Mon-yy) | Expected Disposal Date (Mon-yy) | Actual Disposal Date (dd-Mon-yy) |
|---|---|---|---|---|---|---|---|---|---|
| Inspector: | | | | | | | | | |
| Date of Inspection: | | | | | | | | | |
| NSC Pearl Harbor/ Landfill | 0068 | 0068-LF-DM001 | NSC, Bldg 7 | SB-1 | Soil Cuttings | 100 | 16-Dec-92 | Dec-93 | N/A |
| | | 0068-LF-DM002 | N/A | MW-1<br>MW-2<br>MW-3 | Purge Water | 75 | 20-Dec-92 | Jul 93 | 26-Jul-93 |
| | | 0068-LF-DM003 | N/A | MW-1<br>MW-2<br>MW-3 | Decon. Water | 95 | 20-Dec-92 | Jul-93 | 26-Jul-93 |
| | | 0068-LF-DM004 | NSC, Bldg.16 | SB-1<br>SB-2<br>SB-3<br>SB-4<br>MW-1<br>MW-2<br>MW-3 | PPE | 50 | 16-Dec-92 | Oct-93 | N/A |
| NAVSTA Guam/ Drum Storage | 0047 | 0047-DS-DM001 | Hazmat Storage Area | SB-1<br>SB-2 | Soil Cuttings | 100 | 18-Feb-93 | Sep-93 | N/A |

N/A Not Applicable

# Analytical Data Validation Planning and Coordination

## 1. Purpose

This standard operating procedure describes data validation planning and coordination for all United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific sampling projects involving data validation.

## 2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

## 3. Definitions

### 3.1 CRITICAL SAMPLES

Critical samples are samples that are especially important for assessing exposure and/or risk at a particular site, or are key in identifying remedial options.

### 3.2 DATA QUALITY ASSESSMENT REPORT

The data quality assessment report summarizes the QA/quality control (QC) evaluation of the data according to precision, accuracy, representativeness, completeness, and comparability relative to the Project Quality Objectives (PQOs). The report provides a quantitative and qualitative assessment of the data and identifies potential sources of error, uncertainty, and bias that may affect the overall usability.

### 3.3 DATA VALIDATION

Data validation is a process that determines the technical usability of analytical data by comparison with a set of performance criteria. The performance criteria are designed in a manner that will enable the data user to know if the set of data will meet the intended purpose.

### 3.4 DATA VALIDATION STRATEGY

The data validation strategy includes the percentage of data to be validated (e.g., 100 percent or a smaller percentage), all samples from an entire sample delivery group (SDG) versus selected samples from various SDGs, and whether samples for Level D validation will be identified in advance or only after critical or risk-driving results for the risk assessment have been identified.

### 3.5 DATA VALIDATION LEVELS

The level of data validation possible for a given set of samples is based on the level of data package provided by the laboratory. The three levels of data validation considered are Level B (requires a Level 2 data package), Level C (requires a Level 3 data package), and Level D (requires a Level 4 data package). These levels have been identified in previous standard operating procedures as Cursory (Level B), Standard (Level C), and Full (Level D). Description for the extent of each level of data validation is presented below and further in Procedure II-A, *Data Validation*.

### 3.6 RAW DATA

Raw data is information that has not been processed, formatted, or reduced for end use. Examples of raw data include gas chromatographs, instrument printouts, copies of log books, chemist worksheets, etc.

### 3.7 SAMPLE DELIVERY GROUP (SDG)

A SDG, or analytical batch, typically includes up to 20 field samples plus associated batch QC samples.

## 4. Responsibilities

The prime contractor CTO Manager shall ensure coordination between data validators and appropriate project personnel. The CTO Manager is responsible for critical sample selection. The project chemist, laboratory coordinator, or other designated person, shall coordinate with the data validation task leader.

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

## 5. Procedures

An independent party who is not responsible for the generation of the data shall perform data validation. Section 5.1 discusses guidelines for selecting a data validation strategy, while Section 5.2 presents planning and coordination guidelines.

### 5.1 DATA VALIDATION STRATEGY SELECTION

Consult the Contracting Officer’s Representative, any appropriate regulatory agencies, and any Federal Facilities Agreements when choosing a data validation strategy. Clearly define the proposed level of effort for data validation in the project work plan. Based on the data validation requirements identified in the project planning documents, the analytical data may undergo “Level B,” “Level C,” or “Level D” data validation or some combination of these validation levels.

Guidelines for the required level of effort for data validation is described below and further in Procedure II-A, *Data Validation*.

#### 5.1.1 Amount of Raw Data Acquired

It is recommended to request and obtain from the laboratory all raw data generated for the project sample analyses. While not all of the raw data will likely be reviewed, it is more time-efficient and cost-effective to obtain the data at the time of analysis than to request the laboratory to provide them at a later date. In addition, project chemists and risk assessors may use portions of the raw data to more fully evaluate analytical data. Attachment I-A-7-1 presents the laboratory analytical data reporting requirements that shall be followed for the NAVFAC Pacific Area of Responsibility.

For projects with quick turnaround time (TAT) requirements, one option is to receive results only for the quick TAT, while receiving the remaining data at the normal TAT. This will allow the laboratory more time to compile the entire data package. Consult project-specific PQOs to determine if this approach is feasible.

### 5.1.2 Level B Validation

Level B validation is the least intensive of the three levels of data validation and is appropriate for non-critical data. Level B validation consists of evaluating factors such as holding times, spike analyses, blank analyses, and field QC samples. Examples of analytical results evaluated under data review include data generated during compliance monitoring, field analytical testing, or investigation derived waste sampling.

### 5.1.3 Level C Validation

Level C validation is the intermediary of the three levels of data validation and is appropriate for critical samples used in decision making. Level C validation consists of evaluating factors such as holding times, instrument calibration, spike and blank analyses, and field QC samples. Level C validation may be performed on a percentage or all of the project data. The exact percentage of data to undergo Level C validation will depend on the project objectives. Examples of analytical results evaluated under Level C validation include data generated for risk assessments, removal action verification, remedial designs, etc.

### 5.1.4 Level D Validation

Level D validation is the most rigorous of the three levels of data validation and is appropriate for critical samples used in decision making. Level D validation consists of evaluating factors such as holding times, instrument calibration, spike and blank analyses, field QC samples, and raw data. Level D validation may be performed on a percentage or all of the project data. The exact percentage of data to undergo Level D validation will depend on the project objectives. Examples of analytical results evaluated under Level D validation include data generated for risk assessments, removal action verification, remedial designs, etc.

Depending on the objectives of the project, a representative portion of data shall be chosen for Level D validation by selecting random samples and analyses, or more practically, be selected by identifying certain representative SDGs. This may include selecting all samples and analyses from one of the first SDGs of field samples for Level D data validation, and also for SDGs with different matrices, subsequent phases of work/mobilizations, and for each laboratory if more than one is used.

Larger projects typically require lower frequencies of Level D validation than smaller projects. For example, a project with one SDG may require 100 percent Level D validation. For a CTO with five SDGs, the first SDG may require Level D validation with the remaining four SDGs validated at Level C.

If significant issues, as defined in the data validation procedures presented in Section II of this procedures manual, are noted during Level D validation, additional Level D validation above the originally planned percentage may be warranted and should be proposed. Additionally, the first several SDGs validated should be evaluated and corrective actions taken immediately if issues are identified.

### 5.2 PLANNING AND COORDINATION

During the planning and cost estimating stage of a project, contact the data validation task leader. Discuss the level of quality control, data validation strategy, number of samples per method, number of SDGs, schedule, and due dates. Copy all planning documents to the data validation task leader when they are completed (draft and final).

Hardcopy data validation reports are typically required and electronic entry of data qualifiers and qualification codes may be required if an analytical database is used for data interpretation.

Continuing coordination is critical. Notify the data validation task leader of any changes to the sampling schedule, analytical plan, or number of samples. Inform the data validators as well as the laboratory of every change from the chain of custody/analytical request form in sample numbers and/or requested analyses. Communicate changes to analytical methods agreed upon with the laboratory to the data validation task leader.

A schedule, which is updated as needed, is necessary to track the status of data validation activities. The prime contractor QA Manager or Technical Director shall coordinate and set priorities between CTOs. Attachment I-A-7-2 is an example of a form that may be used by CTO personnel to track the data validation status of hardcopy data.

A cross-reference list of field QC samples associated with site samples is required to validate data. This list must be provided by field personnel or from the chain-of-custody logbook (Procedure III–E, *Record Keeping, Sample Labeling, and Chain-of-Custody*).

## 6. Records

Data validation reports generated by data validators shall include content discussed in Procedure II-A, *Data Validation* and be included as an appendix in the report and summarized in the report. Changes in the schedule, number of samples, or analytical plan shall be sent to the data validators verbally and in writing.

The data validation effort shall be summarized for inclusion as a section of the report. It may also be helpful to summarize the data validation results in the form of a data quality assessment report (DQAR). The DQAR should summarize the net results of data validation for each QC parameter evaluated. It is recommended that precision, accuracy, and percent completeness objectives also be presented in the report. This task could be conducted by the data validators, or by project staff more familiar with the PQOs. The content and format of the DQAR is discussed in Procedure II-S, *Data Quality Assessment Report*.

As part of the summary, the project personnel shall ensure that all data requested for analysis and validation were actually analyzed and validated. Identification of rejected data (and the reasons) may be the most critical results. Data that have been qualified from detections to nondetections, or data for which numerical values have changed significantly, are also important. The summary may focus on the analytes and samples that are considered most critical for each project and include a summary of field QC results by field QC type.

## 7. Health and Safety

Not applicable.

## 8. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Procedure II-A, *Data Validation*.

Procedure II-S, *Data Quality Assessment Report*.

Procedure III–E, *Record Keeping, Sample Labeling, and Chain-of-Custody*.

## 9. Attachments

Attachment I-A-7-1: DoD QSM Appendix DoD A Reporting Requirements

Attachment I-A-7-2: Example Hardcopy Data Validation Status Tracking Form

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# Attachment I-A-7-1

# DoD Quality Systems Manual Appendix DoD A Reporting Requirements

# APPENDIX DOD-A – REPORTING REQUIREMENTS

In the absence of client specified reporting criteria, the reporting requirements outlined below shall be used for hard-copy data reports or electronic versions of hard-copy data (such as pdf). They include mandatory requirements for all printed data reports, and requirements for data reports requiring third party data review or validation. Optional reporting requirements are those that may be required by a specific project, depending upon their needs. The following elements are required: cover sheet, table of contents, case narrative, analytical results, sample management records, and Quality Assessment/Quality Control (QA/QC) information. Information for third-party review may be required depending on project-specific requirements or the method being used.

## 1.0 Cover Sheet

The cover sheet shall specify the following information:

- Title of report (i.e., test report, test certificate);
- Name and location of laboratory (to include a point of contact, phone and facsimile numbers, and e-mail address);
- Name and location of any subcontractor laboratories, and appropriate test method performed (information can also be located in the case narrative as an alternative);
- Unique identification of the report (such as serial number);
- Client name and address;
- Project name and site location;
- Statement of data authenticity and official signature and title of person authorizing report release;
- Amendments to previously released reports that clearly identify the serial number for the previous report and state the reason(s) for reissuance of the report; and
- Total number of pages.

## 2.0 Table of Contents

Laboratory data packages shall be organized in a format that allows for easy identification and retrieval of information. An index or table of contents shall be included for this purpose.

## 3.0 Case Narrative

A case narrative shall be included in each report. The purpose of the case narrative is to:

- Describe any abnormalities and deviations that may affect the analytical results;
- Summarize any issues in the data package that need to be highlighted for the data user to help them assess the usability of the data; and
- Provide a summary of samples included in the report with the methods employed in order to assist the user in interpretation.

The case narrative shall provide (Information need not be repeated if noted elsewhere in the data package):

- A table(s) summarizing samples received, providing a correlation between field sample numbers and laboratory sample numbers, and identifying which analytical, preparation, and clean-up methods were performed. If multiple laboratories performed analyses, the name and location of each laboratory **shall** be associated with each sample;
- A list of samples that were received but not analyzed;
- Date of samples received;
- Sample preservation or condition at receipt;
- A description of extractions or analyses that are performed out of holding times;
- A definition of all data qualifiers or flags used;
- Identification of deviations of any calibration standards or QC sample results from appropriate acceptance limits and a discussion of the associated corrective actions taken by the laboratory;
- Identification of multiple sample runs with reason(s) identified (e.g., dilutions or multiple cleanups);
- Identification of samples and analytes for which manual integration was necessary; and
- Appropriate notation of any other factors that could affect the sample results (e.g., air bubbles in volatile organic compounds (VOC) sample vials, excess headspace in soil VOC containers, the presence of multiple phases, sample temperature or pH excursions, and container type or volume).

## 4.0 Analytical Results

The results for each sample shall contain the following information at a minimum: (Information need not be repeated if noted elsewhere in the data package):

- Project name and site location;
- Field sample ID number as written on custody form;
- Laboratory sample ID number;
- Preparation batch number(s);
- Matrix (soil, water, oil, air, etc.);
- Date and time sample collected;
- Date and time sample prepared;
- Date and time sample analyzed;
- Method numbers for all preparation, cleanup, and analysis procedures employed;
- Analyte or parameter with the Chemical Abstracts Service (CAS) Registry Number if available;

- Sample aliquot analyzed;
- Final extract volume;
- Identification of analytes in which manual integration occurred, including the cause and justification;
- Analytical results with correct number of significant figures;
- Detection Limit, Limit of Detection, and Limit of Quantitation associated with sample results and adjusted for sample-specific factors (e.g., aliquot size, dilution/concentration factors, and moisture content);
- Any data qualifiers assigned;
- Concentration units;
- Dilution factors;
- All multiple sample run results shall be reported;
- Percent moisture or percent solids (all soils are to be reported on a dry weight basis); and
- Statements of the estimated uncertainty of test results (optional).

## 5.0 Sample Management Records

Sample Management records shall include the documentation accompanying the samples, such as:

- Chain-of-custody records;
- Shipping documents;
- Records generated by the laboratory which detail the condition of the samples upon receipt at the laboratory (e.g., sample cooler receipt forms, cooler temperature, and sample pH);
- Telephone conversation or e-mail records associated with actions taken or quality issues; and
- Records of sample compositing done by the laboratory.

## 6.0 QA/QC Information

The minimum laboratory internal QC data package shall include:

- Method blank results;
- Percent recoveries for Laboratory Control Sample (LCS), Laboratory Control Sample Duplicates (LCSD), Matrix spike (MS), and Matrix Spike Duplicates (MSD);
- MSD or matrix duplicate Relative percent differences (RPD);
- Surrogate percent recoveries;
- Tracer recoveries;
- Spike concentrations for LCS, MS, surrogates;
- QC acceptance criteria for LCS, MS, surrogates;
- Post-Digestion Spike (PDS) recoveries;

- In-house or project specified LCS control limits, as applicable;
- Serial dilutions (SD) percent difference; and
- Batch numbers (preparation, analysis, and cleanup).

## 7.0 Data Reports for Third Party Review or Validation

When third party review or data validation is to be performed, the extent (stage) of data validation that can be performed is dependent upon the type (level) of data report delivered by the laboratory. The data report level and data validation stage required to meet project data quality objectives should be specifically defined in the QAPP.

The minimum reporting requirements for each level of data report are outlined below.

- A cover sheet, table of contents, and case narrative including all of the information specified in the above sections are required for all levels of data reports.
- **Level 1**: Analytical results, Sample Management Records.
- **Level 2**: **Level 1** reporting requirements plus QA/QC Information, Instrument QA/QC Information, Instrument and Preparation logs.
- **Level 3**: **Level 2** reporting requirements plus Instrument Quantitation Reports.
- **Level 4**: **Level 3** reporting requirements plus Instrument Chromatograms and Spectra.
- In addition, Standards traceability should be included in Levels 3 and 4 if a legal chain of custody is required.

The data validation guidelines established in other Department of Defense guidance or project-specific guidelines may have distinct reporting formats. The appropriate QAPP should be consulted to determine what type of data package is required.

# Attachment I-A-7-2
# Example Data Validation Status Tracking Form

**Table I-A-7-2-1: CTO xxxx Data Validation Report Status Tracking Form**

| SDG | Due Date | VOCs Rec'd | PCBs Rec'd | TPH Rec'd | Metals Rec'd | Cr+6 Rec'd | Otin Rec'd | TOC Rec'd |
|---|---|---|---|---|---|---|---|---|
| DB360 | 7/30 | 7/21 | 8/21 | 8/21 | 8/7 | X | 8/23 | 5/25 |
| DB383 | 7/30 | 7/21 | 8/21 | 8/21 |  | X | 8/23 | 5/25 |
| DB401 | 6/15 | 6/9 | 6/9 | 6/9 | 6/9 | X | 7/7 | 6/9 |
| DC160 | 8/15 | 7/21 | 8/21 | 8/21 |  |  | X | 8/7 |
| DC180 | 8/15 | 7/21 | 8/21 | 7/23 |  | 7/21 | 8/23 | 8/21 |
| CK0693 | 7/30 | X | X | X | X | 7/20 | X | X |
| CK0694 | 7/30 | X | X | X | X | 7/20 | X | X |
| CK0732 | 7/30 | X | X | X | X | 7/20 | X | X |
| DC205 | 9/15 |  | X |  |  | X | X |  |
| DC209 | 9/15 |  | X |  |  | X | X |  |
| DB429 | 9/15 |  | X |  |  | X | X |  |
| DB439 | 9/15 |  | X |  |  | X | X | X |
| DB458 | 9/15 |  | X |  |  | X | X | X |

| | |
|---|---|
| PCB | polychlorinated biphenyl |
| TOC | total organic carbon |
| TPH | total petroleum hydrocarbons |
| VOC | volatile organic compound |
| 7/21 | date data validation report was received |
| X | no analysis for that method for that SDG |
| blank | data validation report not yet received |

# Sample Naming

## 1. Purpose

This standard operating procedure describes the naming convention for samples collected and analyzed, and whose resulting data will be stored in the database for the United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific projects. Unique sample names are used to facilitate tracking by laboratory personnel and project personnel, and for purposes of storing, sorting, and querying data in the database.

## 2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

## 3. Definitions

### 3.1 CHAIN OF CUSTODY SAMPLE NUMBER

The chain of custody (COC) sample number is a five-character identification number that is used by the laboratory and project personnel for tracking purposes. A unique COC sample number must be used for each sample collected from a particular location at a particular time. It is useful for the first two characters to be letters unique to a particular site or project, while the remaining three characters may be digits from 001 to 999 (e.g., AA001). The COC sample number is the only identifier that should be presented to the laboratory.

### 3.2 SAMPLE IDENTIFICATION NUMBER

The sample identification number is a unique multi-alpha, multi-numeric identifier that is used by the field team to associate sampling results to the particular sampling location, sample type, number of times the location has been sampled, and depth. To avoid potential bias in sample analysis, the sample identifier is not provided to the laboratory. The sample identification number shall be recorded in the field logbook concurrently with the COC sample number.

## 4. Responsibilities

The prime contractor CTO Manager shall ensure that a proper sample naming convention is identified in the field sampling plan. The Field Quality Control (QC) Supervisor or other field-sampling leader shall ensure that the sample naming convention is implemented. The laboratory coordinator, CTO Manager, and/or other designated personnel shall ensure on a daily basis that unique, appropriate COC sample numbers and sample identifiers have been assigned. The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The prime contractor Technical Director will designate one person in each office (e.g., the laboratory coordinator) to track site designations used in the COC sample number.

## 5. Procedures

A COC sample number and sample identifier shall be assigned as described below. It is critical that each sample name have a unique COC sample number and sample identifier; otherwise, data cannot be properly stored and tracked in the database.

### 5.1 COC SAMPLE NUMBER

Use the following format for the COC sample number:

**abccc**

Where:

a = A letter indicating the office managing the CTO

b = A letter indicating the project or site, for example

A = first site

B = second site

C = third site, etc.

ccc = Chronological number, for example

001 = first sample from the site

002 = second sample from the site

105 = 105th sample from the site

Field QC samples should be included in this chronological sequence

For example, the 23rd sample from the Carpentry Shop Dip Tank site (assigned project “A” for b above; the office will be assigned “D”) being investigated would be referred to as “DA023.” This might be a soil sample, water sample, trip blank, equipment blank, field duplicate, or other sample type. Using this COC sample number, the samples will be submitted to the laboratory “blind,” that is, the laboratory should not know whether each sample received is a site or field QC sample.

If a sample is lost during shipping, the replacement sample must be assigned a new COC sample number. If different containers for the same sample are shipped on different days, a new COC sample number must be assigned.

When numbering reaches the letter Z, the 26th site, it may begin with a new first letter “a,” which must be coordinated with the prime contractor QA Manager or Technical Director and Coordinator or designee to ensure that it has not been used by another CTO.

Alternatively, the “ab” designators can serve to identify a unique project field, such as “RH” for the Red Hill site.

## 5.2 SAMPLE IDENTIFICATION NUMBER

The following format is provided as a suggested guidance. Individual site objectives may necessitate variations to the suggested guidance. Coordinate with the prime contractor QA Manager or Technical Director when considering deviating from this guidance.

**AA-bbcc-dee-Dff.f**

Where:

**AA** = Designates the site identification

**bb** = Sample type and matrix (see Table I-A-8-1)

**cc** = Location number (e.g., 01, 02, 03)

**d** = Field QC sample type (see Table I-A-8-2)

**ee** = Chronological sample number from a particular sampling location (e.g., 01, 02, 03)

**D** = The letter “D” denoting depth

**ff.f** = Depth of sample in feet bgs (to the measured decimal place). For field blanks, trip blanks and equipment blanks, the depth field will contain the month and date of collection.

For example, the first subsurface soil sample collected from the Foundry Building (FB) borehole location four at a depth of 10 feet would be designated “FB-BS04-S01-D10.0.” These characters will establish a unique sample identifier that can be used when evaluating data.

Table I-A-8-1 presents the character identifiers to be used in the sample and matrix portion of the sample identification number. In all cases, the second letter indicates the sample matrix. Note grab, composite, and undisturbed sample designations in the field logbook.

**Table I-A-8-1: Sample Type and Matrix Identifiers**

| Identifier | Sample Type | Matrix |
|---|---|---|
| SS | Surface Soil | Soil |
| IS | Surface Soil (ISM) | Soil |
| IB | Subsurface Soil (ISM) | Soil |
| BS | Subsurface Soil | Soil |
| BG | Subsurface Soil (Geotechnical) | Soil |
| SD | Sediment | Sediment |
| GW | Groundwater | Water |
| SW | Surface Water | Water |
| FP | Free Product | Oil |
| WQ | Water Blanks | Water |
| SG | Soil Gas | Soil gas |
| CC | Concrete Chips | Concrete |

| Identifier | Sample Type | Matrix |
|---|---|---|
| WS | Waste (IDW) | Soil |
| WW | Waste (IDW) | Water |

IDW investigation-derived waste
ISM incremental sampling methodology

Table I-A-8-2 describes the field QC designator types. These field QC designators clarify the type of sample collected.

**Table I-A-8-2: Field QC Sample Type Identifiers**

| Identifier | QC Sample Type | Description |
|---|---|---|
| S | Normal (Primary) Sample | All non-field QC samples |
| D | Duplicate | Collocate (adjacent liners) |
| R | Triplicate | Replicate |
| E | Equipment Rinsate | Water |
| B | Field Blank | Water |
| T | Trip Blank | Analytical-laboratory-prepared sample -Water |
| M | Trip Blank | Analytical-laboratory-prepared sample – Methanol |
| L | Batch Test Sample | Batch Test Leaching Model Sample |
| P | Blind Spike | Performance testing sample |

## 6. Records

Sample identifiers (and COC sample numbers, if appropriate) shall be identified in advance if the exact numbers of samples to be collected are known; these numbers may be listed on a spreadsheet along with requested analyses to be used as a reference by field sampling personnel.

The COC/analytical request form must be used to track all sample names. Copies of each COC form shall be sent daily to the CTO Laboratory Coordinator and with the samples to the analytical laboratory. An example of a COC form is included as Attachment III-E-2 of Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*.

In the field, personnel shall record in the field logbook the COC sample number of each sample collected, as well as additional information, such as the sampling, date, time, and pertinent comments.

## 7. Health and Safety

Not applicable.

## 8. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*.

## 9. Attachments

None.

# Soil Sampling

## 1. Purpose

This section sets forth the standard operating procedure for soil sampling (surface samples, trench samples, and boring samples) to be used by United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

## 2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

## 3. Definitions

None.

## 4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that these standard soil sampling procedures are followed during projects conducted under the NAVFAC Pacific ER Program, and that they are conducted or supervised by a qualified individual. A qualified individual for subsurface sampling is defined as a person with a degree in geology, hydrogeology, or geotechnical/civil engineering with at least 1 year of experience in the supervision of soil boring construction. A qualified individual for trenching, excavation (e.g., pit), or surface sampling supervision is one who has sufficient training and experience to accomplish the objectives of the sampling program. The CTO Manager shall also ensure that a qualified person, as defined in Procedure I-E, *Soil and Rock Classification,* conducts soil classification during all types of soil sampling. The CTO Manager is responsible for ensuring that all personnel involved in sampling and/or testing shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for ensuring that all project field staff follow these procedures.

Field sampling personnel are responsible for the implementation of this procedure.

# 5. Procedures

## 5.1 CONSIDERATIONS FOR MUNITIONS AND EXPLOSIVES OF CONCERN

Potential Munitions and Explosives of Concern (MEC) hazards may be encountered in any area formerly or currently occupied or used by the Department of Defense (DoD). MEC hazards may occur on the ground surface, in the subsurface, and within bodies of water, and may not always be readily observable, or identifiable. As a result, whether or not munitions-related activities ever occurred on the specific work area or within waters in which Navy operations/activities will take place, special care should always be taken when conducting field operations, especially intrusive activities, in the event that MEC may be encountered.

If the site is currently recognized as belonging in the Military Munitions Response Program and has a current, Naval Ordnance Safety and Security-accepted, site-specific Explosives Safety Submission (ESS) (per DON 2010), then field activities, especially intrusive activities, shall adhere to the safety procedures outlined within the ESS.

If suspected MEC is encountered on an active DoD installation, immediately notify your supervisor, DoD Point of Contact, and installation Point of Contact, who will contact and facilitate military Explosive Ordnance Disposal response.

## 5.2 SUBSURFACE SOIL SAMPLING

The purpose of subsurface soil sampling is to acquire accurate, representative information about subsurface materials penetrated during drilling or trenching. This is accomplished by logging lithologic information, classifying lithologic materials, and collecting lithologic samples for analysis using geotechnical or chemical methods.

### 5.2.1 Inspection of Equipment

The collection of reliable samples of subsurface materials depends partly on the types of samples that can be collected when using various subsurface exploration techniques. These procedures are described in Section 5.2. In all cases, the equipment shall be inspected prior to commencement of drilling for signs of fluid leakage, which could introduce contaminants into the soil. If, at any time during subsurface exploration, fluid is observed leaking from the rig, operations shall cease and the leak shall be immediately repaired or contained. All soil and other materials affected by the leak will be collected, containerized, and labeled for proper disposal (Procedure I-A-6, *Investigation-Derived Waste Management*).

### 5.2.2 Preparation of Site

Proper preparation of the site prior to the commencement of subsurface exploration is essential for smooth drilling operations. It is required to protect the health and safety of site personnel. First, the site shall be inspected to ensure that there are no overhead hazards that could affect subsurface exploration. Then, all subsurface sampling locations shall be assessed using geophysical methods to identify subsurface utilities or hazards. If possible, the area shall be excavated by hand to a depth of 2 to 3 feet before beginning drilling. If surface or shallow samples are required, it is suggested that the hand excavation be done as close to the actual subsurface exploration as possible. The drill rig must have a means to guard against employee contact with the auger (e.g., guard around the auger; barricade around the perimeter of the auger; electronic brake activated by a presence-sensing device). All members of the field crew shall know the location of the kill switch, which must be readily accessible, for the equipment.

The equipment shall be situated upwind or side-wind of the borehole. The area surrounding, and in the vicinity of, the borehole shall be covered with plastic, including the area where cuttings are placed into 55-gallon drums and the equipment decontamination area. The required exclusion zones shall be established by using plastic tape or cones to designate the various areas.

### 5.2.3 Equipment Decontamination

To avoid cross-contamination, all sampling equipment utilized for borehole drilling and soil sampling that may potentially come into contact with environmental samples shall be thoroughly decontaminated as described in Procedure I-F, *Equipment Decontamination*. All sampling tools shall be decontaminated between each sampling event and between each borehole or trench. At a minimum, all equipment shall be steam-cleaned or undergo the wash-and-rinse process. All wash-and-rinse water shall be collected, containerized, and labeled for proper disposal. Clean equipment (e.g., augers and samplers) shall be protected from contact with contaminated soils or other contaminated materials prior to sample collection. Equipment shall be kept on plastic or protected in another suitable fashion. After a borehole is completed, all augers and contaminated downhole equipment shall be stored on plastic sheeting.

### 5.2.4 Handling of Drill Cuttings

All soil cuttings from borehole drilling shall be placed into 55-gallon U.S. Department of Transportation (DOT)-approved drums or other appropriate containers, such as a roll-off bin. The containerized cuttings shall be stored in a centralized area pending sample analysis to determine their final disposition. The procedure on investigation-derived waste (IDW) (see Procedure I-A-6, *Investigation-Derived Waste Management*) details drum handling and labeling procedures.

## 5.3 SUBSURFACE SOIL SAMPLE COLLECTION METHODS

Table I-B-1-1 describes the characteristics of the sampling methods for the drilling techniques frequently used for soil borings and monitoring well installation, as described in Procedure I-C-1, *Monitoring Well Installation and Abandonment*. The split-spoon sampling method is the most commonly used soil sampling technique. However, in certain circumstances, other methods may have to be used to obtain optimal soil sampling results.

Sampling and handling procedures for samples submitted for volatile organic compound (VOC) analyses are provided in Attachment I-B-1-1. Considerations when using incremental sampling (IS) methods are provided in Attachment I-B-1-1.

**Table I-B-1-1: Characteristics of Common Subsurface Formation-Sampling Methods**

| Type of Formation | Sample Collection Method | Sample Quality | Potential for Continuous Sample Collection? | Samples Suitable for Analytical Testing? | Discrete Zones Identifiable? |
|---|---|---|---|---|---|
| Unconsolidated | Bulk Sampling (Cuttings) | Poor | No | No | No |
| | Thin Wall | Good | Yes | Yes | Yes |
| | Split Spoon | Good | Yes | Yes | Yes |
| | Trench | Good | No | Yes | Yes |
| | Core Barrels | Good | Yes | Yes | Yes |
| Consolidated | Cuttings (direct rotary) | Poor | No | No | No |
| | Core Barrels | Good | Yes | Yes | Yes |

The following text describes the primary soil sampling methods used for the NAVFAC Pacific ER Program.

### 5.3.1 Split-Spoon Samples

Split-spoon sampling is usually used in conjunction with the hollow-stem or solid-stem auger drilling method and can be used for sampling most unconsolidated and semi-consolidated sediments. It is used less frequently for air and mud rotary, and casing drive methods. It cannot normally be used to sample bedrock, such as basalt, limestone, or granite. The method can be used for highly unconsolidated sands and gravels if a stainless-steel sand catcher is placed in the lower end of the sampler.

The split-spoon sampler consists of a hardened metal barrel, 2 to 3 inches in diameter (2 to 2.5 inches inner diameter) with a threaded, removable fitting on the top end for connection to the drill rods and a threaded, removable “shoe” on the lower end that is used to penetrate the formation. The barrel can be split along its length to allow removal of the sample.

The following steps are required to obtain a representative soil sample using a split-spoon sampler:

- Advance the borehole by augering until the top of the desired sampling interval is reached. Then withdraw the drill bit from the hollow-stem augers.
- Equip the sampler with interior liners that are composed of materials compatible with the suspected contaminants if samples are to be retained for laboratory analytical analysis. Generally, these liners consist of brass or stainless steel and are slightly smaller than the inner diameter of the sampler. It is recommended to use stainless-steel liners rather than

brass if samples are to be analyzed for metals. Always evaluate the composition of the liners with respect to the types of contaminants that are suspected.

- Attach the properly decontaminated split-spoon sampler (equipped with liners) either to the drill rods or to a cable system and lower it to the bottom of the borehole through the augers.
- Drive the sampler into the formation by either a manual or automatic hammer (usually a 140-pound weight dropped through a 30-inch interval). Record the number of blows required to drive the sampler at 6-inch intervals in the boring log since blow counts provide an indication of the density/compaction of the soils being sampled. The field geologist, hydrogeologist, or geotechnical engineer shall carefully observe the internal measuring technique of the driller and keep track of sampling materials to ensure the accurate location of samples. Continuous samples can be collected with the split-spoon method by augering or drilling to the bottom of the previously sampled interval and repeating the operation. Whether continuous or intermittent, this collection method disturbs samples and cannot be used for certain geotechnical tests that require undisturbed samples.
- Bring the split-spoon sampler to ground surface and remove it from the drill rods or cable system following sample acquisition. Loosen the upper and lower fittings and take the sampler to the sample handling area. At the sample handling area, remove the fittings, split the barrel of the sampler, and remove one side of the sampler. At this time, it is important to observe and record the percentage of sample recovery.

**Liners**—Sampler liners can be used to collect and store samples for shipment to laboratories, for field index testing of samples, and for removing samples from solid barrel type samplers. Liners are available in plastic, Teflon, brass, and stainless steel. Other materials can be used as testing needs dictate. Liners are available in lengths from 6 inches (152.4 millimeters) to 5.0 feet (1.53 meters). Liner material selection often is based on the chemical composition of liner/soil to minimize sample reaction with liner. Most liner use is short-term as samples are subsampled and preserved immediately on site. Teflon may be required for mixed wastes and for long-term storage. Liners generally are split in the field for subsampling. Individually split liners are available in some sizes for field use. The liner should have a slightly larger inside diameter than the soil specimen to reduce soil friction and enhance recovery. When a slightly oversized liner is used, the potential for air space exists around the sample. Certain chemical samples may be affected by the enclosed air. Liners with less tolerance may be required and a shortened sample interval used to reduce friction in the liner. Metal liners can be reused after proper cleaning and decontamination. Plastic liners should be disposed of properly after use (ASTM 2005).

Immediately remove the liners containing the soil samples from the sampler. Generally, the lowermost liner is considered the least disturbed and shall be retained as the analytical laboratory sample. However, in certain circumstances (such as with the use of a sand catcher), other liners may be more appropriate for retention as the laboratory sample. If liners containing the sample material are to be submitted to the laboratory, then cover the ends of the sample liner to be retained as the analytical laboratory sample with Teflon film and sealed with plastic caps. While currently not preferred by the State of Hawaii, if liners are submitted, the laboratories should be instructed to prepare the soil from the liner as an incremental sample to prevent biasing the results that can occur when discretely collecting the analytical volume. The site geologist, hydrogeologist, or geotechnical engineer shall observe the ends of the liner destined for analytical sampling and describe the physical nature of the sample (e.g., soil or rock type, grain size, color, moisture, as indicated in Procedure I-E, *Soil and Rock Classification*.) Then label the sample according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*, and immediately place it on ice in a cooler as described in Procedure III-F, *Sample Handling, Storage, and Shipping*.

- Collect split-spoon soil samples submitted for VOC analysis using the procedure found in Attachment I-B-1-1.
- Collect split-spoon soil samples submitted for non-VOC analysis using the IS procedure found in Attachment I-B-1-1
- Any remaining liners collected from the sample can then be used for other purposes, such as providing a duplicate sample for field quality control or material for lithologic logging. These samples can also be used for headspace analysis as described in Section 5.4.
- Conduct lithologic logging of each sample in accordance with Procedure I-E, *Soil and Rock Classification*, and enter each sample into the boring log presented in Figure I-B-1-1. In most instances, an additional liner full of material is available for this purpose. Check to ensure that all liners contain similar material. If an extra liner full of material is not available, then log by collecting the extra material present in the end of the sampler shoe. Make a comparison to the material visible at the end of the sample liner destined for laboratory analysis to ensure that the entire sample consists of similar material. If not, then describe the different material to the extent possible by relating it to similar material that was encountered previously.
- If VOCs are suspected to be present, screen the sample with an organic vapor monitor (OVM) or equivalent, and collect headspace samples according to Section 5.4.
- Decontaminate all sampling equipment prior to each use according to Procedure I-F, *Equipment Decontamination*.

### 5.3.2 Thin-Wall Samples

The thin-wall or Shelby tube sampler is usually used in conjunction with the hollow-stem and solid-stem auger drilling methods and is most useful when sampling clay- and silt-rich sediments. It can also be used with air and mud rotary and casing drive drilling techniques. It is amenable only to lithologies that are relatively soft and, in some cases, is not capable of penetrating hard clays or compacted sands. In addition, samples of unconsolidated sands cannot normally be acquired because they cannot be retained within the sampler, although a sand catcher can be utilized, in some cases, with moderate success.

The thin-wall sampler often consists of a single thin tube that is 3 to 4 inches in outer diameter and 1 to 3 feet in length. The upper end of the sampler has a solid metal section with a fitting for drill rods. There is no fitting for the lower end of the sampler, and it is usually open to allow sample acquisition; however, when sampling in poorly consolidated materials, a sand catcher may be placed in the lower end to ensure retention of the sample.

The following steps are required to obtain a representative soil sample using a thin-wall sampler:

- Advance the borehole by augering or drilling until the top of the desired sampling interval is reached. Then withdraw the drill bit from the hollow-stem augers.
- Place the sampler on the end of the drill rods and lower it to the bottom of the borehole.
- Instead of driving the sampler, use the hydraulic apparatus associated with the kelly bar on the drilling rig to press the sampler into the undisturbed formation. The thin-wall sampler may lack sufficient structural strength to penetrate the materials, in which case another sampling technique may be required. The samples obtained using this method cannot be used for certain geotechnical tests where undisturbed samples are required.
- Thin-wall samples submitted for VOC analysis must be collected using the procedure found in Attachment I-B-1-1.
- Following sample acquisition, bring the thin-wall sampler to the ground surface, remove it from the drill rods, and take it to the sample handling area.
- Immediately cover the ends of the sample with Teflon film and sealed with plastic caps if the sample is to be retained as a laboratory sample. Then label the sample according to Procedure III-E*, Record Keeping Sample Labeling, and Chain of Custody* and immediately place it on ice in a cooler. Extrude the sample from the sampler and inspect it if the sample is to be used only for lithologic logging.
- Conduct lithologic logging of each sample in accordance with Procedure I-E, *Soil and Rock Classification* and enter each sample into the boring log presented in Figure I-B-1-1. If the sample is contained in a sleeve, observe the ends of the sample in the sleeve to assess lithologic and stratigraphic characteristics.
- If VOCs are suspected to be present, screen the sample with an OVM or equivalent, and collect headspace samples according to Section 5.4.
- Decontaminate all sampling equipment prior to each use according to Procedure I-F, *Equipment Decontamination.*

### 5.3.3 Cores

A core barrel is often used to obtain core samples from harder lithologic materials, such as basalt, granite, and limestone, in instances where undisturbed samples are required for geotechnical testing, and in cases where completely continuous sampling is required. Complete recovery of samples during coring is often difficult when sampling unconsolidated and semi-consolidated lithologies, such as clays, silts, and sands.

# Field Log of Boring

| |
|---|
| BORING NUMBER |

SHEET ____ OF _____

| | | | | | | |
|---|---|---|---|---|---|---|
| PROJECT NAME | PROJECT NUMBER | ELEVATION AND DATUM | | | LOCATION | |
| DRILLING COMPANY | DRILLER | DATE AND TIME STARTED | | | DATE AND TIME COMPLETED | |
| DRILLING EQUIPMENT | DRILLING METHOD | COMPLETION DEPTH | | | TOTAL NO. OF SAMPLES | |
| SIZE AND TYPE OF BIT | HOLE DIAMETER | NO. OF SAMPLES | BULK | SS | DRIVE | PITCHER |
| DRILLING FLUID | DRILLING ANGLE | WATER LEVEL | FIRST | | AFTER _______ HOURS | |
| SAMPLE HAMMER<br>TYPE DRIVING WT. DROP | | HYDROGEOLOGIST/DATE | | | CHECKED BY/DATE | |

| | | | | | | | ESTIMATED PERCENT OF | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| LITHOLOGY | DEPTH (FEET) | SAMPLES | RECOVERY | BLOW COUNT | DESCRIPTION | USCS SYMBOL | GR | SA | FI | COMMENTS |
| | | | | | | | | | | |
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**Figure I-B-1-1: Field Log of Boring**

ASTM International (ASTM) has standardized rock coring methods (D-2113) (ASTM 2006). Several standardized core sizes for bits, shells, and casings have been established (e.g., RX, NX, SW). Table I-B-1-2 summarizes the various size standards for core barrels and bits.

**Table I-B-1-2: Standard Core Barrel Sizes (in inches)**

| Description | RX or RW | EX or EW | AX or AW | BX or BW | NX or NW | HX or HW | PX or PW | SX or SW | UX or UW | ZX or ZW |
|---|---|---|---|---|---|---|---|---|---|---|
| Bit Set Normal I.D. | 0.750 | 0.845 | 1.185 | 1.655 | 2.155 | 3.000 | — | — | — | — |
| Bit Set Normal and Thin-wall O.D. | 1.160 | 1.470 | 1.875 | 2.345 | 2.965 | 3.890 | — | — | — | — |
| Bit Set Thin-wall. I.D | 0.735 | 0.905 | 1.281 | 1.750 | 2.313 | 3.187 | — | — | — | — |
| Shell Set Normal and Thin-wall O.D. | 1.175 | 1.485 | 1.890 | 2.360 | 2.980 | 3.907 | — | — | — | — |
| Casing Bit Set I.D. | 1.000 | 1.405 | 1.780 | 2.215 | 2.840 | 3.777 | 4.632 | 5.632 | 6.755 | 7.755 |
| Casing Bit Set and Shoe O.D. | 1.485 | 1.875 | 2.345 | 2.965 | 3.615 | 4.625 | 5.650 | 6.780 | 7.800 | 8.810 |

| | |
|---|---|
| I.D. | Inner Diameter |
| O.D. | Outer Diameter |

The selection of the most practical core barrel for the anticipated bedrock conditions is important. The selection of the correct drill bit is also essential to good recovery and drilling production. Although the final responsibility of bit selection usually rests with the drilling contractor, there is a tendency in the trade to use “whatever happens to be at hand.” The selection of the diamond size, bit crown contour, and number of water ports depends upon the characteristics of the rock mass. The use of an incorrect bit can be detrimental to the overall core recovery. Generally, fewer and larger diamonds are used to core soft formations, and more numerous, smaller diamonds, which are mounted on the more commonly used semi-round bit crowns, are used in hard formations. Special impregnated diamond core bits have been developed recently for use in severely weathered and fractured formations where bit abrasion can be very high.

Core barrels are manufactured in three basic types: single tube, double tube, and triple tube. These basic units all operate on the same principle of pumping drilling fluid through the drill rods and core barrel. This is done to cool the diamond bit during drilling and to carry the borehole cuttings to the surface. A variety of coring bits, core retainers, and liners are used in various combinations to maximize the recovery and penetration rate of the selected core barrel.

The simplest type of rotary core barrel is the single tube, which consists of a case hardened, hollow steel tube with a diamond drilling bit attached at the bottom. The diamond bit cuts an annular groove, or kerf, in the formation to allow passage of the drilling fluid and cuttings up the outside of the core barrel. The single tube core barrel cannot be employed in formations that are subject to erosion, slaking, or excessive swelling, as the drilling fluid passes over the recovered sample during drilling.

The most popular and widely used rotary core barrel is the double tube, which is basically a single tube barrel with a separate and additional inner liner that is available in either a rigid or swivel type of construction. In the rigid types, the inner liner is fixed to the outer core barrel so that it rotates with the outer tube. In contrast, the swivel type of inner liner is supported on a ball-bearing carrier, which allows the inner tube to remain stationary, or nearly so, during rotation of the outer barrel. The sample, or core, is cut by rotation of the diamond bit. The bit is in constant contact with the drilling fluid as it flushes out the borehole cuttings. The addition of bottom discharge bits and fluid control valves to the core barrel system minimizes the amount of drilling fluid and its contact with the sample, which further decreases sample disturbance.

The third and most recent advancement in rotary core barrel design is the triple tube core barrel, which adds another separate, non-rotating liner to the double tube core barrel. This liner, which retains the sample, consists of a clear plastic solid tube or a split, thin metal liner. Each type of liner has its distinct advantages and disadvantages; however, they are both capable of obtaining increased sample recovery in poor quality rock or semi-cemented soils, with the additional advantage of minimizing sample handling and disturbance during removal from the core barrel.

The rotary core barrels that are available range from 1 to 10 inches in diameter, and the majority may be used with water, drilling mud, or air for recovering soil samples. Of the three basic types of core barrels, the double tube core barrel is most frequently used in rock core sampling for geotechnical engineering applications. The triple tube core barrel is used in zones of highly variable hardness and consistency. The single tube is rarely used because of its sample recovery and disturbance problems.

Coring to obtain analytical samples requires only filtered air as the drilling fluid. The core barrel operates by rotating the outer barrel to allow the bit to penetrate the formation. The sample is retained in the inner liner, which in most samplers does not rotate with the outer barrel. As the outer barrel is advanced, the sample rises in the inner liner. In general, a secondary liner consisting of plastic or metal is present within the inner liner to ensure the integrity of acquired samples.

Obtain soil or rock core samples with a core barrel or a 5-foot split-spoon core barrel using the following procedure:

- Drill the core barrel to the appropriate sampling depth. It is important to use only clean, filtered air (i.e., particulate- and petroleum-free) as drilling fluid while coring to obtain samples for laboratory analysis. If necessary, distilled water may be added through the delivery system of the coring device by the driller, provided that the drilling returns cannot be brought to the surface by air alone.
- Retrieve the core barrel from the hole. Use care to ensure that the contents of the core barrel do not fall out of the bottom during withdrawal and handling.
- Open the core barrel by removing both the top and bottom fittings. Then remove the sample within the inner liner from the core barrel and take it to the sample handling area.

- Conduct lithologic logging of each sample in accordance with Procedure I-E, *Soil and Rock Classification*, and enter each sample into the boring log presented in Figure I-B-1-1.
- If VOCs are suspected to be present, screen the sample with an OVM or equivalent, and collect headspace samples according to Section 5.4.

Collect core samples submitted for VOC analysis using the procedure found in Attachment I-B-1-1.

- If rock core samples are to be recovered for analytical laboratory or geotechnical analyses, the core barrel will either be lined with a sample container (e.g. stainless steel or acrylic liner), or the samples will be transferred to an appropriate sample container (e.g. stainless steel / acrylic liner, glass jar). Samples collected or placed in stainless steel or acrylic liners shall have the ends of the liners covered with Teflon film and sealed with plastic end caps. The sample containers shall be labeled in accordance with Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*, and Procedure III-F, *Sample Handling, Storage, and Shipping*, and immediately placed on ice in a cooler.
- Place the samples in core boxes if samples are to be catalogued and stored. Affix the CTO number; site name; borehole number; start depth; end depth; date; and name of the geologist, hydrogeologist, or geotechnical engineer to the core box. Store the samples in a clean, dry area on site during the duration of field sampling; samples shall not be brought back to the office or equipment storage area. Document proper disposal at the completion of field sampling.
- Decontaminate all sampling equipment prior to each use according to Procedure I-F, *Equipment Decontamination*.

#### 5.3.4 Bulk Samples

The term "bulk sample" represents a sample collected from borehole cuttings either from the hollow-stem auger flights or the discharge of any of the rotary or cable tool drilling techniques. This type of sample is useful for describing soils or consolidated materials, where no undisturbed samples representative of a specific depth are being collected. It should be noted that this type of sample is generally considered to be the least acceptable of the types of samples previously described in this section and shall be used only when detailed lithologic data are not needed.

Handling and lithologic logging of bulk samples should be performed in a manner consistent with that used for split-spoon samples. An estimate of the depth (or range of depths) from which the sample was obtained, and date and time of collection should be recorded on the boring log. Samples are usually collected every 5 feet, preferably at several different times during a 5-foot drilling run so that lithologic variations occurring over the drilling interval can be noted. Rock fragments commonly range in size from 1/16 to 1/2 inch, with many fragments larger than 1/4 inch. Larger fragments can often be obtained with reverse circulation rotary drilling. Rotary-tool samples usually contain some caved materials from above and, when drilling with mud or water rotary, the cuttings may contain soil and rock recirculated by the mud/water pump; therefore, care must be exercised when interpreting lithologic logs completed using data from this type of sample.

Because the collection of samples at the surface lags behind the actual drilling of a given lithologic bed at depth, the samples usually represent a depth less than that of the current depth of the drill bit. The amount of lag may be significant in deeper boreholes, but can be eliminated by collecting samples after circulating for a period of time sufficient to permit the most recently drilled materials to reach the surface.

#### 5.3.5 Borehole Abandonment

Following completion of soil sampling, the borehole shall be properly abandoned unless a monitoring well is to be installed. Abandonment shall occur immediately following acquisition of the final sample in the boring and shall consist of the placement of a bentonite-cement grout from the bottom of the boring to within 2 feet of ground surface. The grout mixture shall consist of a mix of 7 to 9 gallons of water per 94-pound bag of Portland Type I or II cement with 3 to 5 percent by weight of powdered bentonite. Other commercial products such as Volclay are also acceptable with approval of the CTO Manager and QA Manager or Technical Director. The bentonite-cement grout shall be placed in one continuous pour from the bottom of the boring to within at least 0.5 foot to 2 feet of ground surface through a tremie pipe or hollow-stem augers. Additional grout may need to be placed if significant settlement occurs. The remaining portion of the boring can be filled with topsoil.

#### 5.3.6 Trenching and Pit Sampling

Trenching is used in situations where the depth of investigation generally does not exceed 10 to 15 feet and is most suitable for assessing surface and near-surface contamination and geologic characteristics. In addition, trenching allows detailed observation of shallow subsurface features and exposes a wider area of the subsurface than is exposed in borings. Pit sampling is typically conducted in conjunction with a removal or remedial action.

A backhoe is usually used to excavate shallow trenches to a depth of no greater than 15 feet. Front-end loaders or bulldozers are used when it is not possible to use a backhoe; for example, when materials lack cohesion or are too stiff, or the terrain is too steep for a backhoe. Larger excavations (i.e., pits) may require additional equipment as described in the CTO work plan (WP) or equivalent document.

Typically, trenches have widths of one to two backhoe buckets and range in length from 5 to 20 feet, although larger trenches can be dug depending on the objectives of the study. Pits will vary in size depending upon the scope of the removal/remedial action. Soils removed from the trench/pit shall be carefully placed on plastic sheeting or other appropriate materials in the order of removal from the trench or excavation. The shallow excavated materials can be placed on one side of the trench/excavation and deeper materials on the other side to allow better segregation of shallow and deep materials.

Soil sampling locations within each trench or pit shall be chosen on the basis of visual inspection and any VOC screening results. Samples shall be collected from either the sidewalls or the bottom of the trenches/excavations. Soil sampling should be conducted outside the trench/excavation, and personnel generally should not enter a trench or pit if there is any other means (e.g., backhoe buckets, hand augers, shovels, or equivalent) to perform the work. If entry is unavoidable, then a competent person shall first determine acceptable entry conditions including sloping, shoring, and air monitoring requirements, personal protective equipment (PPE), and inspections. In addition, the site-specific health and safety plan must be amended to include applicable requirements of 29 Code of Federal Regulations (CFR) 1910.146.

Equipment used for trench/pit sampling may include hand augers, core samplers (slide hammer), liners inserted manually into the soil, or hand trowels. In addition, samples may be obtained directly from the trench or from the backhoe bucket. All samples shall be properly sealed and labeled according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*, and immediately placed on ice in a cooler as indicated in Procedure III-F, *Sample Handling, Storage, and Shipping*. Sample locations and descriptions shall be described and recorded on the field trench/pit log.

Trench or pit samples submitted for VOC analysis must be collected using the procedure found in Attachment I-B-1-1.

The exposed materials shall be observed for lithologic and contaminant characteristics following completion of the excavation activities. Detailed mapping of the exposed walls of the trench shall be conducted, although in no instance shall personnel enter a trench without first determining acceptable entry conditions including sloping, shoring, and air monitoring requirements, PPE, and inspections as defined in 29 CFR 1910.146. A useful mapping technique for extremely long trenches or large pits is to examine the vertical profile of the excavation at horizontal intervals of 5 to 10 feet, in a manner similar to the method typically used for preparation of a geologic cross-section using soil borings. Field observations shall be noted in the field logbook and described in detail on a trench/pit log. An example of a field trench/pit log is presented in Figure I-B-1-2. The lithologic description shall include all soil classification information listed in Procedure I-E, *Soil and Rock Classification*. A cross-section of the trench or pit should also be included on the field trench/pit log. Photographs of the trench/pit are also an excellent way to document important subsurface features.

During backfilling of the excavation, the materials excavated from the greatest depth should be placed back into the excavation first. Lithologic materials should be replaced in 2- to 4-foot lifts and recompacted by tamping with the backhoe bucket. For certain land uses or site restoration, more appropriate compaction methods may be required. These methods shall be described in the CTO WP and design documents. The backfilled trench/pit shall be capped with the original surface soil. If materials are encountered that cannot be placed back in the excavation, they should be placed either in DOT-approved open-top drums or placed on and covered with visqueen or equivalent material and treated as IDW in accordance with Procedure I-A-6, *Investigation-Derived Waste Management.*

## 5.4 SURFACE SOIL SAMPLING

All surface soil samples shall be accurately located on field maps in accordance with Procedure I-I, *Land Surveying*. Detailed soil classification descriptions shall be completed in accordance with

Procedure I-E, *Soil and Rock Classification* and recorded on the surface and shallow soil sample log (Figure I-B-1-3).

In general, surface soil samples are not to be analyzed for VOCs unless there is sufficient evidence to suggest the presence of such compounds.

Methods commonly used for collection of surface soil samples are described below. Considerations when using IS methods are provided in Attachment I-B-1-1.

### 5.4.1 Hand Trowel

A stainless-steel or disposable hand trowel may be used for sampling surface soil in instances where samples are not to be analyzed for volatile organics. The hand trowel is initially used to remove the uppermost 2 inches of soil and is then used to acquire a representative sample of deeper materials to a depth of 6 inches. Generally, only samples within the upper 6 inches of soil should be sampled using these methods. The depth of the sample shall be recorded in the surface and shallow soil sample log (Figure I-B-1-3). The soil classification shall include all the information outlined in Procedure I-E, *Soil and Rock Classification*.

Soil samples collected using a hand trowel are usually placed into pre-cleaned, wide-mouth glass jars. The jar is then sealed with a tight-fitting cap, labeled according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*, and placed on ice in a cooler in accordance with Procedure III-F, *Sample Handling, Storage, and Shipping*. All sampling equipment must be decontaminated prior to each use according to the methods presented in Procedure I-F, *Equipment Decontamination*.

### 5.4.2 Hand Auger

A soil recovery hand auger consisting of a metal rod, handle, detachable stainless-steel core barrel, and inner sleeves can be used to obtain both surface soil and trench samples. Multiple extensions can be connected to the sampler to facilitate the collection of samples at depths up to 15 feet below the existing ground surface.

Pre-cleaned sample liners are loaded into the core barrel prior to sampling. In general, these liners are used not only to collect samples, but also to serve as the sample container. Alternatively, in instances where VOCs are not to be analyzed or where not enough samples can be collected to completely fill a liner, samples can be transferred to wide-mouth glass jars. In either case, the sample shall be labeled according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody* and immediately placed on ice in a cooler as indicated in Procedure III-F, *Sample Handling, Storage, and Shipping*. To minimize possible cross-contamination, the soil recovery hand auger and sample liners shall be decontaminated prior to each use according to the procedures described in Procedure I-F, *Equipment Decontamination*.

### 5.4.3 Slide Hammer Sampling

In instances where the soil type precludes the collection of soil samples using the soil recovery hand auger, a manually operated slide hammer can be used to collect relatively undisturbed soil samples from excavations and surface soils. The slide hammer consists of a 6- to 12-inch core barrel that is connected to the slide hammer portion of the device using detachable extensions.

The core sampler is typically loaded with two to four sample liners, depending on the liner length, which are not only used to acquire the samples, but also serve as the sample container. Immediately following acquisition, samples shall be labeled according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody* and immediately placed on ice in a cooler as indicated in Procedure III-F, *Sample Handling, Storage, and Shipping*.

All of the sampling equipment that comes into contact with the sample medium shall be decontaminated in accordance with Procedure I-F, *Equipment Decontamination*. Split-barrel slide hammer core samplers, which have recently become available, are much easier to decontaminate than the older, single-piece core barrel, and should be used in place of the older core barrels where possible.

## FIELD LOG OF TRENCH/PIT

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Project Name | | | | | | | |
| Trench Number | | Project Number | Elevation and Datum | | | Location | |
| Equipment Supplier | | Operator | Date and Time Started | | | Date and Time Completed | |
| Equipment Type | | Trench Orientation | Total Depth | | | Total Number of Samples | |
| Bucket Width | Trench Length | Trench Width | No. Of Samples | Bulk | Ss | Drive | Hand Auger |
| Geologist or Hydrogeologist/Date | | | Check by/Date | | | | |

## SOIL DESCRIPTION

| LITHOLOGY | DEPTH (FEET) | DESCRIPTION | USCS SYMBOL | Est. % of | | | COMMENTS |
|---|---|---|---|---|---|---|---|
| | | | | G | S | F | |
| | | | | | | | Description taken _______ feet |
| | | | | | | | from ______ end of trench. |
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**Figure I-B-1-2: Field Log of Trench/Pit**

# SURFACE AND SHALLOW SOIL SAMPLE LOG

| | | | |
|---|---|---|---|
| Project Number | Project Name | Date | Time |
| Sample Identification Number and Time | | Checked by | |
| Sampled by | | Recorded by | |

Method of Collection

Surface Description

Notes

## Soil Sample Data

Location

| | |
|---|---|
| Coordinates | Elevation |

| LITHOLOGY | DEPTH (FEET) | DESCRIPTION | USCS SYMBOL | Est. % of | | | COMMENTS |
|---|---|---|---|---|---|---|---|
| | | | | G | S | F | |
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**Figure I-B-1-3: Surface and Shallow Soil Sample Log**

### 5.4.4 Hand Sampling Using Sample Liners

Surface soil samples can sometimes be collected by hand using just the sample liners. This method can be used in cases where the surface soils are soft or where it is advantageous to minimize the disturbance of the sample (such as when sampling for volatiles). Obtaining surface soil samples with this method consists merely of pushing or driving the sample tube into the ground by hand.

The sample liner (with the collected sample inside) is then removed from the ground and capped with Teflon film and plastic end caps. The sample is labeled according to Procedure III-E, *Record Keeping, Sampling Labeling, and Chain-Of-Custody* and immediately placed on ice in a cooler. All liners shall be decontaminated prior to use in accordance with Procedure I-F, *Equipment Decontamination*. Since the only pieces of equipment used are the sample liners, this method helps to minimize the required amount of equipment decontamination.

### 5.5 VOLATILE ORGANICS SCREENING AND HEADSPACE ANALYSIS

Volatile organics screening and headspace analysis is performed to preliminarily assess if the sample contains VOCs. Volatile organics screening and headspace analysis of samples shall be performed using a portable organic vapor analyzer (OVA), a portable photoionization detector (PID), or other similar instrument.

Volatile organics screening and headspace analysis is intended as a field screen for the presence of VOCs. The method measures the presence or absence of VOCs in the headspace (air) above a soil sample. Various factors affect the level of VOCs volatilizing from soils, such as concentration in the soil, temperature of the soil and air, organic carbon content of the soil, equilibration time, moisture content of the soil, and the chemical and physical characteristics of the VOCs. Therefore, headspace readings can only be regarded as qualitative assessments of volatiles, and caution should be exercised if using this technique to select samples for analytical testing. OVA and PID readings can vary because the two instruments have different sensitivities to the various VOCs and are usually calibrated relative to different gas standards (i.e., methane for the OVA and isobutylene for the PID).

In order to screen samples for VOCs, the instrument probe shall be inserted into the top of the sample liner immediately after the sampler is opened. The instrument response (normally in parts per million) is then recorded in the field notebook and/or the field log.

For headspace analysis, a portion of the sample is transferred into a zipper storage bag or pre-cleaned glass jar, which is then sealed and agitated. The VOCs are allowed to volatilize into the headspace and equilibrate for 15 to 30 minutes. Next, the instrument probe is then inserted into the container to sample the headspace, and the instrument response is recorded in the field notebook and/or the field log.

## 6. Records

Soil classification information collected during soil sampling should be documented in borehole, trench, and surface soil log forms. All log entries shall be made in indelible ink. Information concerning sampling activities shall be recorded on sample log forms or in the field logbook. The CTO Manager or designee shall review all field logs on at least a monthly basis. Procedures for these activities are contained in this manual. Copies of this information should be sent to the CTO Manager and to the project files.

## 7. Health and Safety

Field Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

## 8. References

ASTM International (ASTM). 2005. *Standard Guide for Direct Push Soil Sampling for Environmental Site Characterizations*. ASTM D6282-98. West Conshohocken, PA.

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Department of the Navy (DON). 2007. *Environmental and Natural Resources Program Manual*. OPNAV Instruction 5090.1C. 30 October.

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Procedure I-A-6, *Investigation-Derived Waste Management.*

Procedure I-C-1, *Monitoring Well Installation and Abandonment.*

Procedure I-E, *Soil and Rock Classification*.

Procedure I-F, *Equipment Decontamination.*

Procedure I-I, *Land Surveying.*

Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*.

Procedure III-F, *Sample Handling, Storage, and Shipping.*

## 9. Attachment

Attachment I-B-1-1: Sampling and Handling Procedure: Analysis of Soil for Volatile Organic Compounds

# Attachment I-B-1-1

## Sampling and Handling Procedure:
## Analysis of Soil for Volatile Organic Compounds

## 1. Laboratory Requirements

The laboratory must be capable of performing (1) United States (U.S.) Environmental Protection Agency (EPA) Solid Waste (SW)-846 Method 5035 and (2) Method 8260, 8021, or 8015 (purgeable hydrocarbons), depending on the project objectives (EPA 2007). The laboratory must have method performance data to verify this capability.

Sampling and handling procedures for the analysis of soil for volatile organic compounds (VOCs) will depend on the project objectives and the sampling approach. The laboratory is responsible for providing the necessary sample containers with preservatives (if applicable) that meet consumable certification requirements. The following section describes the consumable options for VOC soil sampling. In addition, sample containers must have a sample label and be weighed prior to shipment to the field for use. The laboratory is responsible for recording the weight of each container before and after sampling. Alternately, EnCore-type samplers may be employed.

The laboratory must provide a minimum of three prepared containers, or EnCore-type samplers, for each soil sample analyzed for VOCs.

## 2. Supplies

- Disposable coring devices (hereafter referred to as coring devices): either vendor-calibrated sample coring devices, or EnCore-type samplers. One coring device sampler per sampling location, plus additional coring devices (5 percent) in case of breakage.
- The number and type of laboratory prepared sample containers will depend upon the sampling scheme employed.
- For discrete soil VOCs, two 40 milliliter (mL) volatile organic analyte (VOA) vials with 5 mL of ASTM International (ASTM) Type II water, single-use magnetic stir bar with Teflon lined septa cap, one VOA vial with 5 mLs of methanol with a Teflon lined septa cap, and sample label, or three EnCore-type samplers.
- For incremental soil VOC samples, the total number of sample containers will depend upon the number of increments collected. The laboratory shall provide containers which contain a maximum of 30 mL of methanol (or as dictated by Federal Laws for transporting Exempted Limited Quantities of Dangerous Goods (49 CFR 100-185) with a Teflon lined septa cap, and sample label.
- Reagent/trip blanks: laboratory-prepared in identical fashion to sample vials.
- Temperature blanks: laboratory-prepared.
- 2-ounce glass jars with Teflon-lined lid: for dilution purposes and percent moisture determination.
- Nitrile or equivalent gloves.

## 3. Field Sampling

The following directions apply to all sampling techniques for soil coring devices: For reasons stated in section 3.4of this attachment and explained in detail in Sections 8.2.1.8 and A7.2 of EPA Method 5035, core-type (i.e., Terra Core, EnCore, etc.) samplers are recommended for sample collection, not sample collection and transport (EPA 2007).

- Always wear clean gloves while handling sample containers to help prevent soil and other debris from adding to the weight of the vial. Always don a new pair of gloves and use a new core sampler for each sampling location.
- Whenever possible, collect the soil samples for VOC analysis in place. If this is not possible, practical, or safe, collect the sample from a sample liner, or if absolutely necessary, from a backhoe bucket. Avoid having particles of soil adhering to the grooves of the screw cap or the container threads.
- Collect VOA samples as quickly as possible to avoid unnecessary VOC losses. EPA Region 9 recommends total exposure of the soil sample to ambient conditions should not exceed 10 seconds.
- Once the soil has been transferred to the sample container, screw the cap back on and mark the sample ID on the label with a ballpoint pen. Do not use a pen that has high solvent concentrations in the ink such as a Sharpie.
- Place the VOA vial inside a cooler containing either wet ice in sealed bags or gel ice.
- Collect the number of sample containers as describe in Section 2 of this standard operating procedure at each sampling location. The same core sampler may be used to prepare all containers. Duplicate samples require collecting additional sample containers. For percent moisture purposes, soil must also be collected in 2-ounce or greater glass jars with Teflon-lined lids at each sampling location. If other analyses are being conducted for the sampling location, then the percent moisture may be obtained from other sample containers. The 2-ounce jar will be completely filled with zero headspace. If other analyses are not being conducted at the sampling location, then an additional sample must be collected in another 2-ounce glass jar for percent moisture.
- When incrementally collecting samples from a liner for non-VOC analysis, a core sampler may be used to obtain equal incremental sample volumes. The liner will have been sliced open prior to incremental sample collection for access to the entire length of the sample.
- Depending on the 1) pre-selected volume to be collected per sample, 2) the sample/liner length available for incremental sampling, and 3) the size of the core tool, collect as many cores from the entire soil sample/liner section that will total to the required sample volume. For example, if 30 grams is the volume to be collected per sample location, the sample/liner length is 6 inches, and a 5 gram core tool is used, then 6 incremental samples, located throughout the sample length to provide adequate, representative coverage of the entire

6 inches of sample, would be collected (i.e., 6 incremental samples could be taken at equally spaced locations across the sample length, totaling 30 grams of sample).

- Collect one equipment blank per laboratory or vendor shipment of Terra Core, as described in Procedure III-B, *Field QC Samples (Water, Soil)*, unless the syringes are certified clean (e.g., certificate of analysis or equivalent documentation) by the vendor.
- Place samples in bubble wrap or other protective covering. Place custody seals on the covering. Custody seals or tape must not be placed directly on the sample vials, as this will interfere with the analytical instrumentation, final weight of the sample, and ultimate sample VOC concentration.

*The following additional directions for VOC soil sample collection are taken from EPA SW-846 Method 5035A Appendix A7.0* (EPA 2002).

**Collection of Samples for Analysis**

After a fresh surface of the solid material is exposed to the atmosphere, the subsample collection process should be completed in the least amount of time to minimize the loss of VOCs due to volatilization. Removing a subsample from a material should be done with the least amount of disruption (disaggregation) as possible. Additionally, rough trimming of the sampling location’s surface layers should be considered if the material may have already lost VOCs (been exposed for more than a couple of minutes) or if it might be contaminated by other waste, different soil strata, or vegetation. Removal of surface layers can be accomplished by scraping the surface using a clean spatula, scoop, knife, or shovel (ASTM 2005, Hewitt et al. 1999).

*Subsampling of Cohesive Granular but Uncemented Materials Using Devices Designed to Obtain a Sample Appropriate Analysis*

Collect subsamples of the appropriate size for analysis using a metal or rigid plastic coring tool. For example, coring tools for the purpose of transferring a subsample can be made from disposable plastic syringes by cutting off the tapered front end and removing the rubber cap from the plunger or can be purchased as either plastic or stainless-steel coring devices. These smaller coring devices help to maintain the sample structure during collection and transfer to the VOA vials, as do their larger counterparts used to retrieve subsurface materials. When inserting a clean coring tool into a fresh surface for sample collection, air should not be trapped behind the sample. If air is trapped, it could either pass through the sampled material causing VOCs to be lost or push the sample prematurely from the coring tool.

The commercially available EasyDraw Syringe, Powerstop Handle, and Terra Core sampler coring devices are designed to prevent headspace air above the sample contents. For greater ease in pushing into the solid matrix, sharpen the front edge of these tools. The optimum diameter of the coring tool depends on the following:

- Size of the opening on the collection vial or bottle (tool should fit inside mouth)
- Dimensions of the original sample, particle size of the solid materials (e.g., gravel-size particles would require larger samplers)
- Volume of sample required for analysis

For example, when a 5-gram (g) subsample of soil is specified, only a single 3-cubic-centimeter ($cm^3$) volume of soil has to be collected (assuming the soil has density of 1.7 $g/cm^3$). Larger subsample masses or more subsample increments are preferred as the heterogeneity of the material increases. After an undisturbed sample has been obtained by pushing the barrel of the coring tool into a freshly exposed surface and then removing the filled corer, quickly wipe the exterior of the barrel with a clean disposable towel.

The next step varies depending on whether the coring device is used for sample storage and transfer or solely for transfer. If the coring tool is used as a storage container, cap the open end after ensuring that the sealing surfaces are cleaned. If the device is to be solely used for collection and not for storage, immediately extrude the sample into a VOA vial or bottle by gently pushing the plunger while tilting the VOA vial at an angle (to avoid splashing any deionized water or methanol). The volume of material collected should not cause excessive stress on the coring tool during intrusion into the material, or be so large that the sample easily falls apart during extrusion. Obtain and transfer samples rapidly (<10 seconds) to reduce volatilization losses. If the vial or bottle contains ASTM reagent Type II water, hold it at an angle when extruding the sample into the container to minimize splashing. Just before capping, visually inspect the lip and threads of the sample vessel, and remove any foreign debris with a clean towel, allowing an airtight seal to form.

*Devices that Can Be Used for Subsampling a Cemented Material*

The material requiring sampling may be so hard that even metal coring tools cannot penetrate it. Subsamples of such materials can be collected by fragmenting a larger portion of the material using a clean chisel to generate aggregate(s) of a size that can be placed into a VOA vial or bottle. When transferring the aggregate(s), precautions must be taken to prevent compromising the sealing surfaces and threads of the container. Losses of VOCs by using this procedure are dependent on the location of the contaminant relative to the surface of the material being sampled. Therefore, take caution in the interpretation of the data obtained from materials that fit this description. As a last resort, when this task cannot be performed on site, a large sample can be collected in a vapor-tight container and transported to the laboratory for subsampling. Collect, fragment, and add the sample to a container as quickly as possible.

*Devices that Can Be Used for Subsampling a Non-cohesive Granular Material*

As a last resort, gravel, or a mixture of gravel and fines that cannot be easily obtained or transferred using coring tools, can be quickly sampled using a stainless-steel spatula or scoop. If the collection vial or bottle contains ASTM reagent Type II water, transfer samples with minimal splashing and without the spatula or scoop contacting the liquid contents. For some solids, a wide-bottom funnel or similar channeling device may be necessary to facilitate transfer to the container and prevent compromising the sealing surfaces of the container. Take caution when interpreting the data obtained from materials that fit this description. Loss of VOCs is likely due to the nature of the sampling method and the non-cohesive nature of the material, which exposes more surface area to the atmosphere than other types of samples. During the sampling process, non-cohesive materials also allow coarser materials to separate from fines, which can skew the concentration data if the different particle sizes, which have different surface areas, are not properly represented in the sample.

*Use of the EnCore Sampler (or Equivalent) for Sample Transport and Storage*

The EnCore sampler is a sampling device that can be used as both a simultaneous coring tool for cohesive soils and a transport device to a support laboratory (field or off site). The EnCore sampler is intended to be a combined sampler-storage device for soils until a receiving laboratory can initiate either immediate VOC analysis, or preserve extruded soil aliquots for later VOC analysis. It is meant to be disposed of after use. The commercially available device is constructed of an inert composite polymer. It uses a coring/storage chamber to collect either a 5-gram or 25-gram sample of cohesive soils. It has a press-on cap with hermetically a vapor-tight seal and locking arm mechanism. It also has a vapor-tight plunger for the non-disruptive extrusion of the sample into an appropriate container for VOC analysis of soil.

An individual disposable EnCore sampler (or equivalent) is needed for each soil aliquot collected for vapor partitioning or ASTM reagent Type II water sample preparation. Upon soil sample collection, store the EnCore sampler is at 4 ±2 degrees centigrade (°C) until laboratory receipt within 48 hours. Upon laboratory receipt, soil aliquots are extruded to appropriate tared and prepared VOA vials.

Validation data have been provided to support use of the EnCore sampler for VOC concentrations in soil between 5 and 10 parts per million, for two sandy soils, with a 2-day holding time at 4 ±2°C. Preliminary data (Soroni et al. 2001) demonstrate an effective 2-day (48-hour) holding time at 4 ±2°C for three sandy soil types with VOC concentrations at 100 parts per billion (ppb) (benzene and toluene at 300 ppb), as well as an effective 1- or 2-week holding time at <-7°C (freezing temperature). Recent published work (EPA 2001) neither definitively supports nor shows the EnCore device to be ineffective for sample storage at these preservation temperatures. Soils stored in the EnCore device for 2 calendar days at 4 ± 2°C are subject to loss of benzene, toluene, ethylbenzene, and xylene (BTEX) compounds by biodegradation if the soil is an aerated, biologically active soil (e.g., garden soil) (Soroni et al. 1999), but this BTEX loss is eliminated for up to 48 hours under freezing conditions (Hewitt 1999).

Further details on the EnCore sampler can be found in ASTM D4547-09 (ASTM 2009) or other publications.

Since Naval Facilities Engineering Command, Pacific action levels for VOCs in soil are typically associated with EPA Region 9 preliminary remediation goals for residential exposure scenarios, it is recommended that if EnCore samplers are used, they be frozen on site prior to shipment to the laboratory or extruded into a 40-mL VOA vial before shipment.

## 4. Sample Shipping and Holding Times

Samples preserved with water may be shipped either at 4 ±2°C or frozen at –7°C. The primary difference between the two shipping temperatures is the allowable holding time of the sample between sample collection and sample analysis. Samples shipped at 4 ±2°C must either be received and analyzed by the laboratory within 48 hours of sample collection or be received by the laboratory within 48 hours, frozen upon receipt, and analyzed within 14 days of sample collection. Samples shipped at –7°C and received/maintained by the laboratory in a frozen state must be analyzed within 14 days of sample collection.

If soil samples are to be field frozen, place the frozen samples in a cooler containing fresh, frozen gel packs or an ice and rock salt mixture, and ship the cooler using an overnight carrier. Dry ice may be used as a refrigerant for sample shipment, but must be coordinated with the overnight carrier in advance. The sample vials and caps must never be placed in direct contact with the dry ice since cracking may occur.

Soil or sediment samples contained in methanol and 2-ounce glass jars may be shipped in standard coolers using conventional shipping protocols described in Procedure III-F, *Sample Handling, Storage, and Shipping*, if the sample appears to have a moisture content that might cause the sample to expand and the glass jar to break due to freezing. If soil samples contained in 2-ounce glass jars are shipped in this manner, then trip blanks must accompany them during shipment.

Reagent/trip blanks that contain the same volume of ASTM Type II water and sample label used in the sample VOA vials must be included in each shipment. The reagent/trip blanks will be packaged, shipped, and analyzed in the same manner as field samples. Reagent/trip blanks will be analyzed to evaluate cross-contamination during shipment and to identify potential reagent contamination issues.

## 5. Laboratory Receipt

Upon receipt by the analytical laboratory, the sample temperature must be measured and recorded. The laboratory should note whether the samples are frozen. The samples must be logged in and assigned an analysis date to ensure that samples are analyzed within the 14-day holding time.

Once the samples have been logged in, they are placed in a freezer at 0°C or colder until they are analyzed. Samples arriving in a non-frozen state (greater than 0°C) are to be frozen upon receipt or analyzed within 48 hours of sample collection. If the duration of sample shipment exceeds 48 hours, the non-frozen samples should be analyzed on the day of laboratory receipt.

The laboratory will prepare the samples for analysis as dictated by laboratory standard operating procedures and SW-846 Method 5035, and analyzed by Method 8260, 8021, or 8015 (purgeable hydrocarbons), depending on the project objectives.

## 6. References

49 Code of Federal Regulations (CFR) 100-185. *Hazardous Materials and Oil Transportation*.

ASTM International (ASTM). 2005. *Standard Guide for Direct Push Soil Sampling for Environmental Site Characterizations*. ASTM D6282-98. West Conshohocken, PA.

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Environmental Protection Agency, United States (EPA). 2002. *Method 5035A Closed System Purge and Trap and Extraction for Volatile Organics in Soil and Waste Samples*, Draft Revision 1. Office of Solid Waste. July.

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Hewitt, Alan. D. 1999. Frozen Storage of Soil Samples for VOC Analysis. *Environmental Testing & Analysis*, 8 (5), pp. 18–25, 46.

Hewitt, Alan. D. and K. F. Myers. 1999. *Sampling and On-Site Analytical Methods for Volatiles in Soil and Groundwater—Field Guidance Manual*; Special Report 99-16. Hanover, NH: U.S. Army Cold Regions Research and Engineering Laboratory. November.

Soroni, S. S. and J. F. Schaborn. 1999. *Performance of the Disposable EnCore Sampler for Storing Soil for Volatile Organic Analysis*. Proceedings of the 15th Annual Waste Testing and QA Symposium, EPA. Washington. pp. 129-134.

Soroni, S. S., J. F. Schaborn and J. F. Rovani. 2001. *Validation of a New Soil VOC Sampler: Performance of the En Core Sampler for Storage of Low VOC Concentrations and EPA Method 1311 Volatile Organic Analytes*. Topical Report WRI-01-R005; Laramie, WY: Western Research Institute.

Procedure III-B, *Field QC Samples (Water, Soil).*

Procedure III-F, *Sample Handling, Storage, and Shipping*.

# Monitoring Well Sampling

## 1. Purpose

This standard operating procedure describes the monitoring well sampling procedures to be used by United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

## 2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

## 3. Definitions

None.

## 4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that these standard groundwater sampling activities are followed during projects conducted under the NAVFAC Pacific ER Program. The CTO Manager or designee shall review all groundwater sampling forms on a minimum monthly basis. The CTO Manager is responsible for ensuring that all personnel involved in monitoring well sampling shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for ensuring that all project field staff follow these procedures.

Field sampling personnel are responsible for the implementation of this procedure.

Minimum qualifications for sampling personnel require that one individual on the field team shall have a minimum of 1 year experience with sampling monitoring wells.

The field sampler and/or task manager is responsible for directly supervising the groundwater sampling procedures to ensure that they are conducted according to this procedure, and for recording all pertinent data collected during sampling. If deviations from the procedure are required because of anomalous field conditions, they must first be approved by the QA Manager or Technical Director and then documented in the field logbook and associated report or equivalent document.

# 5. Procedures

## 5.1 PURPOSE

This procedure establishes the method for sampling groundwater monitoring wells for water-borne contaminants and general groundwater chemistry. The objective is to obtain groundwater samples of aquifer conditions with as little alteration of water chemistry as possible.

## 5.2 PREPARATION

### 5.2.1 Site Background Information

Establish a thorough understanding of the purposes of the sampling event prior to field activities. Conduct a review of all available data obtained from the site and pertinent to the water sampling. Review well history data including, but not limited to, well locations, sampling history, purging rates, turbidity problems, previously used purging methods, well installation methods, well completion records (including depth of screened interval), well development methods, previous analytical results, presence of an immiscible phase, historical water levels, and general hydrogeologic conditions.

Previous groundwater development and sampling logs give a good indication of well purging rates and the types of problems that might be encountered during sampling, such as excessive turbidity and low well yield. They may also indicate where dedicated pumps are placed in the water column. To help minimize the potential for cross-contamination, well purging and sampling, and water level measurement collection shall proceed from the least contaminated to the most contaminated as indicated in previous analytical results. This order may be changed in the field if conditions warrant it, particularly if dedicated sampling equipment is used. A review of prior sampling procedures and results may also identify which purging and sampling techniques are appropriate for the parameters to be tested under a given set of field conditions.

### 5.2.2 Groundwater Analysis Selection

Establish the requisite field and laboratory analyses prior to water sampling. Decide on the types and numbers of QA/quality control (QC) samples to be collected (Procedure III-B, *Field QC Samples [Water, Soil]*), as well as the type and volume of sample preservatives, the number of sample containers (e.g., coolers), and the quantity of ice or other chilling materials. The sampling personnel shall ensure that the appropriate number and size sample containers are brought to the site, including extras in case of breakage or unexpected field conditions. Document the analytical requirements for groundwater analysis in the project-specific work plan.

## 5.3 GROUNDWATER SAMPLING PROCEDURES

Groundwater sampling procedures at a site shall include: (1) measurement of well depth to groundwater; (2) assessment of the presence or absence of an immiscible phase; (3) assessment of purge parameter stabilization; (4) purging of static water within the well and well bore; and (5) obtaining a groundwater sample. Each step is discussed in sequence below. Depending upon specific field conditions, additional steps may be necessary. As a rule, at least 24 hours should separate well development and well sampling events.

### 5.3.1 Measurement of Static Water Level Elevation

Measure the depth to standing water and the total depth of the well to the nearest 0.01 foot to provide baseline hydrologic data, to calculate the volume of water in the well, and to provide information on the integrity of the well (e.g., identification of siltation problems). Mark each well with a permanent, easily identified reference point for water level measurements whose location and elevation have been surveyed.

Before purging the well, measure water levels in all of the wells within the zone of influence of the well being purged. Measure water levels twice in quick succession and record each measurement. This will provide a water level database that describes water levels across the site at one time (a synoptic sampling). Measure the water level in each well immediately prior to purging the well.

The device used to measure the water level surface and depth of the well shall be sufficiently sensitive and accurate in order to obtain a measurement to the nearest 0.01 foot reliably. An electronic water level meter will usually be appropriate for this measurement; however, when the groundwater within a particular well is highly contaminated, an inexpensive weighted tape measure can be used to determine well depth to prevent adsorption of contaminants onto the meter tape. The presence of light, non-aqueous phase liquids (LNAPLs) and/or dense, non-aqueous phase liquids (DNAPLs) in a well requires measurement of the elevation of the top and the bottom of the product, generally using an interface probe. Water levels in such wells must then be corrected for density effects to accurately determine the elevation of the water table.

### 5.3.2 Decontamination of Equipment

Establish a decontamination station before beginning sampling. The station shall consist of an area of at least 4 feet by 2 feet covered with plastic sheeting and be located upwind of the well being sampled and far enough from potential contaminant sources to avoid contamination of clean equipment. The station shall be large enough to fit the appropriate number of wash and rinse buckets, and have sufficient room to place equipment after decontamination. One central cleaning area may be used throughout the entire sampling event. The area around the well being sampled shall also be covered with plastic sheeting to prevent spillage. Further details are presented in Procedure I-F, *Equipment Decontamination*.

Decontaminate each piece of equipment prior to entering the well. Also conduct decontamination prior to sampling at a site, even if the equipment has been decontaminated subsequent to its last usage. This precaution is taken to minimize the potential for cross-contamination. Additionally, decontaminate each piece of equipment used at the site prior to leaving the site. It is only necessary to decontaminate dedicated sampling equipment prior to installation within the well. Do not place clean sampling equipment directly on the ground or other contaminated surfaces prior to insertion into the well. Dedicated sampling equipment that has been certified by the manufacturer as being decontaminated can be placed in the well without onsite decontamination.

### 5.3.3 Detection of Immiscible Phase Layers

Complete the following steps for detecting the presence of LNAPL and DNAPL, as necessary, before the well is evacuated for conventional sampling:

1. Sample the headspace in the wellhead immediately after the well is opened for organic vapors using either a photoionization detector or an organic vapor analyzer (flame ionization detector), and record the measurements.

2. Lower an interface probe into the well to determine the existence of any immiscible layer(s), LNAPL and/or DNAPL, and record the measurements.
3. Confirm the presence or absence of an immiscible phase by slowly lowering a clear bailer to the appropriate depth, then visually observing the results after sample recovery.
4. In rare instances, such as when very viscous product is present, it may be necessary to utilize hydrocarbon- and water-sensitive pastes for measurement of LNAPL thickness. This is accomplished by smearing adjacent, thin layers of both hydrocarbon- and water-sensitive pastes along a steel measuring tape and inserting the tape into the well. An engineering tape showing tenths and hundredths of feet is required. Record depth to water, as shown by the mark on the water-sensitive paste, and depth to product, as shown by the mark on the product-sensitive paste. In wells where the approximate depth to water and product thickness are not known, it is best to apply both pastes to the tape over a fairly long interval (5 feet or more). Under these conditions, measurements are obtained by trial and error, and may require several insertions and retrievals of the tape before the paste-covered interval of the tape encounters product and water. In wells where approximate depths of air-product and product-water interfaces are known, pastes may be applied over shorter intervals. Water depth measurements should not be used in preparation of water-table contour maps until they are corrected for depression by the product.

If the well contains an immiscible phase, it may be desirable to sample this phase separately. Sections 5.3.5.1 and 5.3.5.2 present immiscible phase sampling procedures. It may not be meaningful to conduct water sample analysis of water obtained from a well containing LNAPLs or DNAPLs. Consult the CTO Manager and QA Manager or Technical Director if this situation is encountered.

### 5.3.4 Purging Equipment and Use

The water present in a well prior to sampling may not be representative of *in situ* groundwater quality and shall be removed prior to sampling. Handle all groundwater removed from potentially contaminated wells in accordance with the investigation-derived waste (IDW) handling procedures in Procedure I-A-6, *Investigation-Derived Waste Management*.

Purging shall be accomplished by removing groundwater from the well at low flow rates using a pump. According to the U.S. Environmental Protection Agency (EPA) (EPA 1996), the rate at which groundwater is removed from the well during purging ideally should be less than 0.2 to 0.3 liters/min. The EPA further states that wells should be purged at rates below those used to develop the well to prevent further development of the well, to prevent damage to the well, and to avoid disturbing accumulated corrosion or reaction products in the well. The EPA also indicates that wells should be purged at or below their recovery rate so that migration of water in the formation above the well screen does not occur.

Realistically, the purge rate should be low enough that substantial drawdown in the well does not occur during purging. The goal is minimal drawdown (less than 0.1 meter) during purging (EPA 1996). The amount of drawdown during purging should be recorded at the same time the other water parameters are measured. Also, a low purge rate will reduce the possibility of stripping volatile organic compounds (VOCs) from the water, and will reduce the likelihood of mobilizing colloids in the subsurface that are immobile under natural flow conditions.

The sampler shall ensure that purging does not cause formation water to cascade down the sides of the well screen. Wells shall not be purged to dryness if recharge causes the formation water to cascade down the sides of the screen, as this will cause an accelerated loss of volatiles. This problem should be anticipated. Water shall be purged from the well at a rate that does not cause recharge water to be excessively agitated unless an extremely slow recharging well is encountered where complete evacuation is unavoidable.

In high yield wells (wells that exhibit 80 percent recovery in less than 2 hours), purging shall be conducted at relatively low flow rates and shall remove water from the entire screened interval of the well to ensure that fresh water from the formation is present throughout the entire saturated interval. In general, place the intake of the purge pump 2 to 3 feet below the air-water interface within the well to allow purging and at the same time minimize disturbance/overdevelopment of the screened interval in the well. During the well purging procedure, collect water level and/or product level measurements to assess the hydraulic effects of purging. Sample the well when it recovers sufficiently to provide enough water for the analytical parameters specified.

Low yield wells (those that exhibit less than 80 percent recovery in less than 2 hours) require one borehole volume of water to be removed. Allow the well to recover sufficiently to provide enough water for the specified analytical parameters, and then sample it.

Evaluate water samples on a regular basis (approximately every 5 minutes) during well evacuation and analyze them in the field preferably using a multi-parameter meter and flow-through cell for temperature, pH (indicates the hydrogen ion concentration – acidity or basicity), specific conductivity, dissolved oxygen (DO), oxidation reduction potential (ORP), turbidity, salinity, and total dissolved solids (TDS). Take at least five readings during the purging process. These parameters are measured to demonstrate that the natural character of the formation water has been pumped into the well. Purging shall be considered complete when three consecutive sets of field parameter measurements stabilize within approximately 10 percent (EPA 2006). However, suggested ranges are ±0.2 degrees Celsius for temperature, ±0.1 standard units for pH, ±3 percent for specific conductance, ±10 percent for DO, and ±10 millivolts for redox potential (ASTM 2001). This criterion may not be applicable to temperature if a submersible pump is used during purging due to the heating of the water by the pump motor. Enter all information obtained during the purging and sampling process including drawdown, into a groundwater sampling log (Figure I-C-3-1). Complete all blanks on this field log during sampling.

In cases where an LNAPL has been detected in the monitoring well, insert a stilling tube of a minimum diameter of 2 inches into the well prior to well purging. The stilling tube shall be composed of a material that meets the performance guidelines for sampling devices. Insert the stilling tube into the well to a depth that allows groundwater from the screened interval to be purged and sampled, but that is below the upper portion of the screened interval where the LNAPL is entering the well screen. The goal is to sample the aqueous phase (groundwater) while preventing the LNAPL from entering the sampling device. To achieve this goal, insert the stilling tube into the well in a manner that prevents the LNAPL from entering the stilling tube. However, sampling groundwater beneath a NAPL layer is not generally recommended due to the fact that the interval with residual NAPL saturation is often unknown and the NAPL can be mobilized into the well from intervals below the water table.

One method of doing this is to cover the end of the stilling tube with a membrane or material that will be ruptured by the weight of the pump. A piece of aluminum foil can be placed over the end of the stilling tube. Slowly lower the stilling tube into the well to the appropriate depth and then attach it firmly to the top of the well casing. When the pump is inserted, the weight of the pump breaks the foil covering the end of the tube, and the well can be purged and sampled from below the LNAPL layer. Firmly fasten the membrane or material that is used to cover the end of the stilling tube so that it remains attached to the stilling tube when ruptured. Moreover, the membrane or material must retain its integrity after it is ruptured. Pieces of the membrane or material must not fall off of the stilling tube into the well. Although aluminum foil is mentioned in this discussion as an example of a material that can be used to cover the end of the tube, a more chemically inert material may be required, based on the site-specific situation. Thoroughly decontaminate stilling tubes prior to each use. Collect groundwater removed during purging, and store it on site until its disposition is determined based upon laboratory analytical results. Storage shall be in secured containers, such as U.S. Department of Transportation-approved drums. Label containers of purge water with the standard NAVFAC Pacific ER Program IDW label.

The following paragraphs list available purging equipment and methods for their use.

#### *5.3.4.1 BAILERS AND PUMPS*

*Submersible Pump:* A stainless steel submersible pump may be utilized for purging both shallow and deep wells prior to sampling groundwater for volatile, semivolatile, and non-volatile constituents. For wells over 200 feet deep, the submersible pump is one of the few technologies available to feasibly accomplish purging under any yield conditions. For shallow wells with low yields, submersible pumps are generally inappropriate due to over stressing of the wells (<1 gallon per minute), which causes increased aeration of the water within the well.

Steam clean or otherwise decontaminate the pump and discharge tubing prior to the placing the pump in the well. The submersible pump shall be equipped with an anti-backflow check valve to keep water from flowing back down the drop pipe into the well. Place the pump intake approximately 2 to 3 feet below the air-water interface within the well and maintain it in that position during purging. Additionally, when pulling the pump out of the well subsequent to purging, take care to avoid dumping water within the drop pipe and pump stages back into the well.

*Bladder Pump:* A stainless steel and/or Teflon bladder pump can be utilized for purging and sampling wells up to 200 feet in depth for volatile, semivolatile, and non-volatile constituents. Additionally, the bladder pump can be used for purging and obtaining groundwater samples overlain by a LNAPL layer as long as care is taken not to draw the product layer into the bladder pump. Use of the bladder pump is most effective in low to moderate yield wells.

Either a battery powered compressor, compressed dry nitrogen, or compressed dry air, depending upon availability, can operate the bladder pump. The driving gas utilized must be dry to avoid damage to the bladder pump control box. Decontaminate the bladder pump prior to use. Once purging is complete, collect the samples directly from the bladder pump.

*Centrifugal or Diaphragm Pump:* A centrifugal, or diaphragm, pump may be used to purge a well if the water level is within 20 feet of ground surface. A new, or properly decontaminated, hose is lowered into the well and water withdrawn at a rate that does not cause excessive well drawdown.

# GROUNDWATER SAMPLING LOG

WELL NO. LOCATION: PROJECT NO.

DATE: TIME: CLIMATIC CONDITIONS:

TIDAL CONDITIONS: Rising ☐ HIGH TIDE: CURRENT TIDE:
Falling ☐ LOW TIDE:

STATIC WATER LEVEL (FT.) and TIME: TOTAL DEPTH (FT.):

WELL PURGING: LENGTH OF SATURATED ZONE: LINEAR FT.

a VOLUME OF WATER TO BE EVACUATED: GALS. (Gals/Linear ft. X linear feet of saturation X 3-casing volumes)

METHOD OF REMOVAL: PUMPING RATE: mL/min

WELL PURGE DATA:

| DATE/ TIME | DTW | GALLONS REMOVED | TDS (g/L) | pH | SP. COND. (mS/cm) | D.O. (mg/L) | TURB. (NTU) | TEMP. (°C) | ORP (mV) | SAL (ppt) |
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SAMPLE WITHDRAWAL METHOD:

APPEARANCE OF SAMPLE: COLOR:
SEDIMENT:
OTHER:

LABORATORY ANALYSIS PARAMETERS AND PRESERVATIVES

NUMBER AND TYPES OF SAMPLE CONTAINERS USED:

SAMPLE IDENTIFICATION NUMBER(S)

DECONTAMINATION PROCEDURES:

NOTES:

SAMPLED BY:

SAMPLES DELIVERED TO: TRANSPORTER:

DATE: TIME:

CAPACITY OF CASING (GALLONS/LINEAR FOOT)
2"-0.16•4"-0.65•6"-1.47•8"-2.61•10"-4.08•12"-5.87

**Figure I-C-3-1: Groundwater Sampling Log**

Place the hose bottom approximately 2 to 3 feet below the air-water interface and maintain it in that position during purging.

*Air Lift Pump:* Airlift pumps are not appropriate for purging or sampling.

*Bailer:* Avoid using a bailer to purge a well because it can result in aeration of the water in the well and possibly cause excessive purge rates. If a bailer must be used, decontaminate the bailer, bailer wire, and reel as described in Section 5.3.2 prior to its use. Teflon-coated cable mounted on a reel is recommended for lowering the bailer in and out of the well.

Lower the bailer below the water level of the well with as little disturbance of the water as possible to minimize aeration of the water in the well. One way to gauge the depth of water on the reel is to mark the depth to water on the bailer wire with a stainless steel clip. In this manner, less time is spent trying to identify the water level in the well. The QA Manager or Technical Director shall approve use of bailers for purging monitoring wells in advance.

### 5.3.5 Monitoring Well Sampling Methodologies

#### *5.3.5.1 SAMPLING LIGHT, NON-AQUEOUS PHASE LIQUIDS (LNAPL)*

Collect LNAPL, if present, prior to any purging activities. The sampling device shall generally consist of a dedicated or disposable bailer equipped with a bottom-discharging device. Lower the bailer slowly until contact is made with the surface of the LNAPL, and to a depth less than that of the immiscible fluid/water interface depth as determined by measurement with the interface probe. Allow the bailer to fill with the LNAPL and retrieve it.

When sampling LNAPLs, never drop bailers into a well, and always remove them from the well in a manner that causes as little agitation of the sample as possible. For example, the bailer should not be removed in a jerky fashion or be allowed to continually bang against the well casing as it is raised. When using bailers to collect LNAPL samples for inorganic analyses, the bailer shall be composed of fluorocarbon resin. Bailers used to collect LNAPL samples for organic analyses shall be constructed of stainless steel. The cable used to raise and lower the bailer shall be composed of an inert material (e.g., stainless steel) or coated with an inert material (e.g., Teflon).

#### *5.3.5.2 SAMPLING DENSE, NON-AQUEOUS PHASE LIQUIDS (DNAPL)*

Collect DNAPL prior to any purging activities. The best method for collecting DNAPL is to use a double-check valve, stainless steel bailer, or a Kemmerer (discrete interval) sampler. The sample shall be collected by slow, controlled lowering of the bailer to the bottom of the well, activation of the closing device, and retrieval.

#### *5.3.5.3 GROUNDWATER SAMPLING METHODOLOGY*

The well shall be sampled when groundwater within it is representative of aquifer conditions and after it has recovered sufficiently to provide enough volume for the groundwater sampling parameters. A period of no more than 2 hours shall elapse between purging and sampling to prevent groundwater interaction with the casing and atmosphere. This may not be possible with a slowly recharging well. Measure and record the water level prior to sampling to demonstrate the degree of recovery of the well. Sampling equipment (e.g., especially bailers) shall never be dropped into the well, as this could cause aeration of the water upon impact. Additionally, the sampling methodology utilized shall allow for the collection of a groundwater sample in as undisturbed a condition as possible, minimizing the potential for volatilization or aeration. This includes minimizing agitation and aeration during transfer to sample containers.

Sampling equipment shall be constructed of inert material. Equipment with neoprene fittings, polyvinyl chloride bailers, tygon tubing, silicon rubber bladders, neoprene impellers, polyethylene, and viton is not acceptable. If bailers are used, an inert cable/chain (e.g., fluorocarbon resin-coated wire or single strand stainless steel wire) shall be used to raise and lower the bailer. Generally, bladder and submersible pumps are acceptable sampling devices for all analytical parameters. Dedicated equipment is highly recommended for all sampling programs. The following text describes sampling methods utilizing submersible pumps, bladder pumps, and bailers.

*Submersible Pumps:* When operated under low-flow rate conditions (100 to 300 milliliters [mL]/minute or less), submersible pumps are as effective as bladder pumps in acquiring samples for volatile organic analysis as well as other analytes. The submersible pump must be specifically designed for groundwater sampling (i.e., pump composed of stainless steel and Teflon, sample discharge lines composed of Teflon) and must have a controller mechanism allowing the required low flow rate. Adjust the pump rate so that flow is continuous and does not pulsate to avoid aeration and agitation within the sample discharge lines. Run the pump for several minutes at the low flow rate used for sampling to ensure that the groundwater in the lines was obtained at the low flow rate. Higher pumping rates than 100 to 300 mL/minute may be used when collecting samples to be analyzed for non-volatile constituents, if significant drawdown does not occur.

*Bladder Pumps:* A gas-operated Teflon or stainless steel bladder pump with adjustable flow control and equipped with Teflon-lined tubing can be effectively utilized to collect a groundwater sample and is considered to be the best overall device for sampling inorganic and organic constituents. Operate positive gas displacement bladder pumps in a continuous manner so that they minimize discharge pulsation that can aerate samples in the return tube or upon discharge. If a bladder pump is utilized for the well purging process, the same bladder pump can also be utilized for sample collection after purging is complete.

Most models of bladder pumps can be operated with a battery powered compressor and control box. The compressor can be powered with either a rechargeable battery pack (provided with the compressor), by running directly off of a vehicle battery (via alligator clips), or by plugging into the vehicle’s direct current connector (cigarette lighter receptacle). When using a vehicle to power a compressor, several precautions should be taken. First, position the vehicle downwind of the well. Second, ensure the purge water exiting the well is collected into a drum or bucket. Finally, connect the compression hose from the well cap to the control box. Do not connect the compression hose from the compressor to the control box until after the engine has been started.

When all precautions are completed and the engine has been started, connect the compression hose to the control box. Slowly adjust the control knobs so as to discharge water at a flow rate (purge rate) that minimizes drawdown in the well, usually around 100 to 300 mL/minute. The compressor should not be set as to discharge the water as hard as possible. The optimal setting is one that produces the required purge rate per minute (not per purge cycle) while maintaining a minimal drawdown.

Prior to sampling volatiles constituents, turn off the vehicle engine, and obtain a flow rate of 100 mL/minute so as not to cause fluctuation in pH, pH-sensitive analytes, the loss of volatile constituents, or draw down of the groundwater table. If necessary (when sampling wells that require a large sample volume) the vehicle engine may be turned back on after sampling volatile constituents. Higher flow rates (100 to 300 mL/minute) can be used once the samples for the analysis of volatile components have been collected, but should not allow for increased draw down in the well. At no time shall the sample flow rate exceed the flow rate used while purging. Preserve the natural conditions of the groundwater, as defined by pH, DO, specific conductivity, and reduction/oxidation (redox).

For those samples requiring filtration, it is recommended to use in-line high capacity filters after all nonfiltered samples have been collected.

*Bailers:* A single- or double-check valve Teflon or stainless steel bailer equipped with a bottom discharging device can be utilized to collect groundwater samples. Bailers have a number of disadvantages, however, including a tendency to alter the chemistry of groundwater samples due to degassing, volatilization, and aeration; the possibility of creating high groundwater entrance velocities; differences in operator techniques resulting in variable samples; and difficulty in determining where in the water column the sample was collected. Therefore, use bailers for groundwater sampling only when other types of sampling devices cannot be utilized for technical or logistical reasons. The QA Manager or Technical Director must approve the use of bailers for groundwater sampling in advance.

Thoroughly decontaminate the bailer before being lowering it into the well if it is not a disposable bailer sealed in plastic. Collect two to three rinse samples and discharge them prior to acquisition of the actual sample. Each time the bailer is lowered to the water table, lower it in such a way as to minimize disturbance and aeration of the water column within the well.

The preferred alternative when using bailers for sampling is to use disposable Teflon bailers equipped with bottom-discharging devices. Use of disposable bailers reduces decontamination time and limits the potential for cross-contamination.

*Passive Sampling:* Passive samplers include passive diffusion bags, HydraSleeve, Snap Sampler, Gore Sorbers, and rigid porous polyethylene samplers. Passive samplers generate minimal waste and purge water, if any. Passive samplers depend on ambient equilibrium with formation water. These are relatively inexpensive, simple to deploy and work well for low-yield wells. However, passive samplers have volume and or analyte limitations and may require consideration of contaminant stratification. Passive samplers should be handled in accordance with the manufacturer’s instructions, Army guidance (USACE 2002), or ITRC guidance (ITRC 2007).

### 5.3.6 Sample Handling and Preservation

Many of the chemical constituents and physiochemical parameters to be measured or evaluated during groundwater monitoring programs are chemically unstable; therefore, preserve samples. The EPA document entitled, *Test Methods for Evaluating Solid Waste – Physical/Chemical Methods, SW-846* (EPA 2007), includes a discussion of appropriate sample preservation procedures. In addition, SW-846 specifies the sample containers to use for each constituent or common set of parameters. In general, check with specific laboratory requirements prior to obtaining field samples. In many cases, the laboratory will supply the necessary sample bottles and required preservatives. In some cases, the field team may add preservatives in the field. Sample containers should be labeled in accordance with Procedure III-E, *Record Keeping, Sample Labeling, and Chain of Custody*.

Improper sample handling may alter the analytical results of the sample. Therefore, transfer samples in the field from the sampling equipment directly into the container that has been prepared specifically for that analysis or set of compatible parameters as described in the CTO-specific work plan. It is not an acceptable practice for samples to be composited in a common container in the field and then split in the laboratory, or poured first into a wide mouth container and then transferred into smaller containers.

Collect groundwater samples and place them in their proper containers in the order of decreasing volatility and increasing stability. A preferred collection order for some common groundwater parameters is:

1. VOCs and total organic halogens (TOX)
2. Dissolved gases, total organic carbon (TOC), total fuel hydrocarbons
3. Semivolatile organics, pesticides
4. Total metals, general minerals (unfiltered)
5. Dissolved metals, general minerals (filtered)
6. Phenols
7. Cyanide
8. Sulfate and chloride
9. Turbidity
10. Nitrate and ammonia
11. Radionuclides

When sampling for VOCs, collect water samples in vials or containers specifically designed to prevent loss of VOCs from the sample. An analytical laboratory shall provide these vials, preferably by the laboratory that will perform the analysis. Collect groundwater from the sampling device in vials by allowing the groundwater to slowly flow along the sides of the vial. Sampling equipment shall not touch the interior of the vial. Fill the vial above the top of the vial to form a positive meniscus with no overflow. No headspace shall be present in the sample container once the container has been capped. This can be checked by inverting the bottle once the sample is collected and tapping the side of the vial to dislodge air bubbles. Sometimes it is not possible to collect a sample without air bubbles, particularly water that is aerated. In these cases, the investigator shall note the problem to account for possible error. Cooling samples may also produce headspace, but this will typically disappear once the sample is warmed prior to analysis. In addition, if the samples are shipped by air, air bubbles form most of the time. Field logs and laboratory analysis reports shall note any headspace in the sample container(s) at the time of receipt by the laboratory, as well as at the time the sample was first transferred to the sample container at the wellhead.

#### *5.3.6.1 SPECIAL HANDLING CONSIDERATIONS*

Samples requiring analysis for organics shall not be filtered. Samples shall not be transferred from one container to another because this could cause aeration or a loss of organic material onto the walls of the container. TOX and TOC samples shall be handled and analyzed in the same manner as VOC samples.

Obtain groundwater samples to be analyzed for metals sequentially. One sample shall be obtained directly from the pump and be unfiltered. The second sample shall be filtered through a 0.45-micron membrane in-line filter. Both filtered and unfiltered samples shall be transferred to a container, preserved with nitric acid to a pH less than 2, and analyzed for dissolved metals. Remember to include a filter blank for each lot of filters used and always record the lot number of the filters. In addition, allow at least 500 mL of effluent to flow through the filter prior to sampling. Any difference in concentration between the total and dissolved fractions may be attributed to the original metallic ion content of the particles and adsorption of ions onto the particles.

#### *5.3.6.2 FIELD SAMPLING PRESERVATION*

Preserve samples immediately upon collection. Ideally, sampling containers will be pre-preserved with a known concentration and volume of preservative. For example, metals require storage in aqueous media at pH of 2 or less. Typically, 0.5 mL of 1:1 nitric acid added to 500 mL of groundwater will produce a pH less than 2. Certain matrices that have alkaline pH (greater than 7) may require more preservative than is typically required. An early assessment of preservation techniques, such as the use of pH strips after initial preservation, may therefore be appropriate. The introduction of preservatives will dilute samples, and may require normalization of results. Guidance for the preservation of environmental samples can be found in the EPA *Handbook for Sampling and Sample Preservation of Water and Wastewater* (EPA 1982). Additional guidance can be found in other EPA documents (EPA 1992, 1996).

#### *5.3.6.3 FIELD SAMPLING LOG*

A groundwater sampling log (Figure I-C-3-1) shall document the following:

- Identification of well
- Well depth
- Static water level depth and measurement technique
- Presence of immiscible layers and detection method
- Well yield
- Purge volume and pumping rate
- Time that the well was purged
- Collection method for immiscible layers
- Sample identification numbers
- Well evacuation procedure/equipment
- Sample withdrawal procedure/equipment
- Date and time of collection
- Well sampling sequence
- Types of sample containers used and sample identification numbers
- Preservative(s) used
- Parameters requested for analysis

- Field analysis data
- Sample distribution and transporter
- Field observations on sampling event
- Name of collector
- Climatic conditions including air temperature

## 6. Records

Document information collected during groundwater sampling on the groundwater sampling log form in indelible ink (Figure I-C-3-1). Send copies of this information to the CTO Manager and to the project files.

## 7. Health and Safety

Field personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

## 8. References

ASTM International (ASTM). 2001. *Standard Guide for Sampling Ground-Water Monitoring Wells*. D4448). Reapproved in 2013). West Conshohocken, PA.

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Environmental Protection Agency, United States (EPA). 1982. *Handbook for Sampling and Sample Preservation of Water and Wastewater.* EPA-600/4-82-029. Cincinnati: EPA Office of Research and Development, Environmental Monitoring and Support Laboratory.

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———. 2006. *Systematic Planning: A Case Study for Hazardous Waste Site Investigations. EPA WA/CS-1.* EPA/240/B-06/004. Office of Environmental Information. March.

———. 2007. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* 3rd ed., Revision 6. Office of Solid Waste. November. On-line updates at: http://www.epa.gov/epawaste/hazard/testmethods/sw846/online/index.htm.

Interstate Technology and Regulatory Council (ITRC). 2007. *Protocol for Use of Five Passive Samplers to Sample for a Variety of Contaminants in Groundwater*. February.

United States Army Corps of Engineers (USACE). 2002. *Study of Five Discrete Interval-Type Groundwater Sampling Devices*. Cold Regions Research and Engineering Laboratory. Hanover, NH. August.

———. 2008. *Consolidated Safety and Health Requirements Manual*. EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-A-6, *Investigation-Derived Waste Management.*

Procedure I-F, *Equipment Decontamination.*

Procedure III-B, *Field QC Samples (Water, Soil).*

Procedure III-E, *Record Keeping, Sample Labeling, and Chain of Custody*.

## 9. Attachments

None.

# Drum Sampling

## 1. Purpose

This standard operating procedure describes the methods by which United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel will sample drum(s) at hazardous waste and non-hazardous waste sites. Prior to disturbing and handling drums of unknown origin and/or with unknown contents, approval from the Navy will be required.

## 2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program. As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations

## 3. Definitions

None.

## 4. Responsibilities

The prime contractor CTO Manager is responsible for ensuring that drums of concern are handled and sampled according to this procedure. The CTO Manager is responsible for ensuring that all personnel involved in drum sampling have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for ensuring that these procedures and the work plan (WP) are followed when drums are sampled.

Field sampling personnel are responsible for the implementation of this procedure.

## 5. Procedures

### 5.1 METHOD SUMMARY

Prior to sampling, drums should be inventoried, staged, and opened. Inventorying entails recording the visible qualities of each drum and any characteristics pertinent to classification of the contents. Staging involves the organization, and sometimes consolidation, of drums containing similar wastes or that share characteristics. Closed drums may be opened manually or remotely. In the interest of worker safety, it is required to open drums remotely unless the drum contents are known not to present any potential physical or chemical threat to workers. Analytical results from associated field samples may be used to evaluate potential threats. The most widely used method of sampling a drum containing liquids involves the use of a glass thief. This method is quick, simple, relatively inexpensive, and does not require decontamination. Additional information related to drum sampling is available in Section 8, References.

### 5.2 INTERFERENCE AND POTENTIAL PROBLEMS

The practice of tapping drums to determine their contents is neither safe nor effective and should not be used. Any necessary air monitoring should be conducted when working near over-pressurized drums.

Do not move drums that are over-pressurized to the extent that the head is swollen several inches above the level of the chime (the protruding rings at the top and bottom of the drum). A number of devices have been developed for venting critically swollen drums. One method that has proven to be effective is a tube and spear device. A light aluminum tube (3 meters long) is positioned at the vapor space of the drum. A rigid, hooking device attached to the tube goes over the chime and holds the tube securely in place. The spear is inserted in the tube and positioned against the drum wall. A sharp blow on the end of the spear drives the sharpened tip through the drum, and the gas vents along the grooves. The venting should be done remotely (e.g., using a backhoe bucket) from behind a wall or barricade. Once the pressure has been relieved, the bung can be removed and the drum sampled. It is necessary that personnel experienced in sampling of over-pressurized or unknown drum contents, or known hazardous waste contents, perform this task. If project team personnel are not experienced in this type of sampling, it is recommended that a subcontractor experienced in this type of sampling implement this portion of the sampling.

### 5.3 EQUIPMENT/APPARATUS

The following are standard materials and equipment required for sampling:

- An approved site-specific sampling plan and health and safety plan (HSP)
- Personal protection equipment
- Sample containers appropriate for the matrix being sampled
- Uniquely numbered sample identification labels
- One-gallon covered cans half-filled with absorbent packing material, to be used as necessary to hold waste
- Chain-of-custody sheets
- Decontamination equipment (Procedure I-F, *Equipment Decontamination*.)
- Glass thieving tubes, composite liquid waste sampler (COLIWASA), or equivalent
- Drum-opening devices
- Monitoring equipment for the detection of toxic and explosive environments, whenever the contents are not known

### 5.3.1 Drum-Opening Devices

#### 5.3.1.1 BUNG WRENCH

A common method for opening drums manually is using a universal bung wrench. The fittings on a bung wrench are made to remove nearly all commonly encountered bungs. They are usually constructed of cast iron, brass, or a bronze-beryllium, non-sparking alloy. The use of a non-sparking wrench does not eliminate the possibility of producing a spark.

#### 5.3.1.2 DRUM DEHEADER

One means by which a drum can be opened manually when a bung is not removable with a bung wrench is by using a drum deheader. This tool is constructed of forged steel with an alloy steel blade and is designed to partially or completely cut off the lid of a drum by means of scissors-like cutting action. A limitation of this device is that it can be attached only to closed head drums. Drums with removable heads or over-pressurized drums should be opened by other means.

#### 5.3.1.3 BACKHOE SPIKE

The most common means of opening drums remotely for sampling is the use of a metal spike attached or welded to a backhoe bucket. In addition to being very efficient, this method can greatly reduce the likelihood of personnel exposure.

#### 5.3.1.4 HYDRAULIC DRUM OPENER

Hydraulic drum openers use hydraulic pressure to pierce the drum. It consists of a manually operated pump that pressurizes oil through a length of hydraulic line attached to a metal point that pierces the side or head of the drum.

#### 5.3.1.5 PNEUMATIC DEVICES

A pneumatic bung remover consists of a compressed air supply that is controlled by a heavy-duty, two-stage regulator. A high-pressure air line of desired length delivers compressed air to a pneumatic drill, which is adapted to turn a bung fitting selected to fit the bung to be removed. An adjustable bracketing system positions and aligns the pneumatic drill over the bung. The bracketing system must be attached to the drum before the drill can be operated. Once the bung has been loosened, the bracketing system must be removed before the drum can be sampled. The pneumatic bung opener does not permit the slow venting of the container, and therefore, appropriate precautions must be taken. The pneumatic bung opener also requires the container to be upright and relatively level. This device cannot remove bungs that are rusted shut.

## 5.4 SAMPLING PROCEDURE

### 5.4.1 Drum Staging

Prior to sampling, stage the drums (if not already staged) for easy access. Ideally, the staging area should be located just far enough from the drum opening area to prevent a chain reaction if one drum with unknown contents or visibly over-pressurized should explode or catch fire when opened.

During staging, physically separate the drums into the following categories: those containing liquids; those containing solids; lab packs; gas cylinders; and those that are empty. The strategy for sampling and handling drum/containers in each of these categories will be different. Categories are determined by:

- Visual inspection of the drum and its labels, codes, etc. Solids and sludges are typically disposed of in open top drums. Closed head drums with a bung opening generally contain liquid.
- Visual inspection of the contents of the drum during sampling, followed by restaging, if needed.

For discovered drums that require excavation, eliminate immediate hazards by over packing or transferring the drum’s contents to another suitable container, affixing with a numbered tag, and transferring to a staging area. Use color-coded tags, labels, or bands to mark similar waste types. Record a description of each drum, its condition, any unusual markings, and the location where it was buried or stored on a drum data sheet (see Attachment I-D-1-1.) This data sheet becomes the principal record-keeping tool for tracking the drum on site.

Where space allows, physically separate the unknown or suspected hazardous waste-containing or over-pressurized drum opening area from the drum removal and drum staging operations. Move drums from the staging area to the drum opening area one at a time using forklift trucks equipped with drum grabbers or a barrel grappler. In a large-scale drum handling operation, drums may be conveyed to the drum opening area using a roller conveyor.

### 5.4.2 Drum Opening

There are three techniques for opening drums at suspected or known hazardous waste sites:

- Manual opening with non-sparking bung wrenches
- Drum deheading
- Remote drum puncturing and bung removal

The choice of drum opening technique and accessories depends on the number of drums to be opened, their waste contents, and their physical condition. Remote drum opening equipment should always be considered to protect worker safety. Under Occupational Safety and Health Administration 1910.120 (OSHA 1998), manual drum opening with bung wrenches or deheaders should be performed only on structurally sound drums whose waste contents are known not to be shock sensitive, reactive, explosive, or flammable.

#### *5.4.2.1 MANUAL DRUM OPENING*

**Bung Wrench**

Do not perform manual drum opening with bung wrenches unless the drums are structurally sound (no evidence of bulging or deformation) and their contents are known to be non-explosive. If opening the drum with bung wrenches is deemed reasonably cost-effective and safe, then certain procedures should be implemented to minimize the hazard:

- Field personnel should be fully outfitted with protective gear.
- Continually monitor atmospheres for toxicity, explosivity, and if applicable, radioactivity.

- Position drums upright with the bung up, or, for drums with bungs on the side, laid on their sides with the bung plugs up.
- The wrenching motion should be a slow, steady pull across the drum. If the length of the bung wrench handle provides inadequate leverage for unscrewing the plug, attach a “cheater bar” to the handle to improve leverage.

#### 5.4.2.2 DRUM DEHEADING

Do not perform drum deheading unless the drums are structurally sound (no evidence of bulging or deformation) and their contents are known to be non-explosive. Drums are opened with a drum deheader by first positioning the cutting edge just inside the top chime and then tightening the adjustment screw so that the deheader is held against the side of the drum. Moving the handle of the deheader up and down while sliding the deheader along the chime will enable the entire top to be rapidly cut off, if desired. If the top chime of a drum has been damaged or badly dented, it may not be possible to cut the entire top off. Because there is always the possibility that a drum may be under pressure, make the initial cut very slowly to allow for the gradual release of any built-up pressure. A safer technique would be to employ a remote method prior to using the deheader.

Self-propelled drum openers, which are either electrically or pneumatically driven, are available and can be used for quicker and more efficient deheading.

#### 5.4.2.3 REMOTE OPENING

Remotely operated drum opening tools are the safest available means of opening a drum. Remote drum opening is slow, but provides a high degree of safety compared to manual methods of opening.

**Backhoe Spike**

“Stage” or place drums in rows with adequate aisle space to allow ease in backhoe maneuvering. Once staged, punching a hole in the drumhead or lid with the spike can quickly open the drums.

Decontaminate the spike after each drum is opened to prevent cross contamination. Even though some splash or spray may occur when this method is used, mounting a large shatter-resistant shield in front of the operator’s cage can protect the operator of the backhoe. When combined with the normal personal protection gear, this practice should protect the operator. Providing the operator with an on-board air line system affords additional respiratory protection.

*Hydraulic Devices*

Hydraulic devices consist of a piercing device with a metal point that is attached to the end of a hydraulic line and is pushed into the drum by hydraulic pressure. The piercing device can be attached so that a hole for sampling can be made in either the side or the head of the drum. Some of the metal piercing devices are hollow or tube-like so that they can be left in place, if desired, to serve as a permanent tap or sampling port. The piercing device is designed to establish a tight seal after penetrating the container.

*Pneumatic Devices*

Pneumatically operated devices using compressed air have been designed to remove drum bungs remotely.

### 5.4.3 Drum Sampling

Immediately after the drum has been opened, sample the headspace gases within the drum using an explosimeter, organic vapor analyzer, and/or a photoionization detector, and record the data on the Drum Data Sheet (see Attachment I-D-1-1) as necessary. The CTO WP shall reference procedures listed in the site HSP.

In most cases, it is impossible to observe the contents of these sealed or partially sealed drums. Because some layering or stratification is likely in any solution left undisturbed over time, take a sample that represents the entire depth of the vessel. In addition, a sample of solid material collected from a drum should include the entire depth to be most representative of the drum contents.

When sampling a previously sealed drum, check for the presence of bottom sludge. This is easily accomplished by measuring the depth to apparent bottom, and then comparing it to the known interior depth.

#### *5.4.3.1 GLASS THIEF SAMPLER*

The most widely used implement for sampling liquids in a drum is a glass tube (glass thief, 6 millimeters inner diameter × 30.47 centimeters [cm] [48 inches] length). This tool is simple, cost effective, quick, and collects a sample without having to decontaminate.

**Specific Sampling Procedure Using a Glass Thief**

1. Remove the cover from the sample container.
2. Slowly insert the glass tubing almost to the bottom of the drum or until a solid layer is encountered. About 1 foot of tubing should extend above the drum.
3. Allow the waste in the drum to reach its natural level in the tube.
4. Cap the top of the sampling tube with a tapered stopper or thumb, ensuring liquid does not come into contact with the stopper.
5. Carefully remove the capped tube from the drum, and insert the uncapped end into the sample container. Do not spill liquid on the outside of the sample container.
6. Release the stopper, and allow the glass thief to drain completely into the sample container. Fill the container to about 2/3 of capacity.
7. Remove the tube from the sample container, carefully break it into pieces, and place the pieces in the drum.
8. Cap the sample container tightly, and place the pre-labeled sample container in a carrier.
9. Replace the bung or place plastic over the drum.
10. Transport the sample to the decontamination zone to be prepared for transport to the analytical laboratory.

In many instances, a drum containing waste material will have a sludge layer on the bottom. Slow insertion of the sampling tube down into this layer and then a gradual withdrawal will allow the sludge to act as a bottom plug to maintain the fluid in the tube. The plug can be gently removed and placed into the sample container by the use of a stainless steel lab spoon.

In some instances, disposal of the tube by breaking it into the drum might interfere with eventual plans for the removal of its contents. Clear this technique with NAVFAC Pacific personnel or evaluate other disposal techniques.

#### 5.4.3.2 COLIWASA SAMPLER

The COLIWASA is a much-cited sampler designed to permit representative sampling of multiphase wastes from drums and other containerized wastes. It collects a sample from the full depth of a drum and maintains it in the transfer tube until delivery to the sample bottle. One configuration consists of a 152 cm by 4 cm-inner diameter section of tubing with a neoprene stopper at one end attached by a rod running the length of the tube to a locking mechanism at the other end. Manipulation of the locking mechanism opens and closes the sampler by raising and lowering the neoprene stopper.

The major drawbacks associated with using a COLIWASA include decontamination and cost. The sampler is difficult (if not impossible) to decontaminate in the field, and its high cost relative to alternative procedures (glass tubes) make it an impractical throwaway item. However, disposable, high-density, inert polyethylene COLIWASAs are available at a nominal cost. Although the applications of a disposable COLIWASA are limited, it is especially effective in instances where a true representation of a multiphase waste is absolutely necessary.

**Procedures for Use**

1. Open the sampler by placing the stopper rod handle in the T-position and pushing the rod down until the handle sits against the sampler’s locking block.
2. Slowly lower the sampler into the liquid waste. Lower the sampler at a rate that permits the levels of the liquid inside and outside the sampler tube to be about the same. If the level of the liquid in the sample tube is lower than that outside the sampler, the sampling rate is too fast and will result in a non-representative sample.
3. When the sampler stopper hits the bottom of the waste container, push the sampler tube downward against the stopper to close the sampler. Lock the sampler in the closed position by turning the T-handle until it is upright and one end rests tightly on the locking block.
4. Slowly withdraw the sampler from the waste container with one hand while wiping the sampler tube with a disposable cloth or rag with the other hand.
5. Carefully discharge the sample into a suitable sample container by slowly pulling the lower end of the T-handle away from the locking block while the lower end of the sampler is positioned in a sample container.
6. Cap the sample container with a Teflon-lined cap, attach a label and seal, and record it on the sample data sheet.
7. Unscrew the T-handle of the sampler, and disengage the locking block.
8. Clean the sampler.

## 5.5 DRUM CLOSING

Upon completion of sampling activities, close the drums, and then store them in a secure area as described in Procedure I-A-6, *Investigation-Derived Waste Management*. If the bung opening and the bung are still intact, then close the drum by replacing the bung. In addition, open top drums that are still in good condition can be closed by replacing the top and securing the drum ring with the attached bolt.

If a drum cannot be closed in the manner discussed above, then secure it by placing it in an approved 85-gallon overpack drum (type UN 1A2/Y43/S). Fill the void spaces between the outer portion of the inner drum and the inside of the overpack drum with vermiculite to secure the drum contents to the extent possible.

### 5.6 EQUIPMENT DECONTAMINATION

Decontamination of sampling equipment should follow Procedure I-F, *Equipment Decontamination*.

### 5.7 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

1. Do not add preservatives to the sample unless specifically required by the analytical method or WP.
2. Place the labeled sample container in two re-sealable plastic bags.
3. If the contents of the investigation-derived waste drum are unknown, or known to contain hazardous waste, place each bagged sample container in a 1-gallon covered can containing absorbent packing material. Place the lid on the can.
4. Mark the sample identification number on the outside of the can.
5. Place the samples in a cooler, and fill the remaining space with absorbent packing material.
6. Fill out the chain-of-custody record for each cooler, place it in a re-sealable plastic bag, and affix it to the inside lid of the cooler.
7. Secure the lid of the cooler, and affix the custody seal.
9. Arrange for the appropriate transport mode consistent with the type of waste involved (hazardous or non-hazardous).

## 6. Records

Keep records of all sampling activities in the field notebook and on the Drum Data Sheets. Document sample custody on the chain-of-custody form. The CTO Manager shall review these documents at the completion of field activities, and, at least on a monthly basis for long-term projects.

## 7. Health and Safety

Field Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

## 8. References

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Occupational Safety and Health Administration (OSHA). 1998. *Occupational Safety and Health Standards* (29 CFR 1910); with special attention to Section 1910.120, *Hazardous Waste Operations and Emergency Response (HAZWOPER)*. Washington, DC: United States Department of Labor.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual*. EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-A-6, *Investigation-Derived Waste Management.*

Procedure I-F, *Equipment Decontamination.*

## 9. Attachments

Attachment I-D-1-1: Drum Data Sheet

# Attachment I-D-1-1
# Drum Data Sheet

## DRUM DATA SHEET

CTO/DO #: ______________________ Date Sampled: ______________________

Drum I.D.#: ______________________ Time: ______________________

Estimated Liquid Quantity: ______________________

Original Drum Location: ______________________

Staging Location: ______________________

Sampler's Name: ______________________

Drum Condition: ______________________

Physical Appearance of the Drum/Bulk Contents: ______________________

Headspace Gas Concentration: ______________________

Odor: ______________________ Color: ______________________

pH: ______________________ % Liquid: ______________________

---

Laboratory Date of Analysis: ______________________

Analytical Data: ______________________

______________________

______________________

______________________

______________________

Compatibility: ______________________

Hazard: ______________________

Waste I.D.: ______________________

Treatment Disposal Recommendations: ______________________

______________________

______________________

______________________

______________________

# Equipment Decontamination

## 1. Purpose

This standard operating procedure describes methods of equipment decontamination for use during site activities by United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

## 2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the Uniform Federal Policy-Quality Assurance Project Plan (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

## 3. Definitions

None.

## 4. Responsibilities

The prime contractor CTO Manager is responsible for identifying instances of non-compliance with this procedure and ensuring that decontamination activities comply with this procedure. The CTO Manager is responsible for ensuring that all personnel involved in equipment decontamination have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager is responsible for field oversight to ensure that all project field staff follow these procedures.

Field personnel are responsible for the implementation of this procedure.

## 5. Procedures

Decontamination of equipment used in sampling of various media, groundwater monitoring, and well drilling and development is necessary to prevent cross-contamination and to maintain the highest integrity possible in collected samples. Planning a decontamination program requires consideration of the following factors:

- The location where the decontamination procedures will be conducted
- The types of equipment requiring decontamination
- The frequency of equipment decontamination
- The cleaning technique and types of cleaning solutions appropriate for the contaminants of concern
- The method for containing the residual contaminants and wash water from the decontamination process
- The use of a quality control measure to determine the effectiveness of the decontamination procedure

The following subsection describes standards for decontamination, including the frequency of decontamination, cleaning solutions and techniques, containment of residual contaminants and cleaning solutions, and effectiveness.

## 5.1 DECONTAMINATION AREA

Select an appropriate location for the decontamination area at a site based on the ability to control access to the area, the ability to control residual material removed from equipment, the need to store clean equipment, and the ability to restrict access to the area being investigated. Locate the decontamination area an adequate distance away and upwind from potential contaminant sources to avoid contamination of clean equipment.

It is the responsibility of the site safety and health officer (SSHO) to set up the site zones (i.e., exclusion, transition, and clean) and decontamination areas. Generally, the decontamination area is located within the transition zone, upwind of intrusive activities, and serves as the washing area for both personnel and equipment to minimize the spread of contamination into the clean zone. For equipment, a series of buckets are set up on a visqueen-lined bermed area. Separate spray bottles containing laboratory-grade isopropyl alcohol (or alternative cleaning solvent as described in the CTO work plan [WP]) and distilled water are used for final rinsing of equipment. Depending on the nature of the hazards and the site location, decontamination of heavy equipment, such as augers, pump drop pipe, and vehicles, may be accomplished using a variety of techniques.

## 5.2 TYPES OF EQUIPMENT

Drilling equipment that must be decontaminated includes drill bits, auger sections, drill-string tools, drill rods, split barrel samplers, tremie pipes, clamps, hand tools, and steel cable. Decontamination of monitoring well development and groundwater sampling equipment includes submersible pumps, bailers, interface probes, water level meters, bladder pumps, airlift pumps, peristaltic pumps, and lysimeters. Other sampling equipment that requires decontamination includes, but is not limited to, hand trowels, hand augers, slide hammer samplers, shovels, stainless-steel spoons and bowls, soil sample liners and caps, wipe sampling templates, composite liquid waste samplers, and dippers. However, equipment that is shipped pre-packaged from the vendor should not have to be decontaminated prior to first use. Equipment with a porous surface, such as rope, cloth hoses, and wooden blocks, cannot be thoroughly decontaminated and shall be properly disposed of after one use.

## 5.3 FREQUENCY OF EQUIPMENT DECONTAMINATION

Decontaminate down-hole drilling equipment and equipment used in monitoring well development and purging prior to initial use and between each borehole or well. Down-hole drilling equipment, however, may require more frequent cleaning to prevent cross-contamination between vertical zones within a single borehole. When drilling through a shallow contaminated zone and installing a surface casing to seal off the contaminated zone, decontaminate the drilling tools prior to drilling deeper. Initiate groundwater sampling by sampling groundwater from the monitoring well where the least contamination is suspected. Decontaminate groundwater, surface water, and soil sampling devices prior to initial use and between collection of each sample to prevent the possible introduction of contaminants into successive samples.

## 5.4 CLEANING SOLUTIONS AND TECHNIQUES

Decontamination can be accomplished using a variety of techniques and fluids. The preferred method of decontaminating major equipment, such as drill bits, augers, drill string, and pump drop-pipe, is steam cleaning. To steam clean, use a portable, high-pressure steam cleaner equipped with a pressure hose and fittings. For this method, thoroughly steam wash equipment, and rinse it with potable tap water to remove particulates and contaminants.

Where appropriate, disposable materials are recommended. A rinse decontamination procedure is acceptable for equipment, such as bailers, water level meters, new and re-used soil sample liners, and hand tools. The decontamination procedure shall consist of the following: (1) wash with a non-phosphate detergent (alconox, liquinox, or other suitable detergent) and potable water solution; (2) rinse in a bath with potable water; (3) spray with laboratory-grade isopropyl alcohol; (4) rinse in a bath with deionized or distilled water; and (5) spray with deionized or distilled water. If possible, disassemble equipment prior to cleaning. Add a second wash at the beginning of the process if equipment is very soiled.

Decontaminating submersible pumps requires additional effort because internal surfaces become contaminated during usage. Decontaminate these pumps by washing and rinsing the outside surfaces using the procedure described for small equipment or by steam cleaning. Decontaminate the internal surfaces by recirculating fluids through the pump while it is operating. This recirculation may be done using a relatively long (typically 4 feet) large-diameter pipe (4-inch or greater) equipped with a bottom cap. Fill the pipe with the decontamination fluids, place the pump within the capped pipe, and operate the pump while recirculating the fluids back into the pipe. The decontamination sequence shall include: (1) detergent and potable water; (2) potable water rinse; (3) potable water rinse; and (4) deionized water rinse. Change the decontamination fluids after each decontamination cycle.

Solvents other than isopropyl alcohol may be used, depending upon the contaminants involved. For example, if polychlorinated biphenyls or chlorinated pesticides are contaminants of concern, hexane may be used as the decontamination solvent. However, if samples are also to be analyzed for volatile organics, hexane shall not be used. In addition, some decontamination solvents have health effects that must be considered. Decontamination water shall consist of distilled or deionized water. Steam-distilled water shall not be used in the decontamination process as this type of water usually contains elevated concentrations of metals. Decontamination solvents to be used during field activities will be specified in CTO WP and site-specific health and safety plan.

Rinse equipment used for measuring field parameters, such as pH, temperature, specific conductivity, and turbidity with deionized or distilled water after each measurement. Also wash new, unused soil sample liners and caps with a fresh detergent solution and rinse them with potable water followed by distilled or deionized water to remove any dirt or cutting oils that might be on them prior to use.

### 5.5 CONTAINMENT OF RESIDUAL CONTAMINANTS AND CLEANING SOLUTIONS

A decontamination program for equipment exposed to potentially hazardous materials requires a provision for catchment and disposal of the contaminated material, cleaning solution, and wash water.

When contaminated material and cleaning fluids must be contained from heavy equipment, such as drilling rigs and support vehicles, the area must be properly floored, preferably with a concrete pad that slopes toward a sump pit. If a concrete pad is impractical, planking can be used to construct solid flooring that is then covered by a nonporous surface and sloped toward a collection sump. If the decontamination area lacks a collection sump, use plastic sheeting and blocks or other objects to create a bermed area for collection of equipment decontamination water. Situate items, such as auger flights, which can be placed on metal stands or other similar equipment, on this equipment during decontamination to prevent contact with fluids generated by previous equipment decontamination. Store clean equipment in a separate location to prevent recontamination. Collect decontamination fluids contained within the bermed area and store them in secured containers as described below.

Use wash buckets or tubs to catch fluids from the decontamination of lighter-weight drilling equipment and hand-held sampling devices. Collect the decontamination fluids and store them on site in secured containers, such as U.S. Department of Transportation-approved drums, until their disposition is determined by laboratory analytical results. Label containers in accordance with Procedure I-A-6, *Investigation-Derived Waste Management*.

### 5.6 EFFECTIVENESS OF DECONTAMINATION PROCEDURES

A decontamination program must incorporate quality control measures to determine the effectiveness of cleaning methods. Quality control measures typically include collection of equipment blank samples or wipe testing. Equipment blanks consist of analyte-free water that has been poured over or through the sample collection equipment after its final decontamination rinse. Wipe testing is performed by wiping a cloth over the surface of the equipment after cleaning. Procedure III-B, *Field QC Samples (Water, Soil)* provides further descriptions of these samples and their required frequency of collection. These quality control measures provide "after-the fact" information that may be useful in determining whether or not cleaning methods were effective in removing the contaminants of concern.

## 6. Records

Describe the decontamination process in the field logbook.

## 7. Health and Safety

Field Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

## 8. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual*. EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-A-6, *Investigation-Derived Waste Management.*

Procedure III-B, *Field QC Samples (Water, Soil).*

## 9. Attachments

None.

# Land Surveying

## 1. Purpose

This standard operating procedure sets forth protocols for acquiring land surveying data to facilitate the location and mapping of geologic, hydrologic, geotechnical data, and analytical sampling points and to establish topographic control over project sites for use by United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

## 2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the *Uniform Federal Policy-Quality Assurance Project Plan* (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

## 3. Definitions

### 3.1 BOUNDARY SURVEY

Boundary surveys are conducted by Certified Land Surveyors in order to delineate a legal property line for a site or section of a site.

### 3.2 GLOBAL POSITIONING SYSTEM (GPS)

A GPS is a system of satellites, computers, and receivers that is able to determine the latitude and longitude of a receiver on Earth by calculating the time difference for signals from different satellites to reach the receiver.

### 3.3 WAYPOINT

A waypoint is a reference point or set of coordinates that precisely identify a location.

## 4. Responsibilities

The prime contractor CTO Manager is responsible for determining the appropriate land surveying protocols for the project and ensuring this procedure is properly implemented. The CTO Manager is responsible for ensuring that all personnel involved in land surveying shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Field Manager (FM) is responsible for ensuring that the appropriate protocols are conducted according to this procedure and the project-specific sampling plan. In virtually all cases, subcontractors will conduct these procedures. The FM is responsible for overseeing the activities of the subcontractor and ensuring that sampling points and topographic features are properly surveyed.

Field personnel are responsible for the implementation of this procedure.

# 5. Procedures

## 5.1 THEODOLITE/ELECTRONIC DISTANCE MEASUREMENT (EDM)

Follow the procedures listed below during theodolite/EDM land surveying conducted under the NAVFAC Pacific ER Program:

- A land surveyor registered in the state or territory in which the work is being performed shall directly supervise all surveying work.
- An authorized manufacturer’s representative shall inspect and calibrate survey instruments in accordance with the manufacturer's specifications regarding procedures and frequencies. At a minimum, instruments shall be calibrated no more than 6 months prior to the start of the survey work.
- Standards for all survey work shall be in accordance with National Oceanic and Atmospheric Administration standards and, at a minimum, with accuracy standards set forth below. The horizontal accuracy for the location of all grid intersection and planimetric features shall be (±) 0.1 feet. The horizontal accuracy for boundary surveys shall be 1 in 10,000 feet (1:10,000). The vertical accuracy for ground surface elevations shall be (±) 0.1 feet. Benchmark elevation accuracy and elevation of other permanent features, including monitoring wellheads, shall be (±) 0.01 feet.
- Reference surveys to the local established coordinate systems, and base all elevations and benchmarks established on U.S. Geological Survey datum, 1929 general adjustment.
- Reference surveyed points to mean sea level (lower low water level).
- Jointly determine appropriate horizontal and vertical control points prior to the start of survey activities. If discrepancies in the survey (e.g., anomalous water level elevations) are observed, the surveyor may be required to verify the survey by comparison to a known survey mark. If necessary, a verification survey may be conducted by a qualified third party.
- All field notes, sketches, and drawings shall clearly identify the horizontal and vertical control points by number designation, description, coordinates, and elevations. Map all surveyed locations using a base map or other site mapping, as specified by the CTO Manager.
- Begin and end all surveys at the designated horizontal and vertical control points to determine the degree of accuracy of the surveys.

- Iron pins used to mark control points shall be made of reinforcement steel or an equivalent material and shall be 18 inches long with a minimum diameter of 5/8 inch. Drive pins to a depth of 18 inches into the soil.
- Stakes used to mark survey lines and points shall be made from 3-foot lengths of 2-inch by 2-inch lumber and pointed at one end. Clearly mark them with brightly colored weatherproof flagging and biodegradable paint.
- Clearly mark the point on a monitoring well casing that is surveyed by filing grooves into the casing on either side of the surveyed point.

## 5.2 GLOBAL POSITIONING SYSTEM (GPS) TO CONDUCT LAND SURVEY

Follow the procedures listed below during GPS land surveying conducted under the NAVFAC Pacific ER Program:

- A land surveyor registered in the state or territory in which the work is being performed shall directly supervise all surveying work.
- An authorized manufacturer's representative shall inspect and calibrate survey instruments in accordance with the manufacturer's specifications regarding procedures and frequencies. At a minimum, instruments shall be calibrated no more than 6 months prior to the start of the survey work.
- Standards for all survey work shall be in accordance with National Oceanic and Atmospheric Administration standards and, at a minimum, with accuracy standards set forth below. The horizontal accuracy for the location of all grid intersection and planimetric features shall be (±) 0.1 feet. The horizontal accuracy for boundary surveys shall be 1 in 10,000 feet (1:10,000). The vertical accuracy for ground surface elevations shall be (±) 0.1 feet. Benchmark elevation accuracy and elevation of other permanent features, including monitoring wellheads, shall be (±) 0.01 feet. Accuracy requirements shall be specified in the project work plan (WP).
- Reference surveys to the local established coordinate systems, and base all elevations and benchmarks established on U.S. Geological Survey datum, 1929 general adjustment.
- All field notes, sketches, and drawings shall clearly identify the horizontal and vertical control points by number designation, description, coordinates, and elevations. Map all surveyed locations using a base map or other site mapping, as specified in the project WP.
- Begin and end all surveys at the designated horizontal and vertical control points (as applicable) to determine the degree of accuracy of the surveys.
- Iron pins used to mark control points shall be made of reinforcement steel or an equivalent material and shall be 18 inches long with a minimum diameter of 5/8 inch. Drive pins to a depth of 18 inches into the soil.
- Stakes used to mark survey lines and points shall be made from 3-foot lengths of 2-inch by 2-inch lumber and pointed at one end. Clearly mark them with brightly colored weatherproof flagging and biodegradable paint.
- Clearly mark the point on a monitoring well casing that is surveyed by filing grooves into the casing on either side of the surveyed point.

## 5.3 GLOBAL POSITIONING SYSTEM (GPS) TO POSITION SAMPLE LOCATIONS OR LOCATE SITE FEATURES

Experienced field personnel may use a GPS system unit to position sample locations (e.g. grid positioned samples) at a site. The decision to use field personnel or a licensed land surveyor will depend on the objectives of the survey (e.g. vertical elevation is not required) and the levels of precision required. Typically when a level of precision greater than (±) 3 to 5 meters is required, a licensed surveyor will be required. When a level of precision of (±) 3 to 5 meters is sufficient to meet project requirements (i.e., when laying sampling grids, identifying significant site features, or locating features identified in geographic information system [GIS] figures) experienced field personnel may use commercially available, consumer-grade GPS units. Follow the procedures listed below to locate samples or site features using GPS:

- A commercially available GPS unit with wide angle averaging system (WAAS), topographic map display, and waypoint storage capabilities should be used.
- If waypoints are to be imported into a GIS database, the same grid projection system should be used. For Guam this is typically WGS84, Zone 55N. For Hawaii this will either be NAD83 Zone 3 and 4 or WGS84 Zone 5N.
- If a permanent reference point near the site is available, it is recommended that the reference point is surveyed each day the GPS unit is used.
- When laying out a sampling grid from a GIS map, upload the coordinates from GIS to the GPS unit, including coordinates for an easily identified, permanent, nearby feature (i.e., building corner, roadway intersection, or USGS benchmark).
- If during the initial site walk, the permanent feature identified does not overlay within (±) 5 meters as identified in the GPS unit, field corrections of the waypoints should be made.
- Field corrections can be made by adding/subtracting the difference in x,y coordinates between the field measurement of the permanent site feature and the anticipated x,y coordinates. This correction should then be applied to the x,y coordinates for each sampling location to be marked. Corrected x,y coordinates can then be uploaded into the GPS unit.
- Sampling points and site features can then be located in the field using the GPS units “Go To” function. When the distance to the sampling point or feature remains close to zero, the location can be marked.
- If no field corrections to the sampling location need to be made, or if sampling locations are to be surveyed by a licensed surveyor at a later date, no additional waypoints need to be taken. If significant changes to the sampling location are made, GPS coordinates at the corrected location shall be stored and labeled.
- It is recommended that GPS coordinates be uploaded to a storage device such as a personal computer at the end of each day.
- Field logs shall indicate manufacturer and model number for GPS unit used, map datum and projection used, and any field corrections made. If the GPS unit cannot lock onto a WAAS system at the site, this should also be noted.

## 6. Records

The surveyor shall record field notes daily using generally accepted practices. The data shall be neat, legible, and easily reproducible. Copies of the surveyor's field notes and calculation forms generated during the work shall be obtained and placed in the project files.

Surveyor's field notes shall, at a minimum, clearly indicate:

- The date of the survey
- General weather conditions
- The name of the surveying firm
- The names and job titles of personnel performing the survey work
- Equipment used, including serial numbers
- Field book designations, including page numbers

A land surveyor registered in the state or territory in which the work was done shall sign, seal, and certify the drawings and calculations submitted by the surveyor.

Dated records of land surveying equipment calibration shall be provided by the surveyor and placed in the project files. Equipment serial numbers shall be provided in the calibration records.

## 7. Health and Safety

Field personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

## 8. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual*. EM-385-1-1. Includes Changes 1–7. 13 July 2012.

## 9. Attachments

None.

# Data Validation

## 1. Purpose

This procedure describes the presentation format and information provided in the data validation reports under the United States (U.S.) Navy Environmental Restoration (ER) Program for Naval Facilities Engineering Command (NAVFAC), Pacific. The objective of data validation is to provide data of known quality to the end user. This procedure also establishes the method by which a Contract Task Order (CTO) Manager selects and confirms the content of data validation reports and is consistent with protocol in the *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories* (DoD QSM) (DoD 2013).

## 2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012) and 2B (2005b) as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA manager) shall also concur with any deviations.

## 3. Definitions

Acronyms and abbreviations used in all data validation procedures and reports are defined in Attachment II-A-1. Commonly used terms are defined in Attachment II-A-2.

## 4. Responsibilities

The CTO Manager, the QA Manager or Technical Director, and the CTO QA Coordinator are responsible for ensuring that this procedure is implemented by data validation personnel.

Data validation personnel are responsible for implementing this procedure for all data validation reports.

## 5. Procedure

### 5.1 INTRODUCTION

This procedure addresses the validation of data obtained under the NAVFAC Pacific ER Program using primarily U.S. Environmental Protection Agency (EPA) Solid Waste (SW)-846 methods (EPA 2007). Based on the data validation requirements identified in the CTO project planning documents, the analytical data may undergo “Level B,” “Level C,” or “Level D” data validation or some combination of these validation levels. This procedure establishes the required format and content of the various validation reports.

### 5.1.1 Confirmation of Data Validation Reports

Prior to shipment of all completed data validation reports to the CTO Manager, a single draft report for one sample delivery group (SDG) should be submitted. The CTO Manager shall review the draft report to confirm that the report contains the requested information, and respond to the Data Validation Project Manager in a timely manner. Once the requested contents are confirmed, the complete data validation packages should be delivered to the CTO Manager.

## 5.2 CONTENT AND FORMAT OF THE DATA VALIDATION REPORT

The data validation report will consist of the following four major components:

1. Cover letter
2. Data validation reference package comprising:
    a. Cover page
    b. Acronyms and abbreviations list
    c. Data qualifier reference table
    d. Qualification code reference table
3. Individual data validation reports by SDG:
    e. Cover page
    f. Introduction
    g. Data validation findings
    h. Appendix of laboratory reports with applied data qualifiers

A discussion of the contents and format of these components is provided in the following sections.

### 5.2.1 Cover Letter

The cover letter will contain the generation date of the cover letter, the address of the CTO office, the CTO number, and the CTO Manager’s name or designee. The cover letter will list the specific reports being sent under that cover letter. A senior data reviewer must review the report and sign the cover letter to denote approval. Attachment II-A-3 is an example of the cover letter.

### 5.2.2 Data Validation Reference Package

One data validation reference package shall be provided per CTO and shall contain the reference information needed for interpretation of the individual data validation reports. The following sections shall be included:

#### *5.2.2.1 COVER PAGE*

The cover page shall indicate the CTO title and number to which the reference package applies.

#### *5.2.2.2 ACRONYMS AND ABBREVIATIONS LIST*

This list shall present all acronyms and abbreviations used in the individual data validation reports. Attachment II-A-1 is an example of the acronyms and abbreviations list.

#### *5.2.2.3 DATA QUALIFIER REFERENCE TABLE*

Data qualifiers are applied in cases where the data do not meet the required quality control (QC) criteria or where special consideration by the data user is required.

The data qualifier reference table lists the data qualifiers used in the validation of the analytical data. Attachment II-A-4 is an example of this table.

#### *5.2.2.4 QUALIFICATION CODE REFERENCE TABLE*

Qualification codes explain why data qualifiers have been applied and identify possible limitations of data use. Attachment II-A-5 provides the qualification codes used by the NAVFAC Pacific ER Program. Qualification codes are to be provided by data validation personnel on the annotated laboratory reports discussed in Section 5.2.3.4.

### 5.2.3 Individual Data Validation Reports by SDG

For all analyses, each SDG shall have a unique data validation report. The procedures used to generate the reports are discussed in the following sub-sections.

#### *5.2.3.1 COVER PAGE*

The cover page shall indicate the CTO title and number, analysis type, and the SDG(s), which the report addresses.

#### *5.2.3.2 INTRODUCTION*

This section will contain a brief description of the CTO information that is pertinent to data validation. This information includes the CTO title and number, CTO Manager, the sample matrices and analyses performed on the samples, the data validation level for the project, and a brief discussion of the methodologies used for data validation. This section will also contain a Sample Identification Table which lists the identification of each sample identification number cross referenced with its associated internal laboratory identification number and COC sample number. Each sample will be listed under every analytical method for which data was validated. Attachment II-A-6 is an example of the sample identification table.

#### *5.2.3.3 DATA VALIDATION FINDINGS*

This section shall present the data validation findings of the data reviewer for the CTO data package. The findings shall be determined on the basis of validation criteria established for each analytical method[1] in the DoD QSM (DoD 2013) or the CTO planning document and Procedure II-B through Procedure II-X. For all data validation levels, the data validation findings are divided into the following analytical categories:

- II-B GC/MS Volatile Organics by SW-846 Method 8260

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[1] Other methods may be included with approval of the CTO and Data Validation Managers.

- II-C GC/MS Semivolatile Organics by SW-846 8270 (full scan and SIM)
- II-D HRGC/HRMS Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs) by SW-846 8290
- II-E Organochlorine Pesticides by SW-846 8081
- II-F Polychlorinated Biphenyls as Aroclors by SW-846 8082
- II-G Polychlorinated Biphenyls as Congeners by SW-846 8082
- II-H Total Petroleum Hydrocarbons by SW-846 8015
- II-I Chlorinated Herbicides by SW-846 8151
- II-J Organophosphorus Pesticides by SW-846 8141
- II-K Halogenated and Aromatic Volatiles by SW-846 8021
- II-L Phenols by SW-846 8041
- II-M Ethylene Dibromide/Dibromochloropropane by SW-846 8011
- II-N Polynuclear Aromatic Hydrocarbons by SW-846 8310
- II-O Explosives by SW-846 8330
- II-P Carbamate and Urea Pesticides by EPA Method 632
- II-Q Metals by EPA Method SW-846 6000/7000
- II-R Wet Chemistry Analyses
- II-S Data Quality Assessment Report
- II-T HRGC/HRMS Polychlorinated Biphenyls as Congeners by EPA Method 1668
- II-U Carbamate and Urea Pesticides by SW-846 8321
- II-V Perchlorate by SW-846 6850
- II-W GC/FID/ECD Volatile Organics and Fixed Gases in Soil Gas/Vapor by EPA Method TO-3 and ASTM D1946
- II-X GC/MS Volatile Organics and Fixed Gases in Soil Gas/Vapor by EPA Method TO-14, TO-15, and TO-17

| | |
|---|---|
| GC/MS | gas chromatography/mass spectrometry |
| ECD | electron capture detector |
| FID | flame ionization detector |
| HRGC/HRMS | high resolution gas chromatograph/high resolution mass spectrometer |
| SIM | selective ion monitoring |

## Level C and Level D Data Validation

Data obtained using any analytical methods in the above categories will be validated in terms of meeting criteria for specific QA/QC factors such as holding times, instrument calibration, and blank analyses. A separate discussion of each QA/QC factor under each analytical method will be presented in the CTO data validation report. The QA/QC factors used to validate data for Level C and Level D validation are presented below for each analytical category.

*Volatile Organics by Gas Chromatography/Mass Spectrometry (GC/MS)*

1. Sample management (sample preservation, handling, and transport, chain-of-custody, and holding times)
2. GC/MS instrument performance check
3. Calibration (initial calibration, initial calibration verification, and continuing calibration)
4. Method blanks
5. Blank spikes and laboratory control samples (LCSs)
6. Surrogate recovery
7. Matrix spike/matrix spike duplicate (MS/MSD)
8. Field QC samples (trip blanks, equipment blanks, field blanks, field duplicates, and field triplicates)
9. Internal standards performance
10. Target compound identification (Level D only*)
11. Compound quantitation and reporting limits (RLs) (Level D only*)
12. Tentatively identified compounds (Level D only*)
13. System performance (Level D only*)

*Semivolatile Organics by Full Scan and SIM GC/MS*

1. Sample management (sample preservation, handling, and transport; chain-of-custody; holding times)
2. GC/MS instrument performance check (full scan)
3. Calibration (initial calibration, initial calibration verification, and continuing calibration)
4. Method blanks
5. Blank spikes and LCSs
6. Surrogate recovery
7. MS/MSD
8. Field QC samples (equipment blanks, field blanks, and field duplicates)
9. Internal standards performance
10. Target Compound identification (Level D only*)
11. Compound quantitation and RLs (Level D only*)
12. Tentatively identified compounds (Level D only*)

13. System performance (Level D only*)

*Dioxins/Dibenzofurans by HRGC/HRMS*

1. Sample management (sample preservation, handling, and transport; chain-of-custody; holding times)
2. HRGC/HRMS instrument performance check
3. Calibration (initial calibration, initial calibration verification, and continuing calibration)
4. Method blanks
5. Blank spikes and LCSs
6. MS/MSD
7. Field QC samples (equipment blanks, field blanks, field duplicates, and field triplicates)
8. Internal standards performance
9. Target compound identification (Level D only*)
10. Compound quantitation and RLs (Level D only*)
11. System performance (Level D only*)

*Organochlorine Pesticides by GC*

1. Sample management (sample preservation, handling, and transport; chain-of-custody; holding times)
2. Pesticides instrument performance (retention time evaluation, 4,4'-DDT/Endrin breakdown evaluation)
3. Calibration (analytical sequence, initial calibration, initial calibration verification, continuing calibration)
4. Method blanks
5. Blank spikes and LCSs
6. Surrogate recovery
7. MS/MSD
8. Sample cleanup performance
9. Field QC samples (equipment blanks, field blanks, field duplicates, and field triplicates)
10. Target compound identification (Level D only*)
11. Compound quantitation and RLs (Level D only*)

*Organic Analyses by GC (QA/QC factors may vary depending on analysis type)*

1. Sample management (sample preservation, handling, and transport; chain-of-custody; holding times)

2. Instrument performance
3. Calibration (initial calibration, initial calibration verification and continuing calibration)
4. Method blanks
5. Blank spikes and LCS
6. Surrogate recovery
7. MS/MSD
8. Field QC samples (trip blanks [volatile organic compounds], equipment blanks, field blanks, field duplicates, and field triplicates)
9. Target compound identification (Level D only*)
10. Compound quantitation and RLs (Level D only*)

*Organic Analyses by High-Performance Liquid Chromatography (QA/QC factors may vary depending on analysis type)*

1. Sample management (sample preservation, handling, and transport; chain-of-custody; holding times)
2. Instrument performance
3. Calibration (initial calibration, initial calibration verification and continuing calibration)
4. Method blanks
5. Blank spikes and LCSs
6. Surrogate recovery
7. MS/MSD
8. Field QC samples (equipment blanks, field blanks, field duplicates, and field triplicates)
9. Target compound identification (Level D only*)
10. Compound quantitation and reporting limits (RLs) (Level D only*)

*Organic Analyses by Liquid Chromatography–Mass Spectrometry (QA/QC factors may vary depending on analysis type)*

1. Sample management (sample preservation, handling, and transport; chain-of-custody; holding times)
2. Instrument performance
3. Calibration (initial calibration, initial calibration verification, and continuing calibration)
4. Method blanks
5. Blank spikes and LCSs
6. MS/MSD
7. Field QC samples (equipment blanks, field blanks, field duplicates, and field triplicates)

8. Internal standards performance
9. Target compound identification (Level D only*)
10. Compound quantitation and RLs (Level D only*)

*Metals*

1. Sample management (sample preservation, handling, and transport; chain-of-custody; holding times)
2. Calibration (initial and continuing)
3. Blanks (Calibration blanks and Method [preparation] blanks)
4. Inductively coupled (argon) plasma (spectroscopy) (ICP) interference check sample
5. Blank spikes and LCSs
6. MS/MSD and Matrix duplicates
7. Furnace atomic absorption QC
8. Internal standards performance (MS methods only)
9. ICP serial dilution
10. Sample result verification (Level D only*)
11. Field QC samples (equipment blanks, field blanks, field duplicates, and field triplicates)

*Inorganic Analyses by Wet Chemical Methods, (QA/QC factors may vary depending on analysis type)*

1. Sample management (sample preservation, handling, and transport; chain-of-custody; and holding times)
2. Calibration (initial and continuing)
3. Method blanks
4. Blank spikes and LCSs
5. MS/MSD and Matrix duplicates
6. Sample result verification (Level D only*)
7. Field QC samples (equipment blanks, field blanks, field duplicates, and field triplicates)

* Sections applicable to Level D validation only will also appear in Level C validation reports with the notation “not applicable for Level C validation.”

## Level B Data Validation

Data obtained using any analytical methods in the Level B Validation analytical categories will be validated in terms of meeting criteria for specific QA/QC factors such as holding times, blank spike analyses, and blank analyses. A separate discussion of each QA/QC factor under each analytical method will be presented in the CTO data validation report. The QA/QC factors used to validate data for QA/QC "Level B Validation" are presented below for each analytical category.

*Organic Analyses*

1. Sample management (sample preservation, handling, and transport; chain-of-custody; and holding times)
2. Method blanks
3. Blank spikes and laboratory control samples
4. Field QC samples (trip blanks (volatile organic compounds), equipment blanks, field blanks, field duplicates, and field triplicates)
5. Surrogate recovery
6. MS/MSD

*Inorganic Analyses*

1. Sample management (sample preservation, handling, and transport; chain-of-custody; and holding times)
2. Blanks (Calibration and Method blanks)
3. Blank spikes and LCSs
4. Field QC samples (equipment blanks, field blanks, field duplicates, and field triplicates)
5. MS/MSD and Laboratory Duplicates
6. ICP serial dilution

### *5.2.3.4* **LABORATORY REPORTS**

Annotated laboratory reports with the appropriate data qualifiers and qualification codes as specified in the NAVFAC Pacific ER Program data validation procedures will be submitted as an appendix to the data validation report. An example is provided as Attachment II-A-7. Records

Copies of all documents generated by data validation personnel will be stored for no less than 10 years. The original validated laboratory data shall be archived to the Federal Records Center at project completion.

## 6. References

Department of Defense, United States (DoD). 2005a. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

———. 2005b. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B: Quality Assurance/quality Control Compendium: Minimum QA/QC Activities*. Final Version 1. DoD: DTIC ADA 426957, EPA-505-B-04-900B. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/swerffrr/pdf/-qaqc_v1_0305.pdf.

———. 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2A: Optimized UFP-QAPP Worksheets*. Revision 1. March.

———. 2013. *Department of Defense Quality Systems Manual for Environmental Laboratories.* Version 5.0. Draft Final. Prepared by DoD Environmental Data Quality Workgroup and Department of Energy Consolidated Audit Program Operations Team. July.

Environmental Protection Agency, United States (EPA). 2007. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* 3rd ed., Final Update IV. Office of Solid Waste. On-line updates at: www.epa.gov/epaoswer/hazwaste/test/new-meth.htm.

## 7. Attachments

Attachment II-A-1: Acronyms and Abbreviations

Attachment II-A-2: Definition of Terms

Attachment II-A-3: Sample Cover Letter

Attachment II-A-4: Data Qualifier Reference Table

Attachment II-A-5: Qualification Code Reference Table

Attachment II-A-6: Sample Identification Table

Attachment II-A-7: Example Annotated Laboratory Report Volatile Organics Analysis Data Sheet

# Attachment II-A-1
# Acronyms and Abbreviations

# ACRONYMS AND ABBREVIATIONS

Following is a list of acronyms and abbreviations that may be used in NAVFAC Pacific ER Program data validation reports and the data quality assessment reports.

| | |
|---|---|
| %D | percent difference |
| %R | percent recovery |
| µg/kg | microgram per kilogram |
| µg/L | microgram per liter |
| 4,4'-DDD | 4,4'-dichlorodiphenyldichloroethane |
| 4,4'-DDE | 4,4'-dichlorodiphenyldichloroethylene |
| 4,4'-DDT | 4,4'-dichlorodiphenyltrichloroethane |
| AA | atomic absorption |
| ARRF | average relative response factor |
| BFB | bromofluorobenzene |
| BNA | base/neutral/acid |
| CCB | continuing calibration blank |
| CCC | calibration check compound |
| CCV | continuing calibration verification |
| CF | calibration factor |
| CLP | Contract Laboratory Program |
| COC | chain-of-custody |
| COD | chemical oxygen demand |
| CTO | contract task order |
| CVAA | cold vapor atomic absorption |
| DBCP | Dibromochloropropane |
| DCB | decachlorobiphenyl |
| DFTPP | decafluorotriphenylphosphine |
| DL | detection limit |
| DoD | Department of Defense |
| DOE | Department of Energy |
| DQAR | data quality assessment report |
| DUP | laboratory duplicate |
| DVP | data validation procedure |
| EB | equipment blank |
| EDB | ethylene dibromide |
| EDL | estimated detection limit |
| EICP | extracted ion current profile |
| EPA | Environmental Protection Agency, United States |
| FB | field blank |
| GC | gas chromatography |
| GC/ECD | gas chromatography/electron capture detector |
| GC/ELCD | gas chromatography/electrolytic conductivity detector (Hall detector) |
| GC/FPD | gas chromatography/flame photometric detector |
| GC/MS | gas chromatography/mass spectrometry |

| | |
|---|---|
| GC/PID | gas chromatography/photoionization detector |
| GFAA | graphite furnace atomic absorption |
| GPC | gel permeation chromatography |
| Hg | mercury |
| HPLC | high-performance liquid chromatography |
| HRGC/HRMS | high resolution gas chromatography/high resolution mass spectrometry |
| HT | holding time |
| ICB | initial calibration blank |
| ICP | inductively coupled plasma |
| ICS | interference check sample |
| ICV | initial calibration verification |
| IDL | instrument detection limit |
| IR | infrared spectroscopy |
| IRP | installation restoration program |
| IS | internal standards |
| LCS | laboratory control sample |
| LOD | limit of detection |
| LOQ | limit of quantitation |
| m/z | mass to charge ratio |
| MBAS | methyl blue active substance |
| mg/kg | milligram per kilogram |
| mg/L | milligram per liter |
| MS | matrix spike |
| MSA | method of standard addition |
| MSD | matrix spike duplicate |
| NFESC | Naval Facilities Engineering Services Center |
| ng/kg | nanogram per kilogram |
| OP | organophosphorus |
| PAH | polynuclear aromatic hydrocarbon |
| PARCC | precision, accuracy, representativeness, comparability, completeness |
| PCB | polychlorinated biphenyl |
| PCDD | polychlorinated dibenzodioxin |
| PCDF | polychlorinated dibenzofuran |
| PE | performance evaluation |
| PEM | performance evaluation mixture |
| PFK | perfluorokerosene |
| pg/g | picogram per gram |
| pg/L | picogram per liter |
| PQO | project quality objective |
| QA | quality assurance |
| QAC | quality assurance coordinator |
| QAPP | quality assurance project plan |
| QC | quality control |
| QSM | quality system manual |

| | |
|---|---|
| r | correlation coefficient |
| $r^2$ | coefficient of determination |
| RF | response factor |
| RIC | reconstructed ion chromatogram |
| RL | reporting limit |
| RPD | relative percent difference |
| RRF | relative response factor |
| RRT | relative retention time |
| RSD | relative standard deviation |
| RT | retention time |
| s/n | signal to noise ratio |
| SDG | sample delivery group |
| SICP | selected ion current profiles |
| SOP | standard operating procedure |
| SOW | statement of work |
| SPCC | system performance check compound |
| SRM | standard reference material |
| SVOC | semivolatile organic compound |
| TB | trip blank |
| TCDD | tetrachlorodibenzodioxin |
| TCX | tetrachloro-m-xylene |
| TDS | total dissolved solids |
| TIC | tentatively identified compound |
| TOC | total organic carbon |
| TOX | total organic halides |
| TPHE | total petroleum hydrocarbons as extractables |
| UV/VIS | ultraviolet/visible |
| VOA | volatile organic analysis |
| VOC | volatile organic compound |
| VTSR | validated time of sample receipt |
| WDM | window defining mixture |

# Attachment II-A-2
# Definition of Terms

# DEFINITION OF TERMS

| | | |
|---|---|---|
| Calibration Curve | – | A plot of response versus concentration of standards. |
| CCB | – | Continuing Calibration Blank – a deionized water sample run every 10 samples designed to detect any carryover contamination. |
| CCV | – | Continuing Calibration Verification – a standard run every 10 samples to test instrument performance. |
| EDL | – | Estimated Detection Limit – The sample specific EDL is the concentration of a given analyte required to produce a signal with a peak height of at least 2.5 times the background signal level. |
| Field Blank | – | Field blanks are intended to identify contaminants that may have been introduced in the field through source water. |
| Field Duplicate | – | A duplicate sample generated in the field, not in the laboratory. |
| Findings | – | Any out-of-control, unacceptable, or out of criteria event which may impact the quality of the data or require corrective action. |
| GPC | – | Gel Permeation Chromatography – A sample clean-up technique that separates compounds by size and molecular weight. Generally used to remove oily materials from sample extracts. |
| Holding Time | – | The time from sample collection to sample analysis. |
| ICB | – | Initial Calibration Blank – the first blank standard run to confirm the calibration curve. |
| ICV | – | Initial Calibration Verification – the first standard run to confirm the calibration curve. |
| Initial Calibration | – | The establishment of a calibration curve with the appropriate number of standards and concentration range. The calibration curve plots instrument response versus concentration of standards. |
| IR | – | Infrared Spectroscopy. |
| IS | – | Internal Standards – compounds added to every VOA and BNA standard, blank, matrix spike duplicate, and sample extract at a known concentration, prior to instrumental analysis. Internal standards are used as the basis for quantitation of the target compounds. |
| Laboratory Duplicate | – | A duplicate sample generated in the laboratory. |
| MDL | – | Method Detection Limit – minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero. |
| MS | – | Matrix Spike – introduction of a known concentration of analyte into a sample to provide information about the effect of the sample matrix on the extraction or digestion and measurement methodology. |
| m/z | – | The ratio of mass (m) to charge (z) of ions measured by GC/MS. |

| | | |
|---|---|---|
| Post Digestion Spike | – | The addition of a known amount of standard after digestion. (Also identified as analytical spike or spike for furnace analysis). |
| Primary Analysis | – | One of two types of pesticide/PCB analysis by GC/EC techniques, the other being confirmation analysis. The primary analysis is used to establish the tentative identification of any pesticides/PCBs detected. The identification is confirmed in the confirmation analysis. If the two analyses are done simultaneously, either may be considered the primary analysis. Either may be used for quantitation if contract criteria are met. |
| QA | – | Quality Assurance – total program for assuring the reliability of data |
| QC | – | Quality Control – routine application of procedures for controlling the monitoring process. |
| RL | – | Reporting Limit – value specified by the client based on sensitivity requirements from project-specific action levels. |
| RPD | – | Relative Percent Difference (between matrix spike and matrix spike duplicate, duplicate laboratory control samples, or blank spikes) |
| Serial Dilution | – | A sample run at a specific dilution to determine whether any significant chemical or physical interferences exist due to sample matrix effects (ICP only). |
| SDG | – | Sample Delivery Group – defined by one of the following, whichever occurs first:<br>• Case of field samples<br>• Each 20 field samples within a case<br>• Each 14-day calendar period during which field samples in a case are received, beginning with receipt of the first sample in the SDG |
| Level B Validation | – | Data validation is performed using sample results and QA/QC summaries (i.e., method blanks, LCS, MS/MSDs, surrogates, and serial dilutions). This level of data validation was previously identified as “Standard.” |
| Level C Data Validation | – | Data validation is performed using sample results and QA/QC summaries (including instrument performance, calibration, and internal standard data). This level of data validation was previously identified as “Cursory.” |
| Level D Data Validation | – | Data validation is performed using sample results, QA/QC summaries (including instrument performance, calibration, and internal standard data) and raw data associated to the sample results and QA/QC summaries. This level of data validation was previously identified as “Full.” |

# Attachment II-A-3
# Sample Cover Letter

# SAMPLE COVER LETTER

(Date)

(CTO Manager or designee) (company address) Dear ( ): Enclosed is Revision __ of the data validation reports for CTO (number) as follows: Semi-volatiles SDG S0221 SDG S0350 Pesticides/PCBs SDG S0201 Metals SDG S0221 SDG S0201 The specific sample identifications are listed in the Sample Identification Table(s). The data packages were reviewed according to the data validation procedures referenced in the introduction to each report.

Sincerely,

(Signature)
Data Validation Project Manager

# Attachment II-A-4
# Data Qualifier Reference Table

### Table II-A-4-1: Data Qualifier Reference Table

| Qualifier | Organics | Inorganics |
|---|---|---|
| U | The analyte was analyzed for, but was not detected above the method detection limit. | The analyte was analyzed for, but was not detected above the method detection limit. |
| J | The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample. | The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample. |
| N | The analysis indicates the presence of an analyte for which there is presumptive evidence to make a "tentative identification." | Not applicable. |
| NJ | The analysis indicates the presence of an analyte that has been "tentatively identified" and the associated numerical value represents its approximate concentration. | Not applicable. |
| UJ | The analyte was not detected above the method detection limit. However, the associated value is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample. | The analyte was analyzed for, but was not detected. The associated value is an estimate and may be inaccurate or imprecise. |
| R | The sample results are rejected due to serious deficiencies in the ability to analyze the sample and to meet quality control criteria. The presence or absence of the analyte cannot be verified. | The data are unusable. The sample results are rejected due to serious deficiencies in meeting the Quality Control (QC) criteria. The analyte may or may not be present in the sample. |

# Attachment II-A-5
# Qualification Code Reference Table

**Table II-A-5-1: Qualification Code Reference Table**

| Qualifier | Organics | Inorganics |
|---|---|---|
| H | Holding times were exceeded. | Holding times were exceeded. |
| S | Surrogate recovery was outside QC limits. | The sequence or number of standards used for the calibration was incorrect. |
| C | Calibration %RSD, r, $r^2$ or %D were noncompliant | Correlation coefficient is <0.995. |
| R | Calibration RRF was <0.05. | %R for calibration is not within control limits |
| B | Presumed contamination from preparation (method blank) | Presumed contamination from preparation (method) blank or calibration blank |
| L | Laboratory Control Sample/Laboratory Control Sample Duplicate %R or RPD was not within control limits | Laboratory Control Sample/Laboratory Control Sample Duplicate %R or RPD was not within control limits |
| Q | MS/MSD recovery was poor | MS/MSD recovery was poor. |
| E | MS/MSD or Duplicate RPD was high. | MS/MSD or Duplicate RPD or difference was high. |
| I | Internal standard performance was unsatisfactory | ICP ICS results were unsatisfactory. |
| A | Not applicable. | ICP Serial Dilution %D were not within control limits |
| M | Instrument Performance Check (BFB or DFTPP) was noncompliant | Not applicable. |
| T | Presumed contamination from trip blank. | Not applicable. |
| F | Presumed contamination from FB or ER. | Presumed contamination from FB or ER. |
| D | The analysis with this flag should not be used because another more technically sound analysis is available. | The analysis with this flag should not be used because another more technically sound analysis is available. |
| P | Instrument performance for pesticides was poor | Post Digestion Spike recovery was not within control limits |
| V | Unusual problems found with the data that have been described in the validation report where a description of the problem can be found. | Unusual problems found with the data that have been described in where a description of the problem can be found. |

# Attachment II-A-6
# Sample Identification Table

**Table II-A-6-1: Sample Identification Table**

| EPA Identification | Sample Identification | Lab Identification Number | COC Sample Number | Matrix |
|---|---|---|---|---|
| FB001 | FB-BS04-E01-D10.0 | 2720-1 | DA001 | water |
| FB002 | FB-BS04-B01-D10.0 | 2720-2 | DA002 | water |
| FB003 | FB-BS04-B02-D10.0 | 2720-3 | DA003 | water |
| FB004 | FB-SS01-S01-D0.5 | 2720-4 | DA004 | soil |
| FB005 | FB-BS01-S01-D10.0 | 2720-5 | DA005 | soil |
| FB006 | FB-SS02-S01-D0.5 | 2720-6 | DA006 | soil |
| FB007 | FB-BS02-S01-D10.0 | 2720-7 | DA007 | soil |
| FB008 | FB-BS02-D01-D10.0 | 2720-8 | DA008 | soil |
| FB009 | FB-SS03-S01-D0.5 | 2720-9 | DA009 | soil |
| FB010 | FB-BS03-S01-D10.0 | 2720-10 | DA010 | soil |

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# Attachment II-A-7
# Example Annotated Laboratory Report
# Volatile Organics Analysis Data Sheet

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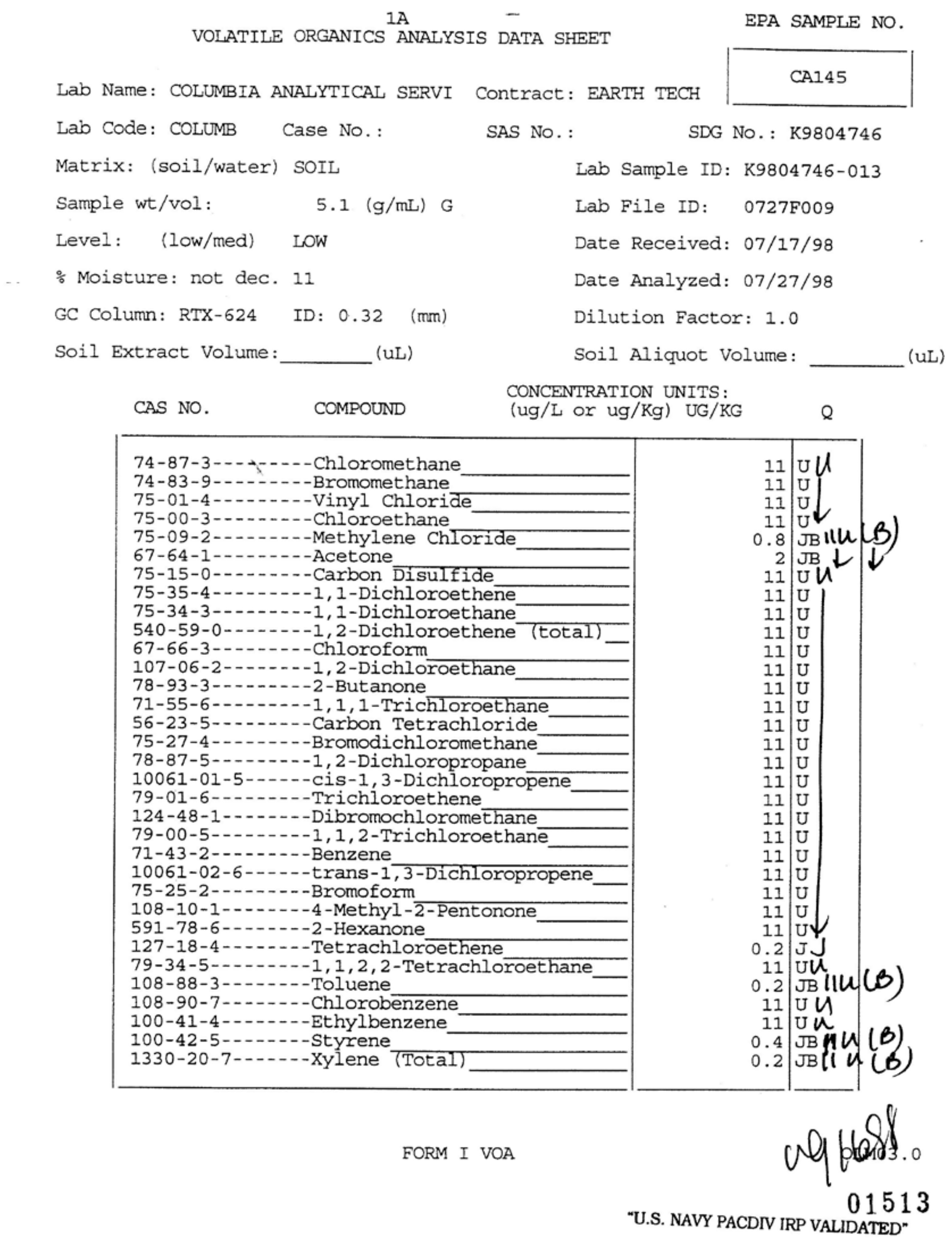
# EXAMPLE ANNOTATED LABORATORY REPORT
# VOLATILE ORGANICS ANALYSIS DATA SHEET



1A
VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.: CA145

Lab Name: COLUMBIA ANALYTICAL SERVI Contract: EARTH TECH

Lab Code: COLUMB Case No.: SAS No.: SDG No.: K9804746

Matrix: (soil/water) SOIL Lab Sample ID: K9804746-013

Sample wt/vol: 5.1 (g/mL) G Lab File ID: 0727F009

Level: (low/med) LOW Date Received: 07/17/98

% Moisture: not dec. 11 Date Analyzed: 07/27/98

GC Column: RTX-624 ID: 0.32 (mm) Dilution Factor: 1.0

Soil Extract Volume:________(uL) Soil Aliquot Volume: ________(uL)

| CAS NO. | COMPOUND | CONCENTRATION UNITS: (ug/L or ug/Kg) UG/KG | Q | |
|---|---|---|---|---|
| 74-87-3 | Chloromethane | 11 | U | U |
| 74-83-9 | Bromomethane | 11 | U | |
| 75-01-4 | Vinyl Chloride | 11 | U | |
| 75-00-3 | Chloroethane | 11 | U | ↓ |
| 75-09-2 | Methylene Chloride | 0.8 | JB | 11U (B) |
| 67-64-1 | Acetone | 2 | JB | ↓ ↓ |
| 75-15-0 | Carbon Disulfide | 11 | U | U |
| 75-35-4 | 1,1-Dichloroethene | 11 | U | |
| 75-34-3 | 1,1-Dichloroethane | 11 | U | |
| 540-59-0 | 1,2-Dichloroethene (total) | 11 | U | |
| 67-66-3 | Chloroform | 11 | U | |
| 107-06-2 | 1,2-Dichloroethane | 11 | U | |
| 78-93-3 | 2-Butanone | 11 | U | |
| 71-55-6 | 1,1,1-Trichloroethane | 11 | U | |
| 56-23-5 | Carbon Tetrachloride | 11 | U | |
| 75-27-4 | Bromodichloromethane | 11 | U | |
| 78-87-5 | 1,2-Dichloropropane | 11 | U | |
| 10061-01-5 | cis-1,3-Dichloropropene | 11 | U | |
| 79-01-6 | Trichloroethene | 11 | U | |
| 124-48-1 | Dibromochloromethane | 11 | U | |
| 79-00-5 | 1,1,2-Trichloroethane | 11 | U | |
| 71-43-2 | Benzene | 11 | U | |
| 10061-02-6 | trans-1,3-Dichloropropene | 11 | U | |
| 75-25-2 | Bromoform | 11 | U | |
| 108-10-1 | 4-Methyl-2-Pentonone | 11 | U | |
| 591-78-6 | 2-Hexanone | 11 | U | ↓ |
| 127-18-4 | Tetrachloroethene | 0.2 | J | J |
| 79-34-5 | 1,1,2,2-Tetrachloroethane | 11 | U | U |
| 108-88-3 | Toluene | 0.2 | JB | 11U (B) |
| 108-90-7 | Chlorobenzene | 11 | U | U |
| 100-41-4 | Ethylbenzene | 11 | U | U |
| 100-42-5 | Styrene | 0.4 | JB | 11U (B) |
| 1330-20-7 | Xylene (Total) | 0.2 | JB | 11U (B) |

FORM I VOA OLM03.0

01513

"U.S. NAVY PACDIV IRP VALIDATED"

# Level C and Level D Data Validation for GC/MS Volatile Organics by SW-846 8260

## 1. Purpose

This data validation procedure sets forth the standard operating procedure for performance of Level C and Level D data validation of volatile organic data obtained under the United States (U.S.) Navy Environmental Restoration (ER) Program for Naval Facilities Engineering Command (NAVFAC), Pacific and is consistent with protocol in the *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories* (DoD QSM) (DoD 2013). Level B validation is addressed separately in Procedure II-A, *Data Validation*.

## 2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

## 3. Responsibilities

The CTO Manager, the QA Manager or Technical Director, and the CTO QA Coordinator are responsible for ensuring that this procedure is implemented by data validation personnel.

Data validation personnel are responsible for implementing this procedure for validation of all gas chromatography/mass spectrometry (GC/MS) volatile data.

## 4. Procedure

This procedure addresses the validation of volatile organic data obtained using U.S. Environmental Protection Agency Method Solid Waste (SW)-846 8260 (EPA 2007). The quality control (QC) criteria identified in this procedure are those specified in the analytical method and the DoD QSM (DoD 2013). Where project specific criteria are identified in the CTO work plan, they will supersede the QC criteria identified in this procedure.

- Form I: Sample Results Summary Form
- Form II: Surrogate Recovery Summary Form
- Form III: Matrix Spike/Matrix Spike Duplicate or Blank Spike/Blank Spike Duplicate Recovery Summary Form

- Form IV: Method Blank Summary Form
- Form V: Instrument Performance Check Summary Form
- Form VI: Initial Calibration Summary Form
- Form VII: Continuing Calibration Summary Form
- Form VIII: Internal Standard Summary Form

Level C data validation consists of review of summary forms only, whereas Level D data validation requires review of both summary forms and all associated raw data. Data review guidelines and how they apply to the different validation levels are indicated in the following text.

## 4.1 SAMPLE MANAGEMENT

QA/QC criteria included under sample management are sample preservation, handling, and transport, chain of custody (COC), and holding times.

### 4.1.1 Sample Preservation, Handling, and Transport

**Level C and Level D:**

Evaluate sample collection, handling, transport, and laboratory receipt from COC and laboratory receipt checklists to ensure that the samples have been properly preserved and handled.

1. Water samples must be preserved with hydrochloric acid at or below a pH of 2 and refrigerated at above freezing to 6 degrees Celsius (°C).
2. Soil samples collected in volatile organic analysis (VOA) vials or coring devices must be refrigerated at or above freezing to 6°C. If the samples are to be analyzed after the 48-hour holding time, the laboratory must preserve the samples with sodium bisulfate or methanol or water or freeze upon receipt in accordance with SW-846 Method 5035.
3. If the analyzed aqueous VOA vial contains air bubbles or headspace, is cracked, or has a cracked cap, positive values shall be flagged as estimated “J” and nondetects as estimated “UJ.” The sample data may be qualified as unusable, “R,” if the container damage is extensive or improper sealing is identified.
4. VOA vials are to be shipped in coolers that are maintained at above freezing to 6°C. If the temperature exceeds 6°C, but is less than or equal to 10°C, note this in the data validation report. If the temperature of receipt is greater than or equal to 11°C, positive values shall be flagged as estimated “J” and nondetects as estimated “UJ.” If the temperature of receipt is greater than or equal to 15°C, positive values shall be flagged as estimated “J” and nondetects as unusable “R.” If the temperature is below 0°C, special note should be made that the samples were frozen and no qualification shall be required. In the event that both a cooler temperature and a temperature blank were measured, the temperature blank shall be evaluated for temperature compliance as it best assimilates the condition of the samples; however, both temperatures shall be noted in the data validation report.
5. If the temperature of the cooler upon receipt at the laboratory was not recorded, document that the laboratory is noncompliant.

6. If the receiving laboratory transferred the samples to another laboratory for analysis, apply the same temperature criteria to both the transfer COC and the original COC.

### 4.1.2 Chain of Custody

**Level C and Level D:**

Examine the COC form for legibility and check that all volatile analyses requested on the COC have been performed by the laboratory. Ensure that the COC Sample Number on the laboratory sample results form (Form I [or equivalent]) matches the Sample Identification on the COC. Read the laboratory case narrative for additional information.

1. Any samples received for analysis that were not analyzed shall be noted in the data validation report, along with the reason(s) for failure to analyze the samples, if the reason(s) can be determined. Conversely, samples that were analyzed for volatiles but were not requested should also be noted.
2. Any discrepancies in sample naming between the COC and sample results form shall be noted in the data validation report with the correct sample name being identified if the correct sample name can be determined.
3. If the receiving laboratory transferred the samples to another laboratory for analysis, both the original COCs and transfer COCs shall be present. Document in the data validation report if the transfer COCs are not present.
4. Internal COC is required for all samples, extracts, and digestates from receipt to disposal. Verify the internal COC forms for completeness. Document in the data validation report if the internal COC forms are not present.
5. Each individual cooler shall have an individual COC that lists only samples contained within that cooler. Document in the data validation report if multiple coolers appear on one COC.

### 4.1.3 Holding Times

**Level C and Level D:**

Holding times for volatile organics are measured from the time of collection (as shown on the COC) to the time of sample analysis (as shown on the sample results form and instrument performance check summary form [Forms I and V (or equivalent)]). Water samples must be preserved with hydrochloric acid and refrigerated at above freezing to 6°C. Preserved water samples shall be analyzed within 14 days from the collection date. If there is no indication of chemical preservation, assume samples are unpreserved. For unpreserved water samples, the holding time is 7 days from date collected for aromatic volatiles and 14 days from date collected for non-aromatic volatiles. Soil samples collected in VOA vials or coring devices that are unpreserved must be refrigerated at above freezing to 6°C and analyzed within 48 hours from the collection date. Soil samples that are preserved with sodium bisulfate or methanol, or frozen upon laboratory receipt shall be analyzed within 14 days from the collection date.

1. If the holding time is exceeded, flag all associated positive results as estimated “J” and all associated limits of detection (LODs) (nondetects) as estimated “UJ,” and document that holding times were exceeded.

2. If holding times are grossly exceeded by greater than a factor of 2.0 (e.g., a preserved water sample has a holding time of more than 28 days), detects will be qualified as estimated "J" and nondetects as unusable "R."

## 4.2 GC/MS INSTRUMENT PERFORMANCE CHECK

**Level C and Level D:**

GC/MS instrument performance checks or tune checks are performed to ensure mass resolution, identification, and to some degree, sensitivity. These criteria are not sample specific. Conformance is determined using standard reference materials; therefore, these criteria should be met in all circumstances.

The analysis of the instrument performance check solution must be performed at the beginning of each 12-hour period during which samples or standards are analyzed. The instrument performance check, bromofluorobenzene (BFB) for volatile analysis, must meet the ion abundance criteria given below.

**Table II-B-1: Ion Abundance Criteria – BFB**

| m/z | Ion Abundance Criteria |
|---|---|
| 50 | 15.0–40.0% of m/z 95 |
| 75 | 30.0–60.0% of m/z 95 |
| 95 | Base peak, 100% relative abundance |
| 96 | 5.0–9.0% of m/z 95 |
| 173 | Less than 2.0% of m/z 174 |
| 174 | Greater than 50.0% of m/z 95 |
| 175 | 5.0–9.0% of m/z 174 |
| 176 | Greater than 95.0% but less than 101.0% of m/z 174 |
| 177 | 5.0–9.0% of m/z 176 |

| | |
|---|---|
| % | percent |
| m/z | mass-to-charge ratio |

Check that all sample runs are associated with an injection. Make certain that a BFB performance check is present for each 12-hour period samples are analyzed (Form V [or equivalent]). Verify that all samples were analyzed within 12 hours of BFB injection.

If ion abundance criteria are not met, professional judgment may be applied to determine to what extent the data may be utilized. The most important factors to consider are the empirical results that are relatively insensitive to location on the chromatographic profile and type of instrumentation; therefore, the critical ion abundance criteria for BFB are the mass-to-charge ratio (m/z) 95/96, 174/175, 174/176, and 176/177 ratios. The relative abundance of m/z 50 and 75 are of lesser importance. Use professional judgment when samples are analyzed beyond the 12-hour time limit.

Decisions to use analytical data associated with BFB instrument performance checks not meeting requirements should be noted in the data validation report.

**Level D:**

Verify by recalculating from the quantitation reports, mass spectra, and chromatograms that the mass assignment is correct and that the mass listing is normalized to the specified m/z. If transcription errors are discovered on the Form V (or equivalent), request a resubmittal from the laboratory. Validate the data using the criteria outlined above.

## 4.3 CALIBRATION

Compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable qualitative and quantitative data for compounds on the volatile target compound list.

### 4.3.1 Initial Calibration

Initial calibration demonstrates that the instrument is capable of acceptable performance in the beginning of the analytical run and of producing an acceptable calibration curve.

**Level C and Level D:**

1. Evaluate the average relative response factors (RRFs) for all target compounds by checking Form VI (or equivalent).
2. If any of the volatile target compounds listed in Table II-B-2 below has an average RRF of less than 0.01 except for 1,4-dioxane (≤0.005) or any of the other volatile target compounds has an average RRF of less than 0.05, flag positive results for that compound as estimated “J” and nondetects as unusable “R” in associated samples.

**Table II-B-2: Volatile Compounds Exhibiting Poor Response**

| | |
|---|---|
| Acetone | 1,2-Dibromo-3-chloropane |
| 2-Butanone | Isopropylbenzene |
| Carbon disulfide | Methyl acetate |
| Chloroethane | Methylene chloride |
| Chloromethane | Methylcyclohexane |
| Cyclohexane | Methyl tert-butyl ether |
| 1,2-Dibromoethane | trans-1,2-Dichloroethene |
| Dichlorodifluoromethane | 4-Methyl-2-pentanone |
| 1,2-Dichloropropane | 2-Hexanone |
| cis-1,2-Dichloroethene | Trichlorofluoromethane |
| 1,4-Dioxane | 1,1,2-Trichloro-trifluoromethane |

3. Check Form VI (or equivalent) and evaluate the percent relative standard deviation (%RSD) for all target compounds. If any volatile target compound has a %RSD of greater than 15 percent, flag detects for the affected compounds as “J” and nondetects as “UJ” in the associated samples that correspond to that initial calibration.

**Level D:**

1. Verify the files reported on Form VI (or equivalent) against the quantitation reports, mass spectra, and chromatograms. If the files do not match, the RRFs reported are likely to be

from another initial calibration and will have to be changed. Request a resubmittal from the laboratory.

2. Recalculate the average RRFs and %RSDs reported on Form VI (or equivalent) for one compound per internal standard (preferably compounds which were identified in the samples) on the low-point calibration standard and one additional calibration standard. If errors are discovered, request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

### 4.3.2 Initial Calibration Verification

The initial calibration curve must be verified with a standard that has been purchased or prepared from an independent source each time initial calibration is performed. A standard from the same manufacturer but independently prepared from different source materials may also be used as an independent source. This initial calibration verification (ICV) must contain all of the method target compounds.

**Level C and Level D:**

1. Verify the ICV was analyzed following the initial calibration and contained all method target compounds.

2. If any target analyte has a percent difference (%D) greater than 20 percent, flag detects for the affected compounds as estimated “J” and nondetects as estimated “UJ” in all samples associated with the initial calibration.

**Level D:**

1. Verify from the raw data that there were no calculation or transcription errors by recalculating a percentage of the ICV calculations.

### 4.3.3 Continuing Calibration

Compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable qualitative and quantitative data. Continuing calibration establishes the 12-hour relative response factors on which the quantitations are based and checks satisfactory performance of the instrument on a day-to-day basis.

**Level C and Level D:**

1. Continuing calibration standards containing both target compounds and system monitoring compounds must be analyzed every 12 hours during operation. Evaluate the continuing RRFs on Form VII (or equivalent).
2. Ensure that the average RRFs reported on Form VII (or equivalent) correspond to the average RRFs reported on Form VI (or equivalent) for the corresponding initial calibration.
3. If any of the volatile target compounds listed in Table II-B-2 has an average RRF of less than 0.01 except for 1,4-dioxane (≤0.005) or any of the other volatile target compounds has an average RRF of less than 0.05, flag positive results for that compound as estimated “J” and nondetects as unusable “R” in associated samples.

4. If any volatile target compound has a %D between the initial calibration average RRF and continuing calibration RRFs outside 20 percent, flag all detects as “J” and all nondetects as “UJ” in all associated samples that correspond to that continuing calibration.

5. An ending continuing calibration is required by DoD QSM Appendix B (an ending continuing calibration is not required by the method) and professional judgment should be used in qualifying associated data when the %D is outside 50 percent.

**Level D:**

1. Verify the file reported on Form VII (or equivalent) against the raw data for the continuing calibration. If the file does not match, the RRFs reported are likely to be from another continuing calibration and will have to be changed. Request a resubmittal from the laboratory.
2. Recalculate the reported RRFs and %Ds reported on Form VII (or equivalent) for one compound per internal standard. If errors are discovered, request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

## 4.4 BLANKS

Method blank analytical results are assessed to determine the existence and magnitude of contamination problems. If problems with any method blank exist, all associated data must be carefully evaluated to determine whether there is any bias associated with the data, or if the problem is an isolated occurrence not affecting other data. Results may not be corrected by subtracting any blank values.

**Level C and Level D:**

1. The reviewer should identify samples associated with each method blank using Form IV (or equivalent). Verify that method blank analysis has been reported per matrix and concentration level for each 12-hour time period on each GC/MS system used to analyze VOA samples. Each sample must have an associated method blank. Medium level samples (samples that are known to have high concentrations of compounds) should have an associated methanol extraction blank. Qualify positive results in samples with no method blank as unusable “R.” Nondetects do not require qualification.
2. Compare the results of each method blank with the associated sample results. The reviewer should note that the blank analyses may not involve the same weights, volumes, percent moistures, or dilution factors as the associated samples. These factors must be taken into consideration when applying the criteria discussed below, such that a comparison of the total amount of contamination is actually made.
3. If a compound is found in the blank, but not in the associated sample, no action is taken.
4. Any compound, other than those listed in Table II-B-3, detected in both the sample and the associated blank shall be qualified when the sample concentration is less than the limit of quantitation (LOQ) and the blank concentration is less than, greater than, or equal to the LOQ. Compounds listed in Table II-B-3 shall be qualified when the sample concentration is less than 2× the LOQ and the blank concentration is less than, greater than, or equal to 2× LOQ. Care should be taken to factor in the percent moisture when comparing detects in the

sample and the method blank. The applicable review qualifier(s) are summarized in Table II-B-4.

**Table II-B-3: Common Laboratory Contaminants**

| |
|---|
| 1. Methylene chloride |
| 2. Acetone |
| 3. 2-Butanone |

**Table II-B-4: Blank Qualifications**

| Sample Result | Sample Value | Reviewer Qualifier(s) |
|---|---|---|
| Less than LOQ* and blank result is <, > or = LOQ* | Leave as reported | U |
| ≥LOQ*, blank result is <LOQ* | Leave as reported | None |
| ≥LOQ*, blank result is >LOQ* and sample result < blank result | Leave as reported | Use professional judgment |
| ≥LOQ*, blank result is >LOQ* and sample result ≥ blank result | Leave as reported | Use professional judgment |
| ≥LOQ* and blank result is = LOQ* | Leave as reported | Use professional judgment |

* 2x LOQ for common laboratory contaminants

5. In the case wherein both the sample concentration and the blank concentration are greater than or equal to the LOQ, previously approved criteria as identified in the planning documents may be applied to qualify associated sample results. Otherwise qualify sample results as non-detect “U” when the sample concentration is less than or equal to 10 times the blank concentration (10× rule) for the compounds listed in Table II-B-3 and tentatively identified compounds (TICs). For all other compounds, qualify sample results as non-detect “U” when the sample concentration is less than or equal to 5 times the blank concentration (5× rule).
6. If gross contamination exists in the blanks (i.e., saturated peaks by GC/MS), all compounds affected shall be flagged as unusable “R” due to interference in all samples affected and this shall be noted in the data validation comments.
7. If target compounds other than common laboratory contaminants are found at low levels in the blank(s), it may be indicative of a problem at the laboratory and shall be noted in the data validation report.
8. Additionally, there may be instances where little or no contamination was present in the associated blanks, but qualification of the sample was deemed necessary. Contamination introduced through dilution water is one example. Although it is not always possible to determine, instances of this occurring can be detected when contaminants are found in the diluted sample result, but are absent in the undiluted sample result. It may be impossible to verify this source of contamination; however, if the reviewer determines that the contamination is from a source other than the sample, the data should be qualified The sample value shall be reported as a nondetect and the reason shall be documented in the data validation report. Qualification of the data will be performed as given in Table II-B-4.

**Level D:**

1. Verify all target compound and TIC detects found in the method blanks against the raw data.
2. Verify that the target compound detects have valid spectra, as defined in Section 4.10 and the tentative identity of any TICs against the raw data, as defined in Section 4.12. If the spectra are not valid or the tentative identity is in error, request for a corrected Form I for the method blank from the laboratory.
3. Verify detected concentrations of target compounds and TICs from the raw data, as defined in Section 4.11. After the validity of the target compounds and TICs is verified, validate the corresponding data using the criteria outlined above.

## 4.5 BLANK SPIKES AND LABORATORY CONTROL SAMPLES

Blank spike/laboratory control sample (LCS) recoveries must be within the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established for a given sample matrix. Use in-house limits if compounds are not listed in Appendix C or project limits are not specified.

**Level C and Level D:**

1. If the blank spike/LCS results are 0 percent, only the spiked compounds that showed low recovery in all associated samples shall be flagged as unusable “R” for nondetects and estimated “J” for detects.
2. If blank spike/LCS results are below the control limits (but above 0 percent), spiked compounds which showed low recovery in all associated samples shall be flagged as estimated “UJ” or “J.”
3. If blank spike/LCS results are above the control limits, detects for only the spiked compounds which showed high recovery in all associated samples shall be flagged as estimated “J.”
4. If the laboratory analyzes a blank spike duplicate/LCS duplicate (LCSD), evaluate and qualify the LCSD results using the criteria noted above.
5. If the relative percent differences (RPDs) between LCS and LCSD results are above the control limits (use the matrix spike [MS]/matrix spike duplicate [MSD] RPD control limits identified in DoD QSM Appendix B. if none are available use laboratory in-house limits), spiked compounds which showed high RPD in all associated samples shall be flagged as estimated “UJ” or “J.”

**Level D:**

To check that the spike percent recovery was calculated and reported correctly using the following equation, recalculate one or more spike recoveries per matrix (and any spike that would result in the qualification of a sample).

$$\%\text{Recovery} = \frac{Q_D}{Q_A} \times 100$$

Where:

$Q_D$ = Quantity determined by analysis

$Q_A$ = Quantity added to samples/blanks

If transcription errors are discovered on Form III (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

## 4.6 SYSTEM MONITORING COMPOUNDS (SURROGATE SPIKES)

Laboratory performance on individual samples is established by means of surrogate spiking activities. All samples are spiked with surrogate compounds prior to sample preparation. The evaluation of the results of these surrogate spikes is not necessarily straightforward. The sample itself may produce effects due to such factors as interference and high concentrations of compounds. Because the effects of the sample matrix are frequently outside the control of the laboratory and may present relatively unique problems, the review and validation of data based on specific sample results is frequently subjective and demands analytical experience and professional judgment. These procedures shall be followed:

**Level C and Level D:**

1. Sample and blank surrogate recoveries for volatiles must be within the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established. Use in-house limits if surrogates are not listed in Appendix C or project limits are not specified. Verify that no samples or blanks have surrogates outside the criteria from Form II (or equivalent).
    a. If one surrogate for the VOA fraction is out of specification, then a re-analysis must be reported even though surrogate results are outside the criteria. (Note: When unacceptable surrogate recoveries are followed by successful re-analyses, the laboratory is required to report only the successful run. The laboratory does not have to re-analyze a sample if a MS/MSD was performed on the sample with out-of-control surrogate results showing the same matrix effects.) Medium level soils must be re-extracted and re-analyzed if the surrogate recoveries are outside the criteria.
    b. The laboratory has failed to perform satisfactorily if surrogate recoveries are out of specification with no evidence of re-purging. The non-surrogate recoveries shall be documented in the data validation report.
2. If surrogate spike recoveries are out of specification, samples will be qualified as follows:
    a. If any surrogate is below the lower acceptance limit but has a recovery greater than or equal to 10 percent, qualify positive results as estimated “J” and nondetects as estimated “UJ.”
    b. If any surrogate is above the upper acceptance limit, qualify detects in the sample as estimated “J.” Compounds with nondetects should not be qualified.

3. If any surrogate in a fraction shows less than 10 percent recovery, flag detects for that fraction as estimated “J,” and nondetects for the fraction as unusable “R.”
4. In the special case of blank analysis with surrogates out of specification, the reviewer must give special consideration to the validity of associated sample data. The basic concern is whether the blank problems represent an isolated problem with the blank alone, or whether there is a fundamental problem with the analytical process. For example, if the samples in the batch show acceptable surrogate recoveries, the reviewer may determine the blank problem to be an isolated occurrence for which no qualification of the data is required.
5. Surrogates may be reported as “diluted out” (D), if dilution is such that the surrogate can no longer be detected. If this is the case, note in the data validation report that surrogate evaluation could not be performed due to a high dilution factor. A full evaluation of the sample chromatogram and quantitation report may be necessary to determine that surrogates are truly “diluted out.”

**Level D:**

To verify that the surrogate percent recovery was calculated and reported correctly using the following equation, recalculate all surrogate recoveries per matrix (and any surrogate that would result in the qualification of a sample).

$$\%\text{Recovery} = \frac{Q_D}{Q_A} \times 100$$

Where:

$Q_D$ = Quantity determined by analysis

$Q_A$ = Quantity added to samples/blanks

If transcription errors are discovered on Form II (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

## 4.7 MATRIX SPIKE/MATRIX SPIKE DUPLICATE

MS/MSD data are used to determine the effect of the matrix on a method’s recovery efficiency and precision for a specific sample matrix.

No action is taken on MS/MSD data alone to qualify an entire data package. Using informed professional judgment; however, the data reviewer may use the MS/MSD results in conjunction with other QC criteria (i.e., surrogates and LCS) and determine the need for some qualification of the data.

In those instances where it can be determined that the results of the MS/MSD affect only the sample spiked, then qualification should be limited to this sample alone. It may be determined through the MS/MSD results, however, that a laboratory is having a systematic problem in the analysis of one or more compounds, which affects all associated samples.

If a field blank was used for the MS/MSD, the information must be included in the data validation summary. Sample matrix effects have not been observed with field blanks therefore the recoveries and precision do not reflect the analytical impact of the site matrix.

**Level C and Level D:**

The laboratory must spike and analyze an MS/MSD from the specific project site as required for each matrix type and analytical batch.

1. MS/MSD data should be reported on a MS/MSD summary form similar to Form III (or equivalent).
2. Compare the percent recovery (%R) and RPD for each spiked compound with the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established. Use in-house limits if spiked compounds are not listed in Appendix C or project limits are not specified.
3. If MS/MSD results are 0 percent, only the spiked compounds that showed low recovery in the parent sample shall be flagged as unusable “R” for nondetects and estimated “J” for detects.
4. If MS/MSD results are below the control limits (but above 0 percent), spiked compounds which showed low recovery in the parent sample shall be flagged as estimated “UJ” or “J.”
5. If MS/MSD results are above the control limits, detects for only the spiked compounds which showed high recovery in the parent sample shall be flagged as estimated “J.”
6. If the RPDs between MS and MSD results are greater than 20 percent, detects for only the spiked compounds which showed high RPD in the parent sample shall be flagged as estimated “J.”
7. Failure of MS/MSD due to the presence of a target compound in the parent sample at greater than two times the spike concentration or diluted by more than a factor of 2 should not result in any qualifications. Note the incident in the data validation report.

**Level D:**

Check the raw data and recalculate one or more %Rs and RPDs, especially %Rs and RPDs that resulted in the qualification of data, using the following equations to verify that results on Form III (or equivalent) are correct.

$$\%R = \frac{(SSR - SR)}{SA} \times 100$$

$$RPD = \frac{ABS|SSR - SDR|}{(SSR + SDR)/2} \times 100$$

Where:

SA = spike added

SR = sample result

SSR = spiked sample result

SDR = spiked duplicate result

ABS = absolute value

If transcription errors are discovered on Form III (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

## 4.8 FIELD QC SAMPLES

Field QC samples discussed in this section of this procedure are trip blanks, equipment blanks, field blanks, field duplicates, and field triplicates.

### 4.8.1 Trip Blanks

Volatile organic parameters detected in trip blanks indicate the possibility of contamination of site samples or cross-contamination between site samples due to sample handling and transport while in the cooler.

One trip blank shall accompany each cooler containing samples to be analyzed for volatile organics. Each trip blank shall be analyzed for all volatile organic parameters for which the associated samples are analyzed. If a cooler contains multiple trip blanks, all samples contained in the cooler shall be associated with the results from all trip blanks contained in the cooler.

**Level C and Level D:**

1. Check that all coolers containing samples to be analyzed for volatile organics contained a trip blank that was also analyzed for volatile organics. If a cooler requiring a trip blank did not have an associated trip blank, no qualification of the samples transported in the cooler is necessary, but the incident shall be discussed in the data validation report.
2. If volatile organic compounds are detected in the trip blanks, the procedure for the qualification of associated sample results using validated and/or qualified trip blank results is identical to the criteria outlined in Section 4.4 of this procedure.

**Level D:**

1. Verify all target compound and TIC detects found in the trip blanks against the raw data.
2. Verify that the target compound detects have valid spectra, as defined in Section 4.10 and verify the tentative identity of any TICs against the raw data, as defined in Section 4.12. If the spectra are not valid, or the tentative identity is in error, request for a corrected Form I (or equivalent) for the trip blank from the laboratory.

3. Verify detected concentrations of target compounds and TICs from the raw data, as defined in Section 4.11. After the validity of the target compounds and TICs is verified, validate the corresponding data using the criteria outlined above.

### 4.8.2 Equipment Blanks and Field Blanks

1. Compounds detected in equipment blanks indicate the possibility of cross-contamination between samples due to improper equipment decontamination.
2. A field blank sample may be collected from each source of water used during each sampling event. The field blank may be analyzed to assess whether the chemical nature of the water used in decontamination may have affected the analytical results of site samples.
3. If volatile organic compounds are detected in the equipment blanks and/or field blanks, the procedure for the qualification of associated sample results is identical to the criteria outlined in Section 4.4 of this procedure.

**Level C and Level D:**

1. Determine which field QC samples apply to samples in the sample delivery group (SDG).
2. Ensure that units are correct when applying field QC blank qualifications. If samples are soil matrix, results must first be converted to micrograms per liter (µg/L) from milligrams per kilogram to make correct comparisons.
3. Because of the way in which the field blanks and equipment blanks are sampled, equipment blanks are not qualified because of field blank contamination. The affected samples are qualified, however, by either the field blank or equipment blank results, whichever has the higher contaminant concentration.
4. Equipment blanks and field blanks are only qualified with method and trip blank results in order to account for laboratory contamination.

**Level D:**

1. Verify all target compound and TIC detects found in the equipment blanks and field blanks against the raw data.
2. Verify that the target compound detects have valid spectra, as defined in Section 4.10 and the tentative identity of any TICs against the raw data, as defined in Section 4.12. If the spectra are not valid, or if the tentative identity is in error, request for a corrected Form I (or equivalent) for the equipment blank or field blank from the laboratory.
3. Verify detected concentrations of target compounds and TICs from the raw data, as defined in Section 4.11. After the validity of the target compounds and TICs is verified, validate the corresponding data using the criteria outlined above.

### 4.8.3 Field Duplicates and Field Triplicates

Field duplicates consist of either collocated or subsampled samples. Field duplicates for ground water and surface water samples are generally considered to be collocates. Soil duplicate samples may be homogenized and subsampled in the field (or at the laboratory) to form an original and duplicate sample, or may be an additional volume of sample collected in a separate sample container to form a collocate sample. Field duplicate results are an indication of both field and laboratory precision; the results may be used to evaluate the consistency of sampling practices.

Field triplicates are collected from different, randomly selected locations to verify that an incremental sample truly represents a decision unit. Field triplicate results are more useful than field duplicates to statistically evaluate sampling precision.

**Level C and Level D:**

1. Check to ensure that field duplicates and/or field triplicates were collected and analyzed as specified in the project planning documents. If the sampling frequency is less than the frequency stated in the planning documents, no qualification of the associated sample results is necessary but the incident shall be discussed in the data validation report.
2. For field duplicate results, if the RPDs are greater than 50 percent for water or 100 percent for soil or as stated in the planning document if more conservative, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.
3. For field triplicate results, if the RSDs are greater than the QC limits stated in the planning document, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.

**Level D:**

1. Verify all target compound and TIC detects found in the field duplicates and/or field triplicates against the raw data.
2. Verify that the target compound detects have valid spectra, as defined in Section 4.10 and the tentative identity of any TICs against the raw data, as defined in Section 4.12. If the spectra are not valid, or if the tentative identity is in error, request for a corrected Form I for the field duplicates from the laboratory.
3. Verify detected concentrations of target compounds and TICs from the raw data, as defined in Section 4.11. After the validity of the target compounds and TICs is verified, validate the corresponding data using the criteria outlined above.

## 4.9 INTERNAL STANDARDS PERFORMANCE

Internal standards performance criteria ensure that GC/MS sensitivity and response are stable during every analytical run.

**Level C and Level D:**

1. If an internal standards area count for a sample is outside –50 percent or +100 percent of the area for the initial calibration midpoint standard:
    a. Positive results for compounds quantitated using an internal standards area count greater than 100 percent should be qualified as estimated “J.” Nondetected compounds should not be qualified.

   b. Compounds quantitated using an internal standards area count less than 50 percent should be qualified as estimated "J" for detects and estimated "UJ" for nondetects.

   c. If extremely low area counts are reported (less than 20 percent of the area for associated standards), detected compounds should be qualified as estimated "J" and nondetected target compounds should then be qualified as unusable "R."

2. If an internal standards retention time (RT) varies by more than 10 seconds from the RT of the initial calibration midpoint standard, the nondetected target compounds should be qualified as unusable "R" at Level C validation. A Level D validation examination of the raw data should be recommended to the CTO Manager. The chromatographic profile for that sample must be examined to determine if any false positives or negatives exist. For shifts of a large magnitude, the reviewer may consider partial or total rejection of the data for that sample fraction. Positive results should be qualified as "NJ" if the mass spectral criteria are met.

**Level D:**

1. Verify the internal standard areas reported on Form VIII (or equivalent) from the raw data for at least one sample per SDG, and verify internal standard areas for samples that were qualified due to out-of-control internal standard areas. If errors are discovered between the raw data and the Form VIII (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

## 4.10 TARGET COMPOUND IDENTIFICATION

The objective of the criteria for GC/MS qualitative analysis is to minimize the number of erroneous identifications of target compounds. An erroneous identification can either be false positive (reporting a compound present when it is not) or a false negative (not reporting a compound that is present).

The identification criteria can be applied more easily in detecting false positives than false negatives. More information is available for false positives due to the requirement for submittal of data supporting positive identifications. However, negatives, or nondetected compounds, represent an absence of data and are therefore more difficult to assess. One example of detecting false negatives is the not reporting of a target compound that is reported as a TIC.

**Level C:**

Target compound identification is not evaluated for Level C validation since it requires the interpretation of mass spectral raw data.

**Level D:**

The following criteria should be followed when evaluating raw data.

1. The relative retention times (RRTs) must be within ± 0.06 RRT units of the standard RRT.
2. Mass spectra of the sample compound and a current laboratory-generated standard (i.e., the mass spectrum from the associated calibration standard) must match according to the following criteria:

a. All ions present in the standard mass spectrum at a relative intensity greater than 10 percent must be present in the sample spectrum.

b. The relative intensities of these ions must agree within ± 20 percent between the standard and sample spectra. (Example: For an ion with an abundance of 50 percent in the standard spectrum, the corresponding sample ion abundance must be between 30 percent and 70 percent.)

c. Ions present at greater than 10 percent in the sample mass spectrum, but not present in the standard spectrum, must be considered and accounted for.

d. The application of qualitative criteria for GC/MS analysis of target compounds requires professional judgment. It is up to the reviewer's discretion to obtain additional information from the laboratory and CTO Manager. If it is determined that incorrect identifications were made, all such data should be qualified as not detected "U" or unusable "R."

e. Professional judgment must be used to qualify the data if it is determined that cross-contamination has occurred. Any changes made to the reported compounds or concerns regarding target compound identifications should be clearly indicated in the data validation report.

## 4.11 COMPOUND QUANTITATION AND REPORTING LIMITS

The objective is to ensure that the reported quantitation results and reporting limits (i.e., LOQ, LOD, detection limit [DL]) are accurate. All soil sample results are reported on a dry weight basis.

**Level C and Level D:**

1. Verify that the reporting limits for nondetects are equal to the LODs. Verify that an annual DL study was performed or quarterly LOD/LOQ verification checks were performed in accordance with the DoD QSM. The LOD verification check must be evaluated to determine whether the laboratory can reliably detect and identify all target analytes at a spike concentration of approximately 2× but not more than four times the current reported DL. Qualify nondetects as unusable "R."
2. Check that reported nondetects and positive values have been adjusted to reflect sample dilutions and for soil samples, sample moisture. When a sample is analyzed at more than one dilution, the lowest LODs are used unless a QC criterion has been exceeded. In this case, the higher LODs from the diluted analysis are used. The least technically sound data will be flagged "R" with a qualification code "D."
3. Verify that reported limits for soils and sediments were calculated based on dry weight. If the LOQs/LODs were reported based on wet weight, the percent moisture must be factored in and the LOQs/LODs must be adjusted accordingly.
4. Verify that no results exceed the highest calibration standard without being diluted. If a result has exceeded the highest calibration standard, verify that a dilution was performed. If not, qualify the detected compound that required dilution as "J" and document the event in the data validation report.

**Level D:**

The compound quantitation must be evaluated for all detects by evaluating the raw data. Compound concentrations must be calculated based on the internal standards associated with that compound, as listed in the following equation. Quantitation must be based on the quantitation ion (m/z) specified in the analytical method for both the internal standards and target compounds. The compound quantitation must be based on the RRF from the appropriate ICAL standard.

**Low Water**

$$\mu g/L = \frac{A_x \times I_s \times D_f}{A_{is} \times ARRF \times V_o}$$

Where:

$A_x$ = area of characteristic ion (extracted ion current profile) for compound being measured

$I_s$ = amount of internal standard added (nanogram)

$D_f$ = dilution factor

$A_{is}$ = area of characteristic ion for the internal standard

ARRF = average relative response factor for compound being measured

$V_o$ = volume of water purged (milliliter [mL])

**Low Soil/Sediment**

$$\text{Concentration } \mu g/kg \text{ (Dry weight basis)} = \frac{A_x \times I_s}{A_{is} \times ARRF \times W_s \times D}$$

Where:

$A_x$, $I_s$, $A_{is}$ are as given for water.

ARRF = Relative response factor from the heated purge of the initial calibration standard

$W_s$ = Weight of sample added to the purge tube, in grams (g)

$D = \frac{100 - \%\text{ moisture}}{100}$

**Medium Soil/Sediment**

$$\text{Concentration } \mu g/kg \text{ (Dry weight basis)} = \frac{A_x \times I_s \times V_t \times 1{,}000 \times D_f}{A_{is} \times ARRF \times V_a \times W_s \times D}$$

Where:

$A_x$, $I_s$, $A_{is}$, D are as given for water.

$V_t$ = Total volume of the methanol extract in mL. Note: This volume is typically 10 mL, even though only 1 mL is transferred to the vial

ARRF = Average relative response factor from the ambient temperature purge of the initial calibration standard

$V_a$ = Volume of the aliquot of the sample methanol extract (i.e., sample extract not including the methanol added to equal 100 microliters [µL]) in µL added to reagent water for purging

$W_s$ = Weight of soil/sediment extracted, in grams (g)

$D_f$ = Dilution factor. The dilution factor for analysis of soil/sediment samples for volatiles by medium level method is defined as:

$$\frac{\mu\text{L most conc. extract used to make dilution} + \mu\text{L clean solvent}}{\mu\text{L most conc. extract used to make dilution}}$$

The dilution factor is equal to 1.0 in all cases other than those requiring dilution of the sample methanol extract ($V_t$). The factor of 1,000 in the numerator converts the value of $V_t$ from mL to µL.

If discrepancies are discovered in the quantitation, request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

### 4.12 TENTATIVELY IDENTIFIED COMPOUNDS

For each sample, the laboratory must conduct a mass spectral search of the spectral library and report the possible identity for up to 30 of the largest volatile fraction peaks that are not system monitoring compounds (surrogates), internal standards, or target compounds, but which have area or height greater than 10 percent of the area or height of the nearest internal standard. TIC results are reported for each sample on the Organic Analyses Data Sheet (Form I VOA-TIC [or equivalent]).

**Level C and Level D:**

1. All TIC results should be qualified "NJ," tentatively identified with approximated concentrations.
2. The reviewer should be aware of common laboratory artifacts and their sources such as siloxane compounds, which indicate capillary column degradation, and carbon dioxide which indicates a possible air leak in the system. These may be qualified as unusable "R."
3. If a target compound is identified as a TIC by non-target library search procedures, the reviewer should request that the laboratory recalculate the result using the proper quantitation ion.
4. TIC results that are not above the 10× level in the blank should be qualified as unusable, "R." (Dilutions and sample size must be taken into account when comparing the amounts present in blanks and samples.)

5. The reviewer may elect to report all similar compounds as a total (e.g., all alkanes may be summarized and reported as total hydrocarbons).

**Level D:**

Check each TIC for each sample using the following criteria.

1. Major ions (greater than 10 percent relative intensity) in the reference spectrum should be present in the sample spectrum.
2. The relative intensities of the major ions should agree within ± 20 percent between the sample and the reference spectra.
3. Molecular ions present in the reference spectrum should be present in the sample spectrum.
4. Ions present in the sample spectrum but not in the reference spectrum should be reviewed for possible background contamination, interference, or co-elution of additional TIC or target compounds.
5. When the above criteria are not met, but in the technical judgment of the data reviewer or mass spectral interpretation specialist, the identification is correct, the data validator may report the identification.
6. Since TIC library searches often yield several candidate compounds having a close matching score, all reasonable choices must be considered. The reviewer may use judgment to change the reported tentative identity.

## 5. Records

A Form I or equivalent that has been validated and verified, and has been determined by the data validator to accurately represent the appropriate sample results to be utilized, shall be stamped “NAVFAC PACIFIC VALIDATED.” Additionally, sample result forms for which the data has been validated at the Level D validation level shall be stamped or noted “Level D.”

Copies of all documents generated by the data validation personnel will be stored for no less than 10 years. The original validated laboratory data shall be archived to the Federal Records Center at project completion.

## 6. References

Department of Defense, United States (DoD). 2005a. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

———. 2005b. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B: Quality Assurance/quality Control Compendium: Minimum QA/QC Activities*. Final Version 1. DoD: DTIC ADA 426957, EPA-505-B-04-900B. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www2.epa.gov/sites/production/files/documents/qaqc_v1_0305.pdf.

———. 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2A: Optimized UFP-QAPP Worksheets*. Revision 1. March.

———. 2013. *Department of Defense Quality Systems Manual for Environmental Laboratories.* Version 5.0. Draft Final. Prepared by DoD Environmental Data Quality Workgroup and Department of Energy Consolidated Audit Program Operations Team. July.

Environmental Protection Agency, United States (EPA). 2007. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* 3rd ed., Final Update IV. Office of Solid Waste. On-line updates at: www.epa.gov/epaoswer/hazwaste/test/new-meth.htm.

Procedure II-A, *Data Validation*.

## 7. Attachments

None.

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# Level C and Level D Data Validation for GC/MS Semivolatile Organics by SW-846 8270 (Full Scan and SIM)

## 1. Purpose

This data validation procedure sets forth the standard operating procedure for performance of Level C and Level D data validation of semivolatile organic data obtained under the United States (U.S.) Navy Environmental Restoration (ER) Program for Naval Facilities Engineering Command (NAVFAC), Pacific and is consistent with protocol in the *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratorie*s (DoD QSM) (DoD 2013). Level B validation is addressed separately in Procedure II-A, *Data Validation*.

## 2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

## 3. Responsibilities

The CTO Manager, the QA Manager or Technical Director, and the CTO QA Coordinator are responsible for ensuring that this procedure is implemented by data validation personnel.

Data validation personnel are responsible for implementing this procedure for validation of all gas chromatography/mass spectrometry (GC/MS) semivolatile data.

## 4. Procedure

This procedure addresses the validation of semivolatile organic data obtained using U.S. Environmental Protection Agency (EPA) Method Solid Waste (SW)-846 8270 (EPA 2007). The quality control (QC) criteria identified in this procedure are those specified in the analytical method and the DoD QSM (DoD 2013). Where project specific criteria are identified in the CTO work plan, they will supersede the QC criteria identified in this procedure.

- Form I: Sample Results Summary Form
- Form II: Surrogate Recovery Summary Form
- Form III: Matrix Spike/Matrix Spike Duplicate or Blank Spike/Blank Spike Duplicate Recovery Summary Form

- Form IV: Method Blank Summary Form
- Form V: Instrument Performance Check Summary Form
- Form VI: Initial Calibration Summary Form
- Form VII: Continuing Calibration Summary Form
- Form VIII: Internal Standard Summary Form

Level C data validation consists of review of summary forms only while Level D data validation requires review of both summary forms and all associated raw data. Data review guidelines and how they apply to the different validation levels are indicated in the following text.

## 4.1 SAMPLE MANAGEMENT

QA/QC criteria included under sample management are sample preservation, handling, and transport; chain of custody (COC); and holding times.

### 4.1.1 Sample Preservation, Handling, and Transport

**Level C and Level D:**

Evaluate sample collection, handling, transport, and laboratory receipt from COC and laboratory receipt checklists to ensure that the samples have been properly preserved and handled.

1. Samples are to be shipped in coolers that are maintained at above freezing to 6 degrees Celsius (°C). If the temperature exceeds 6°C but is less than or equal to 10°C, note this in the data validation report. If the temperature of receipt is greater than or equal to 11°C, positive values shall be flagged as estimated “J” and nondetects as estimated “UJ.” If the temperature is below 0°C, special note should be made that the samples were frozen and no qualification shall be required. In the event that both a cooler temperature and a temperature blank were measured, the temperature blank shall be evaluated for temperature compliance as it best assimilates the condition of the samples; however, both temperatures shall be noted in the data validation report.
2. If the temperature of the cooler upon receipt at the laboratory was not recorded, document that the laboratory is noncompliant.
3. If the receiving laboratory transferred the samples to another laboratory for analysis, apply the same temperature criteria to both the transfer COC and the original COC.

### 4.1.2 Chain of Custody

**Level C and Level D:**

Examine the COC for legibility and check that all semivolatile analyses requested on the COC have been performed by the laboratory. Ensure that the COC Sample Number on the laboratory Form I matches the Sample Identification on the COC. Read the laboratory case narrative for additional information.

1. Any samples received for analysis that were not analyzed shall be noted in the data validation report, along with the reason(s) for failure to analyze the samples, if the reason(s)

can be determined. Conversely, samples that were analyzed for semivolatiles, but were not requested should also be noted.

2. Any discrepancies in sample naming between the COC and sample results form shall be noted in the data validation report with the correct sample name being identified if the correct sample name can be determined.
3. If the receiving laboratory transferred the samples to another laboratory for analysis, both the original COCs and transfer COCs shall be present. Document in the data validation report if the transfer COCs are not present.
4. Internal COC is required for all samples, extracts, and digestates from receipt to disposal. Verify the internal COC forms for completeness. Document in the data validation report if the internal COC forms are not present.
5. Each individual cooler shall have an individual COC that lists only samples contained within that cooler. Document in the data validation report if multiple coolers appear on one COC.

### 4.1.3 Holding Times

**Level C and Level D:**

Holding times for semivolatile organics are measured from the time of collection (as shown on the COC) to the time of sample extraction and from the time of sample extraction to the time of sample analysis (as shown on the Form I). Samples and extracts must be stored and refrigerated at above freezing to 6°C until the time of analysis.

Water samples shall be unpreserved and refrigerated at above freezing to 6°C and shall be extracted within 7 days of collection and analyzed within 40 days of extraction.

Soil samples shall be unpreserved and refrigerated at above freezing to 6°C and shall be extracted within 14 days of collection and analyzed within 40 days of extraction.

1. If the holding time is exceeded, flag all associated positive results as estimated “J” and all associated limits of detection (LODs) (nondetects) as estimated “UJ,” and document that holding times were exceeded.
2. If holding times are grossly exceeded by greater than a factor of 2.0 (e.g., a non-water sample has a holding time of more than 14 days), detects will be qualified as estimated “J” and nondetects as unusable “R.”

## 4.2 GC/MS INSTRUMENT PERFORMANCE CHECK (FULL SCAN)

**Level C and Level D:**

GC/MS instrument performance checks or tune checks are performed for the Full scan analyses to ensure mass resolution, identification, and to some degree, sensitivity. Instrument performance checks are not required for samples analyzed by selected ion monitoring (SIM). These criteria are not sample specific. Conformance is determined using standard materials; therefore, these criteria should be met in all circumstances.

The analysis of the instrument performance check solution must be performed at the beginning of each 12-hour period during which samples or standards are analyzed. The instrument performance check, decafluorotriphenylphosphine (DFTPP) for semivolatile analysis, must meet the ion abundance criteria given below.

**Table II-C-1: Ion Abundance Criteria – DFTPP (SW-846 8270C)**

| m/z | Ion Abundance Criteria |
|---|---|
| 51 | 30.0–60.0% of m/z 198 |
| 68 | Less than 2.0% of m/z 69 |
| 70 | Less than 2.0% of m/z 69 |
| 127 | 40.0–60.0% of m/z 198 |
| 197 | Less than 1.0% of m/z 198 |
| 198 | Base peak, 100% relative abundance |
| 199 | 5.0–9.0% of m/z 198 |
| 275 | 10.0–30.0% of m/z 198 |
| 365 | Greater than 1.0% of m/z 198 |
| 441 | Present, but less than m/z 443 |
| 442 | Greater than 40.0% of m/z 198 |
| 443 | 17.0–23.0% of m/z 442 |

| | |
|---|---|
| % | percent |
| m/z | mass-to-charge ratio |

**Table C-II-2: Ion Abundance Criteria – DFTPP (SW-846 8270D)**

| m/z | Ion Abundance Criteria |
|---|---|
| 51 | 10.0–80.0% of m/z 198 |
| 68 | Less than 2.0% of m/z 69 |
| 70 | Less than 2.0% of m/z 69 |
| 127 | 10.0–80.0% of m/z 198 |
| 197 | Less than 2.0% of m/z 198 |
| 198 | Base peak, 100% relative abundance |
| 199 | 5.0–9.0% of m/z 198 |
| 275 | 10.0–60.0% of m/z 198 |
| 365 | Greater than 1.0% of m/z 198 |
| 441 | Present, but less than 24.0% m/z 442 |
| 442 | Greater than 50.0% of m/z 198 |
| 443 | 15.0–24.0% of m/z 442 |

Check that all sample runs are associated with an injection. Make certain that a DFTPP performance check is present for each 12-hour period samples are analyzed (Form V [or equivalent]). Verify that all samples were analyzed within 12 hours of DFTPP injection.

If ion abundance criteria are not met, professional judgment may be applied to determine to what extent the data may be utilized. The most important factors to consider are the empirical results that are relatively insensitive to location on the chromatographic profile and type of instrumentation; therefore, the critical ion abundance criteria for DFTPP are the mass to charge (m/z) ratios for 198/199 and 442/443. The relative abundances for m/z 68, 70, 197, and 441 are also very important.

The relative abundances of m/z 51, 127, 275, and 365 are of lesser importance. For example, if the relative abundance of m/z 365 is zero, minimum detection limits may be affected. However, if m/z 365 is present, but less than the 1.0 percent minimum abundance criteria, the deficiency is not as serious. Use professional judgment when samples are analyzed beyond the 12-hour time limit.

DFTPP should also be used to assess GC column performance and injection port inertness. Degradation of 4,4'-dichlorodiphenyltrichloroethane to 4,4'-dichlorodiphenyldichloroethane and 4,4'-dichlorodiphenyldichloroethylene should not exceed 20 percent. Benzidine and pentachlorophenol should be present at their normal responses and should not exceed a tailing factor of 2 using the equation presented in EPA SW-846 8270D (or most current version). Decisions to use analytical data associated with DFTPP instrument performance checks not meeting requirements should be noted in the data validation report.

**Level D:**

Verify by recalculating from the raw data (mass spectral listing) that the mass assignment is correct and that the mass listing is normalized to the specified m/z. If transcription or rounding errors are discovered on the Form V (or equivalent), request a resubmittal from the laboratory. Validate the data using the criteria outlined above.

## 4.3 CALIBRATION

Compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable qualitative and quantitative data for compounds on the semivolatile target compound list for both Full Scan and SIM analyses.

### 4.3.1 Initial Calibration

Initial calibration demonstrates that the instrument is capable of acceptable performance in the beginning of the analytical run and of producing an acceptable calibration curve for both Full Scan and SIM analyses.

**Level C and Level D:**

1. Evaluate the average relative response factors (RRFs) for all target compounds by checking Form VI (or equivalent).
2. If any of the semivolatile target compounds listed in Table C-II-3below has an average RRF of less than 0.01 or any other semivolatile target compound has an average RRF of less than 0.05, flag positive results for that compound as estimated “J” and nondetects as unusable “R” in associated samples.

**Table C-II-3: Semivolatile Compounds Exhibiting Poor Response**

| | |
|---|---|
| 2,2’-Oxybis-(1-chloropropane) | Benzaldehyde |
| 4-Chloroaniline | 4-Nitroaniline |
| Hexachlorobutadiene | 4,6-Dinitro-2-methylphenol |
| Hexachlorocyclopentadiene | N-Nitrosodiphenylamine |
| 2-Nitroaniline | 3,3’-Dichlorobenzidine |
| 3-Nitroaniline | 1,1’-Biphenyl |
| 2,4-Dinitrophenol | Dimethylphthalate |
| 4-Nitrophenol | Diethylphthalate |

| | |
|---|---|
| Acetophenone | 1,2,4,5-Tetrachlorobenzene |
| Caprolactam | Carbazole |
| Atrazine | Butylbenzylphthalate |
| Di-n-butylphthalate | Di-n-octylphthalate |
| Bis(2-ethylhexyl)phthalate | |

3. Check Form VI (or equivalent) and evaluate the percent relative standard deviation (%RSD) for all target compounds. If any semivolatile target compound has a %RSD of greater than 15 percent, flag detects for the affected compounds as “J” and nondetects as “UJ” in the associated samples that correspond to that initial calibration.

**Level D:**

1. Verify the files reported on Form VI (or equivalent) against the quantitation reports, mass spectra, and chromatograms. If the files do not match, the RRFs reported are likely to be from another initial calibration and will have to be changed. Request a resubmittal from the laboratory.
2. Recalculate the average RRFs and %RSDs reported on Form VI (or equivalent) for one compound per internal standard from the raw data (preferably compounds which were identified in the samples) on the low-point calibration standard and one additional calibration standard. If errors are discovered, request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

### 4.3.2 Initial Calibration Verification

The initial calibration curve must be verified with a standard that has been purchased or prepared from an independent source each time initial calibration is performed. A standard from the same manufacturer but independently prepared from different source materials may also be used as an independent source. This initial calibration verification (ICV) must contain all of the method target compounds.

**Level C and Level D:**

1. Verify the ICV was analyzed following the initial calibration and contained all method target compounds.
2. If any target analyte has a percent difference (%D) greater than 20 percent, flag detects for the affected compounds as estimated “J” and nondetects as estimated “UJ” in all samples associated with the initial calibration.

**Level D:**

Verify from the raw data that there were no calculation or transcription errors by recalculating a percentage of the ICV calculations.

### 4.3.3 Continuing Calibration

The continuing calibration checks document satisfactory maintenance and adjustment of the instrument on a day-to-day basis for both Full Scan and SIM analyses.

**Level C and Level D:**

1. Continuing calibration standards containing both target compounds and system monitoring compounds must be analyzed every 12 hours during operation. Evaluate the continuing RRFs on Form VII (or equivalent).
2. Ensure that the average RRFs reported on Form VII (or equivalent) correspond to the average RRFs reported on Form VI (or equivalent) for the corresponding initial calibration.
3. If any of the semivolatile target compounds listed in Table C-II-3 has an average RRF of less than 0.01 or any other semivolatile target compound has an average RRF of less than 0.05, flag positive results for that compound as estimated "J" and nondetects as unusable "R" in associated samples.
4. If any semivolatile target compound has a %D between the initial calibration average RRF and continuing calibration RRFs outside 20 percent, flag all detects as "J" and all nondetects as "UJ" in all associated samples that correspond to that continuing calibration.
5. An ending continuing calibration is required by DoD QSM Appendix B (an ending continuing calibration is not required by the method) and professional judgment should be used in qualifying associated data when the %D is outside 50 percent.

**Level D:**

1. Verify the file reported on Form VII (or equivalent) against the raw data for the continuing calibration. If the file does not match, the RRFs reported are likely to be from another continuing calibration and will have to be changed. Request a resubmittal from the laboratory.
2. Recalculate the reported RRFs and %Ds reported on Form VII (or equivalent) for one compound per internal standard. If errors are discovered, request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

## 4.4 BLANKS

Method blank analytical results are assessed to determine the existence and magnitude of contamination problems. If problems with any method blank exist, all associated data must be carefully evaluated to determine whether there is any bias on the data, or if the problem is an isolated occurrence not affecting other data. Results may not be corrected by subtracting any blank values.

**Level C and Level D:**

1. The reviewer should identify samples associated with each method blank using Form IV (or equivalent). Verify that method blank analysis has been reported per matrix and concentration level for each set of samples. Each sample must have an associated method blank. Qualify positive results in samples with no method blank as unusable "R." Nondetects do not require qualification.
2. Compare the results of each method blank with the associated sample results. The reviewer should note that the blank analyses may not involve the same weights, volumes, percent moistures, or dilution factors as the associated samples. These factors must be taken into consideration when applying the criteria discussed below, such that a comparison of the total amount of contamination is actually made.

3. If a compound is found in the blank, but not in the associated sample, no action is taken.
4. Compounds that are detected in both the sample and the associated blank with the exception of bis(2-ethylhexylphthalate) shall be qualified when the sample concentration is less than the limit of quantitation (LOQ) and the blank concentration is less than, greater than, or equal to the LOQ. Bis(2-ethylhexylphthalate) shall be qualified when the sample concentration is less than five times (5×) the LOQ and the blank concentration is less than, greater than, or equal to 5× LOQ. Care should be taken to factor in the percent moisture when comparing detects in the sample and the method blank. The applicable review qualifier(s) are summarized in Table C-II-4.

**Table C-II-4: Blank Qualifications**

| Sample Result | Sample Value | Reviewer Qualifier(s) |
|---|---|---|
| Less than LOQ* and blank result is <, > or = LOQ* | Leave as reported | U |
| ≥ LOQ*, blank result is < LOQ* | Leave as reported | None |
| ≥ LOQ*, blank result is > LOQ* and sample result < blank result | Leave as reported | Use professional judgment |
| ≥ LOQ*, blank result is > LOQ* and sample result ≥ blank result | Leave as reported | Use professional judgment |
| ≥ LOQ* and blank result is = LOQ* | Leave as reported | Use professional judgment |

*5x LOQ for bis(2-ethylhexylphthalate)

In the case wherein both the sample concentration and the blank concentration are greater than or equal to the LOQ, previously approved criteria as identified in the project planning documents may be applied to qualify associated sample results. Otherwise, qualify sample results as non-detect "U" when the sample concentration is less than or equal to 10 times the blank concentration (10× rule) for the phthalates listed in Table C-II-5 and tentatively identified compounds (TICs). For all other compounds, qualify sample results as non-detect "U" when the sample concentration is less than or equal to 5× the blank concentration (5× rule).

**Table C-II-5: Phthalates**

| |
|---|
| Dimethylphthalate |
| Diethylphthalate |
| Di-n-butylphthalate |
| Butylbenzylphthalate |
| Bis(2-ethylhexylphthalate) |
| Di-n-octylphthalate |

5. If gross contamination exists in the blanks (i.e., saturated peaks by GC/MS), all compounds affected shall be flagged as unusable "R" due to interference in all samples affected and this shall be noted in the data validation comments.
6. If target compounds other than common laboratory contaminants are found at low levels in the blank(s), it may be indicative of a problem at the laboratory and shall be noted in the data validation report.
7. Additionally, there may be instances where little or no contamination was present in the associated blanks, but qualification of the sample was deemed necessary. Contamination

introduced through dilution water is one example. Although it is not always possible to determine, instances of this occurring can be detected when contaminants are found in the diluted sample result, but are absent in the undiluted sample result. It may be impossible to verify this source of contamination; however, if the reviewer determines that the contamination is from a source other than the sample, the data should be qualified. The sample value shall be reported as a nondetect and the reason shall be documented in the data validation report.

**Level D:**

1. Verify all target compound and TIC detects found in the method blanks against the raw data.
2. Verify that the target compound detects have valid spectra, as defined in Section 4.10 and the tentative identity of any TICs against the raw data, as defined in Section 4.12. If the spectra are not valid or the tentative identity is in error, request for a corrected Form I for the method blank from the laboratory.
3. Verify detected concentrations of target compounds and TICs from the raw data, as defined in Section 4.11. After the validity of the target compounds and TICs is verified, validate the corresponding data using the criteria outlined above.

## 4.5 BLANK SPIKES AND LABORATORY CONTROL SAMPLES

Blank spike/laboratory control sample (LCS) recoveries must be within the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established for a given sample matrix. Use in-house limits if compounds are not listed in Appendix C or project limits are not specified.

**Level C and Level D:**

1. If the blank spike/LCS results are 0 percent, only the spiked compounds that showed low recovery in all associated samples shall be flagged as unusable “R” for nondetects and estimated “J” for detects.
2. If blank spike/LCS results are below the control limits (but above 0 percent), spiked compounds which showed low recovery in all associated samples shall be flagged as estimated “UJ” or “J.”
3. If blank spike/LCS results are above the control limits, detects for only the spiked compounds which showed high recovery in all associated samples shall be flagged as estimated “J.”
4. If the laboratory analyzes a blank spike duplicate/LCS duplicate (LCSD), evaluate and qualify the LCSD results using the criteria noted above.
5. If the relative percent difference (RPDs) between LCS and LCSD results are above the control limits (use the MS/MSD RPD control limits identified in DoD QSM Appendix B, if none are available use laboratory in-house limits), spiked compounds which showed high RPD in all associated samples shall be flagged as estimated “UJ” or “J.”

**Level D:**

To check that the spike percent recovery was calculated and reported correctly using the following equation, recalculate one or more spike recoveries per matrix (and any spike that would result in the qualification of a sample).

$$\%\text{Recovery} = \frac{Q_d}{Q_a} \times 100$$

Where:

$Q_d$ = Quantity determined by analysis

$Q_a$ = Quantity added to samples/blanks

If transcription errors are discovered on Form III (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

## 4.6 SYSTEM MONITORING COMPOUNDS (SURROGATE SPIKES)

Laboratory performance on individual samples is established by means of surrogate spiking activities. All samples are spiked with surrogate compounds prior to sample preparation. The evaluation of the results of these surrogate spikes is not necessarily straightforward. The sample itself may produce effects because of factors such as interferences and high concentrations of compounds. Since the effects of the sample matrix are frequently outside the control of the laboratory and may present relatively unique problems, the review and validation of data based on specific sample results is frequently subjective and demands analytical experience and professional judgment. The following procedures shall be followed:

**Level C and Level D:**

1. Sample and blank surrogate recoveries for semivolatiles must be within the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established. Use in-house limits if surrogates are not listed in Appendix C or project limits are not specified. Verify that no samples or blanks have surrogates outside the criteria from Form II (or equivalent).
2. If two or more surrogates in a base/neutral fraction or two or more surrogates in an acid fraction are out of specification, or if at least one surrogate has a recovery of less than 10 percent, then the sample should be re-analyzed though surrogate results still could be outside the criteria. (Note: When unacceptable surrogate recoveries are followed by successful re-analyses, the laboratories are required to report only the successful run unless the re-analyses were performed outside the holding times. Laboratories do not have to perform a re-analysis if a matrix spike/matrix spike duplicate was performed on the sample with out-of-control surrogate results showing the same matrix effects.)
3. The laboratory has failed to perform satisfactorily if surrogate recoveries are out of specification with no evidence of re-analysis. The non-surrogate recoveries shall be documented in the data validation report.

4. If two or more surrogates in the base/neutral fraction or two or more surrogates in the acid fraction are less than lower acceptance limit, but have a recovery greater than or equal to 10 percent, qualify positive results for that fraction as estimated "J" and nondetects as estimated "UJ." (Note that all phenols pertain to the acid fraction; all remaining compounds correspond to the base neutral fraction.)
5. If any surrogate in a fraction shows less than 10 percent recovery, qualify positive results for that fraction as estimated "J," and nondetects for the fraction as unusable "R."
6. If two or more surrogates in either base/neutral or acid-faction have a recovery greater than the upper acceptance limit, detected compounds in that fraction are qualified "J." Nondetects should not be qualified.
7. No qualification with respect to surrogate recovery is placed on data unless at least two surrogates in the semivolatile fraction are out of specification or unless any surrogate has less than 10 percent recovery.
8. In the special case of blank analysis with surrogates out of specification, the reviewer must give special consideration to the validity of associated sample data. The basic concern is whether the blank problems represent an isolated problem with the blank alone, or whether there is a fundamental problem with the analytical process. For example, if the samples in the batch show acceptable surrogate recoveries, the reviewer may determine the blank problem to be an isolated occurrence for which no qualification of the data is required.
9. Surrogates may be reported as "diluted out" (D); if dilution is such that the surrogate can no longer be detected. If this is the case, note in the data validation report that surrogate evaluation could not be performed due to a high dilution factor. A full evaluation of the sample chromatogram and quantitation report may be necessary to determine that surrogates are truly "diluted out."

**Level D:**

Verify that the surrogate percent recovery was calculated and reported correctly using the following equation. Recalculate all surrogate recoveries for one sample per matrix:

$$\%\text{Recovery} = \frac{Q_d}{Q_a} \times 100$$

Where:

$Q_d$ = Quantity determined by analysis

$Q_a$ = Quantity added to samples/blanks

If transcription errors are discovered on Form II (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

## 4.7 MATRIX SPIKE/MATRIX SPIKE DUPLICATE

Matrix Spike/Matrix Spike Duplicate (MS/MSD) data are used to determine the effect of the matrix on a method's recovery efficiency and precision for a specific sample matrix.

No action is taken on MS/MSD data alone to qualify an entire data package. Using informed professional judgment; however, the data reviewer may use the MS/MSD results in conjunction with other QC criteria (i.e., surrogates and LCS) and determine the need for some qualification of the data.

The data reviewer should first try to determine the extent to which the results of the MS/MSD affect the associated data. This determination should be made with regard to the MS/MSD sample itself, as well as specific compounds for all samples associated with the MS/MSD.

In those instances where it can be determined that the results of the MS/MSD affect only the sample spiked, then qualification should be limited to this sample alone. It may be determined through the MS/MSD results, however, that a laboratory is having a systematic problem in the analysis of one or more compounds, which affects all associated samples.

Note: If a field blank was used for the MS/MSD, the information must be included in the data validation summary. Sample matrix effects have not been observed with field blanks therefore the recoveries and precision do not reflect the analytical impact of the site matrix.

**Level C and Level D:**

The laboratory must spike and analyze an MS/MSD from the specific project site as required for each matrix type and analytical batch.

1. MS/MSD data should be reported on a MS/MSD summary form similar to Form III (or equivalent).
2. Compare the percent recovery (%R) and relative percent difference (RPD) for each spiked compound with the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established. Use in-house limits if spiked compounds are not listed in Appendix C or project limits are not specified.
3. If MS/MSD results are 0 percent, only the spiked compounds that showed low recovery in the parent sample shall be flagged as unusable “R” for nondetects and estimated “J” for detects.
4. If MS/MSD results are below the control limits (but above 0 percent), spiked compounds which showed low recovery in the parent sample shall be flagged as estimated “UJ” or “J.”
5. If MS/MSD results are above the control limits, detects for only the spiked compounds which showed high recovery in the parent sample shall be flagged as “J.”
6. If the RPDs between MS and MSD results are greater than 20 percent, detects for only the spiked compounds which showed high RPD in the parent sample shall be flagged as estimated “J.”
7. Failure of MS/MSD due to the presence of a target compound in the parent sample at greater than two times the spike concentration or diluted by more than a factor of two should not result in any qualifications. Note the incident in the data validation report.

**Level D:**

Check the raw data and recalculate one or more percent recoveries (%Rs) and RPDs, especially %Rs and RPDs that resulted in the qualification of data, using the following equations to verify that results on Form III (or equivalent) are correct.

$$\%R = \frac{(SSR - SR)}{SA} \times 100$$

$$RPD = \frac{ABS|SSR - SDR|}{(SSR + SDR)/2} \times 100$$

Where:

SA = spike added
SR = sample result
SSR = spiked sample result
SDR = spiked duplicate result
ABS = absolute value

If transcription errors are discovered on Form III (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

## 4.8 FIELD QC SAMPLES

Field QC samples discussed in this section of the procedures are equipment blanks, field blanks, field duplicates, and field triplicates.

### 4.8.1 Equipment Blanks and Field Blanks

Compounds detected in equipment blanks indicate the possibility of cross-contamination between samples due to improper equipment decontamination.

A field blank sample may be collected from each source of water used during each sampling event. The field blank may be analyzed to assess whether the chemical nature of the water used in decontamination may have affected the analytical results of site samples.

If semivolatile organic compounds are detected in the equipment blanks and/or field blanks, the procedure for the qualification of associated sample results is identical to the criteria outlined in Section 4.4 of this procedure.

**Level C and Level D:**

1. Determine which field QC samples apply to samples in the sample delivery group (SDG).

2. Ensure that units are correct when applying field QC blank qualifications. If samples are soil matrix, results must first be converted to microgram per liter from microgram per kilogram (µg/kg) to make correct comparisons.
3. Because of the way in which the field blanks and equipment blanks are sampled, equipment blanks are not qualified because of field blank contamination. The affected samples are qualified, however, by either the field blank or equipment blank results, whichever has the higher contaminant concentration.
4. Equipment blanks and field blanks are only qualified with method blank results in order to account for laboratory contamination.

**Level D:**

1. Verify all target compound and TIC detects found in the equipment blanks and field blanks against the raw data.
2. Verify that the target compound detects have valid spectra, as defined in Section 4.10 and verify the tentative identity of any TICs against the raw data, as defined in Section 4.12. If the spectra are not valid, or the tentative identity is in error, request for a corrected Form I (or equivalent) for the equipment blank or field blank from the laboratory.
3. Verify detected concentrations of target compounds and TICs from the raw data, as defined in Section 4.11. After the validity of the target compounds and TICs is verified, validate the corresponding data using the criteria outlined above.

### 4.8.2 Field Duplicates and Field Triplicates

Field duplicates consist of either collocated or subsampled samples. Field duplicates for ground water and surface water samples are generally considered to be collocates. Soil duplicate samples may be homogenized and subsampled in the field (or at the laboratory) to form an original and duplicate sample, or may be an additional volume of sample collected in a separate sample container to form a collocate sample. Field duplicate results are an indication of both field and laboratory precision; the results may be used to evaluate the consistency of sampling practices.

Field triplicates are collected from different, randomly selected locations to verify that an incremental sample truly represents a decision unit. Field triplicate results are more useful than field duplicates to statistically evaluate sampling precision.

**Level C and Level D:**

1. Check to ensure that field duplicates and/or field triplicates were collected and analyzed as specified in the project planning documents. If the sampling frequency is less than the frequency stated in the planning documents, no qualification of the associated sample results is necessary but the incident shall be discussed in the data validation report.
2. For field duplicate results, if the RPDs are greater than 50 percent for water or 100 percent for soil or as stated in the planning document if more conservative, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.

3. For field triplicate results, if the RSDs are greater than the QC limits stated in the planning document, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.

**Level D:**

1. Verify all target compound and TIC detects found in the field duplicates and/or field triplicates against the raw data.
2. Verify that the target compound detects have valid spectra, as defined in Section 4.10 and the tentative identity of any TICs against the raw data, as defined in Section 4.12. If the spectra are not valid, or the tentative identity is in error, request for a corrected Form I (or equivalent) for the sample or field duplicate from the laboratory.
3. Verify detected concentrations of target compounds and TICs from the raw data, as defined in Section 4.11. After the validity of the target compounds and TICs is verified, validate the corresponding data using the criteria outlined above.

## 4.9 INTERNAL STANDARDS PERFORMANCE

Internal standards performance criteria ensure that GC/MS sensitivity and response are stable during every analytical run.

**Level C and Level D:**

1. If an internal standards area count for a sample is outside –50 percent or +100 percent of the area the initial calibration midpoint standard:
2. Positive results for compounds quantitated using an internal standards area count greater than 100 percent should be qualified as estimated “J.” Nondetected compounds should not be qualified.
3. Compounds quantitated using an internal standards area count less than 50 percent should be qualified as estimated “J” for detects and estimated “UJ” for nondetects.
4. If extremely low area counts are reported (less than 20 percent of the area for associated standards), detected compounds should be qualified as estimated “J” and nondetected target compounds should then be qualified as unusable “R.”
5. If an internal standards retention time varies by more than 10 seconds from the retention time of the initial calibration midpoint standard, the nondetected target compounds should be qualified as unusable “R” for Level C validation. A Level D validation examination of the raw data should be recommended to the CTO Manager. The chromatographic profile for that sample must be examined to determine if any false positives or negatives exist. For shifts of a large magnitude, the reviewer may consider partial or total rejection of the data for that sample fraction. Positive results should be qualified as “NJ” if the mass spectral criteria are met.

**Level D:**

Verify the internal standard areas reported on Form VIII (or equivalent) from the raw data for at least one sample per SDG, and verify internal standard areas for samples that were qualified due to out-of-control internal standard areas. If errors are discovered between the raw data and the Form VIII (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

## 4.10 TARGET COMPOUND IDENTIFICATION

The objective of the criteria for GC/MS qualitative analysis is to minimize the number of erroneous identifications of target compounds. An erroneous identification can either be false positive (reporting a compound present when it is not) or a false negative (not reporting a compound that is present).

The identification criteria can be applied more easily in detecting false positives than false negatives. More information is available for false positives because of the requirement for submittal of data supporting positive identifications. However, negatives, or nondetected compounds, represent an absence of data and are, therefore, more difficult to assess. One example of detecting false negatives is the not reporting of a target compound that is reported as a TIC.

**Level C:**

Target compound identification is not evaluated for Level C validation because it requires the interpretation of mass spectral raw data.

**Level D:**

The following criteria should be followed when evaluating raw data.

1. The relative retention times (RRTs) must be within ±0.06 RRT units of the standard RRT.
2. Mass spectra of the sample compound and a current laboratory-generated standard (i.e., the mass spectrum from the associated calibration standard) must match according to the following criteria:
3. All ions present in the standard mass spectrum at a relative intensity greater than 10 percent must be present in the sample spectrum.
4. The relative intensities of these ions must agree within ± 20 percent between the standard and sample spectra. (Example: For an ion with an abundance of 50 percent in the standard spectrum, the corresponding sample ion abundance must be between 30 percent and 70 percent.)
5. Ions present at greater than 10 percent in the sample mass spectrum, but not present in the standard spectrum, must be considered and accounted for.
6. The application of qualitative criteria for GC/MS analysis of target compounds requires professional judgment. It is up to the reviewer’s discretion to obtain additional information from the laboratory and CTO Manager. If it is determined that incorrect identifications were made, all such data should be qualified as not detected “U” or unusable “R.”
7. Professional judgment must be used to qualify the data if it is determined that cross-contamination has occurred. Any changes made to the reported compounds or concerns regarding target compound identifications should be clearly indicated in the data validation report.

## 4.11 COMPOUND QUANTITATION AND REPORTING LIMITS

The objective is to ensure that the reported quantitation results and reporting limits (i.e., LOQ, LOD, detection limit [DL]) are accurate. All soil sample results are reported on a dry weight basis.

**Level C and Level D:**

1. Verify that the reporting limits for nondetects are equal to the LOD. Verify that an annual DL study was performed or quarterly LOD/LOQ verification checks were performed in accordance with the DoD QSM. The LOD/LOQ verification check must be evaluated to determine whether the laboratory can reliably detect and identify all target analytes at a spike concentration of approximately two times but not more than four times the current reported DL. Qualify nondetects as unusable "R."
2. Check that reported nondetects and positive values have been adjusted to reflect sample dilutions (including clean-up) and for soil samples, sample moisture. When a sample is analyzed at more than one dilution, the lowest LODs are used unless a QC criterion has been exceeded. In this case, the higher LODs from the diluted analysis are used. The least technically sound data will be flagged "R" with a qualification code "D."
3. Verify that LOQs/LODs for soils and sediments were calculated based on dry weight. If the LOQs/LODs were reported based on wet weight, the percent moisture must be factored in and the LOQs/LODs must be adjusted accordingly.
4. Verify that no results exceed the highest calibration standard without being diluted. If a result has exceeded the highest calibration standard, verify that a dilution was performed. If not, qualify the detected compound that required dilution as "J" and document the event in the data validation report.

**Level D:**

The compound quantitation must be evaluated for all detects by evaluating the raw data. Compound concentrations must be calculated based on the internal standards associated with that compound, as listed in the following equation. Quantitation must be based on the quantitation ion (m/z) specified in the method or project planning document for both the internal standards and target compounds. The compound quantitation must be based on the RRF from the appropriate initial calibration standard.

**Water**

$$\mu g/L = \frac{A_x \times I_s \times D_f \times V_t}{A_{is} \times ARRF \times V_o \times V_i}$$

Where:

$A_x$ = area of characteristic ion (extracted ion current profile) for compound being measured

$A_{is}$ = area of characteristic ion for the internal standard

$I_s$ = amount of internal standard added (nanograms)

ARRF = average relative response factor for compound being measured

$V_o$ = volume of water extracted (milliliter)

$D_f$ = dilution factor

$V_t$ = volume of extract injected (microliter [µL])

$V_i$ = volume of concentrated extract (µL)

**Soil/Sediment**

$$\text{Concentration } \mu g/kg \text{ (Dry weight basis)} = \frac{A_x \times I_s \times D_f \times V_t \times 2.0_t}{A_{is} \times ARRF \times Ws \times D \times V_i}$$

Where:

$A_x$, $I_s$, RRF, $A_{is}$, $V_{i,}$ $V_t$ are as given for water, above.

$D = \frac{100 - \%\ \text{moisture}}{100}$

$W_s$ = Weight of sample extracted, in grams (g)

The factor of 2.0 in the numerator is used to account for the amount of extract that is not recovered from gel permeation chromatography clean up.

If discrepancies are discovered in the quantitation, request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

## 4.12 TENTATIVELY IDENTIFIED COMPOUNDS

For each sample analyzed by Full Scan, the laboratory may conduct a mass spectral search of the spectral library and report the possible identity for up to 30 largest semivolatile fraction peaks which are not system monitoring compounds (surrogates), internal standards, or target compounds, but which have area or height greater than 10 percent of the area or height of the nearest internal standard. TIC results are reported for each sample on the Organic Analyses Data Sheet (Form I SV-TIC [or equivalent]). TICs are not reported for SIM analysis.

**Level C and Level D:**

1. All TIC results should be qualified “NJ,” tentatively identified with approximated concentrations.
2. The reviewer should be aware of common laboratory artifacts and their sources such as siloxane compounds, which indicate capillary column degradation, and carbon dioxide, which indicates a possible air leak in the system. These may be qualified as unusable “R.”
3. If a target compound is identified as a TIC by non-target library search procedures, the reviewer should request that the laboratory recalculate the result using the proper quantitation ion.
4. TIC results that are not above the 10× level in the blank should be qualified as unusable, “R.” (Dilutions and sample size must be taken into account when comparing the amounts present in blanks and samples.)

5. The reviewer may elect to report all similar compounds as a total (e.g., all alkanes may be summarized and reported as total hydrocarbons).

**Level D:**

1. Check each TIC for each sample using the following criteria.
2. Major ions (greater than 10 percent relative intensity) in the reference spectrum should be present in the sample spectrum.
3. The relative intensities of the major ions should agree within ±20 percent between the sample and the reference spectra.
4. Molecular ions present in the reference spectrum should be present in the sample spectrum.
5. Ions present in the sample spectrum but not in the reference spectrum should be reviewed for possible background contamination, interference, or co-elution of additional TIC or target compounds.
6. When the above criteria are not met, but in the technical judgment of the data reviewer or mass spectral interpretation specialist, the identification is correct, the data validator may report the identification.
7. Since TIC library searches often yield several candidate compounds having a close matching score, all reasonable choices must be considered. The reviewer may use judgment to change the reported tentative identity.

## 5. Records

A Form I that has been validated and verified, and has been determined by the data validator to accurately represent the appropriate sample results to be utilized, shall be stamped “NAVFAC PACIFIC VALIDATED.” Additionally, sample result forms for which the data has been validated at the Level D validation level shall be stamped or noted “Level D.”

Copies of all documents generated by the data validation personnel will be stored for no less than 10 years. The original validated laboratory data shall be archived to the Federal Records Center at project completion.

## 6. References

Department of Defense, United States (DoD). 2005a. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

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Environmental Protection Agency, United States (EPA). 2007. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* 3rd ed., Final Update IV. Office of Solid Waste. Updates available: www.epa.gov/epaoswer/hazwaste/test/new-meth.htm.

Procedure II-A, *Data Validation.*

## 7. Attachments

None.

# Level C and Level D Data Validation for Total Petroleum Hydrocarbons by SW-846 8015

## 1. Purpose

This data validation procedure sets forth the standard operating procedure for performance of Level C and Level D data validation of total petroleum hydrocarbons (TPH) data obtained under the United States (U.S.) Navy Environmental Restoration (ER) Program for Naval Facilities Engineering Command (NAVFAC), Pacific and is consistent with protocol in the *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories* (DoD QSM) (DoD 2013). Level B validation is addressed separately in Procedure II-A, *Data Validation*.

## 2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

## 3. Responsibilities

The CTO Manager, the QA Manager or Technical Director, and the CTO QA Coordinator are responsible for ensuring that this procedure is implemented by data validation personnel.

Data validation personnel are responsible for implementing this procedure for validation of all gas chromatography (GC) TPH data.

## 4. Procedure

This procedure addresses the validation of TPH data obtained using U.S. Environmental Protection Agency (EPA) Method Solid Waste (SW)-846 8015 (EPA 2007). The quality control (QC) criteria identified in this procedure are those specified in the analytical method and the DoD QSM (DoD 2013). Where project specific criteria are identified in the CTO work plan, they will supersede the QC criteria identified in this procedure.

- Form I: Sample Results Summary Form
- Form II: Surrogate Recovery Summary Form
- Form III: Matrix Spike/Matrix Spike Duplicate or Blank Spike/Blank Spike Duplicate Recovery Summary Form

- Form IV: Method Blank Summary Form
- Form VI: Initial Calibration Summary Form
- Form VII: Continuing Calibration Summary Form
- Form VIII: TPH Analytical Sequence Form

Level C data validation consists of review of summary forms only while Level D data validation requires review of both summary forms and all associated raw data. Data review guidelines and how they apply to the different validation levels are indicated in the following text.

## 4.1 SAMPLE MANAGEMENT

QA/QC criteria included under sample management are sample preservation, handling, and transport; chain of custody (COC); and holding times.

### 4.1.1 Sample Preservation, Handling, and Transport

**Level C and Level D:**

Evaluate sample collection, handling, transport, and laboratory receipt from COC and laboratory receipt checklists to ensure that the samples have been properly preserved and handled.

**TPH as Gasoline**

1. Water samples must be preserved with hydrochloric acid at or below a pH of 2 and refrigerated at above freezing to 6 degrees Celsius (°C).
2. Soil samples collected in volatile organic analysis (VOA) vials or coring devices must be refrigerated at above freezing to 6°C. If the samples are to be analyzed after the 48-hour holding time, the laboratory must preserve the samples with sodium bisulfate or methanol or freeze upon receipt in accordance with EPA SW-846 Method 5035 (EPA 2007).
3. If the analyzed aqueous VOA vial contains air bubbles or headspace, is cracked, or has a cracked cap, positive values shall be flagged as estimated “J” and nondetects as estimated “UJ.” The sample data may be qualified as unusable “R” if the container damage is extensive or improper sealing is identified.
4. VOA vials are to be shipped in coolers that are maintained at above freezing to 6°C. If the temperature exceeds 6°C, but is less than or equal to 10°C, note this in the data validation report. If the temperature of receipt is greater than or equal to 11°C, positive values shall be flagged as estimated “J” and nondetects as estimated “UJ.” If the temperature of receipt is greater than or equal to 15°C, positive values shall be flagged as estimated “J” and nondetects as unusable “R.” If the temperature is below 0°C, special note should be made that the samples were frozen and no qualification shall be required. In the event that both a cooler temperature and a temperature blank were measured, the temperature blank shall be evaluated for temperature compliance as it best assimilates the condition of the samples; however, both temperatures shall be noted in the data validation report.

**TPH as Extractables**

1. Samples are to be shipped in coolers that are maintained at above freezing to 6°C. If the temperature exceeds 6°C but is less than or equal to 10°C, note this in the data validation

report. If the temperature of receipt is greater than or equal to 11°C, positive values shall be flagged as estimated "J" and nondetects as estimated "UJ." If the temperature is below 0°C, special note should be made that the samples were frozen and no qualification shall be required. In the event that both a cooler temperature and a temperature blank were measured, the temperature blank shall be evaluated for temperature compliance as it best assimilates the condition of the samples; however, both temperatures shall be noted in the data validation report.

2. Water samples shall not be preserved; they shall only be kept cool. If the water samples were inappropriately preserved with acid, the samples should not be analyzed. Analysis of an inappropriately preserved sample by the laboratory may require that all results be reported as unusable "R."
3. If the temperature of the cooler upon receipt at the laboratory was not recorded, document that the laboratory is noncompliant.

If the receiving laboratory transferred the samples to another laboratory for analysis, apply the same temperature criteria to both the transfer COC and the original COC.

### 4.1.2 Chain of Custody

**Level C and Level D:**

Examine the COC for legibility and check that all TPH analyses requested on the COC have been performed by the laboratory. Ensure that the COC Sample Number on the laboratory Form I (or equivalent) matches the Sample Identification on the COC. Read the laboratory case narrative for additional information.

1. Any samples received for analysis that were not analyzed shall be noted in the data validation report, along with the reason(s) for failure to analyze the samples, if the reason(s) can be determined. Conversely, samples that were analyzed for TPH but were not requested should also be noted.
2. Any discrepancies in sample naming between the COC and Form I (or equivalent) shall be noted in the data validation report with the correct sample name being identified if the correct sample name can be determined.
3. If the receiving laboratory transferred the samples to another laboratory for analysis, both the original COCs and transfer COCs shall be present. Document in the data validation report if the transfer COCs are not present.
4. Internal COC is required for all samples, extracts, and digestates from receipt to disposal. Verify the internal COC forms for completeness. Document in the data validation report if the internal COC forms are not present.
5. Each individual cooler shall have an individual COC that lists only samples contained within that cooler. Document in the data validation report if multiple coolers appear on one COC.

### 4.1.3 Holding Times

**Level C and Level D:**

Holding times for TPH are measured from the time of collection (as shown on the COC) to the time of sample extraction and from the time of sample extraction to the time of sample analysis (as shown on the Form I [or equivalent]). Samples and extracts must be stored and refrigerated at above freezing to 6°C until the time of analysis.

**TPH as Gasoline**

1. Water samples must be preserved with hydrochloric acid and refrigerated at above freezing to 6°C. Preserved water samples shall be analyzed within 14 days from the collection date. If there is no indication of chemical preservation, assume samples are unpreserved. For unpreserved water samples, the holding time is 7 days from date collected.
2. Soil samples collected in VOA vials or coring devices that are unpreserved must be refrigerated at above freezing to 6°C and analyzed within 48 hours from the collection date. Soil samples that are preserved with sodium bisulfate or methanol, or frozen upon laboratory receipt shall be analyzed within 14 days from the collection date.

**TPH as Extractables**

Water samples shall be unpreserved and refrigerated at above freezing to 6°C and shall be extracted within 7 days of collection and analyzed within 40 days of extraction.

Soil samples shall be unpreserved and refrigerated at above freezing to 6°C and shall be extracted within 14 days of collection and analyzed within 40 days of extraction.

1. If the holding time is exceeded, flag all associated positive results as estimated “J” and all associated limits of detection (LODs) (nondetects) as estimated “UJ,” and document that holding times were exceeded.
2. If holding times are grossly exceeded by greater than a factor of 2.0 (e.g., a non-preserved water sample has an extraction holding time of more than 14 days), detects will be qualified as estimated “J” and nondetects as unusable “R.”

## 4.2 GC INSTRUMENT PERFORMANCE

**Level C:**

Instrument performance is not evaluated for Level C validation.

**Level D:**

Evaluate the blank, standard, laboratory control sample, and sample chromatograms to ascertain the performance of the chromatographic system. Professional judgment should be used to qualify the data when unacceptable chromatographic conditions preclude proper quantitation or identification of TPH.

## 4.3 CALIBRATION

Compliance requirements for satisfactory instrument calibration are established to ensure that an instrument is capable of producing acceptable quantitative data. Initial calibration demonstrates that an instrument is capable of acceptable performance at the beginning of a sequence, and continuing calibration checks document satisfactory maintenance and adjustment of the instrument on a day-to-day basis.

**Level C and Level D:**

1. The proper analytical sequence must be followed to ensure proper quantitation and identification of all target compounds. For the quantitation analysis, standards containing all target compounds, (specific hydrocarbon products or n-alkanes) must be analyzed in the initial calibration at the beginning of the sequence. If n-alkane ranges rather than specific hydrocarbon products are being reported, n-alkane standards must be run in the initial calibration and should be analyzed periodically to ensure proper identification of the n-alkane range reported. An initial calibration verification standard must be analyzed following each initial calibration. The mid-level standard of the initial calibration must be analyzed after every 10 samples as the continuing calibration and at the end of the sequence to ensure system performance has not degraded. If the proper sequence has not been analyzed, use professional judgment to assess the reliability of the data.
2. The laboratory should report retention time window data for each compound and each column used to analyze the samples. The retention time windows are used for qualitative identification. The laboratory should also report quantitation ranges used for integration when analyzing samples. If the compounds in the continuing calibration standard do not fall within the retention time windows established in the initial calibration, the associated sample results should be carefully evaluated, especially the retention time of the surrogate spike compound. All samples injected after the last in-control standard are potentially affected.

### 4.3.1 Initial Calibration

**Level C and Level D:**

For the initial calibration (at least five-points), the relative standard deviation (RSD) of the calibration factor (CF) for each target compound must be less than or equal to 20 percent. Verify the RSDs from the initial calibration summary forms. Alternatively, a linear curve may be used with a coefficient of determination; $r^2$ equal to or greater than 0.990. A second order calibration curve may also be used after evaluating the laboratory's acceptance criteria. If the initial calibration criteria are not met, flag all associated quantitative results as estimated “J” for detects and estimated “UJ” for nondetects.

**Level D:**

Verify the percent RSDs, $r^2$, or laboratory established measure of linearity for the initial calibration from the raw data. Verify the CF for each target compound from the raw data on the low-point calibration standard and one additional calibration standard. If errors are discovered, request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

### 4.3.2 Initial Calibration Verification

The initial calibration curve must be verified with a standard that has been purchased or prepared from an independent source each time initial calibration is performed. A standard from the same manufacturer but independently prepared from different source materials may also be used as an independent source. This initial calibration verification (ICV) must contain all of the method target compounds.

**Level C and Level D:**

1. Verify the ICV was analyzed following the initial calibration and contained all method target compounds.
2. If any target analyte has a percent difference (%D) greater than 20 percent, flag detects for the affected compounds as estimated “J” and nondetects as estimated “UJ” in all samples associated with the initial calibration.

**Level D:**

Verify from the raw data that there were no calculation or transcription errors by recalculating a percentage of the ICV calculations.

### 4.3.3 Continuing Calibration

**Level C and Level D:**

Verify the %D from the continuing calibration summary forms. For the continuing calibration, the %D between the CF from the continuing calibration and the average CF from the initial calibration must be less than 20 percent. Alternatively, if a linear (first-order) calibration curve is utilized in the initial calibration, the %D of the calculated amount and the true amount for each compound must be less than or equal to 20 percent. If the continuing calibration criteria are not met, qualify all associated results as estimated “J” for detects and “UJ” for nondetects.

**Level D:**

Verify the %Ds from the raw data.

## 4.4 BLANKS

Method blank analytical results are assessed to determine the existence and magnitude of contamination problems. If problems with any method blank exist, all associated data must be carefully evaluated to determine whether there is any bias associated with the data, or if the problem is an isolated occurrence not affecting other data. No contaminants should be present in the method blank(s). The method blank should be analyzed on each GC system used to analyze site samples.

1. The reviewer should identify samples associated with each method blank using Form IV (or equivalent). Verify that method blank analysis has been reported per matrix and concentration level for each set of samples. Each sample must have an associated method blank. Qualify positive results in samples with no method blank as unusable “R.” Nondetects do not require qualification.
2. If the method blank was not analyzed on a GC used to analyze site samples, note the deficiency in the data validation report. Professional judgment shall be used for subsequent qualification of the data.
3. Compare the results of each method blank with the associated sample results. The reviewer should note that the blank analyses may not involve the same weights, volumes, percent moistures, or dilution factors as the associated samples. These factors must be taken into consideration when applying the criteria discussed below, such that a comparison of the total amount of contamination is actually made.

4. If a compound is found in the blank, but not in the associated sample, no action is taken.
5. Any compound detected in both the sample and the associated blank shall be qualified when the sample concentration is less than the limit of quantitation (LOQ) and the blank concentration is less than, greater than, or equal to the LOQ. Care should be taken to factor in the percent moisture when comparing detects in the sample and the method blank. The applicable review qualifier(s) are summarized in Table II-H-1.

**Table II-H-1: Blank Qualifications**

| Sample Result | Sample Value | Reviewer Qualifier(s) |
|---|---|---|
| Less than LOQ and blank result is <, > or = LOQ | Leave as reported | U |
| ≥LOQ, blank result is <LOQ | Leave as reported | None |
| ≥LOQ, blank result is >LOQ and sample result <blank result | Leave as reported | Use professional judgment |
| ≥LOQ, blank result is >LOQ and sample result ≥blank result | Leave as reported | Use professional judgment |
| ≥LOQ and blank result is = LOQ | Leave as reported | Use professional judgment |

6. In the case wherein both the sample concentration and the blank concentration are greater than or equal to the LOQ, previously approved criteria as identified in the project planning documents may be applied to qualify associated sample results. Otherwise, qualify sample results as non-detect “U” when the sample concentration is less than or equal to 5 times the blank concentration (5× rule).
7. Instances of contamination can be attributable to the dilution process. These occurrences are difficult to determine; however, the reviewers should qualify the sample data as nondetects, “U,” when the reviewer determines the contamination to be from a source other than the sample.
8. In the event of gross contamination (i.e., saturated peaks) in the blanks, the associated samples must be evaluated for gross contamination. If gross contamination exists in the samples, the affected compounds should be qualified as unusable, “R.”

**Level D:**

1. Verify from the preparation log that the information recorded on Form IV (or equivalent) is correct.
2. Review the results of all blank raw data and Form I (or equivalent) to ensure that there were no false negatives or false positives.
3. Verify all target compound detects found in the method blanks against the raw data. Follow the guidelines specified in Sections 4.9 and 4.10 of this procedure. After the validity of the target compounds are verified, validate the corresponding data using the criteria outlined above for Level C and Level D validation.

## 4.5 BLANK SPIKES AND LABORATORY CONTROL SAMPLES

Blank spike/laboratory control sample (LCS) recoveries must be within the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established for a given sample matrix. Use in-house limits if compounds are not listed in Appendix C or project limits are not specified.

**Level C and Level D:**

1. If the blank spike/LCS results are 0 percent, only the spiked compounds that showed low recovery in all associated samples shall be flagged as unusable “R” for nondetects and estimated “J” for detects.
2. If blank spike/LCS results are below the control limits (but above 0 percent), spiked compounds which showed low recovery in all associated samples shall be flagged as estimated “UJ” or “J.”
3. If blank spike/LCS results are above the control limits, detects for only the spiked compounds which showed high recovery in all associated samples shall be flagged as estimated “J.”
4. If the laboratory analyzes a blank spike duplicate/LCS duplicate (LCSD), evaluate and qualify the LCSD results using the criteria noted above.
5. If the relative percent differences (RPDs) between LCS and LCSD results are above the control limits (use the matrix spike [MS]/matrix spike duplicate [MSD] RPD control limits identified in DoD QSM Appendix B, if none are available use laboratory in-house limits), spiked compounds which showed high RPD in all associated samples shall be flagged as estimated “UJ” or “J.”

**Level D:**

To verify that the spike percent recovery was calculated and reported correctly using the following equation, recalculate one spike recovery per matrix (and any spike that would result in the qualification of a sample).

$$\%\text{Recovery} = \frac{Q_d}{Q_a} \times 100$$

Where:

$Q_d$ = Quantity determined by analysis

$Q_a$ = Quantity added to samples/blanks

If transcription errors are discovered on Form III (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

## 4.6 SURROGATE RECOVERY

Laboratory performance on individual samples is established by means of surrogate spiking activities. All samples are spiked with surrogate compounds prior to sample preparation. The evaluation of the results of these surrogate spikes is not necessarily straightforward. The sample itself may produce effects because of factors such as interferences and high concentrations of compounds. Since the effects of the sample matrix are frequently outside the control of the laboratory and may present relatively unique problems, the review and validation of data based on specific sample results is frequently subjective and demands analytical experience and professional judgment. The following procedures shall be followed:

**Level C and Level D:**

Sample and blank surrogate recoveries for TPH must be within the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established. Use in-house limits if surrogates are not listed in Appendix C or project limits are not specified. Verify that no samples or blanks have surrogates outside the criteria from Form II (or equivalent).

1. If recovery is below the QC limits for any of the surrogates, but above or equal to 10 percent, flag associated positive results as estimated “J” and nondetects as “UJ.”
2. If any surrogate recovery is less than 10 percent, flag all nondetects as unusable “R” and detects as estimated “J.” No qualification is applied if surrogates are diluted beyond detection but note in the data validation report that surrogate evaluation could not be performed due to the high dilution factor.
3. If any surrogate recovery is above the upper QC limit, flag associated positive results as estimated “J.” No qualification of nondetects is necessary in the case of high recoveries.
4. Surrogates may be reported as “diluted out” (D); if dilution is such that the surrogate can no longer be detected. If this is the case, note in the data validation report that surrogate evaluation could not be performed due to a high dilution factor. A full evaluation of the sample chromatogram may be necessary to determine that surrogates are truly “diluted out.”

**Level D:**

The reported surrogate recoveries on Form II should be verified from the raw data for a representative number of samples.

## 4.7 MATRIX SPIKE/MATRIX SPIKE DUPLICATE

MS/MSD data are used to determine the effect of the matrix on a method’s recovery efficiency and precision for a specific sample matrix.

No action is taken on MS/MSD data alone to qualify an entire data package. Using informed professional judgment; however, the data reviewer may use the MS/MSD results in conjunction with other QC criteria (i.e., surrogates and LCS) and determine the need for some qualification of the data.

The data reviewer should first try to determine the extent to which the results of the MS/MSD affect the associated data. This determination should be made with regard to the MS/MSD sample itself, as well as specific compounds for all samples associated with the MS/MSD.

In those instances where it can be determined that the results of the MS/MSD affect only the sample spiked, then qualification should be limited to this sample alone. It may be determined through the

MS/MSD results, however, that a laboratory is having a systematic problem in the analysis of one or more compounds, which affects all associated samples.

Note: If a field blank was used for the MS/MSD, the information must be included in the data validation summary. Sample matrix effects have not been observed with field blanks therefore the recoveries and precision do not reflect the analytical impact of the site matrix.

**Level C and Level D:**

The laboratory must spike and analyze a MS/MSD from the specific project site as required for each matrix type and analytical batch.

1. MS/MSD data should be reported on a MS/MSD summary form similar to Form III (or equivalent).
2. Compare the percent recovery (%R) and RPD for each spiked compound with the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established. Use in-house limits if spiked compounds are not listed in Appendix C or project limits are not specified.
3. If MS/MSD results are 0 percent, only the spiked compounds that showed low recovery in the parent sample shall be flagged as unusable “R” for nondetects and estimated “J” for detects.
4. If MS/MSD results are below the control limits (but above 0 percent), spiked compounds which showed low recovery in the parent sample shall be flagged as estimated “UJ” or “J.”
5. If MS/MSD results are above the control limits, detects for only the spiked compounds which showed high recovery in the parent sample shall be flagged as “J.”
6. If the RPDs between MS and MSD results are greater than 30 percent, detects for only the spiked compounds which showed high RPD in the parent sample shall be flagged as estimated “J.”
7. Failure of MS/MSD due to the presence of a target compound in the parent sample at greater than 2 times the spike concentration and or diluted by more than a factor of 2 should not result in any qualifications. Note the incident in the data validation report.

**Level D:**

Check the raw data and recalculate one or more %Rs and RPDs, especially %Rs and RPDs that resulted in the qualification of data, using the following equations to verify that results on Form III (or equivalent) are correct.

$$\%R = \frac{(SSR - SR)}{SA} \times 100$$

$$RPD = \frac{ABS|SSR - SDR|}{(SSR + SDR)/2} \times 100$$

Where:

SA = spike added

SR = sample result

SSR = spiked sample result

SDR = spiked duplicate result

ABS = absolute value

If transcription errors are discovered on Form III (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

## 4.8 FIELD QC SAMPLES

Field QC samples discussed in this section of the procedures are equipment blanks, field blanks, field duplicates, and field triplicates.

### 4.8.1 Equipment Blanks and Field Blanks

Compounds detected in equipment blanks indicate the possibility of cross-contamination between samples due to improper equipment decontamination.

A field blank sample may be collected from each source of water used during each sampling event. The field blank may be analyzed to assess whether the chemical nature of the water used in decontamination may have affected the analytical results of site samples.

If TPH compounds are detected in the equipment blanks and/or field blanks, the procedure for the qualification of associated sample results is identical to the criteria outlined in Section 4.4 of this procedure.

**Level C and Level D:**

1. Determine which field QC samples apply to samples in the sample deliver group.
2. Ensure that units are correct when applying field QC blank qualifications. If samples are soil matrix, results must first be converted to micrograms per liter from micrograms per kilogram to make correct comparisons.
3. Because of the way in which the field blanks and equipment blanks are sampled, equipment blanks are not qualified because of field blank contamination. The affected samples are qualified, however, by either the field blank or equipment blank results, whichever has the higher contaminant concentration.
4. Equipment blanks and field blanks are only qualified with method blank results in order to account for laboratory contamination.

**Level D:**

Compound identification and quantification of field blank and equipment blank samples must be verified. Follow the guidelines specified in Sections 4.9 and 4.10 of this procedure.

### 4.8.2 Field Duplicates and Field Triplicates

Field duplicates consist of either collocated or subsampled samples. Field duplicates for ground water and surface water samples are generally considered to be collocates. Soil duplicate samples may be homogenized and subsampled in the field (or at the laboratory) to form an original and duplicate sample, or may be an additional volume of sample collected in a separate sample container to form a collocate sample. Field duplicate results are an indication of both field and laboratory precision; the results may be used to evaluate the consistency of sampling practices.

Field triplicates are collected from different, randomly selected locations to verify that an incremental sample truly represents a decision unit. Field triplicate results are more useful than field duplicates to statistically evaluate sampling precision.

**Level C and Level D:**

1. Check to ensure that field duplicates were collected and analyzed as specified in the project planning documents. If the sampling frequency is less than the frequency stated in the planning documents, no qualification of the associated sample results is necessary but the incident shall be discussed in the data validation report.
2. For field duplicate results, if the RPDs are greater than 50 percent for water or 100 percent for soil or as stated in the planning document if more conservative, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.
3. For field triplicate results, if the RSDs are greater than the QC limits stated in the planning document, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.

**Level D:**

Before comparison of duplicates and/or triplicates, the compound identification and quantification must be verified. Follow the guidelines specified in Sections 4.9 and 4.10 of this procedure.

## 4.9 TARGET COMPOUND IDENTIFICATION

Qualitative criteria for compound identification have been established to minimize the number of erroneous identifications of compounds. An erroneous identification can be either a false positive (reporting a compound present when it is not) or a false negative (not reporting a compound that is present).

**Level C:**

Compound identification is not verified for Level C validation.

**Level D:**

1. Review Form I or equivalent. Check for errors.

2. Verify that the retention times of sample compounds reported on the Form X or equivalent fall within the calculated retention time windows.
3. Evaluate all sample chromatograms to ensure that the TPH results were properly identified. Presence of unknown single peaks may result in false positives or false negatives. The reviewer should use professional judgment in evaluating the effect of interference.

## 4.10 COMPOUND QUANTITATION AND REPORTING LIMITS

The objective is to ensure that the reported quantitation results and reporting limits (i.e., LOQ, LOD, detection limit [DL]) are accurate. All soil sample results are reported on a dry weight basis.

**Level C:**

Specific compound quantitation is not verified for Level C validation.

**Level C and Level D:**

1. Verify that the reporting limits for nondetects are equal to the LODs. Verify that an annual DL study was performed or quarterly LOD/LOQ verification checks were performed in accordance with the DoD QSM. The LOD/LOQ verification check must be evaluated to determine whether the laboratory can reliably detect and identify all target analytes at a spike concentration of approximately two times but not more than four times the current reported DL. Qualify nondetects as unusable “R.”
2. Check that reported nondetects and positive values have been adjusted to reflect sample dilutions and for soil samples, sample moisture. When a sample is analyzed at more than one dilution, the lowest LODs are used unless a QC criterion has been exceeded. In this case, the higher LODs from the diluted analysis are used. The least technically sound data will be flagged “R” with a qualification code “D.”
3. Verify that reported limits for soils and sediments were calculated based on dry weight. If the LOQs/LODs were reported based on wet weight, the percent moisture must be factored in and the LOQs/LODs must be adjusted accordingly.
4. If a sample requiring a dilution analysis due to a target compound detect exceeding the calibration linear range was not re-analyzed at a dilution, the compound exceeding calibration range shall be qualified as estimated “J.”
5. If the laboratory re-analyzed a sample and submitted both sample results, the reviewer must determine which of the two analyses has better data quality. Only one analysis should be reported and the other is rejected.

**Level D:**

1. Compound quantification should be verified by recalculation from the raw data for a representative number of samples.
2. Verify from the standard chromatograms that the instrument sensitivity is adequate to support the LODs. Poor sensitivity may result in elevated LODs.

## 5. Records

A Form I that has been validated and verified, and has been determined by the data validator to accurately represent the appropriate sample results to be utilized, shall be stamped "NAVFAC PACIFIC VALIDATED." Additionally, sample result forms for which the data has been validated at the Level D validation level shall be stamped or noted "Level D."

Copies of all documents generated by the data validation personnel will be stored for no less than 10 years. The original validated laboratory data shall be archived to the Federal Records Center at project completion.

## 6. References

Department of Defense, United States (DoD). 2005a. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

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Environmental Protection Agency, United States (EPA). 2007. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* 3rd ed., Final Update IV. Office of Solid Waste. Updates available: www.epa.gov/epaoswer/hazwaste/test/new-meth.htm.

Procedure II-A, *Data Validation*.

## 7. Attachments

None.

# Level C and Level D Data Validation for Wet Chemistry Analyses

## 1. Purpose

This data validation procedure sets forth the standard operating procedure for performance of Level C and Level D data validation of wet chemistry parameters data obtained under the United States (U.S.) Navy Environmental Restoration (ER) Program for Naval Facilities Engineering Command (NAVFAC), Pacific and is consistent with protocol in the *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories* (DoD QSM) (DoD 2013). Cursory validation is addressed separately in Procedure II-A, *Data Validation*.

It covers the following parameters:

- Alkalinity (Standard Methods for the Examination of Water and Wastewater Method 2320B and U.S. Environmental Protection Agency [EPA] Method 310.1 [EPA 2007])
- Bromide, Chloride, Fluoride, Nitrate, Nitrite, Orthophosphate, and Sulfate (EPA Method Solid Waste [SW]-846 9056 and EPA Method 300.0)
- Chemical oxygen demand (EPA Method 410)
- Chloride (EPA Method 325.3)
- Chromium VI (EPA Method SW-846 7195/7196A/7197/7198/7199 and EPA method 218.6 and 218.7)
- Cyanide (EPA Method SW-846 9010B/9012A and EPA Method 335)
- Fluoride (EPA Method 340.2)
- Surfactants (M.B.A.S.) (EPA Method 425.1)
- Nitrate/Nitrite (EPA Method 353.2 and 353.3)
- Perchlorate (EPA Method 314.0)
- Phosphate (EPA Method 365.3)
- Sulfate (EPA Methods 375.3 and 375.4)
- Sulfide (EPA Method 376.1)
- Total dissolved solids (EPA Method 160.1)
- Total suspended solids (EPA Method 160.2)
- Total organic carbon (EPA Method SW-846 9060, Lloyd Kahn, and Walkley-Black)
- Total organic halides (EPA Method SW-846 Method 9020)
- Total recoverable petroleum hydrocarbons (EPA Method 418.1)
- pH (EPA Method SW-846 Method 9040 and EPA Method 150.1)
- Total hardness (Standard Methods for the Examination of Water and Wastewater Method 314A and EPA Method 130.1)

## 2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

## 3. Responsibilities

The CTO Manager, the QA Manager or Technical Director, and the CTO QA Coordinator are responsible for ensuring that this procedure is implemented by data validation personnel.

Data validation personnel are responsible for implementing this procedure for validation of all wet chemistry data.

## 4. Procedures

This procedure addresses the validation of wet chemistry parameters data obtained using EPA Method SW-846 7195/7196A/7197/7198/7199/9000, *Standard Methods for the Examination of Water and Wastewater*, 21st Edition, 2005, (APHA 2005) and EPA *Methods for Chemical Analysis of Water and Wastes*, revised March 1983 (EPA 1983). The quality control (QC) criteria identified in this procedure are those specified in the analytical method and the DoD QSM (DoD 2013). Where project specific criteria are identified in the CTO work plan, they will supersede the QC criteria identified in this procedure.

- Form I: Sample Results Summary Form
- Form II: Initial and Continuing Calibration Verification Form
- Form III: Blanks Form
- Form V: Spike Sample Recovery Form
- Form VI: Duplicates Form
- Form VII: Laboratory Control Sample Form
- Form XIII: Preparation Log Form
- Form XIV: Analysis Run Log Form

Level C data validation consists of review of summary forms only while Level D data validation requires review of both summary forms and all associated raw data. Data review guidelines and how they apply to the different validation levels are indicated in the following text.

## 4.1 SAMPLE MANAGEMENT

QA/QC criteria included under sample management are sample preservation, handling, and transport; chain of custody (COC); and holding times.

### 4.1.1 Sample Preservation, Handling, and Transport

**Level C and Level D:**

Evaluate sample collection, handling, transport, and laboratory receipt from COC and laboratory receipt checklists to ensure that the samples have been properly handled. All samples must be stored at less than 6 degrees Celsius (°C). Water samples for the following analyses should be preserved as listed below or as specified in the analytical method:

- Chemical Oxygen Demand (COD) – Sulfuric acid to pH < 2
- Cyanide – NaOH to pH > 12
- Nitrate/Nitrite – Sulfuric acid to pH < 2
- Sulfide – Zinc acetate and NaOH to pH > 9
- Total Recoverable Petroleum Hydrocarbons – Sulfuric or hydrochloric acid to pH < 2
- Total Phosphorus – Sulfuric acid to pH < 2
- Total Organic Carbon (TOC) - Sulfuric or hydrochloric acid to pH < 2
- Total Organic Halides (TOX) – Sulfuric acid to pH < 2
- Total Hardness – Nitric acid to pH < 2

1. Any sample improperly preserved or arriving at the laboratory in a broken container shall be noted in the data validation report. If there is no indication of chemical preservation, assume samples are unpreserved. Professional judgment may result in the results of an analysis of an inappropriately preserved sample by the laboratory being qualified as estimated “J” or “UJ.” In extreme cases (a preservation destructive to the analyte of interest) the sample data may be qualified as unusable, “R.”
2. If any sample arriving at the laboratory for analysis is not refrigerated or the temperature of any cooler containing samples exceeds 4 ±2°C, this shall be noted in the data validation report; however, no qualification of data will be required.
3. If the temperature of the cooler was not recorded upon its receipt at the laboratory, document that the laboratory is noncompliant.

### 4.1.2 Chain of Custody

**Level C and Level D:**

Examine the COC for legibility and check that all wet chemistry analyses requested on the COC have been performed by the laboratory. Ensure that the COC Sample Number on the laboratory Form I matches the Sample Identification on the COC. Read the laboratory case narrative for additional information.

1. Verify collect dates, sampling times, and time zones. This is critical to evaluating parameters with short holding times.
2. Any samples received for analysis that were not analyzed shall be noted in the data validation report, along with the reason(s) for failure to analyze the samples, if the reason(s) can be determined. Conversely, samples that were analyzed for wet chemistry parameters but were not requested should also be noted.
3. Any discrepancies in sample naming between the COC and sample results form shall be noted in the data validation report with the correct sample name being identified if the correct sample name can be determined.
4. If the receiving laboratory transferred the samples to another laboratory for analysis, both the original COCs and transfer COCs shall be present. Document in the data validation report if the transfer COCs are not present.
5. Internal chain of custody is required for all samples, extracts, and digestates from receipt to disposal. Verify the internal COC forms for completeness. Document in the data validation report if the internal COC forms are not present.
6. Each individual cooler shall have an individual COC that lists only samples contained within that cooler. Document in the data validation report if multiple coolers appear on one COC.

### 4.1.3 Holding Times

Holding times for water samples shall be those given in the most recent version of 40 Code of Federal Regulations (CFR) Part 136 or SW-846, Volume 1, Section C, if not specified in 40 CFR, art 136, or those specified in the analytical method. Holding times are determined from the time of sample collection to the time of sample analysis. Water holding times will be applied to soil/sediment samples. Current water holding times are as follows:

- Alkalinity – 14 days
- Bromide – 28 days
- COD – 28 days
- Chloride – 28 days
- Chromium (VI) – 24 hours for unpreserved water samples (14 days from lab preservation); 28 days for soil samples
- Cyanide – 14 days
- Fluoride – 28 days
- Surfactants (M.B.A.S.) – 48 hours
- Nitrate – 48 hours for water samples; 28 days for soil samples
- Nitrite – 48 hours for water samples; 28 days for soil samples
- Nitrate/Nitrite – 28 days
- Orthophosphate – 48 hours for water samples; 28 days for soil samples
- Perchlorate – 28 days

- Sulfate – 28 days
- Sulfide – 7 days
- Total Phosphorus – 28 days
- Total Dissolved Solids – 7 days
- Total Suspended Solids – 7 days
- TOC – 28 days
- TOX – 28 days (7 days if not preserved)
- Total Recoverable Petroleum Hydrocarbons – 28 days
- pH – immediate upon sampling for water samples; 28 days for soil samples
- Total Hardness – 6 months

**Level C and Level D:**

If holding times are exceeded, flag all results greater than the detection limit (DL) or limit of quantitation (LOQ) as estimated "J" and all results less than the DL or LOQ as estimated "UJ" and document that holding times were exceeded. If holding times are grossly exceeded, the reviewer may determine that the data reported as nondetects are unusable "R." Data will not be qualified unusable "R" unless the holding time was exceeded by more than a factor of 2.

## 4.2 CALIBRATION

Compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable quantitative data. Initial calibration demonstrates that the instrument is capable of acceptable performance at the beginning of the analysis run. Continuing calibration documents that the initial calibration is still valid and that maintenance and adjustment of the instrument on a day-to-day basis is satisfactory.

### 4.2.1 The Initial Calibration

Compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable quantitative data. Initial calibration demonstrates that the instrument is capable of acceptable performance at the beginning of the analysis run.

**Level C and Level D:**

A blank and at least three standards must be used in establishing the analytical curve.

If the correlation coefficient is below 0.995, qualify all associated detects as estimated "J" and all nondetects as "UJ." If the correlation coefficient is significantly lower than 0.995, professional judgment may be used to reject, "R," the analytes associated with the initial calibration.

**Level D:**

Recalculate the correlation coefficient for all initial calibrations. Verify from the raw data that appropriate concentration and number of standards were utilized to establish analytical curves and the associated correlation coefficients.

### 4.2.2 Initial Calibration Verification (ICV) and Continuing Calibration Verification (CCV)

The working calibration curve must be verified at the interval of 10 percent to ensure that the system performance has not degraded. Continuing calibration documents that the initial calibration is still valid and that maintenance and adjustment of the instrument on a day-to-day basis is satisfactory. Calibration must be verified with an independently prepared check standard.

**Level C and Level D:**

Review the ICV and CCV percent recovery (%R) forms. Analysis results must fall within the control limits of 90–110 percent recovery of the true value except perchlorate. Analysis results for perchlorate must fall within the control limits of 75–125 percent recovery of the true value for the ICV and 85–115 percent recovery of the true value for the CCV.

1. Due to possible rounding discrepancies, allow the results to fall within 1 percent of the acceptance windows (e.g., 89–111 percent).
2. If after a failing CCV, two additional consecutive CCVs are analyzed immediately, and both additional CCVs are within the control limits, the data is acceptable. If either of the additional CCVs is not within control limits, then the associated data will need qualification. See below for the recommended qualification guidelines.
3. If the ICV or CCV %R falls outside the acceptance windows, use professional judgment to qualify all associated data. If possible, indicate the bias in the technical review. The following guidelines are recommended:
   a. If the ICV or CCV %R falls outside the acceptance windows but within the ranges of 75–89 percent or 111–125 percent (perchlorate, 70–84 percent or 116–130 percent), qualify results greater than the DL as estimated “J.”
   b. If the ICV or CCV %R is within the range of 111–125 percent (perchlorate, 116-130 percent), results less than the DL are acceptable.
   c. If the ICV or CCV %R is 75–89 percent (perchlorate, 70–84 percent), qualify results less than the DL as nondetected and estimated “UJ.”
   d. If the ICV or CCV %R is less than 75 percent (perchlorate, less than 70 percent), qualify all results as unusable “R.”
   e. If the ICV or CCV %R is greater than 125 percent (perchlorate, greater than 130 percent), qualify results greater than the DL as unusable “R”; results less than the DL are acceptable.

**Level D:**

1. Recalculate and verify one or more of the ICV and CCV %Rs per type of analysis using the following equation for %R. Once again, to correct for possible rounding discrepancies, let the results fall within 1 percent of the contract windows (e.g., 89–111 percent).

$$\%\text{Recovery} = \frac{Q_d}{Q_a} \times 100$$

Where:

$Q_d$ = Concentration (in micrograms per liter [µg/L]) of each analyte measured in the analysis of the ICV or CCV solution.

$Q_a$ = Concentration (in µg/L) of each analyte in the ICV or CCV source.

2. If discrepancies are discovered on any form, request a resubmittal from the laboratory and validate according to the criteria outlined above.

## 4.3 BLANKS

Method (preparation) and calibration blank analyses results are assessed to determine the existence and magnitude of laboratory contamination problems. If problems with any blank exist, all data associated with the blank must be carefully evaluated to determine whether there is a bias on the data, or if the problem is an isolated occurrence not affecting data.

### 4.3.1 Calibration Blanks

**Level C and Level D:**

1. If the blank is less than the LOQ and the samples results are greater than the DL but less than the LOQ, then qualify “U” at the result.
2. If the blank is less than the LOQ and the sample results are greater than the LOQ or nondetect, the data is acceptable.
3. If the blank is greater than the LOQ, then samples less than 5x the blank will be qualified as “U” at the concentration. Samples greater than 5x the blank are acceptable.
4. For negative blanks where the absolute value of the blank is greater than the LOQ, sample results that are less than 10x the absolute value of the negative blank qualify “J” for detect and ‘UJ” for nondetect results. Results that are greater than 10x the absolute value of the negative blank are acceptable.

Ensure that units are correct when applying calibration blank qualifications. If samples are soil matrix, results must first be converted to µg/L from milligrams per kilogram to make correct comparisons.

**Level D:**

Verify one or more of the calibration blank results per type of analysis by comparing the Form III to the raw data. After the validity of the target analytes are verified, validate the corresponding data using the criteria outlined above for Level C and Level D validation.

### 4.3.2 Method (Preparation) Blanks

**Level C and Level D:**

At least one method blank must be prepared with each batch of samples. If a method blank was not prepared and analyzed as required, the reviewer may qualify associated sample results less than the DL as nondetected and estimated “UJ,” and sample results greater than the MDL as estimated “J.”

Professional judgment should be utilized, however, taking into account the results of other associated blanks (e.g., initial calibration blank, continuing calibration blank).

If analytes of interest are detected in the method blanks, the procedure for the qualification of associated sample results is identical to the rules outlined in Section 4.3.1 of this procedure.

**Level D:**

Verify out-of-control method blanks that result in the qualification of numerous analytes against the raw data. Verify the results reported on Form III. After the validity of the target analytes are verified, validate the corresponding data using the criteria outlined above for Level C and Level D validation.

## 4.4 BLANK SPIKES AND LABORATORY CONTROL SAMPLES

Blank spike/laboratory control sample (LCS) recoveries must be within the QSM Appendix C limits specified in the DoD QSM unless project-specific control limits are established for a given sample matrix. Use in-house limits if analytes are not listed in Appendix C or project limits are not specified.

**Level C and Level D:**

1. If the blank spike/LCS results are less than 50 percent, only the spiked analytes that showed low recovery in all associated samples shall be flagged as “R” for nondetects and “J” for detects.
2. If blank spike/LCS results are below the control limits (but above 50 percent), spiked analytes that showed low recovery in all associated samples shall be flagged as estimated “UJ” or “J.”
3. If blank spike/LCS results are above the control limits, detects for only the spiked analytes that showed high recovery in all associated samples shall be flagged as “J.”
4. If the laboratory analyzes a blank spike duplicate/LCS duplicate (LCSD), evaluate and qualify the LCSD results using the criteria noted above.
5. If the relative percent differences (RPDs) between LCS and LCSD results are above the control limits (use the matrix spike [MS]/matrix spike duplicate [MSD] RPD control limits identified in DoD QSM Appendix B, if none are available use laboratory in-house limits), spiked compounds which showed high RPD in all associated samples shall be flagged as estimated “UJ” or “J.”

**Level D:**

To check that the spike %R was calculated and reported correctly using the following equation, recalculate one spike recovery per matrix (and any spike that would result in the qualification of a sample).

$$\%\text{Recovery} = \frac{Q_d}{Q_a} \times 100$$

Where:

$Q_d$ = Quantity determined by analysis

$Q_a$ = Quantity added to samples/blanks

If transcription errors are discovered on Form VII (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

## 4.5 MATRIX SPIKE/MATRIX SPIKE DUPLICATE AND MATRIX DUPLICATE

MS/MSD and matrix duplicate (MD) data are used to determine the effect of the matrix on a method's recovery efficiency and precision for a specific sample matrix. MD analyses are also performed to demonstrate acceptable method precision by the laboratory at the time of analysis.

If the MS/MSD and MD results do not meet the technical criteria, apply the action to the source sample only.

MS/MSD results should be within the QC limits specified in the DoD QSM Appendix C unless project-specific control limits are established for a given sample matrix. Use in-house limits if spiked analytes are not listed in Appendix C or project limits are not specified.

For the MD RPD, samples greater than 5× the LOQ use RPD to evaluate. For samples less than 5× the LOQ, use the difference between the MD and the sample unless project limits are specified. For difference use 1× the LOQ as the control limit for water samples and 2× the LOQ as the control limit for soil samples unless project limits are specified.

**Level C and Level D:**

1. The laboratory must spike and analyze a MS/MSD or MD from the specific project site as required for each matrix type and analytical batch.
2. MS/MSD data should be reported on a MS/MSD summary form similar to Form V. MD data should be reported on a MD summary form similar to Form VI.
3. If MS/MSD results are below the control limits, spiked analytes that showed low recovery shall be flagged as estimated "UJ" or "J."
4. If MS/MSD results are above the control limits, detects for only the spiked analytes that showed high recovery shall be flagged as "J."
5. If the RPD between MS and MSD recoveries or the RPD or difference between the MD and sample are greater than 15 percent, qualify the sample as estimated "UJ" or "J."
6. Failure of MS/MSD due to the presence of a target analyte in the parent sample at greater than four times the spike concentration should not result in any qualifications. Note the incident in the data validation report.

**Level D:**

Check the raw data and recalculate one or more %Rs, especially %Rs that resulted in the qualification of data, using the following equation to verify that results on Forms V and VI (or equivalent) are correct.

$$\%R = \frac{(SSR - SR)}{SA} \times 100$$

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$$RPD = \frac{ABS|SSR - SDR|}{(SSR + SDR)/2} \times 100$$

Where:

SA = spike added
SR = sample result
SSR = spiked sample result
SDR = spiked duplicate result
ABS = absolute value

If transcription errors are discovered on Forms V or VI (or equivalent), request a resubmittal from the laboratory. Validate the data according to the criteria outlined above.

## 4.6 SAMPLE RESULT VERIFICATION

**Level C:**

Level C validation does not require the evaluation of raw data, sample result verification is not required. All soil sample results are reported on a dry weight basis.

**Level D:**

The raw data should be examined to verify that the correct calculation of the sample results was reported by the laboratory. Sample preparation logs, instrument printouts, strip charts, etc. should be compared to the reported sample results recorded on the sample results summary forms. All soil sample results are reported on a dry weight basis.

1. Evaluate the raw data for any anomalies (i.e., baseline shifts, negative absorbance, omissions, legibility).
2. Verify that there are no errors in transcription or calculation. If errors are discovered, request a resubmittal from the laboratory and validate the data according the criteria outlined above.
3. Verify that results fall within the calibrated range. If the positive sample result falls outside the calibrated range, qualify the sample result “J.”

## 4.7 FIELD QC SAMPLES

Field QC samples discussed in this section of the procedure are equipment blanks, field blanks, field duplicates, and field triplicates. Analytical results for field QC samples are utilized to qualify associated sample results.

### 4.7.1 Equipment Blanks and Field Blanks

Analytes detected in equipment blanks indicate the possibility of cross-contamination between samples due to improper equipment decontamination.

A field blank sample may be collected from each source of water used during each sampling event. The field blank may be analyzed to assess whether the chemical nature of the water used in decontamination may have affected the analytical results of site samples.

If analytes are detected in the equipment blanks and/or field blanks, the procedure for the qualification of associated sample results is identical to the criteria outlined in Section 4.3.1 of this procedure.

**Level C and Level D:**

1. Determine which field QC samples apply to samples in the sample delivery group.
2. Ensure that units are correct when applying field QC blank qualifications. If samples are soil matrix, results must first be converted to µg/L from micrograms per kilogram to make correct comparisons.
3. Because of the way in which the field blanks and equipment blanks are sampled, equipment blanks are not qualified because of field blank contamination. The affected samples are qualified, however, by either the field blank or equipment blank results, whichever has the higher contaminant concentration.
4. Equipment blanks and field blanks are only qualified with method blank results in order to account for laboratory contamination.

**Level D:**

1. Verify all target analytes found in the equipment blanks and field blanks against the raw data.
2. After the validity of the target analytes are verified, validate the corresponding data using the criteria outlined above for Level C and Level D validation.

### 4.7.2 Field Duplicates and Field Triplicates

Field duplicates consist of either collocated or subsampled samples. Field duplicates for ground water and surface water samples are generally considered to be collocates. Soil duplicate samples may be homogenized and subsampled in the field (or at the laboratory) to form an original and duplicate sample, or may be an additional volume of sample collected in a separate sample container to form a collocate sample. Field duplicate results are an indication of both field and laboratory precision; the results may be used to evaluate the consistency of sampling practices.

Field triplicates are collected from different, randomly selected locations to verify that an incremental sample truly represents a decision unit. Field triplicate results are more useful than field duplicates to statistically evaluate sampling precision.

**Level C and Level D:**

1. Check to ensure that field duplicates and/or field triplicates were collected and analyzed as specified in the project planning documents. If the sampling frequency is less than the frequency stated in the planning documents, no qualification of the associated sample results is necessary but the incident shall be discussed in the data validation report.

2. For field duplicate results, if the RPDs are greater than 50 percent for water or 100 percent for soil or as stated in the planning document if more conservative, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.
3. For field triplicate results, if the RSDs are greater than the QC limits stated in the planning document, no qualification of the associated sample results is necessary, but the differences should be noted in the data validation summary.

**Level D:**

Verify by recalculating at least two detects common between the sample and its field duplicate and/or field triplicate. If discrepancies are discovered, document in the data validation report.

## 5. Records

A Form I that has been validated and verified, and has been determined by the data validator to accurately represent the appropriate sample results to be utilized, shall be stamped "NAVFAC PACIFIC VALIDATED." Additionally, sample result forms for which the data has been validated at the Level D validation level shall be stamped or noted "Level D."

Copies of all documents generated by the data validation personnel will be stored for no less than 10 years.

## 6. References

American Public Health Association (APHA). 2005. *Standard Methods for the Examination of Water and Wastewater*. 21st ed. Washington. September.

Department of Defense, United States (DoD). 2005a. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

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Procedure II-A, *Data Validation*.

## 7. Attachments

None.

# Data Quality Assessment Report

## 1. Purpose

This procedure describes the presentation format and information provided in the data quality assessment report (DQAR) under the United States (U.S.) Navy Environmental Restoration (ER) Program for Naval Facilities Engineering Command (NAVFAC), Pacific and is consistent with protocol in the *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories* (DoD QSM) (DoD 2013). The objective of DQAR is to summarize the validated data to the end user. This procedure also establishes the method by which a Contract task Order (CTO) Manager selects and confirms the content of the DQAR. Data validation is addressed separately in Procedure II-A, *Data Validation*.

## 2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

## 3. Responsibilities

The CTO Manager, the QA Manager or Technical Director, and the CTO QA Coordinator are responsible for ensuring that this procedure is implemented by data validation personnel.

Data validation personnel (unless otherwise stated) are responsible for implementing this procedure for all DQARs.

## 4. Procedure

### 4.1 INTRODUCTION

The DQAR summarizes the QA/quality control (QC) evaluation of the data according to precision, accuracy, representativeness, completeness, comparability, and sensitivity relative to the project quality objectives (PQOs). The report provides a quantitative and qualitative assessment of the data and identifies potential sources of error, uncertainty, and bias that may affect the overall usability.

The DQAR summary report identifies the level of data validation for each sample and evaluates and summarizes the results of QA/QC data validation for the entire sampling program. Each analytical fraction has a separate section for each of the criteria. These sections interpret specific QC deviations and their effects on both individual data points and the analyses as a whole. The last section presents a summary of the precision, accuracy, representativeness, completeness, comparability, and sensitivity criteria by comparing quantitative parameters with acceptability criteria defined in the PQOs. Qualitative criteria are also summarized in this section. A DQAR example is provided as Attachment II-S-1.

## 4.2 PRECISION AND ACCURACY OF ENVIRONMENTAL DATA

Environmental data quality depends on sample collection procedures, analytical methods and instrumentation, documentation, and sample matrix properties. Both sampling procedures and laboratory analyses contain potential sources of uncertainty, error, and/or bias, which affect the overall quality of a measurement. Errors in sample data may result from incomplete equipment decontamination, inappropriate sampling techniques, sample heterogeneity, improper filtering, and improper preservation. The accuracy of analytical results is dependent on selecting appropriate analytical methods, maintaining equipment properly, and complying with QC requirements. The sample matrix also is an important factor in the ability to obtain precise and accurate results within a given media.

Environmental and laboratory QC samples assess the effects of sampling procedures and evaluate laboratory contamination, laboratory performance, and matrix effects. QC samples include: trip blanks, equipment blanks, field blanks, field duplicates, field triplicates, method blanks, laboratory control samples (LCSs), surrogate spikes, matrix spike/matrix spike duplicates (MS/MSDs), laboratory duplicates, and laboratory triplicates.

Before producing the DQAR, the analytical data should be validated according to the NAVFAC Pacific data validation procedures. Samples not meeting the NAVFAC ER Program validation criteria are qualified with a flag, an abbreviation indicating a deficiency with the data. The following are flags used in data validation.

J Estimated. The associated numerical value is an estimated quantity. The analyte was detected but the reported value may not be accurate or precise. The “J” qualification indicates the data fell outside the QC limits, but the exceedance was not sufficient to cause rejection of the data.

R Rejected. The data is unusable (the compound or analyte may or may not be present). Use of the “R” qualifier indicates a significant variance from functional guideline acceptance criteria. Either resampling or re-analysis is necessary to determine the presence or absence of the rejected analyte.

U Nondetected. Analyses were performed for the compound or analyte, but it was not detected. The “U” designation is also applied to suspected blank contamination. The “U” flag is used to qualify any result detected in an environmental sample at a concentration less than 10 times the value of the concentration in any associated blank for common laboratory contaminants and less than 5 times the concentration in any associated blank for all other contaminants.

UJ Estimated/Nondetected. Analyses were performed for the compound or analyte, but it was not detected and the limit of detection (LOD) is an estimated quantity due to poor accuracy or precision. This qualification is also used to flag possible false negative results in the case where low bias in the analytical system is indicated by low calibration response, surrogate, internal standard, or other spike recovery.

Once the data are reviewed and qualified according to the NAVFAC Pacific data validation procedures, the data set is then evaluated using precision, accuracy, representativeness, completeness, comparability, and sensitivity criteria that provide an evaluation of overall data usability. The following is a discussion of the precision, accuracy, representativeness, completeness, and comparability criteria as related to the PQOs.

### 4.2.1 Precision

Precision is a measure of the agreement or reproducibility of analytical results under a given set of conditions. It is a quantity that cannot be measured directly but is calculated from reported concentrations. Precision is expressed as the relative percent difference (RPD) or percent relative standard deviation (%RSD):

$$\text{RPD} = (\text{D1}-\text{D2})/\{1/2(\text{D1}+\text{D2})\} \times 100$$

$$\%\text{RSD} = \text{SD}/\{1/3(\text{D1}+\text{D2}+\text{D3})\} \times 100$$

Where:

D1 = the reported concentration for primary sample analyses
D2 = the reported concentrations for duplicate analyses
D3 = the reported concentrations for triplicate analyses
SD = the standard deviation for sample, duplicate and triplicate analyses

Precision is primarily assessed by calculating a RPD from the reported concentrations of the spiked compounds for each sample in the MS/MSD pair. In the absence of a MS/MSD pair, a laboratory duplicate or LCS/laboratory control sample duplicate (LCSD) pair can be analyzed as an alternative means of assessing precision. In some cases, samples from multiple sample delivery groups (SDGs) are within one QC batch and therefore are associated with the same laboratory QC samples. An additional measure of sampling precision may be obtained by collecting and analyzing field duplicate samples, which are compared using the RPD result as the evaluation criteria.

MS and MSD samples are field samples spiked by the laboratory with target analytes prior to preparation and analysis. These samples measure the overall efficiency of the analytical method in recovering target analytes from an environmental matrix. A LCS is similar to a MS/MSD sample in that the LCS is spiked with the same target analytes prior to preparation and analysis. However, the LCS is prepared using a controlled interference-free matrix instead of a field sample aliquot. Laboratory reagent water is used to prepare aqueous LCS. Non-aqueous LCSs are prepared using solid media approved by the American Society for Testing and Materials for their homogeneity. The LCS measures laboratory efficiency in recovering target analytes from either a solid or aqueous matrix in the absence of matrix interferences.

For inorganic analysis, one primary sample is analyzed and accompanied by an unspiked laboratory duplicate. The data reviewer compares the reported results of the primary analysis and the laboratory duplicate and calculates RPDs to assess laboratory precision.

Laboratory and field sampling precision are further evaluated by calculating RPDs for field sample duplicate pairs. The sampler collects two field samples at the same location and under identically controlled conditions. The laboratory then analyzes the samples under identical conditions.

If incremental sampling is performed, laboratory and field sampling precision are evaluated by calculating RSDs for laboratory triplicates and field triplicates. At the subsampling step, one sample is prepared in triplicate per batch. Laboratory triplicate data are used to determine that the samples are being reduced to sufficiently small particle sizes during the grinding process. Field triplicates are collected from different, randomly selected locations to verify that an incremental sample truly represents a decision unit. Field triplicate results are more useful than field duplicates to statistically evaluate sampling precision.

An RPD outside the numerical QC limit in either MS/MSD samples or LCS/LCSD or a %RSD outside the numerical QC limit in the laboratory triplicate indicates imprecision. Imprecision is the variance in the consistency with which the laboratory arrives at a particular reported result. Thus, the actual analyte concentration may be higher or lower than the reported result.

Possible causes of poor precision include sample matrix interference, improper sample collection or handling, inconsistent sample preparation, and poor instrument stability. In some duplicates and/or triplicates, results may be reported in the primary, duplicate, or triplicate samples at levels below the limit of quantitation (LOQ) or non-detected. Since these values are considered to be estimates, RPD exceedances from duplicates or %RSD exceedances from triplicates do not suggest a significant impact on the data quality.

#### 4.2.2 Accuracy

Accuracy is a measure of the agreement of an experimental determination and the true value of the parameter being measured. It is used to identify bias in a given measurement system. Recoveries outside acceptable QC limits may be caused by factors such as instrumentation, analyst error, or matrix interference. Accuracy is assessed through the analysis of MS, MSD, LCS, and samples containing surrogate spikes. In some cases, samples from multiple SDGs are within one QC batch and therefore are associated with the same laboratory QC samples. Surrogate spikes are either isotopically labeled compounds or compounds that are not typically detected in the samples. Surrogate spikes are added to every blank, environmental sample, MS/MSD, and standard, for applicable organic analyses. Accuracy of inorganic analyses is determined using the percent recoveries of MS and LCS analyses.

Percent recovery (%R) is calculated using the following equation:

$$\%R = (A-B)/C \times 100$$

Where:

A = measured concentration in the spiked sample

B = measured concentration of the spike compound in the unspiked sample

C = concentration of the spike

The percent recovery of each analyte spiked in MS/MSD samples, LCS, and surrogate compounds added to environmental samples is evaluated against the acceptance criteria specified by the previously noted documents. Spike recoveries outside the acceptable QC accuracy limits provide an indication of bias, where the reported data may overestimate or underestimate the actual concentration of compounds detected or quantitation limits reported for environmental samples.

### 4.3 REPRESENTATIVENESS

Representativeness is a qualitative parameter that expresses the degree to which the sample data are characteristic of a population and is evaluated by reviewing the QC results of blank samples and holding times. Positive detects of compounds in the blank samples identify compounds that may have been introduced into the samples during sample collection, transport, preparation, or analysis. The various types of blanks evaluated are discussed below.

A method blank is a laboratory grade water or solid matrix that contains the method reagents and has undergone the same preparation and analysis as the environmental samples. The method blank provides a measure of the combined contamination derived from the laboratory source water, glassware, instruments, reagents, and sample preparation steps. Method blanks are prepared for each sample of a similar matrix extracted by the same method at a similar concentration level.

For inorganic analyses, initial and continuing calibration blanks consist of acidified laboratory grade water, which are injected at the beginning and at a regular frequency during each 12-hour sample analysis run. These blanks estimate residual contaminants from the previous sample or standards analysis and measure baseline shifts that commonly occur in emission and absorption spectroscopy.

Trip blanks are used to identify possible volatile organic contamination introduced into the sample during transport. A trip blank is a sample volatile organics analysis vial filled in the laboratory with reagent-grade water and preserved to a pH less than 2 with hydrochloric acid. It is transported to the site, stored with the sample containers, and returned unopened to the laboratory for analysis.

Equipment blanks consist of analyte-free water poured over or through the sample collection equipment. The water is collected in a sample container for laboratory analysis. These blanks are collected after the sampling equipment is decontaminated and measure efficiency of the decontamination procedure.

Field blanks consist of analyte-free source water stored at the sample collection site. The water is collected from each source water used during each sampling event.

If sample grinding is performed, grinding blanks, which consist of clean solid matrix (such as Ottawa sand), must be prepared (e.g., ground and subsampled) and analyzed in the same manner as a field sample. Grinding equipment must be thoroughly cleaned between the processing of samples and grinding blanks must be processed and analyzed to prevent cross-contamination.

Contaminants found in both the environmental sample and a blank sample are assumed to be laboratory artifacts if the concentration in the environmental sample is less than 10 times the blank value for common laboratory contaminants (methylene chloride, acetone, 2-butanone, and phthalate esters) or 5 times the blank value for other laboratory contaminants.

Holding times are evaluated to assure that the sample integrity is intact for accurate sample preparation and analysis. Holding times will be specific for each method and matrix analyzed. Holding time exceedances can cause loss of sample constituents due to biodegradation, precipitation, volatization, and chemical degradation.

## 4.4 COMPARABILITY

Comparability is a qualitative expression of the confidence with which one data set may be compared to another. It provides an assessment of the equivalence of the analytical results to data obtained from other analyses. It is important that data sets be comparable if they are used in conjunction with other data sets. The factors affecting comparability include the following: sample collection and handling techniques, matrix type, and analytical method. If these aspects of sampling and analysis are carried out according to standard analytical procedures, the data are considered comparable. Comparability can only be compared with confidence when precision, accuracy, and representativeness are known.

## 4.5 COMPLETENESS

Completeness is defined as the percentage of acceptable sample results compared to the total number of sample results. Completeness is evaluated to determine if an acceptable amount of usable data were obtained so that a valid scientific site assessment can be completed. Completeness equals the total number of sample results for each fraction minus the total number of rejected sample results divided by the total number of sample results multiplied by 100. The goal for completeness for target analytes in each analytical fraction should be specified in the DoD QSM (DoD 2013) or project planning document.

Percent completeness is calculated using the following equation:

$$\%C = (T - R)/T \times 100$$

Where:

$\%C$ = percent completeness

$T$ = total number of sample results

$R$ = total number of rejected sample results

Completeness is also determined by comparing the planned number of samples per method and matrix as specified in the project planning document, with the number determined above.

## 4.6 SENSITIVITY

Sensitivity is the ability of an analytical method or instrument to discriminate between measurement responses representing different concentrations. This capability is established during the planning phase to meet the data quality objectives (DQOs). It is important that calibration requirements, detection limits (DLs), and project-specific LODs and LOQs presented in the work plan are achieved and that target analytes can be detected at concentrations necessary to support the DQOs. In addition, sample results are compared to method blank and field blank results to identify potential effects of laboratory background and field procedures on sensitivity.

# 5. References

Department of Defense, United States (DoD). 2013. *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories*. Final version 5.0. Prepared by Department of Defense Environmental Data Quality Workgroup and the Department of Energy Consolidated Audit Program Operations Team. March.

Procedure II-A, *Data Validation*.

# 6. Attachments

II-S-1: Data Quality Assessment Report Example

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# Attachment II-S-1
# Data Quality Assessment Report Example

# DATA QUALITY ASSESSMENT REPORT

## SITE INVESTIGATION BUILDING E-13
## PEARL HARBOR, CTO XXX

**12/1/03**

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## Table of Contents

## Glossary

| | |
|---|---|
| µg/kg | microgram per kilogram |
| µg/L | microgram per liter |
| BTEX | benzene, toluene, ethylbenzene, xylenes |
| DL | detection limit |
| DQO | data quality objectives |
| EPA | Environmental Protection Agency, United States |
| IDL | instrument detection limit |
| LCS/LCSD | laboratory control sample/laboratory control sample duplicate |
| LOD | limit of detection |
| LOQ | limit of quantitation |
| mg/kg | milligram per kilogram |
| MS/MSD | matrix spike/matrix spike duplicate |
| NAS | Naval Air Station |
| PARCCS | Precision, Accuracy, Representativeness, Comparability, Completeness, Sensitivity |
| PAH | polynuclear aromatic hydrocarbon |
| PCB | polychlorinated biphenyl |
| QA/QC | quality assurance/quality control |
| RPD | relative percent difference |
| RRF | relative response factor |
| RL | reporting limit |
| SDG | sample delivery group |
| %D | percent difference |
| %R | percent recovery |
| %RSD | percent relative standard deviation |

# 1. Introduction

A remediation and closure was conducted at Building E-13 at Pearl Harbor, Oahu, Hawaii. This part of the site investigation included the collection and analyses of 141 environmental and quality control (QC) samples. The analyses were performed by the following methods:

- Polynuclear aromatic hydrocarbons (PAHs) by United States Environmental Protection Agency (EPA) SW-846 8270C-SIM
- Polychlorinated biphenyls (PCBs) by EPA SW-846 Method 8082
- Metals by EPA SW-846 Method 6010B/6020/7471A

Analytical services were provided by ZZZZ Laboratories whom performed analyses on the water and soil samples. The samples were grouped into sample delivery groups (SDGs) of up to 20 field samples received by each laboratory. The environmental samples are associated with QA/QC samples designed to document the data quality of the entire SDG or a sub-group of samples within a SDG. Table I is a cross-reference table listing each sample, analysis, SDG, collection date, laboratory sample number, and matrix. All shaded samples in Table I were reviewed under Level D validation guidelines.

One hundred percent of the analytical data were validated according to NAVFAC Pacific Level D data validation procedures. The analytical data were evaluated for quality assurance and quality control (QA/QC) based on the *Department of the Navy Environmental Restoration Program (NERP) Manual* (2006).

This data quality assessment report (DQAR) summarizes the QA/QC evaluation of the data according to precision, accuracy, representativeness, completeness, comparability, and sensitivity (PARCCS) relative to the project quality objectives (PQOs). This report provides a quantitative and qualitative assessment of the data and identifies potential sources of error, uncertainty, and bias that may affect the overall usability.

The DQAR evaluates and summarizes the results of QA/QC data validation for the entire sampling program. Each analytical fraction has a separate section for each of the PARCC criteria. These sections interpret specific QC deviations and their effects on both individual data points and the analyses as a whole. Section 6 presents a summary of the PARCC criteria by comparing quantitative parameters with acceptability criteria defined in the PQOs. Qualitative PARCC criteria are also summarized in this section.

### Precision and Accuracy of Environmental Data

Environmental data quality depends on sample collection procedures, analytical methods and instrumentation, documentation, and sample matrix properties. Both sampling procedures and laboratory analyses contain potential sources of uncertainty, error, and/or bias, which affect the overall quality of a measurement. Errors in sample data may result from incomplete equipment decontamination, inappropriate sampling techniques, sample heterogeneity, improper filtering, and improper preservation. The accuracy of analytical results is dependent on selecting appropriate analytical methods, maintaining equipment properly, and complying with QC requirements. The sample matrix also is an important factor in the ability to obtain precise and accurate results within a given media.

Environmental and laboratory QA/QC samples assess the effects of sampling procedures and evaluate laboratory contamination, laboratory performance, and matrix effects. QA/QC samples include: equipment blanks, field duplicates, method blanks, laboratory control samples (LCSs), surrogate spikes, matrix spike/matrix spike duplicates (MS/MSDs), and laboratory duplicates.

Before conducting the PARCC evaluation, the analytical data were validated according to the *Department of the Navy Environmental Restoration Program (NERP) Manual* [2006]). Samples not meeting the Project Procedures Manual acceptance criteria were qualified with a flag, an abbreviation indicating a deficiency with the data. The following are flags used in data validation.

| | |
|---|---|
| J | <u>Estimated</u>: The associated numerical value is an estimated quantity. The analyte was detected but the reported value may not be accurate or precise. The “J” qualification indicates the data fell outside the QC limits, but the exceedance was not sufficient to cause rejection of the data. |
| R | <u>Rejected</u>: The data is unusable (the compound or analyte may or may not be present). Use of the "R" qualifier indicates a significant variance from functional guideline acceptance criteria. Either resampling or re-analysis is necessary to determine the presence or absence of the rejected analyte. |
| U | <u>Nondetected</u>: Analyses were performed for the compound or analyte, but it was not detected. The "U" designation is also applied to suspected blank contamination. The "U" flag is used to qualify any result detected in an environmental sample at a concentration less than 10 times the value of the concentration in any associated blank for common laboratory contaminants and less than 5 times the concentration in any associated blank for all other contaminants. |
| UJ | <u>Estimated/Nondetected</u>: Analyses were performed for the compound or analyte, but it was not detected and the limit of detection (LOD) is an estimated quantity due to poor accuracy or precision. This qualification is also used to flag possible false negative results in the case where low bias in the analytical system is indicated by low calibration response, surrogate, internal standard, or other spike recovery. |

Once the data are reviewed and qualified according to the *Department of the Navy Environmental Restoration Program (NERP) Manual* (2006), the data set is then evaluated using PARCCS criteria. PARCCS criteria provide an evaluation of overall data usability. The following is a discussion of PARCCS criteria as related to the PQOs.

**Precision** is a measure of the agreement or reproducibility of analytical results under a given set of conditions. It is a quantity that cannot be measured directly but is calculated from reported concentrations. Precision is expressed as the relative percent difference (RPD):

$$RPD = (D1 - D2)/\{1/2(D1+D2)\} \times 100$$

Where:

D1 and D2 = the reported concentrations for sample and duplicate analyses.

Precision is primarily assessed by calculating a RPD from the reported concentrations of the spiked compounds for each sample in the MS/MSD pair. In the absence of a MS/MSD pair, a laboratory duplicate or LCS/LCSD pair can be analyzed as an alternative means of assessing precision. In some cases, samples from multiple SDGs were within one QC batch and therefore are associated with the same laboratory QC samples. An additional measure of sampling precision was obtained by collecting and analyzing field duplicate samples, which were compared using the RPD result as the evaluation criteria.

MS and MSD samples are field samples spiked by the laboratory with target analytes prior to preparation and analysis. These samples measure the overall efficiency of the analytical method in recovering target analytes from an environmental matrix. A LCS is similar to a MS/MSD sample in that the LCS is spiked with the same target analytes prior to preparation and analysis. However, the LCS is prepared using a controlled interference-free matrix instead of a field sample aliquot. Laboratory reagent water is used to prepare aqueous LCS. Non-aqueous LCSs are prepared using solid media approved by the American Society for Testing and Materials (ASTM) for their homogeneity. The LCS measures laboratory efficiency in recovering target analytes from either a solid or aqueous matrix in the absence of matrix interferences.

For inorganics analysis, one primary sample is analyzed and accompanied by an unspiked laboratory duplicate. The data reviewer compares the reported results of the primary analysis and the laboratory duplicate, then calculates RPDs, which are used to assess laboratory precision.

Laboratory and field sampling precision are further evaluated by calculating RPDs for aqueous field sample duplicate pairs. The sampler collects two field samples at the same location and under identically controlled conditions. The laboratory then analyzes the samples under identical conditions.

An RPD outside the numerical QC limit in either MS/MSD samples or LCS/LCSD indicates imprecision. Imprecision is the variance in the consistency with which the laboratory arrives at a particular reported result. Thus, the actual analyte concentration may be higher or lower than the reported result.

Possible causes of poor precision include sample matrix interference, improper sample collection or handling, inconsistent sample preparation, and poor instrument stability. In some duplicate pairs, results maybe reported in either the primary or duplicate samples at levels below the limit of quantitation (LOQ) or non-detected. Since these values are considered to be estimates, RPD exceedances from these duplicate pairs do not suggest a significant impact on the data quality.

**Accuracy** is a measure of the agreement of an experimental determination and the true value of the parameter being measured. It is used to identify bias in a given measurement system. Recoveries outside acceptable QC limits may be caused by factors such as instrumentation, analyst error, or matrix interference. Accuracy is assessed through the analysis of MS, MSD, LCS, and samples containing surrogate spikes. In some cases, samples from multiple SDGs were within one QC batch and therefore are associated with the same laboratory QC samples. Surrogate spikes are either isotopically labeled compounds or compounds that are not typically detected in the samples. Surrogate spikes are added to every blank, environmental sample, MS/MSD, and standard, for all applicable organic analyses. Accuracy of inorganic analyses is determined using the percent recoveries of MS and LCS analyses.

%R is calculated using the following equation:

$$\%R = (A - B)/C \times 100$$

Where:

A = measured concentration in the spiked sample

B = measured concentration of the spike compound in the unspiked sample

C = concentration of the spike

The percent recovery of each analyte spiked in MS/MSD samples, LCS, and surrogate compounds added to environmental samples is evaluated against the acceptance criteria specified by the previously noted documents. Spike recoveries outside the acceptable QC accuracy limits provide an indication of bias, where the reported data may overestimate or underestimate the actual concentration of compounds detected or quantitation limits reported for environmental samples.

**Representativeness** is a qualitative parameter that expresses the degree to which the sample data are characteristic of a population and is evaluated by reviewing the QC results of blank samples and holding times. Positive detects of compounds in the blank samples identify compounds that may have been introduced into the samples during sample collection, transport, preparation, or analysis. The QA/QC blanks collected and analyzed are method blanks.

A method blank is a laboratory grade water or solid matrix that contains the method reagents and has undergone the same preparation and analysis as the environmental samples. The method blank provides a measure of the combined contamination derived from the laboratory source water, glassware, instruments, reagents, and sample preparation steps. Method blanks are prepared for each sample of a similar matrix extracted by the same method at a similar concentration level.

For inorganic analyses, initial and continuing calibration blanks consist of acidified laboratory grade water, which are injected at the beginning and at a regular frequency during each 12 - hour sample analysis run. These blanks estimate residual contaminants from the previous sample or standards analysis and measure baseline shifts that commonly occur in emission and absorption spectroscopy.

Trip blanks are used to identify possible volatile organic contamination introduced into the sample during transport. A trip blank is a sample bottle filled in the laboratory with reagent-grade water and preserved to a pH less than 2 with hydrochloric acid. It is transported to the site, stored with the sample containers, and returned unopened to the laboratory for analysis.

Equipment blanks consist of analyte-free water poured over or through the sample collection equipment. The water is collected in a sample container for laboratory analysis. These blanks are collected after the sampling equipment is decontaminated and measure efficiency of the decontamination procedure. Equipment blanks were collected and analyzed for all target analytes.

Field blanks consist of analyte-free source water stored at the sample collection site. The water is collected from each source water used during each sampling event. Field blanks were collected and analyzed for all target analytes.

Contaminants found in both the environmental sample and a blank sample are assumed to be laboratory artifacts if the concentration in the environmental sample is less than 10 times the blank value for common laboratory contaminants; methylene chloride, acetone, 2-butanone, and phthalate esters or 5 times the blank value for other laboratory contaminants.

Holding times are evaluated to assure that the sample integrity is intact for accurate sample preparation and analysis. Holding times will be specific for each method and matrix analyzed. Holding time exceedances can cause loss of sample constituents due to biodegradation, precipitation, volatization, and chemical degradation.

**Comparability** is a qualitative expression of the confidence with which one data set may be compared to another. It provides an assessment of the equivalence of the analytical results to data obtained from other analyses. It is important that data sets be comparable if they are used in conjunction with other data sets. The factors affecting comparability include the following: sample collection and handling techniques, matrix type, and analytical method. If these aspects of sampling and analysis are carried out according to standard analytical procedures, the data are considered comparable. Comparability is also dependent upon other PARCC criteria, because only when precision, accuracy, and representativeness are known can data sets be compared with confidence.

**Completeness** is defined as the percentage of acceptable sample results compared to the total number of sample results. Completeness is evaluated to determine if an acceptable amount of usable data were obtained so that a valid scientific site assessment can be completed. Completeness equals the total number of sample results for each fraction minus the total number of rejected sample results divided by the total number of sample results multiplied by 100. As specified in the PQOs, the goal for completeness for target analytes in each analytical fraction is 90 percent.

Percent completeness is calculated using the following equation:

$$\%C = (T - R)/T \times 100$$

Where:

$\%C$ = percent completeness
$T$ = total number of sample results
$R$ = total number of rejected sample results

Completeness is also determined by comparing the planned number of samples per method and matrix as specified in the project planning document, with the number determined above.

**Sensitivity** is the ability of an analytical method or instrument to discriminate between measurement responses representing different concentrations. This capability is established during the planning phase to meet the DQOs. It is important that calibration requirements, detection limits (DLs), and project-specific LODs and LOQs presented in the work plan are achieved and that target analytes can be detected at concentrations necessary to support the DQOs. In addition, sample results are compared to method blank and field blank results to identify potential effects of laboratory background and field procedures on sensitivity.

The following sections present a review of QC data for each analytical method.

# 2. Polynuclear Aromatic Hydrocarbons

A total of 58 soil samples were analyzed for PAH by EPA SW-846 Method 8270C-SIM. All PAH data were assessed to be valid with the exception of 17 of the 986 total results, which were rejected based on QC exceedances. This section discusses the QA/QC supporting documentation as defined by the PARCC criteria and evaluated based on the PQOs.

## 2.1 PRECISION AND ACCURACY

### 2.1.1 Instrument Calibration

Initial and continuing calibration results provide a means of evaluating accuracy within a particular SDG. Relative response factor (RRF), percent relative standard deviation (%RSD), and percent difference (%D) are the three major parameters used to measure the effectiveness of instrument calibration. RRF is a measure of the relative spectral response of an analyte compared to its internal standard. %RSD is an expression of the linearity of instrument response. %D is a comparison of a continuing calibration instrumental response with its initial response. %RSD and %D exceedances suggest routine instrumental anomalies, which typically impact all sample results for the affected compounds.

The relative response factors met the acceptance criteria of 0.05 in the initial and continuing calibration standards.

The relative standard deviation in the initial calibrations and/or %D between the initial calibration mean relative response factors and the continuing calibration relative response factors were within the acceptance criteria of 15 and 20 percent, respectively.

The %Ds in the initial calibration verification were within the acceptance criteria of 20 percent.

### 2.1.2 Surrogates

As a result of non-compliant surrogate recoveries, 17 non-detected results in sample BA368 were qualified as unusable (R). Additionally, 136 results in samples BA267, BA338, BA341, BA363, BA364, BA367, BA368, and BA369 were qualified as detected estimated (J) and non-detected estimated (UJ) due to non-compliant surrogate recoveries. The details regarding the qualification of results are provided in the data validation reports.

### 2.1.3 MS/MSD Samples

As a result of non-compliant MS/MSDs, five results for non-compliant RPDs and 32 results for non-compliant %Rs were qualified as detected estimated (J) and non-detected estimated (UJ). The affected compounds were 2-methylnapthalene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluorene, naphthalene, phenanthrene, and pyrene. The details regarding the qualification of results are provided in the data validation reports.

### 2.1.4 LCS Samples

As a result of non-compliant LCS/LCSD recoveries, 139 results were qualified as detected estimated (J) and non-detected estimated (UJ). The affected compounds were acenaphthene, benzo(a)anthracene, benzo(a)pyrene, dibenz(a,h)anthracene, fluorene, and pyrene. The details regarding the qualification of results are provided in the data validation reports.

### 2.1.5 Internal Standards

No data were qualified based on internal standard nonconformances. The recoveries and retention times were evaluated against the acceptance criteria.

### 2.1.6 Field Duplicate Samples

The field duplicate samples were evaluated for acceptable precision with RPDs for the compounds. The associated data validation narratives provided details regarding criteria exceeded. Sample data were not qualified on the basis of field duplicate precision.

### 2.1.7 Proficiency Testing Samples

Proficiency testing samples were not performed for the sampling event.

### 2.1.8 Compound Quantitation and Target Identification

Due to compound quantitation nonconformances (i.e., co-elution of peaks), 29 benzo(b)fluoranthene and benzo(k)fluoranthene detected results in several samples were qualified as detected estimated (J). The details regarding the qualification of results are provided in the data validation reports.

All target compound identifications were found to be acceptable

## 2.2 REPRESENTATIVENESS

### 2.2.1 Holding Times

The evaluation of holding times to verify compliance with the method was conducted. All holding times were met.

### 2.2.2 Blanks

Method blanks were analyzed to evaluate representativeness. The concentration for an individual target compounds in any of the three types of QA/QC blanks were used for data qualification.

If contaminants were detected in a blank, corrective actions were made for the chemical analytical data during data validation. The corrective action consisted of amending the laboratory reported results for organic compounds based on the following criteria. The validation qualifier codes used in the blank summary tables are described below.

- *Results Below or Above the LOQ:* If a sample result for the blank contaminant was less than the LOQ or greater than the sample LOQ and less than 5× the blank value, the sample result for the blank contaminant was amended as a non-detect at the concentration reported in the sample results.
- *No Action:* If a sample result for the blank contaminant was greater than 10× the blank value for common contaminants or 5× the blank value for other contaminants, the result was not amended.

#### *2.2.2.1 METHOD BLANKS*

As a result of method blank contamination, one benzo(a)anthracene result was qualified as non-detected (U). The details regarding the qualification of results are provided in the data validation reports.

### 2.3 COMPARABILITY

The laboratory used standard analytical methods for all of the analyses. In all cases, the method detection limits attained were at or below the reporting limit. Target compounds detected below the reporting limits flagged (J) by the laboratory should be considered estimated. The comparability of the data is regarded as acceptable.

### 2.4 COMPLETENESS

The completeness level attained for PAH field samples was 98.3 percent. This percentage was calculated as the total number of accepted sample results divided by the total number of sample results multiplied by 100.

### 2.5 SENSITIVITY

The calibration was evaluated for instrument sensitivity and was determined to be technically acceptable. All laboratory reporting limits met the specified requirements described in the work plan although LOD was elevated for benzo(a)anthracene for one sample due to method blank contamination.

## 3. Polychlorinated Biphenyls

A total of 20 soil samples were analyzed for PCB as Aroclors by EPA SW-846 Method 8082. All PCB data were assessed to be valid since none of the 140 total results were rejected based on QC exceedances. This section discusses the QA/QC supporting documentation as defined by the PARCC criteria and evaluated based on the PQOs.

### 3.1 PRECISION AND ACCURACY

#### 3.1.1 Instrument Calibration

Initial and continuing calibration results provide a means of evaluating accuracy within a particular SDG. Percent relative standard deviation (%RSD) and percent difference (%D) are the two major parameters used to measure the effectiveness of instrument calibration. %RSD is an expression of the linearity of instrument response. %D is a comparison of a continuing calibration instrumental response with its initial response. %RSD and %D exceedances suggest more routine instrumental anomalies, which typically impact all sample results for the affected compounds.

Six results were qualified detected estimated (J) and non-detected estimated (UJ). The relative standard deviations in the initial calibrations and/or percent difference between the initial calibration and the continuing calibration concentrations for Aroclor 1016, Aroclor 1221, and Aroclor 1232 were outside the acceptance criteria of 20 and 15 percent, respectively. The affected samples are identified in the data validation reports.

### 3.1.2 Surrogates

No data were qualified based on surrogate recovery nonconformances. In cases where individual recoveries exceeded criteria, the QC exceedance was judged to have no impact on the data quality and no qualifications were made.

### 3.1.3 MS/MSD Samples

No data were qualified based on MS/MSD nonconformances. For those SDGs with MS/MSD results, the recoveries were evaluated against the acceptance criteria. In cases where recoveries exceeded criteria, the QC exceedance was judged to have no impact on the data quality and no qualifications were made.

### 3.1.4 LCS Samples

No data were qualified based on LCS nonconformances. For those SDGs with LCS results, the recoveries were evaluated against the acceptance criteria.

### 3.1.5 Field Duplicate Samples

The field duplicate samples were evaluated for acceptable precision with RPDs for the compounds. The associated data validation narratives provided details regarding criteria exceeded. Sample data were not qualified on the basis of field duplicate precision.

### 3.1.6 Proficiency Testing Samples

Proficiency testing samples were not performed for the sampling event.

### 3.1.7 Compound Quantitation and Target Identification

Due to compound quantitation nonconformances (i.e., %Ds between columns), one Aroclor 1260 result in sample BA245 was qualified as detected estimated (J). The details regarding the qualification of results are provided in the data validation reports.

All target compound identifications were found to be acceptable.

## 3.2 REPRESENTATIVENESS

### 3.2.1 Holding Times

The evaluation of holding times to verify compliance with the method was conducted. All holding times were met.

### 3.2.2 Blanks

As previously discussed in Section 2.2.2, method blanks were analyzed to evaluate representativeness.

#### *3.2.2.1 METHOD BLANKS*

No QC issues were associated with the method blanks for this analysis.

### 3.3 COMPARABILITY

The laboratory used standard analytical methods for all of the analyses. In all cases, the method detection limits attained were at or below the reporting limit. Target compounds detected below the reporting limits flagged (J) by the laboratory should be considered estimated. The comparability of the data is regarded as acceptable.

### 3.4 COMPLETENESS

The completeness level attained for PCB field samples was 100 percent. This percentage was calculated as the total number of accepted sample results divided by the total number of sample results multiplied by 100.

### 3.5 SENSITIVITY

The calibration was evaluated for instrument sensitivity and was determined to be technically acceptable. All laboratory LODs and LOQs met the project requirements described in the work plan.

## 4. Metals

A total of 48 soil samples were analyzed for metals by EPA SW-846 Method 6010B/6020/7471A. All metals data were assessed to be valid since none of the 465 total results were rejected based on QC exceedances. This section discusses the QA/QC supporting documentation as defined by the PARCC criteria and evaluated based on the PQOs.

### 4.1 PRECISION AND ACCURACY

#### 4.1.1 Instrument Calibration

Initial and continuing calibration verification results provide a means of evaluating accuracy within a particular SDG. Correlation coefficient (r) and percent recovery (%R) are the two major parameters used to measure the effectiveness of instrument calibration. The correlation coefficient indicates the linearity of the calibration curve. %R is used to verify the ongoing calibration acceptability of the analytical system. The most critical of the two calibration parameters, r, has the potential to affect data accuracy across a SDG when it is outside the acceptable QC limits. %R exceedances suggest more routine instrumental anomalies, which typically impact all sample results for the affected analytes.

The correlation coefficients in the initial calibrations and/or percent recoveries in the continuing calibration verifications were within the acceptance criteria of ≥ 0.995 and 90-110 percent, respectively.

#### 4.1.2 MS Samples

As a result of non-compliant MS recoveries, 21 results were qualified as detected estimated (J) and non-detected estimated (UJ). The analytes affected were barium, cadmium, and chromium. The details regarding the qualification of results are provided in the data validation reports.

#### 4.1.3 Duplicate (DUP) Samples

No data were qualified based on duplicate nonconformances. For those SDGs with DUP results, the relative percent differences/differences were evaluated against the acceptance criteria. In cases where

RPDs or differences exceeded criteria, the QC exceedance was judged to have no impact on the data quality and no qualifications were made.

#### 4.1.4 LCS Samples

No data were qualified based on LCS nonconformances. For those SDGs with LCS results, the recoveries were evaluated against the acceptance criteria.

#### 4.1.5 ICP Serial Dilution

No data were qualified based on ICP serial dilution nonconformances. All recoveries were evaluated against the acceptance criteria.

#### 4.1.6 ICP Interference Check Sample

As a result of ICP interference check sample exceedances, 16 results were qualified as detected estimated (J) and non-detected estimated (UJ). The analytes affected were arsenic, cadmium, chromium, and silver. The details regarding the qualification of results are provided in the data validation reports.

#### 4.1.7 Field Duplicate Samples

The field duplicate samples were evaluated for acceptable precision with RPDs for the analytes. The associated data validation narratives provided details regarding criteria exceeded. Sample data were not qualified on the basis of field duplicate precision.

#### 4.1.8 Proficiency Testing Samples

Proficiency testing samples were not performed for the sampling event.

#### 4.1.9 Sample Result Verification

All sample results were found to be acceptable.

### 4.2 REPRESENTATIVENESS

#### 4.2.1 Holding Times

The evaluation of holding times to verify compliance with the method was conducted. All holding times were met.

#### 4.2.2 Blanks

Method blanks were analyzed to evaluate representativeness. The concentration for an individual target compounds in any of the three types of QA/QC blanks were used for data qualification.

If contaminants were detected in a blank, corrective actions were made for the chemical analytical data during data validation. The corrective action consisted of amending the laboratory reported results for organic analytes based on the following criteria. The validation qualifier codes are described below.

- *Results Below or Above the LOQ:* If a sample result for the blank contaminant was less than the LOQ or greater than the sample LOQ and less 5× the method blank value or the highest applicable calibration blank value, the sample result for the blank contaminant was amended as a non-detect at the concentration reported in the sample results.

- *No Action:* If a sample result for the blank contaminant was greater than 5× the blank value, the result was not amended.

#### *4.2.2.1 METHOD BLANKS*

No QC issues were associated with the method blanks for this analysis.

### 4.3 COMPARABILITY

The laboratory used standard analytical methods for all of the analyses. In all cases, the method detection limits attained were at or below the reporting limit. Target analytes detected below the reporting limits flagged (J) by the laboratory should be considered estimated. The comparability of the data is regarded as acceptable.

### 4.4 COMPLETENESS

The completeness level attained for metal field samples was 100 percent. This percentage was calculated as the total number of accepted sample results divided by the total number of sample results multiplied by 100.

### 4.5 SENSITIVITY

The calibration was evaluated for instrument sensitivity and was determined to be technically acceptable. All laboratory LODs and LOQs met the project requirements described in the work plan.

## 5.0 Variances in Analytical Performance

The laboratory used standard analytical methods for all of the analyses throughout the project. No systematic variances in analytical performance were noted according to the laboratory SOW.

## 6.0 Summary of PARCC criteria

The validation reports present the PARCC results for all SDGs. Each PARCC criterion is discussed in detail in the following sections.

### 6.1 PRECISION AND ACCURACY

Precision and accuracy were evaluated using data quality indicators such as MS/MSD, LCS, and surrogates. The precision and accuracy of the data set were considered acceptable after integration of qualification of estimated results as specifically noted in the data validation reports.

### 6.2 REPRESENTATIVENESS

All samples for each method and matrix were evaluated for holding time compliance. All samples were associated with a method blank in each individual SDG. The representativeness of the project data is considered acceptable after qualification for blank contamination.

## 6.3 COMPARABILITY

Sampling frequency requirements were met in obtaining duplicates and necessary field blanks. The laboratory used standard analytical methods for their analyses. The analytical results were reported in correct standard units. Holding times, sample preservation, and sample integrity were within QC criteria. The overall comparability is considered acceptable.

## 6.4 COMPLETENESS

Of the 1591 total analytes reported, 17 of the sample results were rejected. The completeness for all SDGs is as follows:

| **Parameter/Method** | **Total Analytes** | **No. of Rejects** | **%Completeness** |
|---|---|---|---|
| PAHs | 986 | 17 | 98.3 |
| PCBs | 140 | 0 | 100 |
| Metals | 465 | 0 | 100 |
| **Total** | **1,591** | **17** | **98.9** |

The completeness percentage based on rejected data met the 90 percent DQO goal. A less quantifiable loss of data occurred in the application of blank qualifications.

## 6.5 SENSITIVITY

Sensitivity was achieved by the laboratory to support the DQOs. Calibration concentrations and reporting limits met the project requirements and low level PAH contamination in the method blanks did not affect sensitivity.

**Table 1: Validation Sample Table, SDG 42300**

| Client ID # | Lab ID # | QC Type | Matrix | Date Collected | Mercury (7470A) | PAH (8270C-SIM) | PCBs (8082) |
|---|---|---|---|---|---|---|---|
| BA268 | AP55206 | | soil | 7-30-03 | X | | |
| BA269 | AP55207 | | soil | 7-30-03 | X | | |
| BA270 | AP55208 | | soil | 7-30-03 | X | | |
| BA271 | AP55209 | | soil | 7-30-03 | X | | |
| BA272 | AP55210 | | soil | 7-30-03 | X | | |
| BA273 | AP55211 | | soil | 7-30-03 | X | | |
| BA274 | AP55212 | | soil | 7-30-03 | X | | |
| BA275 | AP55213 | | soil | 7-30-03 | X | | |
| BA276 | AP55214 | | soil | 7-30-03 | X | | |
| BA277 | AP55215 | | soil | 7-30-03 | X | | |
| BA278 | AP55216 | | soil | 7-31-03 | X | | |
| BA279 | AP55217 | | soil | 7-31-03 | X | | |
| BA280 | AP55218 | | soil | 7-31-03 | X | | |
| BA281 | AP55219 | | soil | 7-31-03 | X | | |
| BA282 | AP55220 | | soil | 7-31-03 | X | | |
| BA283 | AP55221 | | soil | 7-31-03 | X | | |
| BA284 | AP55222 | | soil | 7-31-03 | X | | |
| BA285 | AP55223 | | soil | 7-31-03 | X | | |
| BA286 | AP55224 | | soil | 7-31-03 | X | | |
| BA287 | AP55225 | | soil | 7-31-03 | X | | |
| BA245 | AP54789 | | soil | 7-25-03 | | | X |
| BA246 | AP54790 | | soil | 7-25-03 | | | X |
| BA247 | AP54791 | | soil | 7-25-03 | | | X |
| BA248 | AP54792 | | soil | 7-25-03 | | | X |
| BA249 | AP54793 | | soil | 7-25-03 | | | X |
| BA250 | AP54794 | | soil | 7-25-03 | | | X |
| BA251 | AP54795 | | soil | 7-25-03 | | | X |
| BA252 | AP54796 | | soil | 7-25-03 | | | X |
| BA253 | AP54797 | | soil | 7-25-03 | | | X |
| BA254 | AP54798 | | soil | 7-25-03 | | | X |
| BA255 | AP54799 | | soil | 7-25-03 | | | X |
| BA256 | AP54800 | | soil | 7-25-03 | | | X |
| BA257 | AP54801 | | soil | 7-25-03 | | | X |
| BA258 | AP54802 | | soil | 7-25-03 | | | X |
| BA259 | AP54803 | | soil | 7-25-03 | | | X |
| BA260 | AP54804 | | soil | 7-25-03 | | | X |
| BA261 | AP54805 | | soil | 7-25-03 | | | X |
| BA262 | AP54806 | | soil | 7-25-03 | | | X |
| BA263 | AP54807 | | soil | 7-25-03 | | | X |
| BA264 | AP54808 | | soil | 7-25-03 | | | X |
| BA265 | AP54809 | | soil | 7-26-03 | | X | |
| BA265DL | AP54809DL | DL | soil | 7-26-03 | | X | |

| Client ID # | Lab ID # | QC Type | Matrix | Date Collected | Mercury (7470A) | PAH (8270C-SIM) | PCBs (8082) |
|---|---|---|---|---|---|---|---|
| BA266 | AP54810 | | soil | 7-26-03 | | X | |
| BA266DL | AP54810DL | DL | soil | 7-26-03 | | X | |
| BA266DL2 | AP54810DL2 | DL2 | soil | 7-26-03 | | X | |
| BA267 | AP54811 | | soil | 7-26-03 | | X | |
| BA245MS | AP54789MS | MS | soil | 7-25-03 | | | X |

# Laboratory QC Samples (Water, Soil)

## 1. Purpose

This section sets forth the standard operating procedure for identifying the number and type of laboratory quality control (QC) samples that will be analyzed during each contract task order (CTO) associated with the United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific. Laboratory QC analyses serve as a check on the precision and accuracy of analytical methods and instrumentation, and the potential contamination that might occur during laboratory sample preparation and analyses. Laboratory QC analyses include blank, surrogate, blank spike, laboratory control sample (LCS), and matrix spike (MS)/matrix spike duplicate (MSD) analyses. These laboratory QC analyses are discussed in general below.

## 2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

## 3. Definitions

### 3.1 PRECISION

Precision is the degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves. Precision is usually expressed as a standard deviation, variance, or range, in either absolute or relative terms. Examples of QC measures for precision include laboratory duplicates, laboratory triplicates, and matrix spike/matrix spike duplicates.

### 3.2 ACCURACY

Accuracy is the degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias), components which are due to sampling and analytical operations. Examples of QC measures for accuracy include performance evaluation samples, matrix spikes, LCSs, and equipment blanks.

### 3.3 MATRIX

A specific type of medium (e.g., surface water, drinking water), in which the analyte of interest may be contained. Medium is a substance (e.g., air, water, soil), which serves as a carrier of the analytes of interest (EPA 2010).

### 3.4 METHOD BLANK

An analyte-free matrix (water, soil, etc.) subjected to the entire analytical process to demonstrate that the analytical system itself does not introduce contamination.

### 3.5 MATRIX SPIKE

A sample prepared by adding a known concentration of a target analyte to an aliquot of a specific homogenized environmental sample for which an independent estimate of the target analyte concentration is available. The MS is accompanied by an independent analysis of the unspiked aliquot of the environmental sample. Spiked samples are used to determine the effect of the matrix on a method's recovery efficiency.

### 3.6 LABORATORY CONTROL SAMPLES AND BLANK SPIKES

A sample of known composition prepared using reagent-free water or an inert solid that is spiked with analytes of interest at the midpoint of the calibration curve or at the level of concern. It is analyzed using the sample preparation, reagents, and analytical methods employed for regular samples.

### 3.7 SURROGATES

A pure substance with properties that mimic the analyte of interest (organics only). Surrogates are typically brominated, fluorinated, or isotopically labeled compounds unlikely to be found in environmental samples. These analytes are added to samples to evaluate analytical efficiency by measuring recovery.

### 3.8 INTERNAL STANDARDS

A pure substance added to both samples and laboratory standards at a known concentration with the purpose of providing a basis of comparison in the quantitation of analytes of interest. Internal standards are primarily used to increase the accuracy and precision of analytical methods where the primary source of variability is in sample preparation or sample injection on instrument.

## 4. Responsibilities

The prime contractor's QA Manager or Technical Director, as well as QC coordinators are responsible for ensuring that sample analytical activities during all CTOs are in compliance with this procedure.

The CTO QC Coordinators and the Laboratory Manager are responsible for identifying instances of non-compliance with this procedure and ensuring that future laboratory analytical activities are in compliance with it.

## 5. Procedures

Laboratory QC checks include all types of samples specified in the requested analytical methods, such as the analysis of laboratory blank, duplicate, and MS samples. QC requirements are specified in each analytical method and in Appendix B, *Quality Control Requirements*, and Appendix C, *Laboratory Control Sample (LCS) Control Limits and Requirements*, of the *Department of Defense Quality Systems Manual for Environmental Laboratories* Version 5.0 (or most current version)

(DoD QSM). Types of QC samples are discussed in general below. Detailed discussion and minimum QA/QC requirements are presented in the DoD QSM (DoD 2013).

A comprehensive discussion of the minimum number of laboratory QC samples can be found in the *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B, Quality Assurance/Quality Control Compendium: Minimum QA/QC Activities* (DoD 2005b). However, additional QA/QC samples may be necessary based on the project quality objectives. Information pertaining to laboratory QC samples shall be documented in Worksheet 28 Laboratory QC Samples Table of the project UFP QAPP-style planning document.

## 5.1 LABORATORY BLANKS

Laboratory blank samples are analyzed to assess the degree to which laboratory contamination by reagent or method preparation may have affected sample analytical results. At a minimum, one laboratory blank will be analyzed per matrix per analytical method for each batch of at most 20 samples. In evaluating the blank results, all blank data are reviewed to identify any compounds detected in the blanks. The laboratory shall be contacted to discuss detection of analytes in blank samples only in the event of unusual contamination, but not for common laboratory contaminants at low levels. The following compounds are considered to be common laboratory contaminants: acetone, methylene chloride, 2-butanone, and common phthalate esters. The data for samples analyzed during the same time period as the blank are then evaluated to identify the presence of any contaminants found in the blanks. The presence of the blank contaminants found in associated samples is then evaluated to avoid potential misinterpretation of actual sample constituents. Briefly, as discussed in the data validation procedures, any analyte detected above the LOQ in both the sample and the associated blank is qualified as not detected if the sample concentration is less than five times the blank concentration (5× rule). For common laboratory contaminants (methylene chloride, acetone, 2-butanone, and common phthalate esters), a 10× rule applies.

## 5.2 LABORATORY REPLICATES (DUPLICATES AND TRIPLICATES)

Replicates are analyzed to evaluate the reproducibility, or precision, of the analytical procedures for a given sample. A replicate is two (duplicates) or three (triplicates) representative portions taken from one homogeneous sample by the laboratory and analyzed in the same laboratory (DoD 2005a). One duplicate sample is analyzed for each batch of twenty samples analyzed in a given matrix. Lab triplicates are assigned by the field team and identified on the chain of custody. The identification of a sample for lab triplicate analysis is typically selected from one of the field triplicates to allow for the evaluation of total study error of the sampling and analysis process. Duplicate analyses are normally performed on sample portions analyzed for inorganic constituents. For organic analyses, duplicate analyses are performed on MS samples (Section 5.5 of this procedure).

## 5.3 SURROGATES

Surrogate compounds must be added to all samples, standards, and blanks for all organic chromatography methods except when the matrix precludes its use or when a surrogate is not available. Poor surrogate recovery may indicate a problem with the sample composition and shall be reported to the client whose sample produced the poor recovery. Surrogate compounds to be included for organic analysis are specified in each analytical method.

### 5.4 LABORATORY CONTROL SAMPLES AND BLANK SPIKES

LCSs are used to demonstrate that the laboratory process for sample preparation and analysis is under control.

Analytes selected for spiking of LCSs are usually the same compounds used to spike MS/MSD samples and are representative target compounds. Control limits for LCS recoveries are provided in Appendix C of DoD QSM. If no control limits for LCS recoveries are listed in Appendix C of the DoD QSM for a given analyte, the laboratory's in-house derived control limits should be used.

For wet chemistry methods, a single spike of an appropriate control for each method may be used for LCS analyses (i.e., cyanide, a control standard of sodium cyanide from a source other than that used for calibration may be spiked into water samples and analyzed with the water samples). LCSs should be analyzed at a frequency of one per batch of at most twenty samples analyzed of similar matrix.

### 5.5 MATRIX SPIKES/MATRIX SPIKE DUPLICATES

MS analyses are conducted by the laboratory to assess the accuracy of specific analytical methods and to provide information on the effect of the sample matrix on the analytical methodology. Spike analyses are performed by adding compounds of known concentration to a sample, an unspiked portion of which has previously been analyzed or is concurrently analyzed. The spiked analytes are representative target compounds for each analytical method performed. The spiked sample results are evaluated with the original sample results to evaluate any effects the matrix has on the analysis. One MS is analyzed for each batch of at most 20 samples of similar matrix. Since MS samples only provide information about the specific sample matrix used for the spike, MS analyses should be performed for each type of matrix collected.

For the MSD, a separate aliquot of the sample is separately spiked and analyzed. As discussed in Section 5.2, results of MSD analyses are expressed as a relative percent difference, which is calculated by dividing the difference in concentration between the MSD and the MS sample analyses by the arithmetic mean of their concentrations. One MSD analysis is required for at most each 20 samples of similar matrix.

Acceptance criteria for both the MS and the MSD are based on historic laboratory performance and are laboratory-specific. As a general rule, the acceptance criteria should be no more stringent than the LCS acceptance criteria.

It is important to note that the UFP QAPP Part 2B, QA/QC Compendium: Minimum QA/QC Activities (DoD 2005b) states that for organic analysis, MS and MSDs are not considered a minimum QC activity as long as surrogate spikes properly mimic the analytes of concern and can identify matrix effects. Project quality objectives should be evaluated to determine if organic MS/MSDs are useful for individual projects.

## 6. Records

Records of QC samples analyzed during ER Program CTO activities will be maintained on laboratory bench sheets, raw data sheets, in the laboratory computerized data system, and on QC summary forms, as requested. Analytical laboratories maintain records in accordance with their quality assurance manual (QAM) as part of performing environmental analytical work under DoD.

Records shall be maintained in accordance with the analytical laboratory subcontract agreement specifications or the laboratory-specific QAM, whichever is more stringent.

## 7. Health and Safety

Applicable to laboratory personnel only.

## 8. References

Department of Defense, United States (DoD). 2005a. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

———. 2005b. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B: Quality Assurance/quality Control Compendium: Minimum QA/QC Activities*. Final Version 1. DoD: DTIC ADA 426957, EPA-505-B-04-900B. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/swerffrr/pdf/-qaqc_v1_0305.pdf.

———. 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2A: Optimized UFP-QAPP Worksheets*. Revision 1. March.

———. 2013. *Department of Defense Quality Systems Manual for Environmental Laboratories*. Version 5.0. Final. Prepared by DoD Environmental Data Quality Workgroup and Department of Energy Consolidated Audit Program Operations Team. July.

Environmental Protection Agency, United States (EPA). 2010. Environmental Monitoring and Assessment Program: QA Glossary. November 8. On-line updates available at: http://www.epa.gov/emfjulte/html/pubs/docs/resdocs/qa_terms.html#mm. Accessed 2015.

Procedure I-A-7, *Analytical Data Validation Planning and Coordination.*

## 9. Attachments

None.

# Field QC Samples (Water, Soil)

## 1. Purpose

This standard operating procedure describes the number and types of field quality control (QC) samples that will be collected during United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific site field work.

## 2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the Contract Task Order (CTO) Manager and the Quality Assurance (QA) Manager or Technical Director, as well as QC coordinators responsible for compliance with the procedure. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

## 3. Definitions

### 3.1 TRIP BLANK

Trip blanks are samples that originate from organic-free water (e.g., ASTM Type II water, high performance liquid chromatography grade water, etc.) prepared by the laboratory, shipped to the sampling site, and returned to the laboratory with samples to be analyzed for volatile organic compounds (VOCs). Trip blanks are analyzed to assess whether contamination was introduced during sample shipment (DoD 2005a). Trip blanks are prepared using the same sample container (typically a 40 ml VOA vial) as that used to collect field samples.

### 3.2 EQUIPMENT BLANK SAMPLES

An equipment blank (i.e., “decontamination rinsate,” or “equipment rinsate”) sample consists of a sample of water free of measurable contaminants poured over or through decontaminated field sampling equipment that is considered ready to collect or process an additional sample. Equipment blanks are to be collected from non-dedicated sampling equipment to assess the adequacy of the decontamination process.

### 3.3 FIELD BLANKS

A blank used to provide information about contaminants that may be introduced during sample collection, storage, and transport. It can also be a clean sample carried to the sampling site, exposed to sampling conditions, transported to the laboratory, and treated as an environmental sample.

### 3.4 FIELD DUPLICATE

A generic term for two field samples taken at the same time in approximately the same location is referred to as a field duplicate. The location of the duplicate (distance and direction from primary sample) should be specified in the project planning documents. They are intended to represent the same population and are taken through all steps of the analytical procedure in an identical manner and provide precision information for the data collection activity. There are two categories of field duplicate samples defined by the collection method: co-located field duplicates and subsample field duplicates. Co-located field duplicates are two or more independent samples collected from side-by-side locations at the same point in time and space so as to be considered identical. Co-located samples are collected from adjacent locations or liners (e.g., laterally or vertically, in separate containers), or water samples collected from the same well at the same time that have not been homogenized. Subsample field duplicates samples are obtained from one sample collection at one sample location.

### 3.5 FIELD REPLICATES

Two or more field replicates are used with incremental sampling approaches to statistically evaluate the sampling precision or error for each decision unit (DU). The location of the replicates (distance and direction from primary sample) and the number of DUs with replicates should be specified in the project planning documents. Increments for replicate samples are collected from completely separate locations (i.e., separate systematic random or stratified random grid). Triplicate samples (i.e., primary incremental sample plus two replicates) are required for incremental sampling and are more useful than just duplicates for statistical evaluation. The replicate samples are collected, prepared, and analyzed in the same manner as carried out for the primary sample.

### 3.6 TEMPERATURE INDICATORS (BLANKS)

A temperature indicator sample is often referred to as a temperature blank, but it is not analyzed nor does it measure introduced contamination. It may be a small sample bottle or VOA vial filled with distilled water that is placed in each shipping container to evaluate if samples were adequately cooled during sample shipment.

### 3.7 SOURCE WATER

Source water is water free from measurable contaminants that is used as the final decontamination rinse water.

## 4. Responsibilities

The prime contractor CTO Manager and QA Manager or Technical Director are responsible for ensuring that field QC samples are collected and analyzed according to this procedure. The CTO Manager is responsible for ensuring that all personnel involved in sampling or testing shall have the appropriate education, experience, and training to perform their assigned tasks as specified in Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

The prime contractor QC Coordinator is responsible for determining the QC sample requirements.

The Laboratory Manager is responsible for ensuring that field QC samples are analyzed according to the specifications of the project statement of work and the analytical methods used.

The Field Manager is responsible for ensuring that all project field staff follow these procedures.

Field sampling personnel are responsible for the implementation of this procedure.

# 5. Procedures

Field QC checks may include submission of trip blank, equipment blank, field blank, duplicate, triplicate, and temperature indicator (blank) samples to the laboratory. Types of field QC samples are discussed in general below. Table III-B-1 identifies the minimum frequency at which field QC samples should be collected, with the actual frequency to be determined by the individual project needs. For additional information on field QC frequency, see the State of Hawaii Department of Health 2009 *Technical Guidance Manual for the Implementation of the Hawaii State Contingency Plan*.

A comprehensive discussion of the minimum types and numbers of field QC samples can be found in the *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B, Quality Assurance/Quality Control Compendium: Minimum QA/QC Activities* (DoD 2005).

**Table III-B-1: Field QC Samples per Sampling Event**

| | Minimum QC Sample Frequency | |
|---|---|---|
| Type of Sample | Metals | Organic |
| Trip blank (for volatiles only) | N/A | 1/analytical method/cooler |
| Equipment blank | 5% | 5% |
| Field blank | 1/decontamination water source/event [a]/for all analytes | |
| Field replicates [b] | 10% | 10% |
| Temperature Indicator (blank) | 1/shipping container | |

% percent
N/A not applicable
[a] A sampling event is considered to be from the time sampling personnel arrive at a site until they leave for more than a week. The use of controlled-lot source water makes one sample per lot, rather than per event, an option.
[b] To the extent practical, field replicates should be collected from the same locations as the samples designated for a laboratory matrix spike/matrix spike duplicate (organic analysis) where applicable, or from the sample used as a laboratory duplicate (inorganic analysis).

## 5.1 TRIP BLANKS

The laboratory prepares trip blanks using organic-free water, and then sends them to the field. The laboratory shall place trip blanks in sample coolers prior to transport to the site so that they accompany the samples throughout the sample collection/handling/transport process. Once prepared, trip blanks should not be opened until they reach the laboratory. One set of two 40-milliliter vials per volatile analysis forms a trip blank and accompanies each cooler containing samples to be analyzed for volatiles. Trip blanks are only analyzed for volatiles. Results of trip blank analyses are used to assess whether samples have been contaminated by volatiles during sample handling and transport to the laboratory.

Trip blanks are not typically associated with tissue samples; however, project-specific quality objectives shall determine if trip blanks for tissue samples are required.

## 5.2 EQUIPMENT BLANK SAMPLES

Collect equipment blank samples by pumping the source water over and/or through the decontaminated sampling equipment. Collect this runoff water into the sample containers directly or with the use of a funnel, if necessary. The source water may be pumped or poured by tipping the jug of water upside down over the equipment. Results of equipment blank samples are used to evaluate whether equipment decontamination was effective.

At a minimum, equipment blank samples should be collected at a rate of 5 percent of the total samples planned for collection for each sampling technique used. This rate may be adjusted depending on the nature of the investigation (site inspection, remedial investigation, remedial site evaluation, long-term monitoring) and the associated project quality objectives (PQOs). Equipment blank samples will be analyzed for the same parameters as the samples collected with that particular equipment. If analytes pertinent to the project are found in the equipment blanks, the frequency of equipment blank samples may be increased after decontamination procedures have been modified to further evaluate the effectiveness of the decontamination procedure.

When disposable or dedicated sampling equipment is used, equipment blank samples do not need to be collected.

Sampling devices (e.g., gloved hands, dip nets, or traps) used for collection of tissue samples are generally non-intrusive into the organisms collected, so equipment blank samples will not be collected as long as the devices have been properly cleaned following Procedure I-F, *Equipment Decontamination*, and appear clean.

## 5.3 FIELD BLANKS

Field blanks, consisting of samples of the source water used as the final decontamination rinse water, will be collected on site by field personnel by pouring the source water into sample containers and then analyzed to assess whether contaminants may have been introduced during sample collection, storage, and transport.

The final decontamination rinse water source (the field blank source water) and equipment blank source water should all be from the same purified water source. Tap water used for steam cleaning augers or used in the initial decontamination buckets need not be collected and analyzed as a field blank since augers typically do not touch the actual samples and the final decontamination rinse water should be from a purified source.

Field blanks should be collected at a minimum frequency of one per sampling event per each source of water. A sampling event is considered to be from the time sampling personnel arrive at a site until they leave for more than a week. Field blanks will be analyzed for the same parameters as the samples collected during the period that the water sources are being used for decontamination. Additional field blanks may be required based on PQOs.

## 5.4 FIELD DUPLICATES

Field duplicates consist of either co-located or subsampled samples. Field duplicates for ground water and surface water samples are generally considered to be co-located samples. Soil duplicate samples may be homogenized and subsampled in the field (or at the laboratory) to form an original and duplicate sample, or may be an additional volume of sample collected in a separate sample container to form a co-located sample.

The interpretation of co-located duplicate data may be more complex than subsample duplicate data because of the number of variables associated with the results of this type of duplicate sample. Duplicate soil samples for VOC analysis shall always be co-located (i.e., not homogenized or otherwise processed or subsampled). Duplicates will be analyzed for the same analytical parameters as their associated original sample. Collection of both co-located and subsampled versions of the same sample may be performed to aid in approximating sampling and analysis error.

Field duplicates for biological tissue samples will consist of subsamples of the original sample. Twice the required volume of organisms for one sample will be collected and placed into one food-grade, self-sealing bag. The sample will later be homogenized in the laboratory and subsampled, producing an original and a duplicate sample. Tissue duplicate samples will be analyzed for the same analytical parameters as their associated original samples.

### 5.5 FIELD REPLICATES

Field replicates are completely separate incremental replicate samples (collected from a set of systematic random or stratified random locations within the DU that are different from those used for the primary incremental samples). A different random starting location is determined for each replicate collected in the selected DU. Field replicates are typically collected in sets of three (the primary sample and two replicate samples) to produce a triplicate.

Replicate sample increments are collected from the same sampling grid established through the DU for the primary incremental sample, though at different systematic random locations than initially used. The replicate increments should not be collected from the same points or co-located with those used for the primary incremental sample. Replicate samples are sent to the laboratory as “blind” samples, meaning the laboratory does not know they represent replicate samples of the primary incremental sample.

### 5.6 TEMPERATURE INDICATORS (BLANKS)

Temperature indicators (blanks) may be prepared in the lab or field by filling a small sample bottle or VOA vial with distilled water and sealing the container. One temperature indicator sample should be placed in each sample cooler or shipping container. Upon arrival at the laboratory, the temperature of the bottle is measured to determine if samples were adequately cooled during the shipment.

## 6. Records

Records of QC samples analyzed during ER Program CTO activities will be maintained on laboratory bench sheets, raw data sheets, in the laboratory computerized data system, and on QC summary forms, as requested. Analytical laboratories maintain records in accordance with their quality assurance manual (QAM) as part of performing environmental analytical work under DoD. Records shall be maintained in accordance with the analytical laboratory subcontract agreement specifications or the laboratory-specific QAM, whichever is more stringent.

## 7. Health and Safety

Field personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2008) and site-specific health and safety plan.

## 8. References

Department of Defense, United States (DoD). 2005a. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

———. 2005b. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B: Quality Assurance/quality Control Compendium: Minimum QA/QC Activities*. Final Version 1. DoD: DTIC ADA 426957, EPA-505-B-04-900B. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/swerffrr/pdf/-qaqc_v1_0305.pdf.

———. 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2A: Optimized UFP-QAPP Worksheets*. Revision 1. March.

———. 2013. *Department of Defense Quality Systems Manual for Environmental Laboratories*. Version 5.0. Draft Final. Prepared by DoD Environmental Data Quality Workgroup and Department of Energy Consolidated Audit Program Operations Team. July.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual*. EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure I-F, *Equipment Decontamination*.

Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*.

## 9. Attachments

None.

# Logbooks

## 1. Purpose

This standard operating procedure describes the activities and responsibilities pertaining to the identification, use, and control of logbooks and associated field data records for use by United States Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel.

## 2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan Appendix A. Section 1.4 *Field Documentation SOPs* (DoD 2005). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the Contract Task Order (CTO) Manager and the Quality Assurance Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

## 3. Definitions

### 3.1 LOGBOOK

A logbook is a bound field notebook with consecutively numbered, water-repellent pages that is clearly identified with the name of the relevant activity, the person assigned responsibility for maintenance of the logbook, and the beginning and ending dates of the entries.

### 3.2 DATA FORM

A data form is a predetermined format used for recording field data that may become, by reference, a part of the logbook (e.g., soil boring logs, trenching logs, surface soil sampling logs, groundwater sample logs, and well construction logs are data forms).

## 4. Responsibilities

The prime contractor CTO Manager or delegate is responsible for determining which team members shall record information in field logbooks and for obtaining and maintaining control of the required logbooks. The CTO Manager shall review the field logbook on at least a monthly basis. The CTO Manager or designee is responsible for reviewing logbook entries to determine compliance with this procedure and to ensure that the entries meet the project requirements.

A knowledgeable individual such as the Field Manager, CTO Manager, or quality control (QC) Supervisor shall perform a technical review of each logbook at a frequency commensurate with the level of activity (weekly is suggested, or, at a minimum, monthly). Document these reviews by the dated signature of the reviewer on the last page or page immediately following the material reviewed.

The Field Manager is responsible for ensuring that all project field staff follow these procedures and that the logbook is completed properly and daily. The Field Manager is also responsible for submitting copies to the CTO Manager, who is responsible for filing them and submitting a copy to the Navy (if required by the CTO Statement of Work).

The logbook user is responsible for recording pertinent data into the logbook to satisfy project requirements and for attesting to the accuracy of the entries by dated signature. The logbook user is also responsible for safeguarding the logbook while having custody of it.

Field personnel are responsible for the implementation of this procedure.

All NAVFAC Pacific ER Program field personnel are responsible for complying with Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

# 5. Procedure

The field logbook serves as the primary record of field activities. Make entries chronologically and in sufficient detail to allow the writer or a knowledgeable reviewer to reconstruct the applicable events. Store the logbook in a clean location and use it only when outer gloves used for personal protective equipment (PPE) have been removed.

Individual data forms may be generated to provide systematic data collection documentation. Entries on these forms shall meet the same requirements as entries in the logbook and shall be referenced in the applicable logbook entry. Individual data forms shall reference the applicable logbook and page number. At a minimum, include names of all samples collected in the logbook even if they are recorded elsewhere.

Enter field descriptions and observations into the logbook, as described in Attachment III-D-1, using indelible black ink.

Typical information to be entered includes the following:

- Dates (month/day/year) and times (military) of all onsite activities and entries made in logbooks/forms
- Site name, and description
- Site location by longitude and latitude, if known
- Weather conditions, including estimated temperature and relative humidity
- Fieldwork documentation, including site entry and exit times
- Descriptions of, and rationale for, approved deviations from the work plan or field sampling plan
- Field instrumentation readings
- Names, job functions, and organizational affiliations of personnel on-site

- Photograph references
- Site sketches and diagrams made on-site
- Identification and description of sample morphology, collection locations and sample numbers as described in Procedure I-A-8, *Sample Naming*
- Sample collection information, including dates (month/day/year) and times (military) of sample collections, sample collection methods and devices, station location numbers, sample collection depths/heights, sample preservation information, sample pH (if applicable), analysis requested (analytical groups), etc., as well as chain-of-custody (COC) information such as sample identification numbers cross-referenced to COC sample numbers
- Sample naming convention
- Field QC sample information
- Site observations, field descriptions, equipment used, and field activities accomplished to reconstruct field operations
- Meeting information
- Important times and dates of telephone conversations, correspondence, or deliverables
- Field calculations
- PPE level
- Calibration records
- Contractor and subcontractor information (address, names of personnel, job functions, organizational affiliations, contract number, contract name, and work assignment number)
- Equipment decontamination procedures and effectiveness
- Laboratories receiving samples and shipping information, such as carrier, shipment time, number of sample containers shipped, and analyses requested
- User signatures

The logbook shall reference data maintained in other logs, forms, etc. Correct entry errors by drawing a single line through the incorrect entry, then initialing and dating this change. Enter an explanation for the correction if the correction is more than for a mistake.

At least at the end of each day, the person making the entry shall sign or initial each entry or group of entries.

Enter logbook page numbers on each page to facilitate identification of photocopies.

If a person’s initials are used for identification, or if uncommon acronyms are used, identify these on a page at the beginning of the logbook.

At least weekly and preferably daily, the preparer shall photocopy (or scan) and retain the pages completed during that session for backup. This will prevent loss of a large amount of information if the logbook is lost.

## 6. Records

Retain the field logbook as a permanent project record. If a particular CTO requires submittal of photocopies of logbooks, perform this as required.

## 7. Health and Safety

Store the logbook in a clean location to keep it clean and use it only when outer gloves used for PPE have been removed.

## 8. References

Department of Defense, United States (DoD). 2005a. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Procedure I-A-8, *Sample Naming*.

## 9. Attachments

Attachment III-D-1: Description of Logbook Entries

# Attachment III-D-1
# Description of Logbook Entries

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Logbook entries shall be consistent with Section A.1.4 *Field Documentation SOPs* of the UFP-QAPP Manual (DoD 2005) and contain the following information, as applicable, for each activity recorded. Some of these details may be entered on data forms, as described previously.

| | |
|---|---|
| Name of Activity | For example, Asbestos Bulk Sampling, Charcoal Canister Sampling, Aquifer Testing. |
| Task Team Members and Equipment | Name all members on the field team involved in the specified activity. List equipment used by serial number or other unique identification, including calibration information. |
| Activity Location | Indicate location of sampling area as indicated in the field sampling plan. |
| Weather | Indicate general weather and precipitation conditions. |
| Level of PPE | Record the level of PPE (e.g., Level D). |
| Methods | Indicate method or procedure number employed for the activity. |
| Sample Numbers | Indicate the unique numbers associated with the physical samples. Identify QC samples. |
| Sample Type and Volume | Indicate the medium, container type, preservative, and the volume for each sample. |
| Time and Date | Record the time and date when the activity was performed (e.g., 0830/08/OCT/89). Use the 24-hour clock for recording the time and two digits for recording the day of the month and the year. |
| Analyses | Indicate the appropriate code for analyses to be performed on each sample, as specified in the WP. |
| Field Measurements | Indicate measurements and field instrument readings taken during the activity. |
| Chain of Custody and Distribution | Indicate chain-of-custody for each sample collected and indicate to whom the samples are transferred and the destination. |
| References | If appropriate, indicate references to other logs or forms, drawings, or photographs employed in the activity. |
| Narrative (including time and location) | Create a factual, chronological record of the team’s activities throughout the day including the time and location of each activity. Include descriptions of general problems encountered and their resolution. Provide the names and affiliations of non-field team personnel who visit the site, request changes in activity, impact the work schedule, request information, or observe team activities. Record any visual or other observations relevant to the activity, the contamination source, or the sample itself.<br>It should be emphasized that logbook entries are for recording data and chronologies of events. The logbook author must include observations and descriptive notations, taking care to be objective and recording no opinions or subjective comments unless appropriate. |
| Recorded by | Include the signature of the individual responsible for the entries contained in the logbook and referenced forms. |
| Checked by | Include the signature of the individual who performs the review of the completed entries. |

# Record Keeping, Sample Labeling, and Chain-Of-Custody

## 1. Purpose

The purpose of this standard operating procedure is to establish standard protocols for all United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific field personnel for use in maintaining field and sampling activity records, writing sample logs, labeling samples, ensuring that proper sample custody procedures are used, and completing chain-of-custody/analytical request forms.

## 2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

## 3. Definitions

### 3.1 LOGBOOK

A logbook is a bound field notebook with consecutively numbered, water-repellent pages that is clearly identified with the name of the relevant activity, the person responsible for maintenance of the logbook, and the beginning and ending dates of the entries.

### 3.2 CHAIN-OF-CUSTODY

Chain-of-custody (COC) is documentation of the process of custody control. Custody control includes possession of a sample from the time of its collection in the field to its receipt by the analytical laboratory, and through analysis and storage prior to disposal.

## 4. Responsibilities

The prime contractor CTO Manager is responsible for determining which team members shall record information in the field logbook and for checking sample logbooks and COC forms to ensure compliance with these procedures. The CTO Manager shall review COC forms on a monthly basis at a minimum.

The prime contractor CTO Manager and QA Manager or Technical Director are responsible for evaluating project compliance with the Project Procedures Manual. The QA Manager or Technical Director is responsible for ensuring overall compliance with this procedure.

The Laboratory Project Manager or Sample Control Department Manager is responsible for reporting any sample documentation or COC problems to the CTO Manager or CTO Laboratory Coordinator within 24 hours of sample receipt.

The Field Manager is responsible for ensuring that all field personnel follow these procedures. The CTO Laboratory Coordinator is responsible for verifying that the COC/analytical request forms have been completed properly and match the sampling and analytical plan. The CTO Manager or CTO Laboratory Coordinator is responsible for notifying the laboratory, data managers, and data validators in writing if analytical request changes are required as a corrective action. These small changes are different from change orders, which involve changes to the scope of the subcontract with the laboratory and must be made in accordance with a respective contract (e.g., Comprehensive Long-Term Environmental Action Navy, remedial action contract).

NAVFAC Pacific ER Program field personnel are responsible for following these procedures while conducting sampling activities. Field personnel are responsible for recording pertinent data into the logbook to satisfy project requirements and for attesting to the accuracy of the entries by dated signature. All NAVFAC Pacific ER Program field personnel are responsible for complying with Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

# 5. Procedures

This procedure provides standards for documenting field activities, labeling the samples, documenting sample custody, and completing COC/analytical request forms. The standards presented in this section shall be followed to ensure that samples collected are maintained for their intended purpose and that the conditions encountered during field activities are documented.

## 5.1 RECORD KEEPING

The field logbook serves as the primary record of field activities. Make entries chronologically and in sufficient detail to allow the writer or a knowledgeable reviewer to reconstruct each day’s events. Field logs such as soil boring logs and groundwater sampling logs will also be used. These procedures are described in Procedure III-D, *Logbooks*.

## 5.2 SAMPLE LABELING

Affix a sample label with adhesive backing to each individual sample container with the exception of pre-tared containers. Record the following information with a waterproof marker (ballpoint pen for containers for volatile analyses) on each label:

- Project name or number (optional)
- COC sample number
- Date and time of collection
- Sampler's initials
- Matrix (optional)
- Sample preservatives (if applicable)

- Analysis to be performed on sample (This shall be identified by the method number or name identified in the subcontract with the laboratory)
- Indicate if sample is to be used as the matrix spike (MS)/matrix spike duplicate (MSD) or laboratory triplicate sample

With the exception of sample containers with pre-tared labels, place clear tape over each label (preferably prior to sampling) to prevent the labels from tearing off, falling off, or being smeared, and to prevent loss of information on the label.

These labels may be obtained from the analytical laboratory or printed from a computer file onto adhesive labels.

For volatile soil organic analyses (VOA), labels are not to be affixed to vials that are pre-tared by the laboratory. Instead, on each of the VOA vials in the sample set (typically three per sample), mark the sample COC Sample identification (ID) on the vial in ballpoint pen. Then wrap the vials together in bubble wrap and place one sample label on the bubble wrap and cover with tape. It is imperative that the COC Sample ID be clearly marked on each vial as this will help prevent laboratory error if the vials are inadvertently separated after removal from the bubble wrap.

## 5.3 CUSTODY PROCEDURES

For samples intended for chemical analysis, sample custody procedures shall be followed through collection, transfer, analysis, and disposal to ensure that the integrity of the samples is maintained. Maintain custody of samples in accordance with the U.S. Environmental Protection Agency (EPA) COC guidelines prescribed in U.S. Environmental Protection Agency (EPA) *NEIC Policies and Procedures*, National Enforcement Investigations Center, Denver, Colorado, revised August 1991 (EPA 1978); EPA *RCRA Ground Water Monitoring Technical Enforcement Guidance Document* (TEGD), *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA OSWER Directive 9355 3-01) (EPA 1988, Appendix 2 of the *Technical Guidance Manual for Solid Waste Water Quality Assessment Test (SWAT) Proposals and Reports* (Cal/EPA 1988), and *Test Methods for Evaluating Solid Waste* (EPA 2007). A description of sample custody procedures is provided below.

### 5.3.1 Sample Collection Custody Procedures

According to the EPA guidelines, a sample is considered to be in custody if one of the following conditions is met:

- It is in one’s actual physical possession or view
- It is in one’s physical possession and has not been tampered with (i.e., it is under lock or official seal)
- It is retained in a secured area with restricted access
- It is placed in a container and secured with an official seal such that the sample cannot be reached without breaking the seal

Place custody seals on sample containers (on bubble wrap for pre-tared containers) immediately after sample collection and on shipping coolers if the cooler is to be removed from the sampler's custody.

Place custody seals in such a manner that they must be broken to open the containers or coolers. Label the custody seals with the following information:

- Sampler's name or initials
- Date and time that the sample/cooler was sealed

These seals are designed to enable detection of sample tampering. An example of a custody seal is shown in Attachment III-E-1.

Field personnel shall also log individual samples onto COC forms (carbon copy or computer generated) when a sample is collected or just prior to shipping. These forms may also serve as the request for analyses. Procedures for completing these forms are discussed in Section 5.4, indicating sample identification number, matrix, date and time of collection, number of containers, analytical methods to be performed on the sample, and preservatives added (if any). The samplers will also sign the COC form signifying that they were the personnel who collected the samples. The COC form shall accompany the samples from the field to the laboratory. When a cooler is ready for shipment to the analytical laboratory, the person delivering the samples for transport will sign and indicate the date and time on the accompanying COC form. One copy of the COC form will be retained by the sampler and the remaining copies of the COC form shall be placed inside a self-sealing bag and taped to the inside of the cooler. Each cooler must be associated with a unique COC form. Whenever a transfer of custody takes place, both parties shall sign and date the accompanying carbon copy COC forms, and the individual relinquishing the samples shall retain a copy of each form. One exception is when the samples are shipped; the delivery service personnel will not sign or receive a copy because they do not open the coolers. The laboratory shall attach copies of the completed COC forms to the reports containing the results of the analytical tests. An example COC form is provided in Attachment III-E-2.

### 5.3.2 Laboratory Custody Procedures

The following custody procedures are to be followed by an independent laboratory receiving samples for chemical analysis; the procedures in their Naval Facilities Engineering and Expeditionary Warfare Center-evaluated Laboratory Quality Assurance Plan must follow these same procedures. A designated sample custodian shall take custody of all samples upon their arrival at the analytical laboratory. The custodian shall inspect all sample labels and COC forms to ensure that the information is consistent, and that each is properly completed. The custodian will also measure the temperature of the temperature blank in the coolers upon arrival using either a National Institute for Standards and Technology calibrated thermometer or an infra-red temperature gun. The custodian shall note the condition of the samples including:

- If the samples show signs of damage or tampering
- If the containers are broken or leaking
- If headspace is present in sample vials
- Proper preservation of samples (made by pH measurement, except volatile organic compounds (VOCs) and purgeable total petroleum hydrocarbons (TPH) and temperature). The pH of VOC and purgeable TPH samples will be checked by the laboratory analyst after the sample aliquot has been removed from the vial for analysis.

- If any sample holding times have been exceeded

All of the above information shall be documented on a sample receipt sheet by the custodian.

Discrepancies or improper preservation shall be noted by the laboratory as an out-of-control event and shall be documented on an out-of-control form with corrective action taken. The out-of-control form shall be signed and dated by the sample control custodian and any other persons responsible for corrective action. An example of an out-of-control form is included as Attachment III-E-4.

The custodian shall then assign a unique laboratory number to each sample and distribute the samples to secured storage areas maintained at 4 degrees Celsius (soil samples for VOC analysis are to be stored in a frozen state until analysis). The unique laboratory number for each sample, the COC sample number, the client name, date and time received, analysis due date, and storage shall also be manually logged onto a sample receipt record and later entered into the laboratory's computerized data management system. The custodian shall sign the shipping bill and maintain a copy.

Laboratory personnel shall be responsible for the care and custody of samples from the time of their receipt at the laboratory through their exhaustion or disposal. Samples should be logged in and out on internal laboratory COC forms each time they are removed from storage for extraction or analysis.

## 5.4 COMPLETING COC/ANALYTICAL REQUEST FORMS

COC form/analytical request form completion procedures are crucial in properly transferring the custody and responsibility of samples from field personnel to the laboratory. This form is important for accurately and concisely requesting analyses for each sample; it is essentially a release order from the analysis subcontract.

Attachment III-E-2 is an example of a generic COC/analytical request form that may be used by field personnel. Multiple copies may be tailored to each project so that much of the information described below need not be handwritten each time. Attachment III-E-3 is an example of a completed site-specific COC/analytical request form, with box numbers identified and discussed in text below.

Box 1 *Project Manager:* This name shall be the name that will appear on the report. Do not write the name of the Project Coordinator or point of contact for the project instead of the CTO manager.

*Project Name:* Write the project name as it is to appear on the report.

*Project Number:* Write the project number as it is to appear on the report. It shall include the project number and task number. Also include the laboratory subcontract number.

Box 2 *Bill to:* List the name and address of the person/company to bill only if it is not in the subcontract with the laboratory.

Box 3 *Sample Disposal Instructions:* These instructions will be stated in the Master Service Agreement or each CTO statement of work with each laboratory.

*Shipment Method:* State the method of shipment (e.g., hand carry; air courier via FED EX, AIR BORNE, or DHL).

*Comment:* This area shall be used by the field team to communicate observations, potential hazards, or limitations that may have occurred in the field or additional information regarding analysis (e.g., a specific metals list, samples expected to contain high analyte concentrations).

Box 4 *Cooler Number:* This will be written on the inside or outside of the cooler and shall be included on the COC. Some laboratories attach this number to the trip blank identification, which helps track volatile organic analysis samples. If a number is not on the cooler, field personnel shall assign a number, write it on the cooler, and write it on the COC.

*QC Level:* Enter the reporting/QC requirements (e.g., Full Data Package, Summary Data Package).

*Turn around time (TAT):* TAT will be determined by a sample delivery group (SDG), which may be formed over a 14-day period, not to exceed 20 samples. Once the SDG has been completed, standard TAT is 21 calendar days from receipt of the last sample in the SDG. Entering NORMAL or STANDARD in this field will be acceptable. If quicker TAT is required, it shall be in the subcontract with the laboratory and reiterated on each COC to remind the laboratory.

Box 5 *Type of containers:* Write the type of container used (e.g., 1 liter glass amber, for a given parameter in that column).

*Preservatives:* Field personnel must indicate on the COC the correct preservative used for the analysis requested. Indicate the pH of the sample (if tested) in case there are buffering conditions found in the sample matrix.

Box 6 *COC sample number:* This is typically a five-character alpha-numeric identifier used by the contractor to identify samples. The use of this identifier is important since the labs are restricted to the number of characters they are able to use. See Procedure I-A-8, *Sample Naming*.

*Description (sample identification):* This name will be determined by the location and description of the sample, as described in Procedure I-A-8, *Sample Naming*. This sample identification should not be submitted to the laboratory, but should be left blank. If a computer COC version is used, the sample identification can be input, but printed with this block black. A cross-referenced list of COC Sample Number and sample identification must be maintained separately.

Identify if sample requires laboratory subsampling.

*Date Collected:* Record the collection date to track the holding time of the sample. Note: For trip blanks, record the date it was placed in company with samples.

*Time Collected:* When collecting samples, record the time the sample is first collected. Use of the 24-hour military clock will avoid a.m. or p.m. designations (e.g., 1815 instead of 6:15 p.m.). Record local time; the laboratory is responsible for calculating holding times to local time.

*Lab Identification:* This is for laboratory use only.

Box 7 *Matrix and QC:* Identify the matrix (e.g., water, soil, air, tissue, fresh water sediment, marine sediment, or product). If a sample is expected to contain high analyte concentrations (e.g., a tank bottom sludge or distinct product layer), notify the laboratory in the comment section. Mark an “X” for the sample(s) that have extra volume for laboratory QC matrix spike/matrix spike duplicate (MS/MSD) or laboratory triplicate purposes. The sample provided for MS/MSD purposes is usually a field duplicate.

Box 8 *Analytical Parameters:* Enter the parameter by descriptor and the method number desired (e.g. benzene, toluene, ethylbenzene, and xylenes 8260B, polynuclear aromatic hydrocarbons 8270C, etc.). Whenever practicable, list the parameters as they appear in the laboratory subcontract to maintain consistency and avoid confusion.

If the COC does not have a specific box for number of sample containers, use the boxes below the analytical parameter, to indicate the number of containers collected for each parameter.

Box 9 *Sampler’s Signature:* The person who collected samples must sign here.

*Relinquished By:* The person who turned over the custody of the samples to a second party other than an express mail carrier, such as FEDEX, must sign here.

*Received By:* Typically, a representative of the receiving laboratory signs here. Or, a field crew member who delivered the samples in person from the field to the laboratory might sign here. A courier, such as Federal Express, does not sign here because they do not open the coolers. It must also be used by the prime contracting laboratory when samples are to be sent to a subcontractor.

*Relinquished By:* In the case of subcontracting, the primary laboratory will sign the Relinquished By space and fill out an additional COC to accompany the samples being subcontracted.

*Received By (Laboratory):* This space is for the final destination (e.g., at a subcontracted laboratory).

Box 10 *Lab Number and Questions:* This box is to be filled in by the laboratory only.

Box 11 *Control Number:* This number is the "COC" followed by the first contractor identification number in that cooler, or contained on that COC. This control number must be unique (i.e., never used twice). Record the date the COC is completed. It should be the same date the samples are collected.

Box 12 *Total No. of Containers/row:* Sum the number of containers in that row.

Box 13 *Total No. of Containers/column:* Sum the number of containers in that column. Because COC forms contain different formats depending on who produced the form, not all of the information listed in items 1 to 13 may be recorded; however, as much of this information as possible shall be included.

COC forms tailored to each CTO can be drafted and printed onto multi-ply forms. This eliminates the need to rewrite the analytical methods column headers each time. It also eliminates the need to write the project manager, name, and number; QC Level; TAT; and the same general comments each time.

Complete one COC form per cooler. Whenever possible, place all volatile organic analyte vials into one cooler in order to reduce the number of trip blanks. Complete all sections and be sure to sign and date the COC form. One copy of the COC form must remain with the field personnel.

## 6. Records

The COC/analytical request form shall be faxed or e-mailed to the CTO Laboratory Coordinator for verification of accuracy. Following the completion of sampling activities, the sample logbook and COC forms will be transmitted to the CTO Manager for storage in project files. The data validators shall receive a copy also. The original COC/analytical request form shall be submitted by the laboratory along with the data delivered. Any changes to the analytical requests that are required shall be made in writing to the laboratory. A copy of this written change shall be sent to the data validators and placed in the project files. The reason for the change shall be included in the project files so that recurring problems can be easily identified.

## 7. Health and Safety

Not applicable.

## 8. References

California Environmental Protection Agency (Cal/EPA). 1988. *Technical Guidance Manual, Solid Waste Water Quality Assessment Test (SWAT) Proposals and Reports.* Solid Waste Disposal Program, Hydrogeology Section, Land Disposal Branch, Division of Water Quality, State Water Resources Control Board. August.

Department of Defense, United States (DoD). 2005a. Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

———. 2005b. Uniform Federal Policy for Quality Assurance Project Plans, Part 2B: Quality Assurance/quality Control Compendium: Minimum QA/QC Activities. Final Version 1. DoD: DTIC ADA 426957, EPA-505-B-04-900B. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/swerffrr/pdf/-qaqc_v1_0305.pdf.

———. 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2A: Optimized UFP-QAPP Worksheets*. Revision 1. March.

———. 2013. *Department of Defense Quality Systems Manual for Environmental Laboratories.* Version 5.0. Draft Final. Prepared by DoD Environmental Data Quality Workgroup and Department of Energy Consolidated Audit Program Operations Team. July.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

Environmental Protection Agency, United States (EPA). 1978. *NEIC Policies and Procedures.* EPA-330/9-78-001-R. Revised August 1991. National Enforcement Investigation Center. Denver. May.

———. 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA.* Interim Final. EPA/540/G-89/004. Office of Emergency and Remedial Response. October.

———. 2007. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846.* 3rd ed., Revision 6. Office of Solid Waste. November. On-line updates at: http://www.epa.gov/epawaste/hazard/testmethods/sw846/online/index.htm.

Procedure I-A-8, *Sample Naming.*

Procedure III-D, *Logbooks.*

## 9. Attachments

Attachment III-E-1, Chain-of-Custody Seal

Attachment III-E-2, Generic Chain-of-Custody/Analytical Request Form

Attachment III-E-3, Sample Completed Chain-of-Custody

Attachment III-E-4, Sample Out-of-Control Form

# Attachment III-E-1
# Chain-of-Custody Seal

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# CHAIN-OF-CUSTODY SEAL

| | |
|---|---|
| **CUSTODY SEAL** | |
| Company Name (808) XXX-XXXX | |
| Sampler's Name/Initials:____________________ | Date: _____________ Time: _____________ |

# Attachment III-E-2
# Generic Chain-of-Custody/Analytical Request Form

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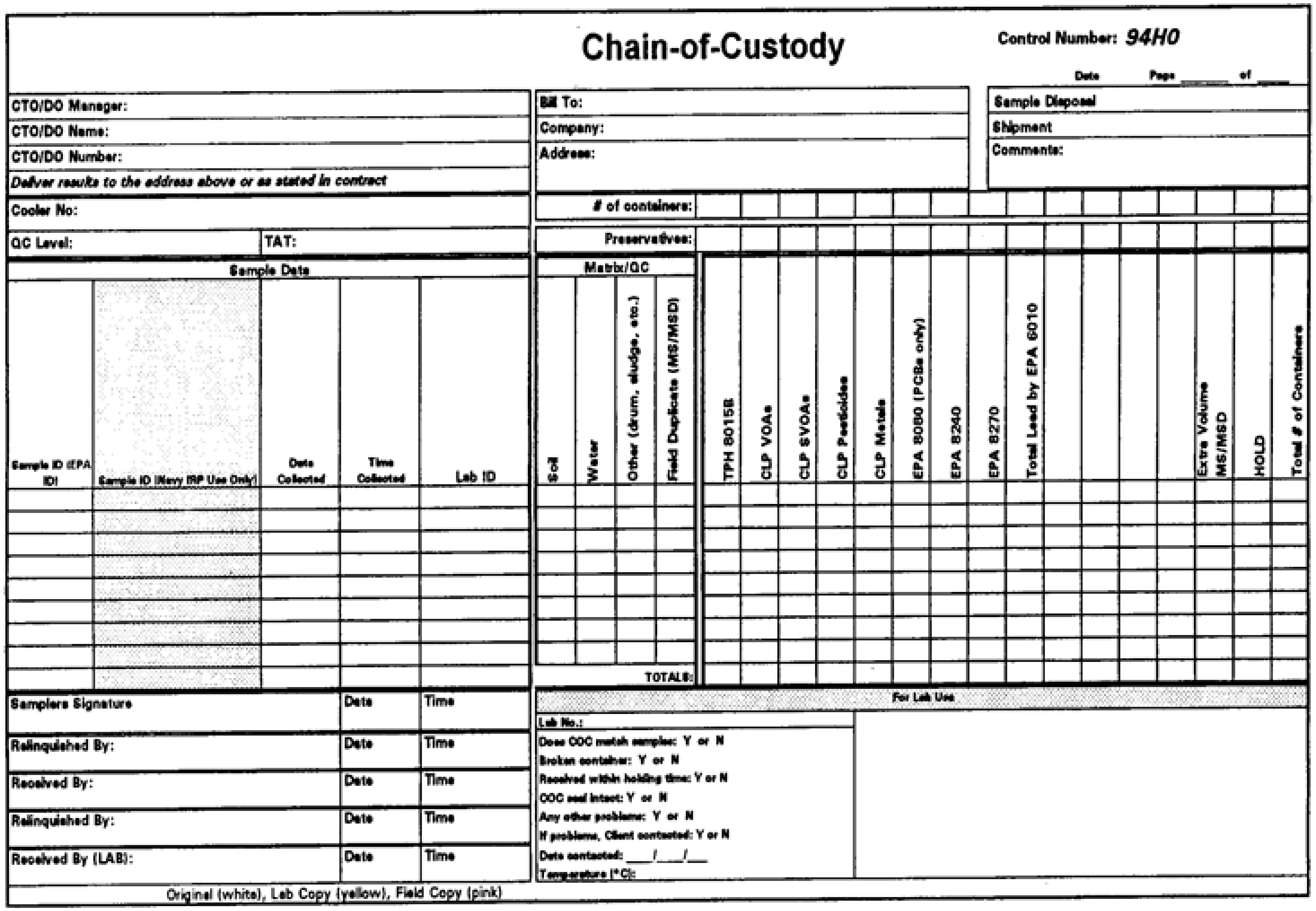

**Chain-of-Custody**

**Control Number:** 94H0

Date Page ______ of ______

CTO/DO Manager:
CTO/DO Name:
CTO/DO Number:
*Deliver results to the address above or as stated in contract*

Cooler No:
QC Level: TAT:

Bill To:
Company:
Address:

Sample Disposal
Shipment
Comments:

| Sample Data | | | | |
|---|---|---|---|---|
| Sample ID (EPA ID) | Sample ID (Navy IRP Use Only) | Date Collected | Time Collected | Lab ID |
| | | | | |
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| | Matrix/QC | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # of containers: | | | | | | | | | | | | | | | | | | |
| Preservatives: | | | | | | | | | | | | | | | | | | |
| | Soil | Water | Other (drum, sludge, etc.) | Field Duplicate (MS/MSD) | TPH 8015B | CLP VOAs | CLP SVOAs | CLP Pesticides | CLP Metals | EPA 8080 (PCBs only) | EPA 8240 | EPA 8270 | Total Lead by EPA 6010 | | | | Extra Volume MS/MSD | HOLD | Total # of Containers |
| | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | | | | | |
| | | | | TOTALS: | | | | | | | | | | | | | | |

| | | |
|---|---|---|
| Samplers Signature | Date | Time |
| Relinquished By: | Date | Time |
| Received By: | Date | Time |
| Relinquished By: | Date | Time |
| Received By (LAB): | Date | Time |

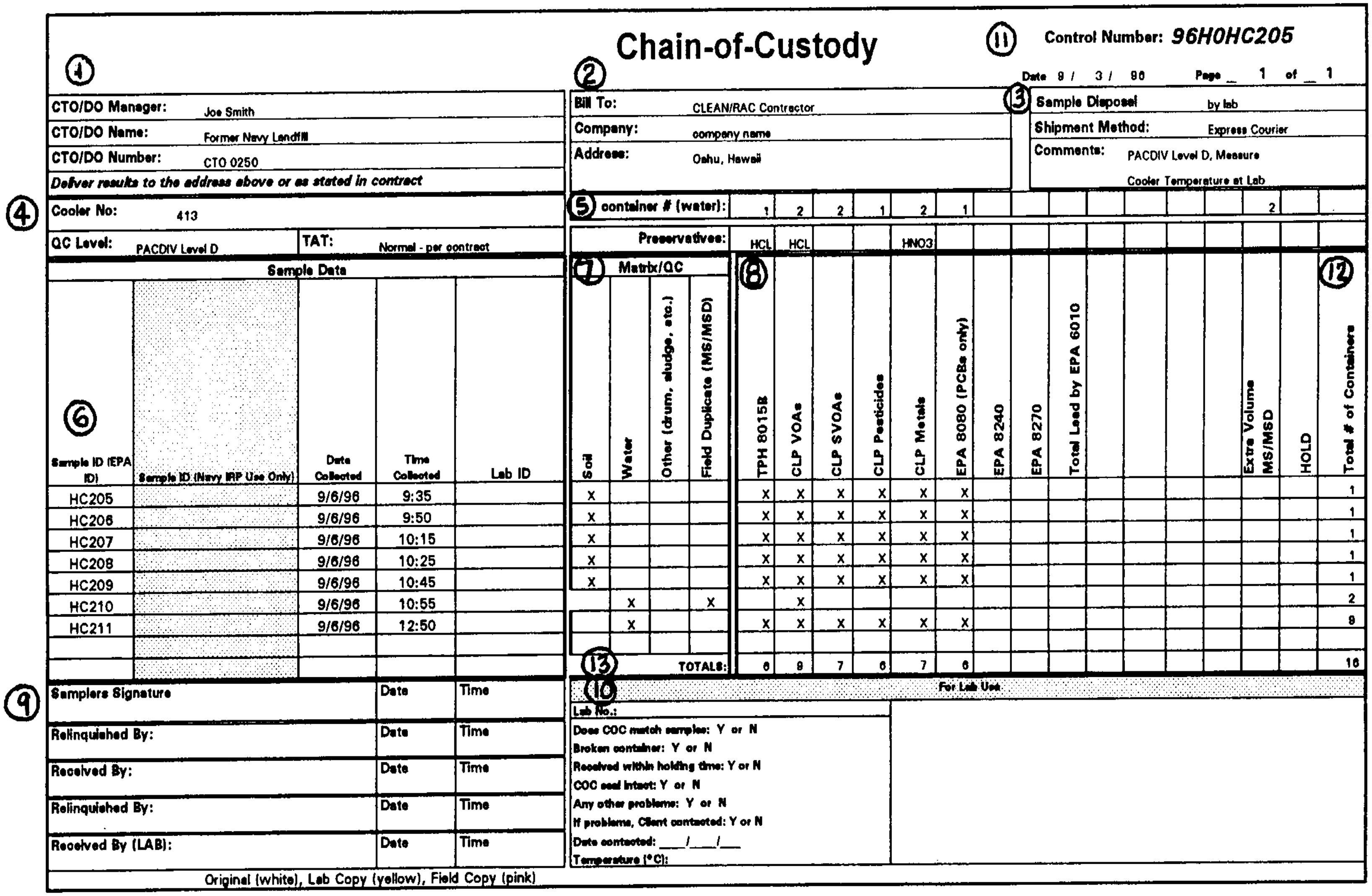
**For Lab Use**

Lab No.:
Does COC match samples: Y or N
Broken container: Y or N
Received within holding time: Y or N
COC seal intact: Y or N
Any other problems: Y or N
If problems, Client contacted: Y or N
Date contacted: ____/____/____
Temperature (°C):

Original (white), Lab Copy (yellow), Field Copy (pink)

Generic Chain-of-Custody/Analytical Request Form

# Attachment III-E-3
# Sample Completed Chain-of-Custody



## Chain-of-Custody

⑪ **Control Number:** *96H0HC205*

**Date** 9 / 3 / 96 **Page** 1 **of** 1

①
**CTO/DO Manager:** Joe Smith
**CTO/DO Name:** Former Navy Landfill
**CTO/DO Number:** CTO 0250
***Deliver results to the address above or as stated in contract***

④
**Cooler No:** 413
**QC Level:** PACDIV Level D **TAT:** Normal - per contract

②
**Bill To:** CLEAN/RAC Contractor
**Company:** company name
**Address:** Oahu, Hawaii

③
**Sample Disposal** by lab
**Shipment Method:** Express Courier
**Comments:** PACDIV Level D, Measure Cooler Temperature at Lab

**Sample Data** ⑥ ⑦ ⑧ ⑫

| Sample ID (EPA ID) | Sample ID (Navy IRP Use Only) | Date Collected | Time Collected | Lab ID | Soil | Water | Other (drum, sludge, etc.) | Field Duplicate (MS/MSD) | TPH 8015B | CLP VOAs | CLP SVOAs | CLP Pesticides | CLP Metals | EPA 8080 (PCBs only) | EPA 8240 | EPA 8270 | Total Lead by EPA 6010 | | | | | Extra Volume MS/MSD | HOLD | Total # of Containers |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | ⑤ container # (water): | 1 | 2 | 2 | 1 | 2 | 1 | | | | | | | | 2 | | |
| | | | | | | | | Preservatives: | HCL | HCL | | | HNO3 | | | | | | | | | | | |
| HC205 | | 9/6/96 | 9:35 | | X | | | | X | X | X | X | X | X | | | | | | | | | | 1 |
| HC206 | | 9/6/96 | 9:50 | | X | | | | X | X | X | X | X | X | | | | | | | | | | 1 |
| HC207 | | 9/6/96 | 10:15 | | X | | | | X | X | X | X | X | X | | | | | | | | | | 1 |
| HC208 | | 9/6/96 | 10:25 | | X | | | | X | X | X | X | X | X | | | | | | | | | | 1 |
| HC209 | | 9/6/96 | 10:45 | | X | | | | X | X | X | X | X | X | | | | | | | | | | 1 |
| HC210 | | 9/6/96 | 10:55 | | | X | | X | | X | | | | | | | | | | | | | | 2 |
| HC211 | | 9/6/96 | 12:50 | | | X | | | X | X | X | X | X | X | | | | | | | | | | 9 |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | ⑬ | | | TOTALS: | 6 | 9 | 7 | 6 | 7 | 6 | | | | | | | | | | 16 |

⑨

| | | |
|---|---|---|
| **Samplers Signature** | **Date** | **Time** |
| **Relinquished By:** | **Date** | **Time** |
| **Received By:** | **Date** | **Time** |
| **Relinquished By:** | **Date** | **Time** |
| **Received By (LAB):** | **Date** | **Time** |

⑩ **For Lab Use**

**Lab No.:**
**Does COC match samples:** Y or N
**Broken container:** Y or N
**Received within holding time:** Y or N
**COC seal intact:** Y or N
**Any other problems:** Y or N
**If problems, Client contacted:** Y or N
**Date contacted:** ___/___/___
**Temperature (°C):**

Original (white), Lab Copy (yellow), Field Copy (pink)

**Sample Completed Chain-of-Custody**

# Attachment III-E-4
# Sample Out-of-Control Form

| | | | |
|---|---|---|---|
| **OUT OF CONTROL FORM** | Status | Date | Initial |
| | Noted OOC | | |
| | Submit for CA* | | |
| | Resubmit for CA* | | |
| | Completed | | |

| | |
|---|---|
| Date Recognized: | By: |
| Dated Occurred: | Matrix |
| Parameter (Test Code): | Method: |
| Analyst: | Supervisor: |
| 1. Type of Event<br>(Check all that apply) | 2. Corrective Action (CA)*<br>(Check all that apply) |

| |
|---|
| Samples Affected<br>(List by Accession<br>AND Sample No.) |
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|---|---|---|---|
| | Calibration Corr. Coefficient <0.995 | | Repeat calibration |
| | %RSD>20% | | Made new standards |
| | Blank >MDL | | Reran analysis |
| | Does not meet criteria: | | Sample(s) redigested and rerun |
| | Spike | | Sample(s) reextracted and rerun |
| | Duplicate | | Recalculated |
| | LCS | | Cleaned system |
| | Calibration Verification | | Ran standard additions |
| | Standard Additions | | Notified |
| | MS/MSD | | Other (please explain) |
| | BS/BSD | | |
| | Surrogate Recovery | | |
| | Calculations Error | | |

| | |
|---|---|
| ☐ Holding Times Missed | |
| ☐ Other (Please explain | Comments: |
| | |
| | |
| | |
| | |
| | |
| | |
| | |

| |
|---|
| 3. Results of Corrective Action |
| ☐ Return to Control (indicated with) |
| |
| |
| ☐ Corrective Actions Not Successful - DATA IS TO BE FLAGGED with _____________. |

| | |
|---|---|
| Analyst: | Date: |
| Supervisor: | Date: |
| QA Department: | Date: |

# Sample Handling, Storage, and Shipping

## 1. Purpose

This standard operating procedure sets forth the methods for use by the United States (U.S.) Navy Environmental Restoration (ER) Program, Naval Facilities Engineering Command (NAVFAC), Pacific personnel engaged in handling, storing, and transporting samples.

## 2. Scope

This procedure applies to all Navy ER projects performed in the NAVFAC Pacific Area of Responsibility.

This procedure shall serve as management-approved professional guidance for the ER Program and is consistent with protocol in the most recent version of the Uniform Federal Policy-Quality Assurance Project Plan (UFP QAPP) Part 1 (DoD 2005a), 2A (DoD 2012), and 2B (2005b), as well as the DoD Quality Systems Manual (DoD 2013). As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved and documented by the following prime contractor representatives: the CTO Manager and the Quality Assurance (QA) Manager or Technical Director. A Navy project representative (i.e., Remedial Project Manager or QA Manager) shall also concur with any deviations.

## 3. Definitions

None.

## 4. Responsibilities

The prime contractor CTO Manager and the Laboratory Project Manager are responsible for identifying instances of non-compliance with this procedure and ensuring that future sample transport activities are in compliance with this procedure.

The Field Manager is responsible for ensuring that all samples are shipped according to this procedure.

Field personnel are responsible for the implementation of this procedure.

The QA Manager or Technical Director is responsible for ensuring that sample handling, storage, and transport activities conducted during all CTOs are in compliance with this procedure.

All field personnel are responsible for complying with Chief of Naval Operations Instruction 5090.1, under *Specific Training Requirements* (DON 2014).

## 5. Procedures

### 5.1 HANDLING AND STORAGE

Immediately following collection, label all samples according to Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*. In addition, when more than one volatile organic analyte

(VOA) vial is used to collect one sample, the chain-of-custody (COC) identification (ID) will be written on the VOA vials (even pre-tared vials) with a ball point pen for that sample. The lids of the containers shall not be sealed with duct tape, but should be covered with custody seals (except pre-tared containers which should have the custody seal placed on the outside of the protective bubble wrap). Wrap glass sample containers on the sides, tops, and bottoms with bubble wrap or other appropriate padding to prevent breakage during transport. When collecting three VOA vials per sample, it is acceptable to wrap all three vials together and store in one plastic bag. Store all glass containers for water samples in an upright position, never stacked or placed on their sides. Samples will be maintained as close to 4 degrees Celsius (°C) as possible from the time of collection through transport to the analytical laboratory, using refrigerators and/or freezers when appropriate. Place all containers into self-sealing bags and into an insulated cooler with wet ice while still in the field. Samples should occupy the lower portion of the cooler, while the ice should occupy the upper portion. Place an absorbent material (e.g., proper absorbent cloth material) on the bottom of the cooler to contain liquids in case of spillage. Ship samples as soon after collection as possible to allow the laboratory to meet holding times for analyses. Check with the laboratory for operating/sample receipt hours prior to all traditional and non-traditional holidays to ensure sample shipment will be received. When not shipping samples directly upon field collection, store samples in a refrigerator or freezer (never freeze water samples) until shipped to the laboratory.

## 5.2 PACKING

Each cooler must contain a temperature blank (small plastic bottle with sterile water) to confirm cooler temperature upon receipt at the laboratory. Water samples can be used as such, but it is best to include a designated temperature blank bottle, typically supplied by the laboratory with the coolers.

One trip blank must be included in each cooler containing samples for volatile analysis (e.g., volatile organic compounds, total petroleum hydrocarbons-gasoline range organics.

Cooler must be lined completely in ice at the bottom and all four sides. After confirming all project samples are accounted for and labeled correctly, place samples in cooler. Record sample IDs on cooler-specific COC(s). Pack glass containers for water samples in an upright position, never stacked or placed on their sides. Fill all empty space between sample containers with bubble wrap or other appropriate material (not Styrofoam). Place a layer of ice on top of samples and fill all empty space between ice and cooler lid with bubble wrap or other appropriate material.

Place laboratory copies of completed COC(s), and soil permit if applicable, into resealable bag and tape to underside of cooler lid.

## 5.3 SHIPPING

Follow all appropriate U.S. Department of Transportation regulations (e.g., 49 Code of Federal Regulations [CFR], Parts 171-179) for shipment of air, soil, water, and other samples. Elements of these procedures are summarized below.

### 5.3.1 Hazardous Materials Shipment

Field personnel must state whether any sample is suspected to be a hazardous material. A sample should be assumed to be hazardous unless enough evidence exists to indicate it is non-hazardous. If not suspected to be hazardous, shipments may be made as described in the Section 5.3.3 for non-hazardous materials. If hazardous, follow the procedures summarized below.

Any substance or material that is capable of posing an unreasonable risk to life, health, or property when transported is classified as hazardous. Perform hazardous materials identification by checking the list of dangerous goods for that particular mode of transportation. If not on that list, materials can be classified by checking the Hazardous Materials Table (49 CFR 172.102 including Appendix A) or by determining if the material meets the definition of any hazard class or division (49 CFR Part 173), as listed in Attachment III-F-2.

All persons shipping hazardous materials must be properly trained in the appropriate regulations, as required by HM-126F, Training for Safe Transportation of Hazardous Materials (49 CFR HM-126F Subpart H). The training covers loading, unloading, handling, storing, and transporting of hazardous materials, as well as emergency preparedness in the case of accidents. Carriers, such as commercial couriers, must also be trained. Modes of shipment include air, highway, rail, and water.

When shipping hazardous materials, including bulk chemicals or samples suspected of being hazardous, the proper shipping papers (49 CFR 172 Subpart C), package marking (49 CFR 172 Subpart D), labeling (49 CFR 172 Subpart E), placarding (49 CFR 172 Subpart F, generally for carriers), and packaging must be used. Attachment III-F-1 shows an example of proper package markings. Refer to a copy of 49 CFR each time hazardous materials/potentially hazardous samples are shipped.

According to Section 2.7 of the International Air Transport Association Dangerous Goods Regulations publication, very small quantities of certain dangerous goods may be transported without certain marking and documentation requirements as described in 49 CFR Part 172. However, other labeling and packing requirements must still be followed. Attachment III-F-2 shows the volume or weight for different classes of substances. A “Dangerous Goods in Excepted Quantities” label must be completed and attached to the associated shipping cooler (Attachment III-F-3). Certain dangerous goods are not allowed on certain airlines in any quantity.

As stated in item 4 of Attachment III-F-4, the Hazardous Materials Regulations do not apply to hydrochloric acid (HCl), nitric acid ($HNO_3$), sulfuric acid ($H_2SO_4$), and sodium hydroxide (NaOH) added to water samples if their pH or percentage by weight criteria are met. Hazardous Materials Regulations also do not apply to methanol (MeOH) for soil samples if the percentage by weight criterion is met. These samples may be shipped as non-hazardous materials as discussed below.

### 5.3.2 Non-hazardous Materials Shipment

If the samples are suspected to be non-hazardous based on previous site sample results, field screening results, or visual observations, if applicable, then samples may be shipped as non-hazardous.

If preservatives (HCl, $HNO_3$, $H_2SO_4$, NaOH, or MeOH) are used, ensure their individual pH or percentage by weight criteria, as shown in item 4 of Attachment III-F-4, are met to continue shipping as non-hazardous samples.

When a cooler is ready for shipment to the laboratory, place the receiving laboratory address on the top of the cooler, place chain-of-custody seals on the coolers as discussed in Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*, place soil permit labels on top if applicable, and seal the cooler with waterproof tape.

### 5.3.3 Shipments from Outside the Continental United States

Shipment of sample coolers to the continental U.S. from locations outside the continental U.S. is controlled by the U.S. Department of Agriculture (USDA) and is subject to their inspection and regulation. A “USDA Soil Import Permit” is required to prove that the receiving analytical laboratory is certified by the USDA to receive and properly dispose of soil. In addition, all sample coolers must be inspected by a USDA representative, affixed with a label indicating that the coolers contain environmental samples, and accompanied by shipping forms stamped by the USDA inspector prior to shipment. In addition, the U.S. Customs Service must clear samples shipped from U.S. territorial possessions or foreign countries upon entry into the U.S. As long as the commercial invoice is properly completed (see below), shipments typically pass through U.S. Customs Service without the need to open coolers for inspection.

In Hawaii, soil sample shipments are typically brought to the courier at the airport where the courier contacts a USDA representative to make an inspection. Alternatively, the contractor may enter into an agreement with the USDA to ship soil samples. In this way, the USDA does not need to inspect each soil sample shipment. If the contractor maintains a Domestic Soil Permit, place the permit label and the soil origination label (Attachment III-F-9) on the top of the cooler. Place a copy of the receiving laboratory’s soil permit with the COC inside the cooler. Confirm custody seals were placed on each container (Section 5.1) to ensure proper chain-of-custody control in the event coolers are opened for inspection.

In Guam, shipments can be dropped off directly to the Federal Express branch or to the courier at the airport. Alternatively, the courier can pick up shipments at each site provided that arrangements have been made regarding pickup time and location. USDA inspections occur outside of Guam. The laboratory’s soil permit shall be placed with the COC inside the cooler, and the soil origination label (see Attachment III-F-9) should be placed on top of the cooler.

The USDA does not need to inspect water sample shipments.

Completion and use of proper paperwork will, in most cases, minimize or eliminate the need for the USDA and U.S. Customs Service to inspect the contents. Attachment III-F-5 shows an example of how paperwork may be placed on the outside of coolers for non-hazardous materials. For hazardous materials, refer to Section 5.3.1.

In summary, tape the paperwork listed below to the outside of the coolers to assist sample shipments. If a shipment is made up of multiple pieces (e.g., more than one cooler), the paperwork need only be attached to one cooler, provided that the courier agrees. All other coolers in the shipment need only be taped and have address and COC seals affixed.

1. **Courier Shipping Form & Commercial Invoice**. See Attachment III-F-6, and Attachment III-F-7 for examples of the information to be included on the commercial invoice for soil and water. Place the courier shipping form and commercial invoice inside a clear, plastic, adhesive-backed pouch that adheres to the package (typically supplied by the courier) and place it on the cooler lid as shown in Attachment III-F-5.
2. **Soil Import Permit (soil only)**. See Attachment III-F-8 and Attachment III-F-9 for examples of the soil import permit and soil samples restricted entry labels. The laboratory shall supply these documents prior to mobilization. The USDA in Hawaii often <u>does</u> stop

shipments of soil without these documents. Staple together the 2 inch × 2 inch USDA label (described below), and soil import permit, and place them inside a clear plastic pouch. The courier typically supplies the clear, plastic, adhesive-backed pouches that adhere to the package.

Placing one restricted entry label as shown in Attachment III-F-5 (covered with clear packing tape) and one stapled to the actual permit is suggested.

The USDA does not control water samples, so the requirements for soil listed above do not apply.

3. **Chain-of-Custody Seals**. The laboratory should supply the seals. CTO personnel must sign and date these. At least two seals should be placed in such a manner that they stick to both the cooler lid and body. Placing the seals over the tape (as shown in Attachment III-F-5), then covering it with clear packing tape is suggested. This prevents the seal from coming loose and enables detection of tampering.
4. **Address Label**. Affix a label stating the destination (laboratory address) of each cooler.
5. **Special Requirements for Hazardous Materials**. See Section 5.3.1.

Upon receipt of sample coolers at the laboratory, the sample custodian shall inspect the sample containers as discussed in Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*. The samples shall then be either immediately extracted and/or analyzed, or stored in a refrigerated storage area until they are removed for extraction and/or analysis. Whenever the samples are not being extracted or analyzed, they shall be returned to refrigerated storage.

## 6. Records

Maintain records as required by implementing these procedures.

## 7. Health and Safety

Personnel shall perform work in accordance with the current (or as contractually obligated) United States Army Corps of Engineers Safety and Health Requirements Manual EM-385-1-1 (USACE 2012) and site-specific health and safety plan.

## 8. References

Department of Defense, United States (DoD). 2005a. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/fedfac/pdf/ufp_qapp_v1_0305.pdf.

———. 2005b. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2B: Quality Assurance/quality Control Compendium: Minimum QA/QC Activities*. Final Version 1. DoD: DTIC ADA 426957, EPA-505-B-04-900B. In conjunction with the U. S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March. On-line updates available at: http://www.epa.gov/swerffrr/pdf/-qaqc_v1_0305.pdf.

———. 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2A: Optimized UFP-QAPP Worksheets*. Revision 1. March.

———. 2013. *Department of Defense Quality Systems Manual for Environmental Laboratories.* Version 5.0. Draft Final. Prepared by DoD Environmental Data Quality Workgroup and Department of Energy Consolidated Audit Program Operations Team. July.

Department of the Navy (DON). 2014. *Environmental Readiness Program Manual*. OPNAV Instruction 5090.1D. 10 January.

United States Army Corps of Engineers (USACE). 2008. *Consolidated Safety and Health Requirements Manual.* EM-385-1-1. Includes Changes 1–7. 13 July 2012.

Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody*.

## 9. Attachments

Attachment III-F-1: Example Hazardous Materials Package Marking

Attachment III-F-2: Packing Groups

Attachment III-F-3: Label for Dangerous Goods in Excepted Quantities

Attachment III-F-4: SW-846 Preservative Exception

Attachment III-F-5: Non-Hazardous Material Cooler Marking Figure for Shipment From Outside The Continental United States

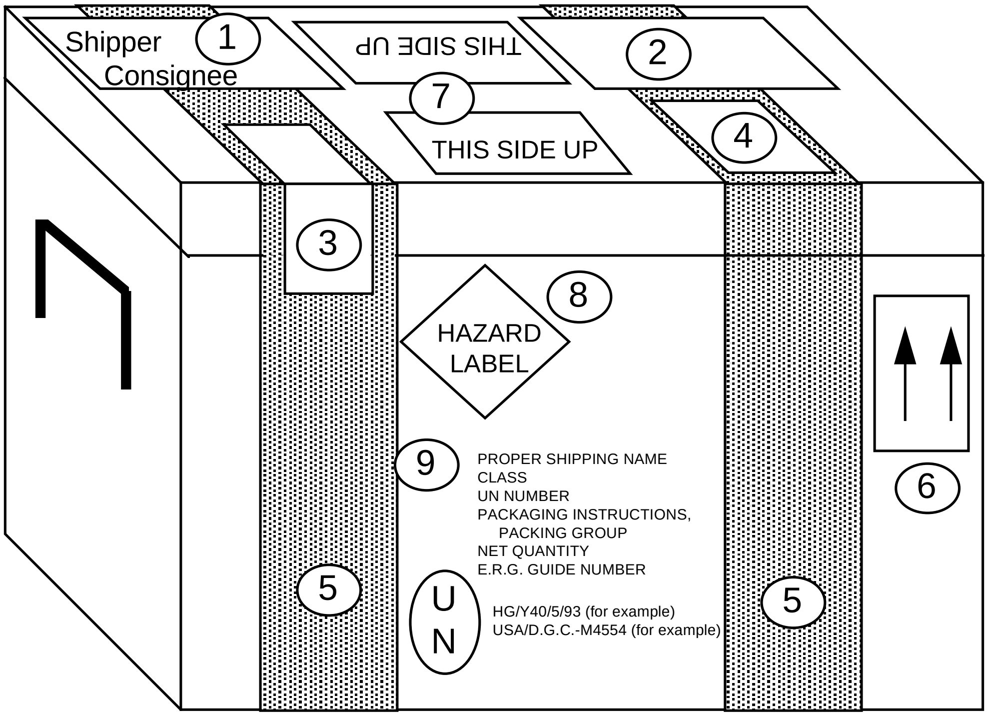
Attachment III-F-6: Commercial Invoice – Soil

Attachment III-F-7: Commercial Invoice – Water

Attachment III-F-8: Soil Import Permit

Attachment III-F-9: Soil Samples Restricted Entry Labels

# Attachment III-F-1
# Example Hazardous Material Package Marking



① **AIR BILL/COMMERCIAL INVOICE**

② **USDA PERMIT (Letter to Laboratory from USDA)**

③ **CUSTODY SEAL**

④ **USDA 2" X 2" SOIL IMPORT PERMIT**

⑤ **WATERPROOF STRAPPING TAPE**

⑥ **DIRECTION ARROWS STICKER - TWO REQUIRED**

⑦ **THIS SIDE UP STICKERS**

⑧ **HAZARD LABEL**

⑨ **HAZARDOUS MATERIAL INFORMATION**

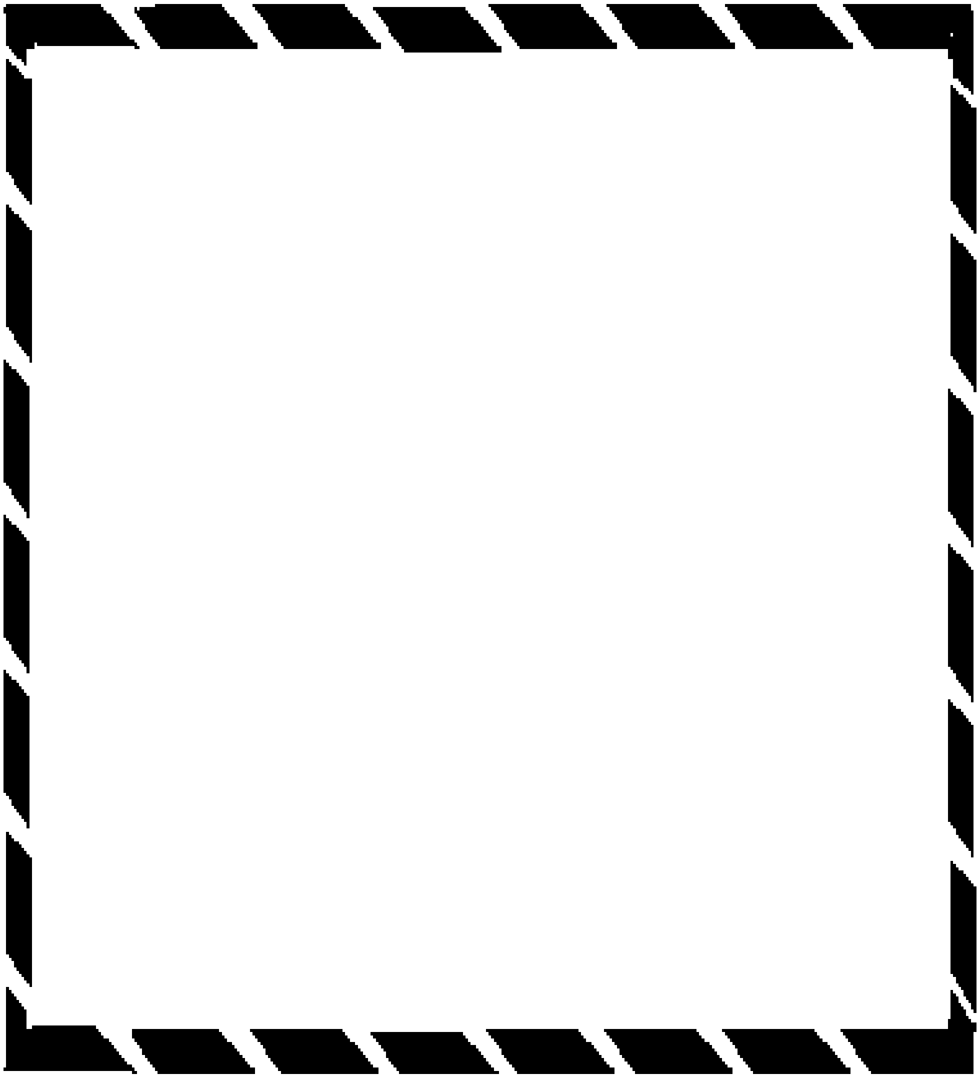
⑩ **PACKAGE SPECIFICATIONS**

# Attachment III-F-2
# Packing Groups

| PACKING GROUP OF THE SUBSTANCE | PACKING GROUP 1 | | PACKING GROUP II | | PACKING GROUP III | |
|---|---|---|---|---|---|---|
| CLASS or DIVISION of PRIMARY or SUBSIDIARY RISK | Packagings | | Packagings | | Packagings | |
| | Inner | Outer | Inner | Outer | Inner | Outer |
| 1: Explosives | ---------------------------- Forbidden (Note A) ---------------------------------- | | | | | |
| 2.1: Flammable Gas | ---------------------------- Forbidden (Note B) ---------------------------------- | | | | | |
| 2.2: Non-Flammable, non-toxic gas | ---------------------------- See Notes A and B ---------------------------------- | | | | | |
| 2.3: Toxic gas | ---------------------------- Forbidden (Note A) ---------------------------------- | | | | | |
| 3. Flammable liquid | 30 mL | 300 mL | 30 mL | 500 mL | 30 mL | 1 L |
| 4.1 Self-reactive substances | Forbidden | | Forbidden | | Forbidden | |
| 4.1: Other flammable solids | Forbidden | | 30 g | 500 g | 30 g | 1 kg |
| 4.2: Pyrophoric substances | Forbidden | | Not Applicable | | Not Applicable | |
| 4.2 Spontaneously combustible substances | Not Applicable | | 30 g | 500 g | 30 g | 1 kg |
| 4.3: Water reactive substances | Forbidden | | 30 g or 30 mL | 500 g or 500 mL | 30 g or 30 mL | 1 kg or 1 L |
| 5.1: Oxidizers | Forbidden | | 30 g or 30 mL | 500 g or 500 mL | 30 g or 30 mL | 1 kg or 1 L |
| 5.2: Organic peroxides (Note C) | See Note A | | 30 g or 30 mL | 500 g or 250 mL | Not Applicable | |
| 6.1: Poisons - Inhalation toxicity | Forbidden | | 1 g or 1 mL | 500 g or 500 mL | 30 g or 30 mL | 1 kg or 1 L |
| 6.1: Poisons - oral toxicity | 1 g or 1 mL | 300 g or 300 mL | 1 g or 1 mL | 500 g or 500 mL | 30 g or 30 mL | 1 kg or 1 L |
| 6.1: Poisons - dermal toxicity | 1 g or 1 mL | 300 g or 300 mL | 1 g or 1 mL | 500 g or 500 mL | 30 g or 30 mL | 1 kg or 1 L |
| 6.2: Infectious substances | ---------------------------- Forbidden (Note A) ---------------------------------- | | | | | |
| 7: Radioactive material (Note D) | ---------------------------- Forbidden (Note A) ---------------------------------- | | | | | |
| 8: Corrosive materials | Forbidden | | 30 g or 30 mL | 500 g or 500 mL | 30 g or 30 mL | 1 kg or 1 L |
| 9: Magnetized materials | ---------------------------- Forbidden (Note A) ---------------------------------- | | | | | |
| 9: Other miscellaneous materials (Note E) | Forbidden | | 30 g or 30 mL | 500 g or 500 mL | 30 g or 30 mL | 1 kg or 1 L |

***Note A:*** *Packing groups are not used for this class or division.*
***Note B:*** *For inner packagings, the quantity contained in receptacle with a water capacity of 30 mL. For outer packagings, the sum of the water capacities of all the inner packagings contained must not exceed 1 L.*
***Note C:*** *Applies only to Organic Peroxides when contained in a chemical kit, first aid kit or polyester resin kit.*
***Note D:*** *See 6.1.4.1, 6.1.4.2 and 6.2.1.1 through 6.2.1.7, radioactive material in excepted packages.*
***Note E:*** *For substances in Class 9 for which no packing group is indicated in the List of Dangerous Goods, Packing Group II quantities must be used.*

# Attachment III-F-3
# Label for Dangerous Goods in Excepted Quantities



# Attachment III-F-4
# SW-846 Preservative Exception

| Measurement | Vol. Req. (mL) | Container[2] | Preservative [3,4] | Holding Time[5] |
|---|---|---|---|---|
| MBAS | 250 | P,G | Cool, 4ºC | 48 Hours |
| NTA | 50 | P,G | Cool, 4ºC | 24 Hours |

1. More specific instructions for preservation and sampling are found with each procedure as detailed in this manual. A general discussion on sampling water and industrial wastewater may be found in ASTM, Part 31, p. 72-82 (1976) Method D-3370.

2. Plastic (P) or Glass (G). For metals, polyethylene with a polypropylene cap (no liner) is preferred.

3. Sample preservation should be performed immediately upon sample collection. For composite samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then samples may be preserved by maintaining at 4ºC until compositing and sample splitting is completed.

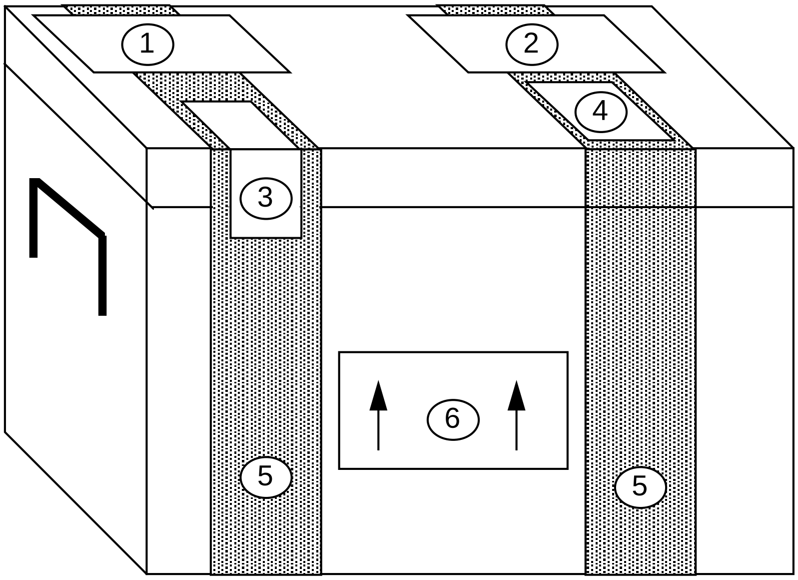
4. When any sample is to be shipped by common carrier or sent through the United States Mail, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172). The person offering such material for transportation is responsible for ensuring such compliance. for the preservation requirements of Table 1, the Office of Hazardous Materials, Materials Transportation Bureau, Department of Transportation has determined that the Hazardous Materials regulations do not apply to the following materials: Hydrochloric acid (HCl) in water solutions at concentration of 0.04% by weight or less (pH about 1.96 or greater); Nitric acid ($HNO_3$) in water solutions at concentrations of 0.15% by weight or less (pH about 1.62 or greater); Sulfuric acid ($H_2SO_4$) in water solutions at concentrations of 0.35% by weight or less (pH about 1.15 or greater); Sodium hydroxide (NaOH) in water solutions at concentrations of 0.080% by weight or less (pH about 12.30 or less).

5. Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of sample under study are stable for the longer time, and has received a variance from the Regional Administrator. Some samples may not be stable for the maximum time period given in the table. A permittee, or monitoring laboratory, is obligated to hold the sample for a shorter time if knowledge exists to show this is necessary to maintain sample stability.

6. Should only be used in the presence of residual chlorine.

# Attachment III-F-5

# Non-Hazardous Material Cooler Marking Figure for Shipment from outside the Continental United States



① AIR BILL/COMMERCIAL INVOICE

② USDA PERMIT (Letter to Laboratory from USDA)

③ CUSTODY SEAL

④ USDA 2" X 2" SOIL IMPORT PERMIT

⑤ WATERPROOF STRAPPING TAPE

⑥ DIRECTION ARROWS STICKER - TWO REQUIRED

# Attachment III-F-6
# Commercial Invoice – Soil

| | |
|---|---|
| DATE OF EXPORTATION<br>1/1/94 | EXPORT REFERENCES (i.e., order no., invoice no., etc.)<br><CTO #> |
| SHIPPER/EXPORTER (complete name and address)<br>Joe Smith<br>Ogden<br>c/o <hotel name><br><hotel address> | CONSIGNEE<br>Sample Receipt<br><Lab Name><br><Lab Address> |
| COUNTRY OF EXPORT<br>Guam, USA | IMPORTER - IF OTHER THAN CONSIGNEE |
| COUNTRY OF ORIGIN OF GOODS<br>Guam, USA | |
| COUNTRY OF ULTIMATE DESTINATION<br>USA | |

INTERNATIONAL
AIR WAYBILL NO.

(NOTE: All shipments must be accompanied by a Federal Express International Air Waybill)

| MARKS/NOS | NO. OF PKGS | TYPE OF PACKAGING | FULL DESCRIPTION OF GOODS | QTY | UNIT OF MEASURE | WEIGHT | UNIT VALUE | TOTAL VALUE |
|---|---|---|---|---|---|---|---|---|
| | 3 | coolers | Soil samples for labora analysis only | | | | $1.00 | $3.00 |
| | TOTAL NO. OF PKGS. | | | | | TOTAL WEIGHT | | TOTAL INVOICE VALUE |
| | 3 | | | | | | | $3.00 |

Check one
☐ F.O.B.
☐ C&F
☐ C.I.F.

THESE COMMODITIES ARE LICENSED FOR THE ULTIMATE DESTINATION SHOWN.

DIVERSION CONTRARY TO UNITED STATES LAW IS PROHIBITED.

I DECLARE ALL THE INFORMATION CONTAINED IN THIS INVOICE TO BE TRUE AND CORRECT

SIGNATURE OF SHIPPER/EXPORTER (Type name and title and sign)

Name/Title: Joe Smith, Ogden
Signature: Joe Smith
Date: 1/1/94

# Attachment III-F-7
# Commercial Invoice – Water

| | |
|---|---|
| DATE OF EXPORTATION<br>1/1/94 | EXPORT REFERENCES (i.e., order no., invoice no., etc.)<br><CTO #> |
| SHIPPER/EXPORTER (complete name and address)<br>Joe Smith<br>Ogden<br>c/o <hotel name><br><hotel address> | CONSIGNEE<br>Sample Rece<br><Lab Name><br><Lab Address> |
| COUNTRY OF EXPORT<br>Guam, USA | IMPORTER - IF OTHER THAN CONSIGNEE |
| COUNTRY OF ORIGIN OF GOODS<br>Guam, USA | |
| COUNTRY OF ULTIMATE DESTINATION<br>USA | |

INTERNATIONAL AIR WAYBILL NO.

(NOTE: All shipments must be accompanied by a Federal Express International Air Waybill)

| MARKS/NOS | NO. OF PKGS | TYPE OF PACKAGING | FULL DESCRIPTION OF GOODS | QTY | UNIT OF MEASURE | WEIGHT | UNIT VALUE | TOTAL VALUE |
|---|---|---|---|---|---|---|---|---|
| | 3 | coolers | Water samples for labo analysis only | | | | $1.00 | $3.00 |
| | TOTAL NO. OF PKGS. | | | | | TOTAL WEIGHT | | TOTAL INVOICE VALUE |
| | 3 | | | | | | | $3.00 |

Check one
☐ F.O.B.
☐ C&F
☐ C.I.F.

THESE COMMODITIES ARE LICENSED FOR THE ULTIMATE DESTINATION SHOWN.

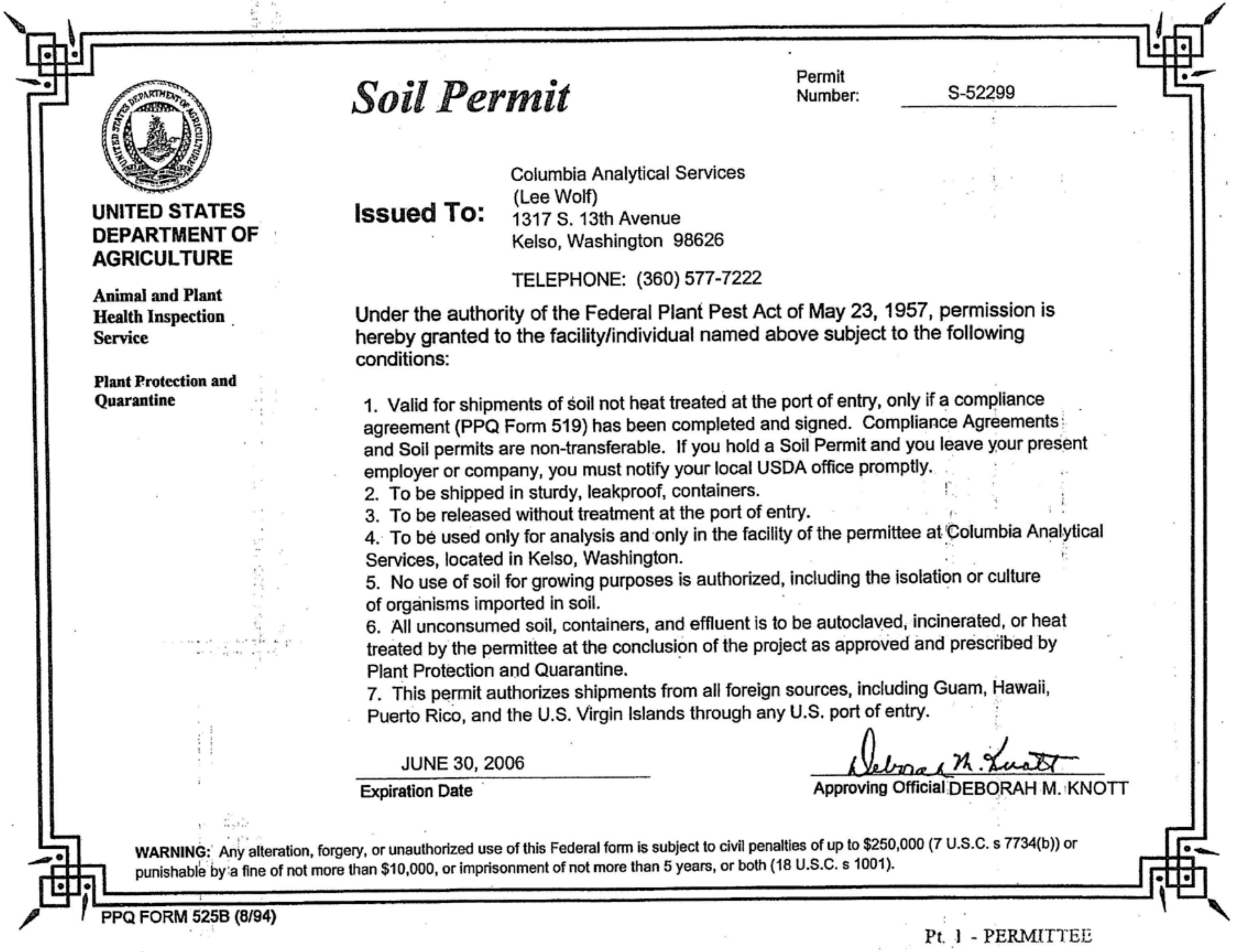
DIVERSION CONTRARY TO UNITED STATES LAW IS PROHIBITED.

I DECLARE ALL THE INFORMATION CONTAINED IN THIS INVOICE TO BE TRUE AND CORRECT

SIGNATURE OF SHIPPER/EXPORTER (Type name and title and sign)

| Name/Title | Signature | Date |
|---|---|---|
| Joe Smith, Ogden | Joe Smith | 1/1/94 |

# Attachment III-F-8
# Soil Import Permit



**UNITED STATES DEPARTMENT OF AGRICULTURE**

**Animal and Plant Health Inspection Service**

**Plant Protection and Quarantine**

# Soil Permit

Permit Number: S-52299

**Issued To:**
Columbia Analytical Services
(Lee Wolf)
1317 S. 13th Avenue
Kelso, Washington 98626

TELEPHONE: (360) 577-7222

Under the authority of the Federal Plant Pest Act of May 23, 1957, permission is hereby granted to the facility/individual named above subject to the following conditions:

1. Valid for shipments of soil not heat treated at the port of entry, only if a compliance agreement (PPQ Form 519) has been completed and signed. Compliance Agreements and Soil permits are non-transferable. If you hold a Soil Permit and you leave your present employer or company, you must notify your local USDA office promptly.
2. To be shipped in sturdy, leakproof, containers.
3. To be released without treatment at the port of entry.
4. To be used only for analysis and only in the facility of the permittee at Columbia Analytical Services, located in Kelso, Washington.
5. No use of soil for growing purposes is authorized, including the isolation or culture of organisms imported in soil.
6. All unconsumed soil, containers, and effluent is to be autoclaved, incinerated, or heat treated by the permittee at the conclusion of the project as approved and prescribed by Plant Protection and Quarantine.
7. This permit authorizes shipments from all foreign sources, including Guam, Hawaii, Puerto Rico, and the U.S. Virgin Islands through any U.S. port of entry.

JUNE 30, 2006
**Expiration Date**

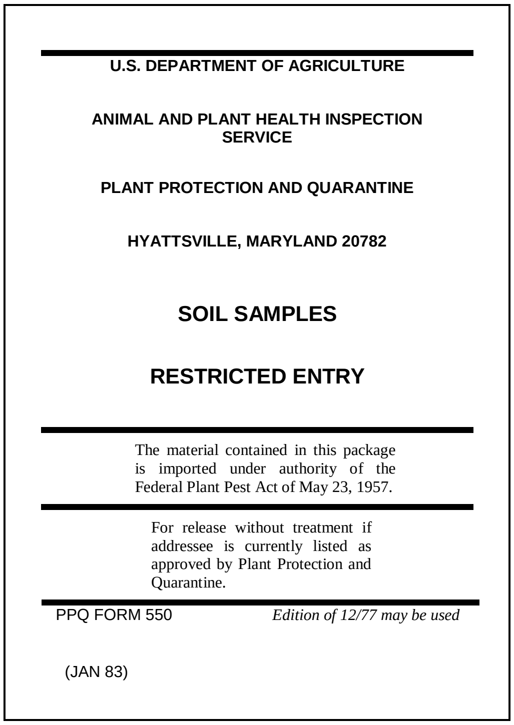
Deborah M. Knott
**Approving Official** DEBORAH M. KNOTT

**WARNING:** Any alteration, forgery, or unauthorized use of this Federal form is subject to civil penalties of up to $250,000 (7 U.S.C. s 7734(b)) or punishable by a fine of not more than $10,000, or imprisonment of not more than 5 years, or both (18 U.S.C. s 1001).

**PPQ FORM 525B (8/94)**

Pt. 1 - PERMITTEE

# Attachment III-F-9
# Soil Samples Restricted Entry Label and Soil Origin Label



**U.S. DEPARTMENT OF AGRICULTURE**

**ANIMAL AND PLANT HEALTH INSPECTION SERVICE**

**PLANT PROTECTION AND QUARANTINE**

**HYATTSVILLE, MARYLAND 20782**

**SOIL SAMPLES**

**RESTRICTED ENTRY**

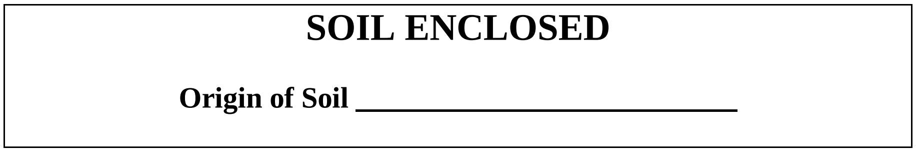
The material contained in this package is imported under authority of the Federal Plant Pest Act of May 23, 1957.

For release without treatment if addressee is currently listed as approved by Plant Protection and Quarantine.

PPQ FORM 550 *Edition of 12/77 may be used*

(JAN 83)

**Soil Samples Restricted Entry Label**



**SOIL ENCLOSED**

**Origin of Soil __________________________**

**Soil Origin Label**

**JBPHH Green Waste Disposal Direction**

Intent: The intent of this document is to provide direction to all tenants, contractors and all others working on JBPHH for the proper disposal of green waste to prevent the spread of the Coconut Rhinoceros Beetle (CRB).

Scope: All green waste generated on JBPHH or Navy owned property on Oahu.

Definitions:

- Green waste as used in this document
  - Includes: all tree, bush, hedge, flower trimmings in part or whole, grass, mulch, compost heaps, fruit and vegetable scraps, decaying stumps and other plant matter.
  - Excludes: fresh grass clippings removed from JBPHH within 12 hrs, soil

Direction: All green waste will be brought to a designated green waste collection point throughout JBPHH (see below) between the hours of 0700-1800 on M-F except federal holidays. At least 1 hour advanced notification to the NAVFAC Green Waste Disposal Coordinator is required for all disposals (contact info below). If any stage of CRB is suspected in your green waste, do not disturb or transfer material and call the Pest Hotline immediately at 679-5244. All material disposed of must be free of garbage or any other non-green waste.

Leave whole vs. chipping:

- Deciduous and evergreen material- If 2” (inch) diameter or greater, cut in 5 to 6 foot lengths. If less than 2” diameter, chip.
- Palmaceous material - If 2” (inch) diameter or greater, cut in 3 foot lengths. If less than 2” diameter, chip.

How to transport green waste: All green waste will be completely enclosed or covered with tarp to prevent spread of CRB during transport.

Stock piling: Stockpiling green waste for more than 24 hrs is not permitted on JBPHH.

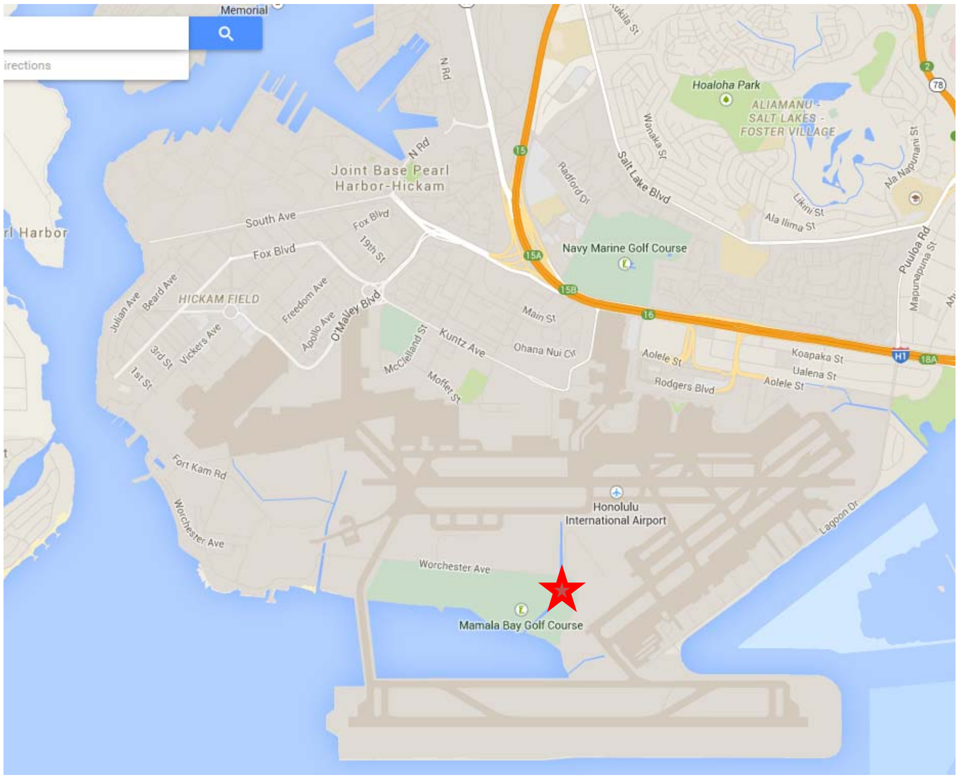
Green waste collection points:

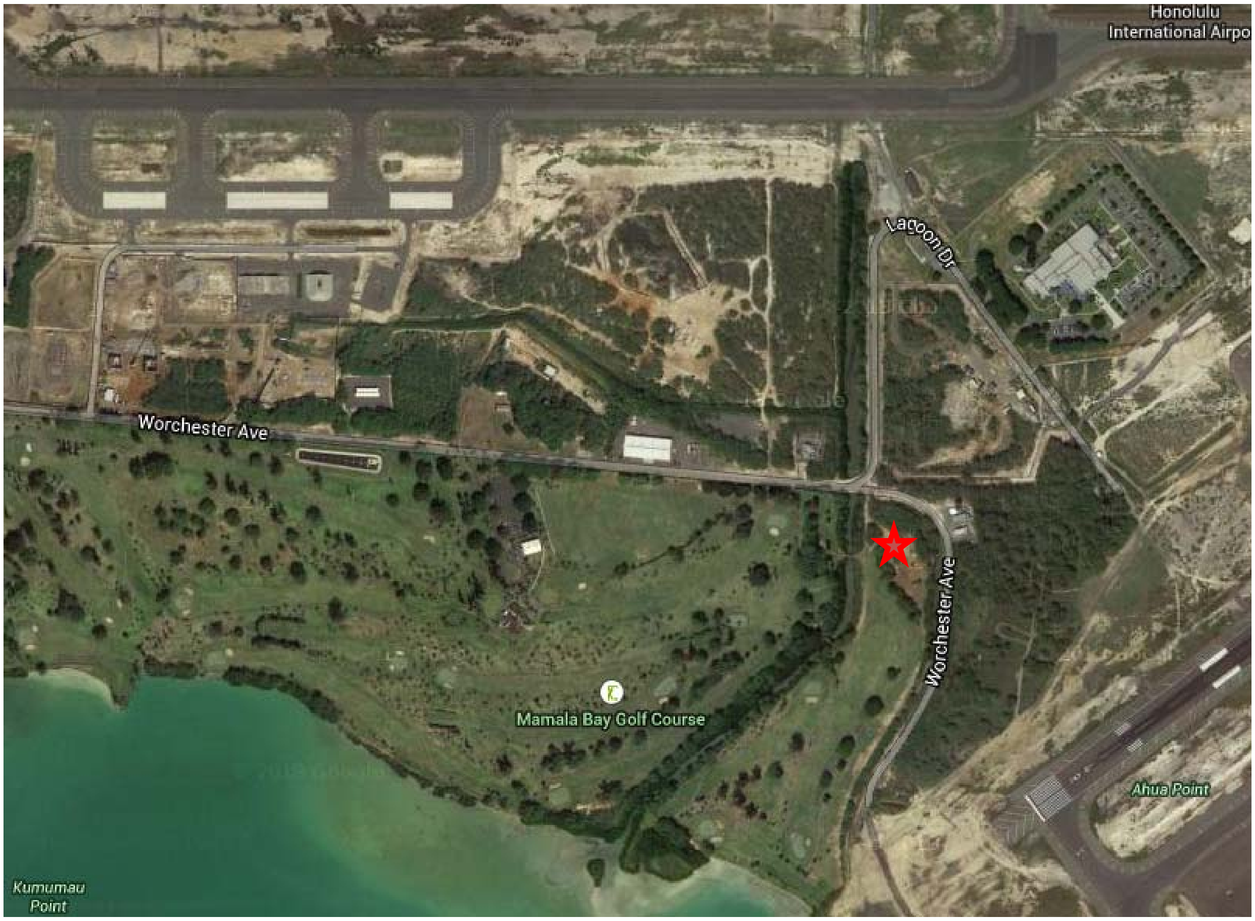
- Main base
  - Mamala Bay Golf Course (see map below)

Points of Contacts:

- NAVFAC Green Waste Disposal Coordinator – Lonnie Felise , 347-2645
- Pest Hotline/HDOA – 679-5244

Updated 29 April 2015





Updated 29 April 2015

# Appendix D:
# Historical Quarterly Monitoring Data
## (on CD-ROM at end of document)

## APPENDIX D

D.1 Screen of Historical Groundwater Long-Term Monitoring Analytical Results for COPCs

D.2 Cumulative Groundwater Measurements and Analytical Results for Tunnel Wells

D.3 Inside Well Trends (2005–2016)

D.4 Cumulative Groundwater Measurements and Analytical Results for Outside-Tunnel Wells

D.5 Outside Well Trends (2005–2016)

D.6 Well Summary Stats (2005–2016)

D.7 Well Summary Stats 5-year (2011–2016)

D.8 Lead Scavenger Stats (2005–2016)

D.9 Soil Vapor Tables (2008–2016)

D.10 Soil Vapor Graphs (2008–2016)

## Appendix D.1: Screen of Historical Groundwater Long-Term Monitoring Analytical Results for COPCs
## WP/SOW, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, RHSF, JBPHH, O‘ahu, HI

| | | **Analytical Method** | **8015** | | | | | | **8260B** | | | | | | | | | | | | **8270B** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Well Name** | **Sample ID** | **Date Sampled** | **TPH-d** | | **TPH-g** | | **TPH-o** | | **TPH-g** | | **Benzene** | | **Ethylbenzene** | | **Naphthalene** | | **Toluene** | | **Xylenes, Total (p/m-, o-xylene)** | | **1-Methylnaphthalene** | | **2-Methylnaphthalene** | | **Naphthalene** | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| | | **EAL** | **100** | | **100** | | **100** | | **100** | | **5** | | **30** | | **17** | | **40** | | **20** | | **4.7** | | **10** | | **17** | |
| | | **SSRBL** | **4500** | | **NA** | | **750** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | |
| RHMW01 | RH-W-001 | 2/17/2005[b] | 1,400 | Y | ND<50b | U | **770** | **O** | — | | ND<0.50b | U | ND<0.50b | U | — | | ND<0.50b | U | ND<0.50b | U | — | | 0.14 | | 0.25 | |
| RHMW01 | RH-W-002 | 2/17/2005*[b] | 1,500 | | ND<50b | U | **890** | | — | | ND<0.50b | U | ND<0.50b | U | — | | ND<0.50b | U | ND<0.50b | U | — | | 0.057 | | 0.21 | |
| RHMW01 | RH-W-003 | 6/28/2005[a] | 1,300 | Z | ND<13 | U | — | | — | | ND<0.50b | U | ND<0.50b | U | — | | ND<0.50b | U | ND<0.50b | U | — | | 0.054 | | 0.073 | |
| RHMW01 | RH-W-004 | 6/28/2005*[a] | 1,100 | Z | ND<13 | U | — | | — | | ND<0.50b | U | ND<0.50b | U | — | | ND<0.50b | U | ND<0.50b | U | — | | 0.051 | | 0.055 | |
| RHMW01 | RH-W-005 | 9/8/2005[a] | 950 | Y | ND<13 | U | 540 | O | — | | ND<0.14 | U | ND<0.13 | U | — | | 0.15 | J | ND<0.22 | U | — | | 0.038 | | 0.83 | |
| RHMW01 | RH-W-006 | 9/8/2005*[a] | 1,100 | Y | ND<13 | U | 720 | O | — | | ND<0.14 | U | ND<0.13 | U | — | | 0.15 | J | ND<0.22 | U | — | | 0.038 | | 0.78 | |
| RHMW01 | RHMW01W01 | 9/20/2005[b] | — | | — | | — | | — | | ND<0.50 | U | ND<0.50 | U | ND<1.0 | U | ND<0.50 | U | ND<0.50 | U | — | | — | | — | |
| RHMW01 | RH-W-007 | 12/6/2005[a] | 670 | Z | ND<13 | U | — | | — | | ND<0.14 | U | ND<0.13 | U | — | | 0.12 | J | ND<0.33 | U | — | | 0.098 | | 0.51 | |
| RHMW01 | RH-W-008 | 12/6/2005*[a] | 740 | Z | ND<13 | U | — | | — | | ND<0.14 | U | ND<0.13 | U | — | | ND<11 | U | ND<0.33 | U | — | | 0.11 | | 0.48 | |
| RHMW01 | RHMW01-GW02 | 7/10/2006[ad] | 509 | | ND<50 | U | — | | — | | ND<0.50 | U | ND<0.50 | U | ND<1.0 | U | ND<0.50 | U | ND<0.50 | U | ND<0.25 | U | ND<0.25 | U | ND<0.25 | U |
| RHMW01 | RHMW01-GW06 | 12/5/2006[ad] | 303 | | ND<50 | U | — | | — | | ND<0.50 | U | ND<0.50 | U | ND<1.0 | U | ND<0.50 | U | ND<0.50 | U | ND<0.25 | U | ND<0.25 | U | ND<0.25 | U |
| RHMW01 | RHMW01-WG07 | 3/27/2007[ad] | 307 | | ND<50 | U | — | | — | | ND<0.50 | U | ND<0.50 | U | ND<1.0 | U | ND<0.50 | U | ND<0.50 | U | ND<0.25 | U | ND<0.25 | U | ND<0.25 | U |
| RHMW01 | RHMW01-WG08 | 6/12/2007[ad] | 274 | | ND<50 | U | — | | — | | ND<0.50 | U | ND<0.50 | U | ND<1.0 | U | ND<0.50 | U | ND<0.50 | U | ND<0.25 | U | ND<0.25 | U | ND<0.25 | U |
| RHMW01 | RHMW01-WG09 | 9/10/2007[a] | 261 | | ND<50 | U | — | | — | | ND<0.20 | U | ND<0.20 | U | ND<0.44 | U | ND<0.27 | U | ND<0.36 | U | ND<0.25 | U | ND<0.25 | U | ND<0.25 | U |
| RHMW01 | RHMW01-WG10 | 1/15/2008[a] | 574 | | ND<10.0 | U | — | | — | | ND<0.120 | U | ND<0.310 | U | 5.98 | | ND<0.310 | U | ND<0.620 | U | 0.0640 | | 0.0478 | J | 0.210 | |
| RHMW01 | RHMW01-WG11 | 4/15/2008[a] | 427 | J | 13.6 | J | — | | — | | ND<0.120 | U | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.620 | U | 0.101 | | 0.0789 | | 0.216 | |
| RHMW01 | RHMW01-WG12 | 7/29/2008[a] | 327 | J | ND<10.0 | U | — | | — | | ND<0.120 | U | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.620 | U | ND<0.0150 | U | ND<0.0150 | U | 0.114 | |
| RHMW01 | RHMW01-WG13 | 10/22/2008[a] | 459 | | ND<10.0 | U | — | | — | | ND<0.120 | U | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.620 | U | ND<0.0150 | U | ND<0.0150 | U | 0.103 | |
| RHMW01 | RHMW01-WG14 | 2/4/2009[a] | 387 | J | 14.4 | J | — | | — | | ND<0.120 | U | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.620 | U | ND<0.0165 | U | ND<0.0165 | U | 0.173 | |
| RHMW01 | RHMW01-WG15 | 5/13/2009[a] | 373 | J | 16.6 | J | — | | — | | ND<0.120 | U | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.620 | U | ND<0.0150 | U | ND<0.0150 | U | 0.182 | |
| RHMW01 | RHMW01-WG16 | 7/15/2009[a] | 248 | J | ND<30.0 | U | — | | — | | ND<0.120 | U | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.620 | U | 9.44 | | 3.07 | | 5.61 | |
| RHMW01 | RHMW01-WG17 | 10/14/2009[a] | 299 | F | ND<30 | U | — | | — | | ND<0.12 | U | ND<0.31 | U | ND<0.62 | U | ND<0.31 | U | ND<1 | U | ND<0.0174 | U | ND<0.0174 | U | 0.193 | |
| RHMW01 | RHMW01-WG18 | 1/27/2010 | 312 | J | ND<60.0 | U | — | | — | | ND<0.240 | U | ND<0.620 | U | ND<1.24 | U | ND<0.620 | U | ND<1.24 | U | ND<0.0334 | U | 0.0559 | | 0.330 | |
| RHMW01 | RHMW01-WG19 | 4/13/2010 | 377 | J | ND<60.0 | U | — | | — | | ND<0.240 | U | ND<0.620 | U | ND<1.24 | U | ND<0.620 | U | ND<1.24 | U | ND<0.0322 | U | ND<0.0322 | U | ND<0.0666 | U |
| RHMW01 | RHMW01-WG20 | 7/13/2010 | 228 | J | ND<60.0 | U | — | | — | | ND<0.240 | U | ND<0.620 | U | ND<1.24 | U | ND<0.620 | U | ND<1.24 | U | ND<0.0316 | U | ND<0.0316 | U | 0.184 | |
| RHMW01 | ES009 | 11/3/2010 | ND< 80.8 | U | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | 0.17 | J |
| RHMW01 | ES015 | 1/20/2011 | ND< 80.8 | U | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW01 | ES033 | 4/28/2011 | 300 | | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW01 | ES041 | 7/20/2011 | 290 | | — | | *ND<212.0* | *U* | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | 0.12 | J |
| RHMW01 | ES057 | 11/2/2011 | 210 | | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW01 | ES069 | 2/14/2012 | 210 | ++ | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW01 | ES075 | 4/17/2012 | ND< 80.8 | U | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW01 | ES088 | 7/20/2012 | ND< 80.8 | U | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | 0.13 | J |
| RHMW01 | ES001 | 10/22/2012 | 85 | J,HD | — | | — | | 20 | B,J | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | ND<0.050 | U |
| RHMW01 | ES010 | 2/4/2013 | 79 | | — | | — | | 13 | J | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | 0.10 | J |
| RHMW01 | ES019 | 4/22/2013 | 340 | HD | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.052 | U | ND<0.052 | U | ND<0.052 | U |
| RHMW01 | ES028 | 7/22/2013 | 99 | HD | — | | — | | ND<30 | U | ND<0.501 | U | ND<0.501 | U | — | | ND<0.501 | U | ND<1.01 | U | ND<0.050 | U | ND<0.050 | U | 0.048 | J |
| RHMW01 | ES037 | 10/21/2013 | 92 | HD | — | | — | | 15 | B,J | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.052 | U | ND<0.052 | U | ND<0.052 | U |
| RHMW01 | ES048 | 1/15/2014 | 250 | HD | — | | — | | — | | ND<0.50 | U | ND<0.50 | U | — | | 2.5 | | ND<1.0 | U | 0.040 | J | 0.039 | J | 0.062 | J |
| RHMW01 | ES056 | 1/28/2014 | 130 | HD | — | | — | | 26 | B,J | ND<0.50 | U | ND<0.50 | U | — | | 1.3 | | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | 0.045 | J |
| RHMW01 | ES062 | 2/24/2014 | 89 | HD | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | 0.037 | J |
| RHMW01 | ES064 | 3/5/2014 | 93 | | — | | — | | — | | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.050 | U | 0.038 | J | ND<0.050 | U |
| RHMW01 | ES069 | 3/10/2014 | 38 | HD | — | | — | | — | | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.052 | U | ND<0.052 | U | ND<0.052 | U |
| RHMW01 | ES072 | 3/25/2014 | 82 | HD | — | | — | | — | | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.051 | U | ND<0.051 | U | ND<0.051 | U |
| RHMW01 | ES077 | 4/7/2014 | 140 | HD | — | | — | | — | | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | ND<0.050 | U |
| RHMW01 | ES080 | 4/21/2014 | 88 | HD | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | ND<0.050 | U |
| RHMW01 | ES091 | 5/27/2014 | 66 | HD | — | | — | | — | | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.051 | U | ND<0.051 | U | ND<0.051 | U |
| RHMW01 | ES098 | 6/23/2014 | 77 | | — | | — | | — | | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | ND<0.050 | U |
| RHMW01 | ES103 | 7/21/2014 | 67 | HD | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.051 | U | ND<0.051 | U | ND<0.051 | U |
| RHMW01 | ES113 | 10/27/2014 | 120 | J,HD | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.10 | U | ND<0.052 | U | ND<0.052 | U |
| RHMW01 | ES120X | 1/27/2015 | 33 | HD | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.11 | U | ND<0.054 | U | ND<0.054 | U |
| RHMW01 | ES130 | 4/20/2015 | 170 | Y | ND<25 | U | 23 | B,J | — | | ND<0.10 | U | ND<0.10 | U | — | | ND<0.10 | U | ND<0.20 | U | 0.014 | J | 0.0093 | J | 0.056 | J |
| RHMW01 | ES143 | 6/25/2015 | 130 | Y | — | | 40 | J | — | | — | | — | | — | | — | | — | | 0.0068 | JX | 0.0058 | JX | 0.040 | X |
| RHMW01 | ES145 | 7/20/2015 | 150 | Y | ND<25 | U | 21 | J | — | | ND<0.10 | U | ND<0.10 | U | — | | ND<0.10 | U | ND<0.20 | U | 0.014 | JX | 0.013 | J | 0.057 | |
| RHMW01 | ERH011 | 10/20/2015 | 330 | B,Y | ND<25 | U | ND<54 | B,U | — | | ND<0.10 | U,** | ND<0.10 | U,** | — | | 0.420 | J,** | ND<0.20 | U,** | 0.037 | | 0.024 | B | 0.2 | B |
| RHMW01 | ERH024 | 1/20/2016 | 430 | B,Y | ND<25 | U | 60 | B,J | — | | ND<0.10 | U | ND<0.10 | U | — | | 0.170 | J,Tb | ND<0.20 | U | 0.029 | X | 0.023 | X | 0.18 | |

## Appendix D.1: Screen of Historical Groundwater Long-Term Monitoring Analytical Results for COPCs (cont'd)
## WP/SOW, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, RHSF, JBPHH, O‘ahu, HI

| | | Analytical Method | 8015 | | | | | | 8260B | | | | | | | | | | | | 8270B | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | TPH-d | | TPH-g | | TPH-o | | TPH-g | | Benzene | | Ethylbenzene | | Naphthalene | | Toluene | | Xylenes, Total (p/m-, o-xylene) | | 1-Methylnaphthalene | | 2-Methylnaphthalene | | Naphthalene | |
| Well Name | Sample ID | Date Sampled | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| | | **EAL** | **100** | | **100** | | **100** | | **100** | | **5** | | **30** | | **17** | | **40** | | **20** | | **4.7** | | **10** | | **17** | |
| | | **SSRBL** | **4500** | | **NA** | | **750** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | |
| RHMW02 | RHMW02W01 | 9/20/2005[b] | 2,660 | | ND<50 | U | — | | — | | ND<2.5 | U | ND<2.5 | U | 283 | J | ND<2.5 | U | ND<2.5 | U | 104 | | 88.5 | | 120 | |
| RHMW02 | RHMW02Q01 | 9/20/2005*[b] | 2,500 | | ND<50 | U | — | | — | | ND<2.5 | U | ND<2.5 | U | 319 | | ND<2.5 | U | ND<2.5 | U | 102 | | 87.2 | | 123 | |
| RHMW02 | RHMW02-GW02 | 7/10/2006[a] | 2,800 | | 124 | | — | | — | | ND<0.50 | U | 1.3 | | 343 | | ND<0.50 | U | ND<0.50 | U | 142 | | 65.8 | | 171 | |
| RHMW02 | RHMW05-GW02 | 7/10/2006*[a] | 2,790 | | 119 | | — | | — | | ND<2.5 | U | ND<2.5 | U | 335 | | ND<2.5 | U | ND<2.5 | U | 133 | | 67.1 | | 180 | |
| RHMW02 | RHMW02-GW06 | 12/5/2006[a] | 2,600 | | 110 | | — | | — | | ND<0.50 | U | 1.2 | | 257 | | ND<0.50 | U | ND<0.50 | U | 124 | | 45.1 | | 160 | |
| RHMW02 | RHMWA01-GW06 | 12/5/2006*[a] | 2,690 | | 138 | | — | | — | | ND<0.50 | U | 1.1 | | 269 | | ND<0.50 | U | ND<0.50 | U | 114 | | 51.1 | | 147 | |
| RHMW02 | RHMW02-WG07 | 3/27/2007[a] | 2,750 | O | 122 | O | — | | — | | ND<0.50 | U | ND<0.50 | U | 196 | O | ND<0.50 | U | ND<0.50 | U | 72 | O | 30.3 | O | 105 | O |
| RHMW02 | RHMWA01-WG07 | 3/27/2007*[a] | 2,250 | O | 148 | O | — | | — | | ND<0.50 | U | ND<0.50 | U | 207 | O | ND<0.50 | U | ND<0.50 | U | 59 | O | 26.2 | O | 90.1 | O |
| RHMW02 | RHMW02-WG08 | 6/12/2007[a] | 2,750 | | 52.5 | J | — | | — | | ND<0.50 | U | ND<0.50 | U | 209 | | ND<0.50 | U | ND<0.5 | U | 67 | | 26.5 | | 87.2 | |
| RHMW02 | RHMWA01-WG08 | 6/12/2007*[a] | 2,900 | | 56.5 | J | — | | — | | ND<0.50 | U | ND<0.50 | U | 207 | | ND<0.50 | U | ND<0.50 | U | 88 | | 33.0 | | 128 | |
| RHMW02 | RHMW02-WG09 | 9/10/2007[a] | 2,810 | | 76 | J | — | | — | | ND<0.20 | U | ND<0.20 | U | 206 | | ND<0.27 | U | ND<0.36 | U | 109 | | 21.5 | | 144 | |
| RHMW02 | RHMWA01-WG09 | 9/10/2007*[a] | 3,180 | | 78.2 | J | — | | — | | ND<0.2 | U | ND<0.20 | U | 264 | | ND<0.27 | U | ND<0.38 | U | 102 | | 19.7 | | 136 | |
| RHMW02 | RHMW02-WG10 | 1/15/2008[a] | 2,310 | | 64.3 | J | — | | — | | 0.170 | J | ND<0.310 | U | 195 | | ND<0.310 | U | 1.06 | | 67 | | 23.8 | | 93.6 | |
| RHMW02 | RHMWA01-WG10 | 1/15/2008*[a] | 3,230 | | 66.2 | J | — | | — | | 0.170 | J | 0.350 | J | 194 | | ND<0.310 | U | 1.10 | | 73 | | 27.6 | | 102 | |
| RHMW02 | RHMW02-WG11 | 4/15/2008[a] | 3,120 | | 58.9 | J | — | | — | | ND<0.120 | U | ND<0.310 | U | 290 | | ND<0.310 | U | 0.740 | J | 76 | | 34.5 | | 73.0 | |
| RHMW02 | RHMWA01-WG11 | 4/15/2008*[a] | 3,020 | | 58.9 | J | — | | — | | 0.150 | J | ND<0.310 | U | 293 | | ND<0.310 | U | 0.750 | J | 72 | | 40.8 | | 105 | |
| RHMW02 | RHMW02-WG12 | 7/29/2008[a] | 4,470 | | 61.7 | J | — | | — | | ND<0.120 | U | 0.580 | J | 320 | | ND<0.310 | U | ND<0.620 | U | 102 | | 31.5 | | 140 | |
| RHMW02 | RHMWA01-WG12 | 7/29/2008*[a] | 3,640 | | 61.2 | J | — | | — | | 0.120 | J | 0.560 | J | 309 | | ND<0.310 | U | ND<0.620 | U | 96 | | 42.2 | | 132 | |
| RHMW02 | RHMW02-WG13 | 10/22/2008[a] | **4,540** | | 52.8 | J | — | | — | | 0.140 | J | 0.450 | J | 239 | | ND<0.310 | U | 0.450 | J | 72 | | 13.7 | | 97.4 | |
| RHMW02 | RHMWA01-WG13 | 10/22/2008*[a] | **6,300** | | 52.9 | J | — | | — | | 0.150 | J | 0.420 | J | 245 | | ND<0.310 | U | 0.490 | J | 62 | | 12.7 | | 82.3 | |
| RHMW02 | RHMW02-WG14 | 2/4/2009[a] | 2,840 | | 52.3 | J | — | | — | | 0.260 | J | 0.490 | J | 42.8 | | ND<0.310 | U | 0.400 | J | 21 | | 10.5 | | 15.2 | |
| RHMW02 | RHMWA01-WG14 | 2/4/2009*[a] | 2,840 | | 54.3 | J | — | | — | | 0.240 | J | 0.520 | J | 43.0 | | ND<0.310 | U | 0.470 | J | 23 | | 11.1 | | 16.6 | |
| RHMW02 | RHMW02-WG15 | 5/13/2009[a] | 1,620 | | 39.1 | J | — | | — | | ND<0.120 | U | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | 0.310 | J | 18 | | 0.136 | | 1.17 | |
| RHMW02 | RHMWA01-WG15 | 5/13/2009*[a] | 2,000 | | 36.7 | J | — | | — | | ND<0.120 | U | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.620 | U | 25 | | 0.107 | | 1.08 | |
| RHMW02 | RHMW02-WG16 | 7/15/2009[a] | 1,450 | | ND<30.0 | U | — | | — | | ND<0.120 | U | ND<0.310 | U | 10.1 | | ND<0.310 | U | ND<0.620 | U | 13 | | 3.66 | | 8.37 | |
| RHMW02 | RHMWA01-WG16 | 7/15/2009*[a] | 1,300 | | ND<30.0 | U | — | | — | | ND<0.120 | U | ND<0.310 | U | 11.2 | | ND<0.310 | U | ND<0.620 | U | 11 | | 2.58 | | 6.71 | |
| RHMW02 | RHMW02-WG17 | 10/13/2009[ad] | 2,570 | | 36.9 | F | — | | — | | ND<0.12 | U | ND<0.31 | U | 23.3 | | ND<0.31 | U | ND<1 | U | 2.46 | | 0.486 | | 6.77 | |
| RHMW02 | RHMWA01-WG17 | 10/13/2009*[a] | 2,570 | | ND<30 | U | — | | — | | ND<0.12 | U | ND<0.31 | U | 20.0 | | ND<0.31 | U | ND<1 | U | 4.03 | | 0.783 | | 7.82 | |
| RHMW02 | RHMW02-WG18 | 1/26/2010 | 2,130 | | 42.3 | J | — | | — | | ND<0.240 | U | ND<0.620 | U | 31.5 | | ND<0.620 | U | ND<1.24 | U | 9.03 | | 3.85 | | 17.3 | |
| RHMW02 | RHMWA01-WG18 | 1/26/2010* | 3,410 | | 38.1 | J | — | | — | | ND<0.240 | U | ND<0.620 | U | 9.30 | | ND<0.620 | U | ND<1.24 | U | 8.26 | | 2.65 | | 15.7 | |
| RHMW02 | RHMW02-WG19 | 4/13/2010 | 2,350 | | 39.3 | J | — | | — | | ND<0.240 | U | ND<0.620 | U | 20.6 | | ND<0.620 | U | ND<1.24 | U | 6.61 | | 1.69 | | 14.3 | |
| RHMW02 | RHMWA01-WG19 | 4/13/2010* | 2,080 | | 39.0 | J | — | | — | | ND<0.240 | U | ND<0.620 | U | 21.4 | | ND<0.620 | U | ND<1.24 | U | 5.9 | | 1.90 | | 12.7 | |
| RHMW02 | RHMW02-WG20 | 7/13/2010 | 3,060 | | 46.5 | J | — | | — | | ND<0.240 | U | ND<0.620 | U | 107 | | ND<0.620 | U | 0.690 | J | 7.43 | | 1.06 | | 59.9 | |
| RHMW02 | RHMWA01-WG20 | 7/13/2010* | 3,110 | | 45.4 | J | — | | — | | ND<0.240 | U | ND<0.620 | U | 102 | | ND<0.620 | U | 0.660 | J | 7.05 | | 0.937 | | 61 | |
| RHMW02 | ES002 | 10/18/2010 | 1,700 | ++ | — | | — | | 150 | ++ | ND<0.32 | U | 0.25 | J | — | | ND<0.34 | U | 0.60 | J | 15 | | 5.0 | | 59 | |
| RHMW02 | ES003 | 10/18/2010* | 1,700 | ++ | — | | — | | 160 | ++ | ND<0.32 | U | 0.32 | J | — | | ND<0.34 | U | 0.51 | J | 15 | | 6.3 | | 54 | |
| RHMW02 | ES010 | 1/18/2011 | 1,100 | ++ | — | | — | | 17 | J, ++ | ND<0.32 | U | 0.29 | J | — | | ND<0.34 | U | 0.48 | J | 19 | | 3.6 | | 57 | |
| RHMW02 | ES011 | 1/18/2011* | 1,100 | ++ | — | | — | | 20 | ++ | ND<0.32 | U | 0.25 | J | — | | ND<0.34 | U | 0.58 | J | 23 | | 5.6 | | 63 | |
| RHMW02 | ES020 | 4/19/2011 | 1,100 | ++ | — | | — | | 24 | ++ | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | 0.41 | J | 5.1 | | 0.43 | | 3.5 | |
| RHMW02 | ES021 | 4/19/2011* | 1,100 | ++ | — | | — | | 29 | ++ | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | 0.41 | J | 5.2 | | 0.53 | | 4.2 | |
| RHMW02 | ES037 | 7/19/2011 | 1,100 | | — | | *ND<212.0* | *U* | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | 0.85 | | 0.16 | J | 2.2 | |
| RHMW02 | ES038 | 7/19/2011* | 1,800 | | — | | *ND<212.0* | *U* | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | 0.90 | | 0.12 | J | 2.7 | |
| RHMW02 | ES046 | 10/24/2011 | 750 | | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | 0.53 | | 0.15 | J | 0.80 | |
| RHMW02 | ES047 | 10/24/2011* | 730 | | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | 0.62 | | 0.20 | | 1.0 | |
| RHMW02 | ES061 | 1/26/2012 | 1,700 | | — | | — | | ND<12.12 | U | ND<0.32 | U | 0.30 | J | — | | ND<0.34 | U | ND<0.38 | U | 0.57 | | 0.17 | J | 1.7 | |
| RHMW02 | ES071 | 4/16/2012 | 1,200 | | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | 0.30 | | ND<0.12 | U | 0.86 | |
| RHMW02 | ES072 | 4/16/2012* | 1,100 | | — | | — | | ND<12.12 | U | ND<0.32 | U | 0.23 | J | — | | ND<0.34 | U | ND<0.38 | U | 1.2 | | 0.61 | | 2.9 | |
| RHMW02 | ES082 | 7/18/2012 | 1,700 | ++ | — | | *ND<212.0* | *U* | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | 0.43 | J | 4.7 | | 0.88 | | 17 | |
| RHMW02 | ES002 | 10/22/2012 | 2,200 | HD | — | | — | | 320 | B | ND<0.50 | U | 0.18 | J | — | | 0.59 | J | 0.51 | J | 24 | | 14 | | 63 | |
| RHMW02 | ES003 | 10/22/2012* | 1,800 | HD | — | | — | | 360 | B | ND<0.50 | U | 0.18 | J | — | | 0.60 | J | 0.47 | J | 21 | | 12 | | 61 | |
| RHMW02 | ES011 | 1/28/2013 | 1,700 | HD | — | | — | | 660 | | ND<0.50 | U | 0.21 | J | — | | ND<0.50 | U | 0.65 | J | 47 | | 35 | | 110 | |
| RHMW02 | ES012 | 1/28/2013* | 1,500 | HD | — | | — | | 650 | | ND<0.50 | U | 0.24 | J | — | | ND<0.50 | U | 0.69 | J | 41 | | 31 | | 100 | |
| RHMW02 | ES020 | 4/22/2013 | 2,600 | HD | — | | — | | 54 | | ND<0.50 | U | 0.21 | J | — | | ND<0.50 | U | 0.58 | J | 16 | | 13 | | 53 | |
| RHMW02 | ES021 | 4/22/2013* | 3,300 | HD | — | | — | | 56 | | ND<0.50 | U | 0.21 | J | — | | ND<0.50 | U | 0.58 | J | 20 | | 16 | | 61 | |
| RHMW02 | ES029 | 7/22/2013 | 2,500 | HD | — | | — | | 55 | | ND<0.501 | U | 0.17[1] | J | — | | ND<0.501 | U | 0.45[1] | J | 21 | | 9.1 | | 73 | |
| RHMW02 | ES030 | 7/22/2013* | 2,600 | HD | — | | — | | 61 | | ND<0.501 | U | 0.19[1] | J | — | | ND<0.501 | U | 0.50[1] | J | 18 | | 6.6 | | 67 | |

## Appendix D.1: Screen of Historical Groundwater Long-Term Monitoring Analytical Results for COPCs (cont'd)
## WP/SOW, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, RHSF, JBPHH, O‘ahu, HI

| | | Analytical Method | 8015 | | | | | | 8260B | | | | | | | | | | | | 8270B | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | TPH-d | | TPH-g | | TPH-o | | TPH-g | | Benzene | | Ethylbenzene | | Naphthalene | | Toluene | | Xylenes, Total (p/m-, o-xylene) | | 1-Methylnaphthalene | | 2-Methylnaphthalene | | Naphthalene | |
| Well Name | Sample ID | Date Sampled | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| | | **EAL** | **100** | | **100** | | **100** | | **100** | | **5** | | **30** | | **17** | | **40** | | **20** | | **4.7** | | **10** | | **17** | |
| | | **SSRBL** | **4500** | | **NA** | | **750** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | |
| RHMW02 | ES038 | 10/21/2013 | 2,400 | HD | — | | — | | 48 | B,J | ND<0.50 | U | 0.14 | J | — | | ND<0.50 | U | 0.37 | J | 9.0 | | 9.0 | | 30 | |
| RHMW02 | ES039 | 10/21/2013* | 2,400 | HD | — | | — | | 63 | B | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | 0.37 | J | 7.5 | | 7.5 | | 25 | |
| RHMW02 | ES046 | 1/15/2014 | **5,000** | | — | | — | | — | | ND<0.50 | U | 0.17 | J | — | | ND<0.50 | U | 0.48 | J | 6.0 | | 4.9 | | 18 | |
| RHMW02 | ES047 | 1/15/2014* | **5,200** | | — | | — | | — | | ND<0.50 | U | 0.17 | J | — | | ND<0.50 | U | 0.45 | J | 5.3 | | 4.3 | | 17 | |
| RHMW02 | ES057 | 1/28/2014 | 2,300 | HD | — | | — | | 50 | B | 0.14 | J | 0.20 | J | — | | ND<0.50 | U | 0.38 | J | 8.8 | | 5.4 | | 18 | |
| RHMW02 | ES058 | 1/28/2014* | 2,100 | HD | — | | — | | 52 | B | 0.15 | J | 0.20 | J | — | | ND<0.50 | U | 0.34 | J | 9.0 | | 5.9 | | 18 | |
| RHMW02 | ES063 | 2/24/2014 | 2,200 | HD | — | | — | | 40 | J | ND<0.50 | U | 0.15 | J | — | | ND<0.50 | U | 0.29 | J | 5.2 | | 2.5 | | 15 | |
| RHMW02 | ES065 | 3/5/2014 | 2,100 | | — | | — | | — | | ND<0.50 | U | 0.15 | J | — | | ND<0.50 | U | 0.29 | J | 2.6 | | 1.5 | | 10 | |
| RHMW02 | ES066 | 3/5/2014* | 2,200 | | — | | — | | — | | ND<0.50 | U | 0.15 | J | — | | ND<0.50 | U | 0.32 | J | 3.9 | | 2.9 | | 13 | |
| RHMW02 | ES070 | 3/10/2014 | 930 | | — | | — | | — | | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | 0.30 | J | 3.7 | | 2.5 | | 11 | |
| RHMW02 | ES071 | 3/10/2014* | 890 | | — | | — | | — | | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | 0.31 | J | 4.2 | | 3.0 | | 12 | |
| RHMW02 | ES073 | 3/25/2014 | 1,700 | HD | — | | — | | — | | ND<0.50 | U | 0.15 | J | — | | ND<0.50 | U | 0.38 | J | 9.0 | | 4.9 | | 33 | |
| RHMW02 | ES074 | 3/25/2014* | 1,700 | HD | — | | — | | — | | ND<0.50 | U | 0.16 | J | — | | ND<0.50 | U | 0.41 | J | 8.1 | | 4.0 | | 33 | |
| RHMW02 | ES078 | 4/7/2014 | 3,500 | HD | — | | — | | — | | ND<0.50 | U | 0.18 | J | — | | ND<0.50 | U | 0.40 | J | 6.2 | | 4.4 | | 25 | |
| RHMW02 | ES079 | 4/7/2014* | 3,300 | HD | — | | — | | — | | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | 0.33 | J | 9.0 | | 7.6 | | 31 | |
| RHMW02 | ES081 | 4/21/2014 | 1,900 | | — | | — | | 53 | | ND<0.50 | U | 0.17 | J | — | | ND<0.50 | U | 0.43 | J | 8.7 | | 8.1 | | 31 | |
| RHMW02 | ES082 | 4/21/2014* | 1,500 | | — | | — | | 50 | | ND<0.50 | U | 0.16 | J | — | | ND<0.50 | U | 0.42 | J | 8.3 | | 7.7 | | 32 | |
| RHMW02 | ES092 | 5/27/2014 | 1,500 | HD | — | | — | | — | | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | 0.31 | J | 9.3 | | 2.7 | | 34 | |
| RHMW02 | ES093 | 5/27/2014* | 1,300 | HD | — | | — | | — | | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | 0.32 | J | 7.8 | | 1.5 | | 28 | |
| RHMW02 | ES099 | 6/23/2014 | 1,800 | | — | | — | | — | | ND<0.50 | U | 0.16 | J | — | | ND<0.50 | U | 0.40 | J | 11 | | 3.4 | | 38 | |
| RHMW02 | ES100 | 6/23/2014* | 1,600 | | — | | — | | — | | ND<0.50 | U | 0.18 | J | — | | ND<0.50 | U | 0.37 | J | 12 | | 4.5 | | 41 | |
| RHMW02 | ES104 | 7/21/2014 | 1,200 | HD | — | | — | | 48 | J | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | 0.36 | J | 25 | | 20 | | 71 | |
| RHMW02 | ES105 | 7/21/2014* | 1,300 | HD | — | | — | | 49 | J | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | 0.33 | J | 26 | | 22 | | 76 | |
| RHMW02 | ES114 | 10/27/2014 | 2,000 | J,HD | — | | — | | 57 | | ND<0.50 | U | 0.15 | J | — | | ND<0.50 | U | 0.32 | J | 59 | | 43 | | 140 | |
| RHMW02 | ES115 | 10/27/2014 | 2,000 | J,HD | — | | — | | 53 | | ND<0.50 | U | 0.14 | J | — | | ND<0.50 | U | 0.29 | J | 54 | | 36 | | 130 | |
| RHMW02 | ES126 | 1/28/2015 | 1,100 | HD | — | | — | | 54 | | ND<0.50 | U | 0.16 | J | — | | ND<0.50 | U | 0.35 | J | 34 | | 7.6 | J | 90 | |
| RHMW02 | ES127 | 1/28/2015* | 1,700 | HD | — | | — | | 59 | | ND<0.50 | U | 0.17 | J | — | | ND<0.50 | U | 0.35 | J | 25 | | 2.7 | J | 63 | |
| RHMW02 | ES131 | 4/20/2015 | **5,200** | **Y** | 46 | J | 360 | L | — | | 0.090 | J | 0.18 | J | — | | ND<0.10 | U | 0.26 | J | 31 | JD | 15 | JD | 39 | JD |
| RHMW02 | ES132 | 4/20/2015* | **5,400** | **Y** | 47 | J | 360 | L | — | | 0.080 | J | 0.19 | J | — | | ND<0.10 | U | 0.30 | J | 68 | JD | 37 | JD | 140 | JD |
| RHMW02 | ES144 | 6/25/2015 | 3,800 | Y | — | | 250 | L | — | | — | | — | | — | | — | | — | | 71 | JD | 48 | JD | 150 | JD |
| RHMW02 | ES146 | 7/20/2015 | 3,900 | Y | 40 | J | 240 | L | — | | ND<0.10 | U | 0.16 | J | — | | 0.060 | J | 0.26 | J | 65 | JD | 43 | JD | 150 | JD |
| RHMW02 | ES147 | 7/20/2015* | 3,200 | Y | 41 | J | 260 | L | — | | 0.10 | J | 0.17 | J | — | | ND<0.10 | U | 0.27 | J | 66 | D | 43 | D | 160 | D |
| RHMW02 | ERH012 | 10/20/2015 | 6,100 | B,Y | 47 | J | 310 | B,L | — | | 0.09 | J,** | 0.29 | J,** | — | | 0.3 | J,** | 0.32 | J,** | 60 | D | 27 | U,D | 120 | U,D |
| RHMW02 | ERH013 | 10/20/2015 | 6,200 | B,Y | 47 | J | 320 | B,L | — | | 0.09 | J,** | 0.26 | J,** | — | | 0.49 | J,** | 0.30 | J,** | 57 | D | 24 | U,D | 88 | U,D |
| RHMW02 | ERH025 | 1/20/2016 | 6,500 | B,Y | 36 | J | 340 | B,L | — | | 0.08 | J | 0.014 | J | — | | 0.070 | Tb,J | 0.21 | J | 48 | D | 7.9 | D | 120 | D |
| RHMW03 | RHMW03W01 | 9/20/2005[b] | 162 | J | ND<0.50 | U | — | | — | | ND<0.50 | U | ND<0.50 | U | ND<1.0 | U | ND<0.50 | U | ND<0.50 | U | ND<0.24 | U | ND<0.24 | U | ND<0.24 | U |
| RHMW03 | RHMW03-GW02 | 7/10/2006[ad] | 142 | J | ND<50 | U | — | | — | | ND<0.50 | U | ND<0.50 | U | ND<1.0 | U | ND<0.50 | U | ND<0.50 | U | ND<0.25 | U | ND<0.25 | U | ND<0.25 | U |
| RHMW03 | RHMW03-GW06 | 12/5/2006[ad] | ND<100 | U | ND<50 | U | — | | — | | ND<0.50 | U | ND<0.50 | U | ND<1.0 | U | ND<0.50 | U | ND<0.50 | U | ND<0.25 | U | ND<0.25 | U | ND<0.25 | U |
| RHMW03 | RHMW03-WG07 | 3/27/2007[a] | 95.7 | J | ND<50 | U | — | | — | | ND<0.50 | U | ND<0.50 | U | ND<1.0 | U | ND<0.50 | U | ND<0.50 | U | ND<0.25 | U | ND<0.25 | U | ND<0.25 | U |
| RHMW03 | RHMW03-WG08 | 6/12/2007[a] | 123 | J | ND<50 | U | — | | — | | ND<0.50 | U | ND<0.50 | U | ND<1.0 | U | ND<0.50 | U | ND<0.50 | U | ND<0.25 | U | ND<0.25 | U | ND<0.25 | U |
| RHMW03 | RHMW03-WG09 | 9/10/2007[a] | ND<96 | U | ND<50 | U | — | | — | | ND<0.20 | U | ND<0.20 | U | ND<0.44 | U | ND<0.27 | U | ND<0.36 | U | ND<0.25 | U | ND<0.25 | U | ND<0.25 | U |
| RHMW03 | RHMW03-WG10 | 1/15/2008[a] | 242 | J | ND<10.0 | U | — | | — | | ND<0.120 | U | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.620 | U | ND<0.0156 | U | ND<0.0156 | U | ND<0.0323 | U |
| RHMW03 | RHMW03-WG11 | 4/15/2008[a] | 190 | J | ND<10.0 | U | — | | — | | ND<0.120 | U | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.620 | U | 0.0268 | J | 0.0279 | J | ND<0.0341 | U |
| RHMW03 | RHMW03-WG12 | 7/29/2008[a] | 199 | J | ND<10.0 | U | — | | — | | ND<0.120 | U | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.620 | U | 0.0294 | J | ND<0.0156 | U | 0.0689 | J |
| RHMW03 | RHMW03-WG13 | 10/22/2008[a] | 244 | J | ND<10.0 | U | — | | — | | ND<0.120 | U | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.620 | U | 0.0658 | | 0.0937 | | 0.219 | |
| RHMW03 | RHMW03-WG14 | 2/4/2009[a] | 207 | J | 16.1 | J | — | | — | | ND<0.120 | U | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.620 | U | ND<0.0161 | U | ND<0.0161 | U | ND<0.0333 | U |
| RHMW03 | RHMW03-WG15 | 5/13/2009[a] | *ND<161* | *U* | 14.8 | J | — | | — | | ND<0.120 | U | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.620 | U | ND<0.0152 | U | ND<0.0152 | U | ND<0.0313 | U |
| RHMW03 | RHMW03-WG16 | 7/15/2009[a] | *ND<150* | *U* | ND<30.0 | U | — | | — | | ND<0.120 | U | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.620 | U | ND<0.0158 | U | ND<0.0158 | U | ND<0.0326 | U |
| RHMW03 | RHMW03-WG17 | 10/14/2009[a] | *ND<163* | *U* | ND<30 | U | — | | — | | ND<0.12 | U | ND<0.31 | U | ND<0.62 | U | ND<0.31 | U | ND<1 | U | ND<0.0169 | U | ND<0.0169 | U | ND<0.0348 | U |
| RHMW03 | RHMW03-WG18 | 1/27/2010 | *ND<330* | *U* | ND<60.0 | U | — | | — | | ND<0.240 | U | ND<0.620 | U | ND<1.24 | U | ND<0.620 | U | ND<1.24 | U | ND<0.0322 | U | ND<0.0322 | U | ND<0.0666 | U |
| RHMW03 | RHMW03-WG19 | 4/13/2010 | *ND<320* | *U* | ND<60.0 | U | — | | — | | ND<0.240 | U | ND<0.620 | U | ND<1.24 | U | ND<0.620 | U | ND<1.24 | U | ND<0.0322 | U | ND<0.0322 | U | ND<0.0666 | U |
| RHMW03 | RHMW03-WG20 | 7/13/2010 | *ND<324* | *U* | ND<60.0 | U | — | | — | | ND<0.240 | U | ND<0.620 | U | ND<1.24 | U | ND<0.620 | U | ND<1.24 | U | ND<0.0322 | U | ND<0.0322 | U | ND<0.0666 | U |
| RHMW03 | ES001 | 10/18/2010 | 330 | ++ | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW03 | ES012 | 1/19/2011 | ND<80.8 | U | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW03 | ES025 | 4/20/2011 | ND<80.8 | U | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW03 | ES035 | 7/19/2011 | ND<80.8 | U | — | | *ND<212.0* | *U* | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |

| | | **Analytical Method** | **8015** | | | | | | **8260B** | | | | | | | | | | | | **8270B** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Well Name** | **Sample ID** | **Date Sampled** | **TPH-d** | | **TPH-g** | | **TPH-o** | | **TPH-g** | | **Benzene** | | **Ethylbenzene** | | **Naphthalene** | | **Toluene** | | **Xylenes, Total (p/m-, o-xylene)** | | **1-Methylnaphthalene** | | **2-Methylnaphthalene** | | **Naphthalene** | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| | | **EAL** | **100** | | **100** | | **100** | | **100** | | **5** | | **30** | | **17** | | **40** | | **20** | | **4.7** | | **10** | | **17** | |
| | | **SSRBL** | **4500** | | **NA** | | **750** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | |
| RHMW03 | ES049 | 10/24/2011 | ND<80.8 | U | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW03 | ES060 | 1/26/2012 | ND<80.8 | U | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW03 | ES073 | 4/16/2012 | ND<80.8 | U | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW03 | ES081 | 7/18/2012 | ND<80.8 | U | — | | *ND<212.0* | *U* | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW03 | ES004 | 10/22/2012 | 45 | J,HD | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | 0.54 | J | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | 0.029 | J |
| RHMW03 | ES013 | 1/28/2013 | 59 | HD | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | 0.10 | J | 0.069 | J | 0.32 | |
| RHMW03 | ES022 | 4/22/2013 | 69 | HD | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.053 | U | ND<0.053 | U | ND<0.053 | U |
| RHMW03 | ES031 | 7/22/2013 | 48 | J,HD | — | | — | | ND<30 | U | ND<0.501 | U | ND<0.501 | U | — | | ND<0.501 | U | ND<1.01 | U | ND<0.050 | U | ND<0.050 | U | 0.064 | J |
| RHMW03 | ES040 | 10/21/2013 | 54 | HD | — | | — | | 23 | B,J | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | ND<0.050 | U |
| RHMW03 | ES059 | 1/28/2014 | 74 | | — | | — | | 20 | B,J | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | 0.15 | J |
| RHMW03 | ES083 | 4/21/2014 | 39 | HD | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.049 | U | ND<0.049 | U | 0.11 | J |
| RHMW03 | ES106 | 7/22/2014 | 37 | HD | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.047 | U | ND<0.047 | U | ND<0.047 | U |
| RHMW03 | ES116 | 10/27/2014 | 80 | J,HD | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.11 | U | ND<0.054 | U | ND<0.054 | U |
| RHMW03 | ES123 | 1/28/2015 | 39 | HD | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.097 | U | ND<0.048 | U | ND<0.048 | U |
| RHMW03 | ES133 | 4/20/2015 | 100 | B,Y | ND<25 | U | 110 | B,L | — | | ND<0.10 | U | ND<0.10 | U | — | | ND<0.10 | U | ND<0.20 | U | 0.015 | J | 0.0083 | J | 0.035 | J |
| RHMW03 | ES148 | 7/20/2015 | 130 | Y | ND<25 | U | 150 | L | — | | ND<0.10 | U | ND<0.10 | U | — | | ND<0.10 | U | ND<0.20 | U | ND<0.0052 | U | ND<0.0052 | U | ND<0.0052 | U |
| RHMW03 | ERH014 | 10/20/2015 | 130 | B,Y | ND<25 | U | 160 | B,L | — | | ND<0.10 | U,** | ND<0.10 | U,** | — | | 0.4 | J,** | ND<0.20 | U,** | 0.0039 | B,J | 0.0034 | B,J | 0.0094 | B,J |
| RHMW03 | ERH026 | 1/20/2016 | 150 | B,Y | ND< 25 | U | 160 | B,L | — | | ND<0.10 | U | ND<0.10 | U | — | | 0.140 | Tb,J | ND<0.20 | U | ND<0.0050 | U | ND<0.0050 | U | ND<0.0050 | U |
| RHMW05 | RHMW05-WG15 | 5/13/2009[a] | 200 | J | 13.2 | J | — | | — | | ND<0.120 | U | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.620 | U | ND<0.0158 | U | ND<0.0158 | U | ND<0.0326 | U |
| RHMW05 | RHMW05-WG16 | 7/15/2009[a] | 491 | | ND<30.0 | U | — | | — | | ND<0.120 | U | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.620 | U | ND<0.0165 | U | ND<0.0165 | U | ND<0.0341 | U |
| RHMW05 | RHMW05-WG17 | 10/13/2009[ad] | 673 | | ND<30 | U | — | | — | | ND<0.12 | U | ND<0.31 | U | ND<0.62 | U | ND<0.31 | U | ND<1 | U | ND<0.017 | U | ND<0.017 | U | ND<0.0352 | U |
| RHMW05 | RHMW05-WG18 | 1/26/2010 | 2,060 | | ND<60.0 | U | — | | — | | ND<0.240 | U | ND<0.620 | U | ND<1.24 | U | ND<0.620 | U | ND<1.24 | U | 0.0207 | J | 0.0246 | J | ND<0.0712 | U |
| RHMW05 | RHMW05-WG19 | 4/13/2010 | *ND<300* | *U* | ND<60.0 | U | — | | — | | ND<0.240 | U | ND<0.620 | U | ND<1.24 | U | ND<0.620 | U | ND<1.24 | U | 0.0335 | J | ND<0.0326 | U | 0.0752 | J |
| RHMW05 | RHMW05-WG20 | 7/13/2010 | *ND<320* | *U* | ND<60.0 | U | — | | — | | ND<0.240 | U | ND<0.620 | U | ND<1.24 | U | ND<0.620 | U | ND<1.24 | U | ND<0.0316 | U | ND<0.0316 | U | 0.0643 | J |
| RHMW05 | ES005 | 10/20/2010 | ND<80.8 | U | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW05 | ES013 | 1/19/2011 | ND<80.8 | U | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW05 | ES024 | 4/20/2011 | ND<80.8 | U | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW05 | ES039 | 7/19/2011 | ND<80.8 | U | — | | *ND<212.0* | *U* | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW05 | ES051 | 10/25/2011 | ND<80.8 | U | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW05 | ES063 | 2/1/2012 | ND<80.8 | U | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW05 | ES070 | 4/16/2012 | ND<80.8 | U | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW05 | ES079 | 7/17/2012 | ND<80.8 | U | — | | *ND<212.0* | *U* | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW05 | ES080 | 7/17/2012* | ND<80.8 | U | — | | *ND<212.0* | *U* | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW05 | ES005 | 10/22/2012 | 17 | J,HD | — | | — | | 15 | B,J | ND<0.50 | U | ND<0.50 | U | — | | 0.31 | J | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | 0.038 | J |
| RHMW05 | ES015 | 1/29/2013 | 62 | HD | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | 0.075 | J |
| RHMW05 | ES024 | 4/23/2013 | 27 | J | — | | — | | 15 | J | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.048 | U | ND<0.048 | U | 0.033 | J |
| RHMW05 | ES033 | 7/23/2013 | ND<20 | U | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.051 | U | ND<0.051 | U | 0.033 | J |
| RHMW05 | ES042 | 10/22/2013 | ND<20 | U | — | | — | | 17 | B,J | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.051 | U | ND<0.051 | U | 0.17 | J |
| RHMW05 | ES049 | 1/16/2014 | ND<20 | U | — | | — | | — | | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | ND<0.050 | U |
| RHMW05 | ES061 | 1/29/2014 | 16 | J,HD | — | | — | | 23 | B,J | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | 0.064 | J |
| RHMW05 | ES068 | 3/6/2014 | ND<21 | U | — | | — | | — | | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | 0.038 | J |
| RHMW05 | ES076 | 3/26/2014 | 17 | J,HD | — | | — | | — | | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | 0.092 | J |
| RHMW05 | ES084 | 4/22/2014 | ND<10 | U | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.051 | U | ND<0.051 | U | 0.066 | J |
| RHMW05 | ES095 | 5/28/2014 | ND<12 | U | — | | — | | — | | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.049 | U | ND<0.049 | U | ND<0.049 | |
| RHMW05 | ES101 | 6/24/2014 | ND<12 | U | — | | — | | — | | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.051 | U | ND<0.051 | U | ND<0.051 | |
| RHMW05 | ES108 | 7/22/2014 | ND<12 | U | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.049 | U | ND<0.049 | U | ND<0.049 | U |
| RHMW05 | ES118 | 10/28/2014 | 16 | J,HD | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.096 | U | ND<0.048 | U | ND<0.048 | U |
| RHMW05 | ES124 | 1/27/2015 | ND<13 | U | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.096 | U | ND<0.048 | U | ND<0.048 | U |
| RHMW05 | ES135 | 4/21/2015 | 17 | B,J | ND<25 | U | 34 | B,J | — | | ND<0.10 | U | ND<0.10 | U | — | | ND<0.10 | U | ND<0.20 | U | ND<0.0050 | UJ | ND<0.0050 | UJ | ND<0.0050 | UJ |
| RHMW05 | ES142 | 6/25/2015 | 15 | J | — | | 41 | J | — | | — | | — | | — | | — | | — | | 0.0046 | J | 0.0029 | J | ND<0.0050 | U |
| RHMW05 | ES150 | 7/21/2015 | 18 | J | ND<25 | U | 44 | J | — | | ND<0.10 | U | ND<0.10 | U | — | | ND<0.10 | U | ND<0.20 | U | 0.0041 | J | 0.0036 | J | 0.0058 | J |
| RHMW05 | ERH010 | 10/20/2015 | 20 | B,J | ND<25 | U | ND<54 | B,U | — | | ND<0.10 | U,** | ND<0.10 | U,** | — | | 0.59 | ** | ND<0.20 | U,** | 0.0050 | J | 0.0066 | B,J | 0.0074 | B,J |
| RHMW05 | ERH022 | 1/20/2016 | 27 | B,J | ND<25 | U | 45 | B,J | — | | ND<0.10 | U | ND<0.10 | U | — | | 0.18 | Tb,J | ND<0.20 | U | ND<0.0050 | U | 0.0031 | J | ND<0.0050 | U |
| RHMW05 | ERH023 | 1/20/2016 | 26 | B,J | ND<25 | U | 44 | B,J | — | | ND<0.10 | U | ND<0.10 | U | — | | 0.120 | Tb,J | ND<0.20 | U | ND<0.0050 | U | 0.0039 | J | 0.0046 | J |

## Appendix D.1: Screen of Historical Groundwater Long-Term Monitoring Analytical Results for COPCs (cont'd)
## WP/SOW, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, RHSF, JBPHH, O‘ahu, HI

|  |  | Analytical Method | 8015 |  |  |  |  |  | 8260B |  |  |  |  |  |  |  |  |  |  |  | 8270B |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Well Name | Sample ID | Date Sampled | TPH-d (µg/l) |  | TPH-g (µg/l) |  | TPH-o (µg/l) |  | TPH-g (µg/l) |  | Benzene (µg/l) |  | Ethylbenzene (µg/l) |  | Naphthalene (µg/l) |  | Toluene (µg/l) |  | Xylenes, Total (p/m-, o-xylene) (µg/l) |  | 1-Methylnaphthalene (µg/l) |  | 2-Methylnaphthalene (µg/l) |  | Naphthalene (µg/l) |  |
|  |  | **EAL** | **100** |  | **100** |  | **100** |  | **100** |  | **5** |  | **30** |  | **17** |  | **40** |  | **20** |  | **4.7** |  | **10** |  | **17** |  |
|  |  | **SSRBL** | **4500** |  | **NA** |  | **750** |  | **NA** |  | **NA** |  | **NA** |  | **NA** |  | **NA** |  | **NA** |  | **NA** |  | **NA** |  | **NA** |  |
| RHMW2254-01 | RH-B-001 | 2/16/2005[be] | ND<50 | U | ND<50 | U | ND<100 | U | — |  | ND<0.50 | U | ND<0.50 | U | — |  | 1.0 |  | ND<0.50 | U | — |  | ND<0.020 | U | ND<0.020 | U |
| RHMW2254-01 | RH-B-002 | 2/16/2005[bf] | ND<53 | U | ND<50 | U | *ND<110* | *U* | — |  | ND<0.50 | U | ND<0.50 | U | — |  | 1.2 |  | ND<0.50 | U | — |  | ND<0.022 | U | ND<0.022 | U |
| RHMW2254-01 | RH-B-003 | 2/16/2005*[bf] | ND<50 | U | ND<50 | U | ND<100 | U | — |  | ND<0.50 | U | ND<0.50 | U | — |  | 0.81 |  | ND<0.50 | U | — |  | ND<0.021 | U | ND<0.021 | U |
| RHMW2254-01 | RH-B-004 | 6/28/2005[ae] | 43 | J | ND<13 | U | — |  | — |  | ND<0.50b | U | ND<0.50b | U | — |  | ND<0.50b | U | ND<0.50b | U | — |  | ND<0.020b | U | ND<0.020b | U |
| RHMW2254-01 | RH-B-005 | 6/28/2005*[ae] | 67 | Z | ND<13 | U | — |  | — |  | ND<0.50b | U | ND<0.50b | U | — |  | ND<0.50b | U | ND<0.50b | U | — |  | ND<0.020b | U | ND<0.020b | U |
| RHMW2254-01 | RH-B-006 | 6/28/2005*[af] | 58 | Z | ND<13 | U | — |  | — |  | ND<0.50b | U | ND<0.50b | U | — |  | ND<0.50b | U | ND<0.50b | U | — |  | ND<0.021b | U | ND<0.021b | U |
| RHMW2254-01 | RH-B-007 | 9/8/2005[ae] | 45 | J | ND<13 | U | 59 | J | — |  | ND<0.14 | U | ND<0.13 | U | — |  | ND<0.11 | U | ND<0.22 | U | — |  | ND<0.020b | U | 0.085 |  |
| RHMW2254-01 | RH-B-008 | 9/8/2005[af] | ND<50 | U | ND<13 | U | ND<28 | U | — |  | ND<0.14 | U | ND<0.13 | U | — |  | ND<0.11 | U | ND<0.22 | U | — |  | ND<0.020b | U | ND<0.020b | U |
| RHMW2254-01 | RH-B-009 | 9/8/2005*[af] | ND<50d | U | ND<13 | U | ND<100d | U | — |  | ND<0.14 | U | ND<0.13 | U | — |  | ND<0.11 | U | ND<0.22 | U | — |  | ND<0.020b | U | 0.045 |  |
| RHMW2254-01 | RHMW2254W01 | 9/20/2005[bd] | — |  | — |  | — |  | — |  | ND<0.50 | U | ND<0.50 | U | ND<1.0 | U | ND<0.50 | U | ND<0.50 | U | — |  | — |  | — |  |
| RHMW2254-01 | RH-B-010 | 12/6/2005[ae] | 38 | J | ND<13 | U | — |  | — |  | ND<0.14 | U | ND<0.13 | U | — |  | ND<0.11 | U | ND<0.22 | U | — |  | 0.038 |  | 0.036 |  |
| RHMW2254-01 | RH-B-011 | 12/6/2005*[ae] | 24 | J | ND<13 | U | — |  | — |  | ND<0.14 | U | ND<0.13 | U | — |  | ND<0.11 | U | ND<0.22 | U | — |  | 0.022 |  | 0.024 |  |
| RHMW2254-01 | RH-B-012 | 12/7/2005[af] | ND<20 | U | ND<13 | U | — |  | — |  | ND<0.14 | U | ND<0.13 | U | — |  | ND<0.11 | U | ND<0.22 | U | — |  | 0.0071 | J | 0.011 | J |
| RHMW2254-01 | RHMW2254-01-GW02 | 7/10/2006[ad] | *ND<110* | *U* | ND<50 | U | — |  | — |  | ND<0.50 | U | ND<0.50 | U | ND<1.0 | U | ND<0.50 | U | ND<0.50 | U | ND<0.26 | U | ND<0.26 | U | ND<0.26 | U |
| RHMW2254-01 | RHMW2254-01-GW06 | 12/5/2006[ad] | ND<100 | U | ND<50 | U | — |  | — |  | ND<0.50 | U | ND<0.50 | U | ND<1.0 | U | ND<0.50 | U | ND<0.50 | U | ND<0.25 | U | ND<0.25 | U | ND<0.25 | U |
| RHMW2254-01 | RHMW2254-01-WG07 | 3/27/2007[a] | ND<98 | U | ND<50 | U | — |  | — |  | ND<0.50 | U | ND<0.50 | U | ND<1.0 | U | ND<0.50 | U | ND<0.50 | U | ND<0.24 | U | ND<0.24 | U | ND<0.24 | U |
| RHMW2254-01 | RHMW2254-01-WG08 | 6/12/2007[a] | ND<98 | U | ND<50 | U | — |  | — |  | ND<0.50 | U | ND<0.50 | U | ND<1.0 | U | ND<0.50 | U | ND<0.50 | U | ND<0.25 | U | ND<0.25 | U | ND<0.25 | U |
| RHMW2254-01 | RHMW2254-01-WG0 | 9/10/2007[a] | ND<97 | U | ND<50 | U | — |  | — |  | ND<0.20 | U | ND<0.20 | U | ND<0.44 | U | ND<0.27 | U | ND<0.36 | U | ND<0.25 | U | ND<0.25 | U | ND<0.25 | U |
| RHMW2254-01 | RHMW2254-01-WG10 | 1/15/2008[a] | *ND<102* | *U* | ND<10.0 | U | — |  | — |  | ND<0.120 | U | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.620 | U | ND<0.0150 | U | ND<0.0150 | U | ND<0.0310 | U |
| RHMW2254-01 | RHMW2254-01-WG10.1 | 2/6/2008[a] | ND<100 | U | — |  | — |  | — |  | — |  | — |  | — |  | — |  | — |  | — |  | — |  | — |  |
| RHMW2254-01 | RHMW2254-01-WG10.1 | 2/6/2008[a] | ND<10.3 | U | — |  | — |  | — |  | — |  | — |  | — |  | — |  | — |  | — |  | — |  | — |  |
| RHMW2254-01 | RHMW2254-01-WG11 | 4/15/2008[a] | ND<86.0 | U | ND<10.0 | U | — |  | — |  | ND<0.120 | U | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.620 | U | 0.0435 | J | 0.0561 |  | ND<0.0332 | U |
| RHMW2254-01 | RHMW2254-01-WG12 | 7/29/2008[a] | ND<83.3 | U | ND<10.0 | U | — |  | — |  | ND<0.120 | U | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.620 | U | ND<0.0156 | U | ND<0.0156 | U | ND<0.0323 | U |
| RHMW2254-01 | RHMW2254-01-WG13 | 10/22/2008[a] | ND<84.2 | U | ND<10.0 | U | — |  | — |  | ND<0.120 | U | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.620 | U | 0.0276 | J | ND<0.0150 | U | 0.0466 | J |
| RHMW2254-01 | RHMW2254-WG13B | 12/16/2008[c] | — |  | — |  | — |  | — |  | ND<0.120 | U | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.93 | U | — |  | — |  | — |  |
| RHMW2254-01 | RHMWA01-WG13B | 12/16/2008*[c] | — |  | — |  | — |  | — |  | ND<0.120 | U | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.93 | U | — |  | — |  | — |  |
| RHMW2254-01 | RHMW2254-01-WG14 | 2/4/2009[a] | ND<92.0 | U | 14.0 | J | — |  | — |  | ND<0.120 | U | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.620 | U | ND<0.0161 | U | ND<0.0161 | U | ND<0.0333 | U |
| RHMW2254-01 | RHMW2254-01-WG15 | 5/13/2009[a] | *ND<169* | *U* | 19.1 | J | — |  | — |  | ND<0.120 | U | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.620 | U | ND<0.0156 | U | 0.0180 | J | ND<0.0323 | U |
| RHMW2254-01 | RHMW2254-01-WG16 | 7/15/2009[a] | *ND<163* | *U* | ND<30.0 | U | — |  | — |  | ND<0.120 | U | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.620 | U | ND<0.0165 | U | ND<0.0165 | U | ND<0.0341 | U |
| RHMW2254-01 | RHMW2254-WG17 | 10/14/2009[a] | *ND<158* | *U* | ND<30 | U | — |  | — |  | ND<0.12 | U | ND<0.31 | U | ND<0.62 | U | ND<0.31 | U | ND<1 | U | ND<0.017 | U | ND<0.017 | U | ND<0.0352 | U |
| RHMW2254-01 | RHMW2254-01-WG18 | 1/27/2010 | *ND<320* | *U* | ND<60.0 | U | — |  | — |  | ND<0.240 | U | ND<0.620 | U | ND<1.24 | U | ND<0.620 | U | ND<1.24 | U | ND<0.0316 | U | ND<0.0316 | U | 0.0375 | J |
| RHMW2254-01 | RHMW2254-01-WG19 | 4/13/2010 | *ND<320* | *U* | ND<60.0 | U | — |  | — |  | ND<0.240 | U | ND<0.620 | U | ND<1.24 | U | ND<0.620 | U | ND<1.24 | U | ND<0.0330 | U | ND<0.0330 | U | ND<0.0682 | U |
| RHMW2254-01 | RHMW2254-01-WG20 | 7/13/2010 | *ND<320* | *U* | ND<60.0 | U | — |  | — |  | ND<0.240 | U | ND<0.620 | U | ND<1.24 | U | ND<0.620 | U | ND<1.24 | U | ND<0.0320 | U | ND<0.0320 | U | ND<0.0664 | U |
| RHMW2254-01 | ES004 | 10/19/2010 | ND<80.0 | U | — |  | — |  | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — |  | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW2254-01 | ES014 | 1/20/2011 | ND<80.8 | U | — |  | — |  | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — |  | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW2254-01 | ES019 | 4/19/2011 | ND<80.8 | U | — |  | — |  | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — |  | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW2254-01 | ES040 | 7/20/2011 | ND<80.8 | U | — |  | *ND<212.0* | *U* | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — |  | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW2254-01 | ES050 | 10/25/2011 | ND<80.8 | U | — |  | — |  | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — |  | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW2254-01 | ES062 | 2/1/2012 | ND<80.8 | U | — |  | — |  | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — |  | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW2254-01 | ES074 | 4/17/2012 | ND<80.8 | U | — |  | — |  | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — |  | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW2254-01 | ES077 | 7/17/2012 | ND<80.8 | U | — |  | *ND<212.0* | *U* | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — |  | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| RHMW2254-01 | ES006 | 10/22/2012 | ND<20 | U | — |  | — |  | 18 | B,J | ND<0.50 | U | ND<0.50 | U | — |  | 0.71 | J | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | 0.037 | J |
| RHMW2254-01 | ES014 | 1/29/2013 | 22 | J,HD | — |  | — |  | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — |  | ND<0.50 | U | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | 0.052 | J |
| RHMW2254-01 | ES023 | 4/23/2013 | ND<20 | U | — |  | — |  | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — |  | ND<0.50 | U | ND<1.0 | U | ND<0.051 | U | ND<0.051 | U | ND<0.051 | U |
| RHMW2254-01 | ES032 | 7/23/2013 | ND<20 | U | — |  | — |  | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — |  | ND<0.50 | U | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | 0.099 | J |
| RHMW2254-01 | ES041 | 10/22/2013 | ND<20 | U | — |  | — |  | 13 | B,J | ND<0.50 | U | ND<0.50 | U | — |  | ND<0.50 | U | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | 0.036 | J |
| RHMW2254-01 | ES050 | 1/16/2014 | ND<20 | U | — |  | — |  | — |  | ND<0.50 | U | ND<0.50 | U | — |  | ND<0.50 | U | ND<1.0 | U | ND<0.049 | U | ND<0.049 | U | 0.046 | J |
| RHMW2254-01 | ES060 | 1/29/2014 | ND<20 | U | — |  | — |  | 16 | B,J | ND<0.50 | U | ND<0.50 | U | — |  | ND<0.50 | U | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | 0.049 | J |
| RHMW2254-01 | ES067 | 3/6/2014 | ND<20 | U | — |  | — |  | — |  | ND<0.50 | U | ND<0.50 | U | — |  | ND<0.50 | U | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | 0.081 | J |
| RHMW2254-01 | ES075 | 3/26/2014 | ND<10 | U | — |  | — |  | — |  | ND<0.50 | U | ND<0.50 | U | — |  | ND<0.50 | U | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | ND<0.050 | U |
| RHMW2254-01 | ES085 | 4/22/2014 | ND<10 | U | — |  | — |  | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — |  | ND<0.50 | U | ND<1.0 | U | ND<0.049 | U | ND<0.049 | U | ND<0.049 | U |
| RHMW2254-01 | ES094 | 5/28/2014 | ND<12 | U | — |  | — |  | — |  | ND<0.50 | U | ND<0.50 | U | — |  | ND<0.50 | U | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | ND<0.050 | U |
| RHMW2254-01 | ES102 | 6/24/2014 | ND<12 | U | — |  | — |  | — |  | ND<0.50 | U | ND<0.50 | U | — |  | ND<0.50 | U | ND<1.0 | U | ND<0.049 | U | ND<0.049 | U | ND<0.049 | U |
| RHMW2254-01 | ES107 | 7/22/2014 | ND<12 | U | — |  | — |  | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — |  | ND<0.50 | U | ND<1.0 | U | ND<0.048 | U | ND<0.048 | U | ND<0.048 | U |
| RHMW2254-01 | ES117 | 10/28/2014 | 22 | J,HD | — |  | — |  | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — |  | ND<0.50 | U | ND<1.0 | U | ND<0.097 | U | ND<0.049 | U | ND<0.049 | U |
| RHMW2254-01 | ES125 | 1/27/2015 | ND<12 | U | — |  | — |  | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — |  | ND<0.50 | U | ND<1.0 | U | ND<0.10 | U | ND<0.050 | U | ND<0.050 | U |
| RHMW2254-01 | ES134 | 4/21/2015 | 14 | B,J | ND<25 | U | 37 | B,J | — |  | ND<0.10 | U | ND<0.10 | U | — |  | ND<0.10 | U | ND<0.20 | U | ND<0.0050 | UJ | ND<0.0050 | UJ | ND<0.0050 | UJ |
| RHMW2254-01 | ES149 | 7/21/2015 | 17 | J | ND<25 | U | 42 | J | — |  | ND<0.10 | U | ND<0.10 | U | — |  | ND<0.10 | U | ND<0.20 | U | ND<0.0050 | U | ND<0.0050 | U | ND<0.0050 | U |
| RHMW2254-01 | ERH009 | 10/20/2015 | 16 | B,J | ND<25 | U | ND<53 | B,U | — |  | ND<0.10 | U,** | ND<0.10 | U,** | — |  | 0.99 | ** | ND<0.20 | U,** | ND<0.0050 | U | ND<0.0050 | B,U | ND<0.0050 | B,U |
| RHMW2254-01 | ERH021 | 1/20/2016 | 21 | B,J | ND<25 | U | ND<54 | B,U | — |  | ND<0.10 | U | ND<0.10 | U | — |  | 0.160 | Tb,J | ND<0.20 | U | ND<0.0050 | U | ND<0.0050 | U | ND<0.0050 | U |

## Appendix D.1: Screen of Historical Groundwater Long-Term Monitoring Analytical Results for COPCs (cont'd)

## WP/SOW, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, RHSF, JBPHH, O‘ahu, HI

| | | **Analytical Method** | **8015** | | | | | | **8260B** | | | | | | | | | | | | **8270B** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **TPH-d** | | **TPH-g** | | **TPH-o** | | **TPH-g** | | **Benzene** | | **Ethylbenzene** | | **Naphthalene** | | **Toluene** | | **Xylenes, Total (p/m-, o-xylene)** | | **1-Methylnaphthalene** | | **2-Methylnaphthalene** | | **Naphthalene** | |
| **Well Name** | **Sample ID** | **Date Sampled** | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| | | **EAL** | **100** | | **100** | | **100** | | **100** | | **5** | | **30** | | **17** | | **40** | | **20** | | **4.7** | | **10** | | **17** | |
| | | **SSRBL** | **4500** | | **NA** | | **750** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | |
| OWDFMW01 | OWDFMW01-WG-01 | 8/4/2009[a] | *ND<171* | *U* | ND<30.0 | U | — | | — | | 0.470 | | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.620 | U | ND<0.0164 | U | ND<0.0164 | U | ND<0.0339 | U |
| OWDFMW01 | OWDFMW01-WG-02 | 10/13/2009[ab] | *ND<167* | *U* | ND<30 | U | — | | — | | ND<0.12 | U | ND<0.31 | U | ND<0.62 | U | ND<0.31 | U | ND<0.62 | U | ND<0.0168 | U | ND<0.0168 | U | ND<0.0346 | U |
| OWDFMW01 | OWDFMW01-WG-03 | 1/26/2010 | 1,490 | | ND<60.0 | U | — | | — | | ND<0.240 | U | ND<0.620 | U | ND<1.24 | U | ND<0.620 | U | ND<1.24 | U | ND<0.0320 | U | ND<0.0320 | U | ND<0.0664 | U |
| OWDFMW01 | OWDFMW01-WG-04 | 4/26/2010 | 288 | J | ND<60.0 | U | — | | — | | ND<0.240 | U | ND<0.620 | U | ND<1.24 | U | ND<0.620 | U | ND<1.24 | U | ND<0.0352 | U | ND<0.0352 | U | ND<0.0730 | U |
| OWDFMW01 | ES007 | 10/21/2010 | ND<80.8 | U | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| OWDFMW01 | ES008 | 10/21/2010* | ND<80.8 | U | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| OWDFMW01 | ES017 | 1/21/2011 | ND<80.8 | U | — | | — | | ND<12.12 | U | 0.54 | J | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| OWDFMW01 | ES018 | 1/21/2011* | ND<80.8 | U | — | | — | | ND<12.12 | U | 0.69 | J | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| OWDFMW01 | ES029 | 4/21/2011 | ND<80.8 | U | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | 0.21 | J | 0.39 | J | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| OWDFMW01 | ES031 | 4/21/2011* | ND<80.8 | U | — | | — | | ND<12.12 | U | 0.29 | J | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| OWDFMW01 | ES044 | 7/21/2011 | ND<80.8 | U | — | | *ND<212.0* | *U* | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| OWDFMW01 | ES045 | 7/21/2011* | ND<80.8 | U | — | | *ND<212.0* | *U* | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| OWDFMW01 | ES055 | 10/26/2011 | ND<80.8 | U | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| OWDFMW01 | ES056 | 10/26/2011* | ND<80.8 | U | — | | — | | ND<12.12 | U | 0.28 | J | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| OWDFMW01 | ES058 | 1/24/2012 | ND<80.8 | U | — | | *ND<212.0* | *U* | ND<12.12 | U | 0.70 | J | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| OWDFMW01 | ES059 | 1/24/2012* | ND<80.8 | U | — | | *ND<212.0* | *U* | ND<12.12 | U | 0.58 | J | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| OWDFMW01 | ES077 | 4/26/2012 | 220 | ++ | — | | — | | ND<12.12 | U | 0.71 | J | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| OWDFMW01 | ES084 | 7/19/2012 | ND<80.8 | U | — | | — | | ND<12.12 | U | 1.3 | | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| OWDFMW01 | ES008 | 11/7/2012 | 2,500 | HD | — | | — | | 17 | BU,B | 0.38 | BU,J | ND<0.50 | U | — | | ND<0.50 | U | ND<1 | U | ND<0.050 | U | ND<0.050 | U | 0.025 | J |
| OWDFMW01 | ES007 | 11/7/2012* | 2,500 | HD | — | | — | | ND<30 | BU,U | 0.49 | BU,J | ND<0.50 | U | — | | ND<0.50 | U | ND<1 | U | ND<0.050 | U | ND<0.050 | U | 0.035 | J |
| OWDFMW01 | ES016 | 1/30/2013 | 1,000 | | — | | — | | ND<30 | U | 0.39 | J | ND<0.50 | U | — | | ND<0.50 | U | ND<1 | U | ND<0.050 | U | ND<0.050 | U | 0.032 | J |
| OWDFMW01 | ES017 | 1/30/2013* | 1,000 | | — | | — | | ND<30 | U | 0.17 | J | ND<0.50 | U | — | | ND<0.50 | U | ND<1 | U | ND<0.050 | U | ND<0.050 | U | 0.039 | J |
| OWDFMW01 | ES025 | 4/24/2013 | 1,900 | HD | — | | — | | ND<30 | U | 0.82 | J | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.051 | U | ND<0.051 | U | 0.063 | J |
| OWDFMW01 | ES026 | 4/24/2013* | 1,600 | HD | — | | — | | ND<30 | U | 0.67 | J | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | 0.068 | J |
| OWDFMW01 | ES034 | 7/24/2013 | 470 | HD | — | | — | | ND<30 | U | 0.42 | J | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | 0.081 | J |
| OWDFMW01 | ES035 | 7/24/2013* | 340 | HD | — | | — | | ND<30 | U | 0.44 | J | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.048 | U | ND<0.048 | U | 0.12 | J |
| OWDFMW01 | ES043 | 10/23/2013 | 170 | HD | — | | — | | 17 | B,J | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.049 | U | ND<0.049 | U | ND<0.049 | U |
| OWDFMW01 | ES044 | 10/23/2013* | 200 | HD | — | | — | | 14 | B,J | 0.17 | J | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.049 | U | ND<0.049 | U | ND<0.049 | U |
| OWDFMW01 | ES053 | 1/27/2014 | 170 | HD | — | | — | | 26 | B,J | 0.15 | J | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | 0.093 | J |
| OWDFMW01 | ES054 | 1/27/2014* | 140 | HD | — | | — | | 23 | B,J | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | 0.085 | J |
| OWDFMW01 | ES086 | 4/23/2014 | 270 | HD | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.049 | U | ND<0.049 | U | 0.035 | J |
| OWDFMW01 | ES087*** | 4/23/2014* | 32 | HD | — | | — | | 31 | B,J | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | 0.035 | J |
| OWDFMW01 | ES109 | 7/24/2014 | 17 | HD,J | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.051 | U | ND<0.051 | U | 0.031 | J |
| OWDFMW01 | ES110 | 7/24/2014* | 15 | HD,J | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.050 | U | ND<0.050 | U | 0.027 | J |
| OWDFMW01 | ES121 | 10/22/2014 | 19 | HD,J | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.10 | U | ND<0.052 | U | 0.047 | J |
| OWDFMW01 | ES122 | 10/22/2014* | 19 | HD,J | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.10 | U | ND<0.052 | U | ND<0.052 | U |
| OWDFMW01 | ES121X | 1/26/2015 | 24 | HD,J | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.10 | U | ND<0.052 | U | ND<0.052 | U |
| OWDFMW01 | ES122X | 1/26/2015* | 16 | HD,J | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.10 | U | ND<0.051 | U | ND<0.051 | U |
| OWDFMW01 | ES137 | 4/22/2015 | 120 | Z | ND<25 | U | 110 | B,Z | — | | 0.070 | J | ND<0.10 | U | — | | ND<0.10 | U | ND<0.20 | U | 0.023 | | 0.017 | J | 0.025 | |
| OWDFMW01 | ES138 | 4/22/2015* | 120 | Z | ND<25 | U | 140 | B,Z | — | | ND<0.10 | U | ND<0.10 | U | — | | ND<0.10 | U | ND<0.20 | U | 0.020 | | 0.015 | J | 0.023 | |
| OWDFMW01 | ES152 | 7/22/2015 | 3,100 | Z | ND<25 | U | 390 | Z | — | | ND<0.10 | U | ND<0.10 | U | — | | ND<0.10 | U | ND<0.20 | U | 0.0088 | J | 0.0086 | J | 0.014 | J |
| OWDFMW01 | ES153 | 7/22/2015* | 3,000 | Z | ND<25 | U | 330 | Z | — | | ND<0.10 | U | ND<0.10 | U | — | | 0.060 | J | ND<0.20 | U | 0.0096 | J | 0.0097 | J | 0.016 | J |
| OWDFMW01 | ERH002 | 10/19/2015 | 680 | B,Z | ND<25 | U | 100 | B,J | — | | ND<0.10 | U,** | ND<0.10 | U,** | — | | 0.4 | J,** | ND<0.20 | U,** | 0.019 | J | 0.013 | B,J | 0.025 | B,J |
| OWDFMW01 | ERH016 | 1/19/2016 | 320 | B,Z | ND<25 | U | 69 | B,J | — | | ND<0.10 | U | ND<0.10 | U | — | | 0.180 | Tb,J | ND<0.20 | U | 0.03 | | 0.02 | | 0.024 | |

## Appendix D.1: Screen of Historical Groundwater Long-Term Monitoring Analytical Results for COPCs (cont'd)
## WP/SOW, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, RHSF, JBPHH, O‘ahu, HI

| | | **Analytical Method** | **8015** | | | | | | **8260B** | | | | | | | | | | | | | | **8270B** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Well Name** | **Sample ID** | **Date Sampled** | **TPH-d** | | **TPH-g** | | **TPH-o** | | **TPH-g** | | **Benzene** | | **Ethylbenzene** | | **Naphthalene** | | **Toluene** | | **Xylenes, Total (p/m-, o-xylene)** | | **1-Methylnaphthalene** | | **2-Methylnaphthalene** | | **Naphthalene** | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| | | **EAL** | **100** | | **100** | | **100** | | **100** | | **5** | | **30** | | **17** | | **40** | | **20** | | **4.7** | | **10** | | **17** | |
| | | **SSRBL** | **4500** | | **NA** | | **750** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | | **NA** | |
| HDMW2253-03 | HDMW2253-03-WG-02 | 10/13/2009[ab] | *ND<185* | *U* | ND<30 | U | — | | — | | ND<0.12 | U | ND<0.31 | U | ND<0.62 | U | ND<0.31 | U | ND<0.62 | U | ND<0.0169 | U | ND<0.0169 | U | ND<0.035 | U |
| HDMW2253-03 | HDMW2253-03-WG-03 | 1/26/2010 | 322 | J | ND<60.0 | U | — | | — | | ND<0.240 | U | ND<0.620 | U | ND<1.24 | U | ND<0.620 | U | ND<1.24 | U | ND<0.0500 | U | ND<0.0500 | U | ND<0.103 | U |
| HDMW2253-03 | HDMW2253-03-WG-04 | 4/26/2010 | *ND<352* | *U* | ND<60.0 | U | — | | — | | ND<0.240 | U | ND<0.620 | U | ND<1.24 | U | ND<0.620 | U | ND<1.24 | U | ND<0.0348 | U | ND<0.0348 | U | ND<0.0720 | U |
| HDMW2253-03 | HDMW2253-03-WG-05 | 7/8/2010 | *ND<320* | *U* | ND<60.0 | U | — | | — | | ND<0.240 | U | ND<0.620 | U | ND<1.24 | U | ND<0.620 | U | ND<1.24 | U | ND<0.0348 | U | ND<0.0348 | U | 0.0596 | J |
| HDMW2253-03 | ES006 | 10/21/2010 | ND<80.8 | U | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| HDMW2253-03 | ES016 | 1/21/2011 | ND<80.8 | U | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| HDMW2253-03 | ES028 | 4/21/2011 | ND<80.8 | U | — | | — | | ND<12.12 | U | 0.42 | J | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| HDMW2253-03 | ES043 | 7/21/2011 | ND<80.8 | U | — | | *ND<212.0* | *U* | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| HDMW2253-03 | ES053 | 10/26/2011 | ND<80.8 | U | — | | — | | ND<12.12 | U | 0.92 | J | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| HDMW2253-03 | ES057 | 1/24/2012 | ND<80.8 | U | — | | *ND<212.0* | *U* | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| HDMW2253-03 | ES076 | 4/26/2012 | 160 | ++ | — | | — | | ND<12.12 | U | 0.20 | J | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| HDMW2253-03 | ES083 | 7/19/2012 | ND<80.8 | U | — | | — | | ND<12.12 | U | ND<0.32 | U | ND<0.46 | U | — | | ND<0.34 | U | ND<0.38 | U | ND<0.12 | U | ND<0.12 | U | ND<0.10 | U |
| HDMW2253-03 | ES009 | 11/7/2012 | 25 | HD,J | — | | — | | 15 | BU,B | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1 | U | ND<0.050 | U | ND<0.050 | U | ND<0.050 | U |
| HDMW2253-03 | ES018 | 1/30/2013 | 600 | | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1 | U | ND<0.050 | U | ND<0.050 | U | 0.037 | J |
| HDMW2253-03 | ES027 | 4/24/2013 | 45 | J | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.052 | U | ND<0.052 | U | 0.16 | J |
| HDMW2253-03 | ES036 | 7/24/2013 | ND<21 | U | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.047 | U | ND<0.047 | U | 0.030 | J |
| HDMW2253-03 | ES045 | 10/23/2013 | ND<20 | U | — | | — | | 15 | B,J | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.052 | U | ND<0.052 | U | 0.041 | J |
| HDMW2253-03 | ES051 | 1/22/2014 | 18 | HD,J | — | | — | | — | — | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.051 | U | ND<0.051 | U | ND<0.051 | U |
| HDMW2253-03 | ES052 | 1/22/2014* | 18 | HD,J | — | | — | | — | — | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.051 | U | ND<0.051 | U | ND<0.051 | U |
| HDMW2253-03 | ES055 | 1/27/2014 | 35 | HD,J | — | | — | | 27 | B,J | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.051 | U | ND<0.051 | U | 0.064 | J |
| HDMW2253-03 | ES088*** | 4/23/2014 | 220 | HD | — | | — | | 27 | B,J | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.051 | U | ND<0.051 | U | ND<0.051 | U |
| HDMW2253-03 | ES111 | 7/23/2014 | ND<12 | U | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.053 | U | ND<0.053 | U | ND<0.053 | U |
| HDMW2253-03 | ES120 | 10/22/2014 | 14 | HD,J | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | 3.8 | | ND<1.0 | U | ND<0.10 | U | ND<0.051 | U | ND<0.051 | U |
| HDMW2253-03 | ES128 | 1/29/2015 | 16 | HD,J | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.11 | U | ND<0.053 | U | ND<0.053 | U |
| HDMW2253-03 | ES136 | 4/22/2015 | 13 | J | ND<25 | U | 55 | B,J | — | | ND<0.10 | U | ND<0.10 | U | — | | 0.070 | J | ND<0.20 | U | ND<0.0052 | U | ND<0.0052 | U | ND<0.0052 | U |
| HDMW2253-03 | ES151 | 7/22/2015 | 18 | J | ND<25 | U | 77 | J | — | | ND<0.10 | U | ND<0.10 | U | — | | ND<0.10 | U | ND<0.20 | U | ND<0.0050 | U | ND<0.0050 | U | ND<0.0050 | U |
| HDMW2253-03 | ERH001 | 10/19/2015 | 21 | B,J | 16 | J | ND<56 | B,U | — | | ND<0.10 | U,** | ND<0.10 | U,** | — | | 0.37 | J,** | ND<0.20 | U,** | ND<0.005 | U | ND<0.0050 | B,U | 0.0042 | B,J |
| HDMW2253-03 | ERH015 | 1/19/2016 | 43 | B,J | ND<25 | U | 63 | B,J | — | | ND<0.10 | U | ND<0.10 | U | — | | 0.240 | Tb,J | ND<0.20 | U | ND<0.0050 | U | ND<0.0050 | U | ND<0.0050 | U |
| RHMW04 | RHMW04W01 | 9/19/2005[a,b] | 338 | | ND<50.0 | U | — | | — | | ND<0.50 | U | ND<0.50 | U | ND<1.0 | U | ND<0.50 | U | ND<0.50 | U | ND<0.28 | U | ND<0.28 | U | ND<0.28 | U |
| RHMW04 | RHMW04-GW02 | 7/10/2006[a,b] | ND<100 | U | ND<50.0 | U | — | | — | | ND<0.50 | U | ND<0.50 | U | ND<1.0 | U | ND<0.50 | U | ND<0.50 | U | ND<0.26 | U | ND<0.26 | U | ND<0.26 | U |
| RHMW04 | RHMW04-WG-01 | 8/4/2009[a] | *ND<157* | *U* | ND<30.0 | U | — | | — | | ND<0.120 | U | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.620 | U | ND<0.0162 | U | ND<0.0162 | U | ND<0.0335 | U |
| RHMW04 | RHMWA01-WG-01 | 8/4/2009*[a] | *ND<161* | *U* | ND<30.0 | U | — | | — | | 0.250 | J | ND<0.310 | U | ND<0.620 | U | ND<0.310 | U | ND<0.620 | U | ND<0.0167 | U | ND<0.0167 | U | ND<0.0344 | U |
| RHMW04 | RHMW04-WG-02 | 10/13/2009[ab] | *ND<169* | *U* | ND<30 | U | — | | — | | ND<0.12 | U | ND<0.31 | U | ND<0.62 | U | ND<0.31 | U | ND<0.62 | U | ND<0.0172 | U | ND<0.0172 | U | ND<0.0356 | U |
| RHMW04 | RHMWA01-WG-02 | 10/13/2009*[ab] | *ND<174* | *U* | ND<30 | U | — | | — | | ND<0.12 | U | ND<0.31 | U | ND<0.62 | U | ND<0.31 | U | ND<0.62 | U | ND<0.0169 | U | ND<0.0169 | | ND<0.0348 | U |
| RHMW04 | RHMW04-WG-03 | 1/26/2010 | *ND<334* | *U* | ND<60.0 | U | — | | — | | ND<0.240 | U | ND<0.620 | U | ND<1.24 | U | ND<0.620 | U | ND<1.24 | U | ND<0.0326 | U | ND<0.0326 | U | ND<0.0674 | U |
| RHMW04 | RHMWA01-WG-03 | 1/26/2010* | *ND<330* | *U* | ND<60.0 | U | — | | — | | ND<0.240 | U | ND<0.620 | U | ND<1.24 | U | ND<0.620 | U | ND<1.24 | U | ND<0.0338 | U | ND<0.0338 | U | ND<0.0696 | U |
| RHMW04 | RHMW04-WG-04 | 4/26/2010 | *ND<348* | *U* | ND<60.0 | U | — | | — | | ND<0.240 | U | ND<0.620 | U | ND<1.24 | U | ND<0.620 | U | ND<1.24 | U | ND<0.0352 | U | ND<0.0352 | U | ND<0.0730 | U |
| RHMW04 | RHMWA01-WG-04 | 4/26/2010* | *ND<352* | *U* | ND<60.0 | U | — | | — | | ND<0.240 | U | ND<0.620 | U | ND<1.24 | U | ND<0.620 | U | ND<1.24 | U | ND<0.0352 | U | ND<0.0352 | U | ND<0.0730 | U |
| RHMW04 | ES112 | 7/23/2014 | 17 | HD,J | ND<60.0 | U | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.052 | U | ND<0.052 | U | ND<0.052 | U |
| RHMW04 | ES119 | 10/29/2014 | ND<12 | U | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.099 | U | ND<0.050 | U | ND<0.050 | U |
| RHMW04 | ES129 | 1/29/2015 | 10 | HD,J | — | | — | | ND<30 | U | ND<0.50 | U | ND<0.50 | U | — | | ND<0.50 | U | ND<1.0 | U | ND<0.10 | U | ND<0.052 | U | ND<0.052 | U |
| RHMW04 | ES139 | 4/22/2015 | ND<21 | U | ND<25 | U | 25 | B,J | — | | ND<0.10 | U | ND<0.10 | U | — | | ND<0.10 | U | ND<0.20 | U | ND<0.0050 | U | ND<0.0050 | U | ND<0.0050 | U |
| RHMW04 | ES156 | 8/20/2015 | 24 | B,J | ND<25 | U | 40 | B,J | — | | ND<0.10 | U | ND<0.10 | U | — | | ND<0.10 | U | ND<0.20 | U | ND<0.0050 | U | 0.0059 | J | 0.0075 | J |
| RHMW04 | ERH006 | 10/19/2015 | ND<22 | B,U | ND<25 | U | ND<53 | B,U | — | | ND<0.10 | U,** | ND<0.10 | U,** | — | | 0.5 | ** | ND<0.20 | U,** | 0.0043 | J | 0.0047 | B,J | 0.0051 | B,J |
| RHMW04 | ERH019 | 1/19/2016 | 36 | B,J | ND< 25 | U | 52 | B,J | — | | ND<0.10 | U | ND<0.10 | U | — | | ND<0.10 | U | ND<0.20 | U | ND<0.0050 | U | ND<0.0050 | U | ND<0.0050 | U |
| RHMW04 | ERH020 | 1/19/2016 | 29 | B,J | ND< 25 | U | ND<53 | B,U | — | | ND<0.10 | U | ND<0.10 | U | — | | 0.110 | Tb,J | ND<0.20 | U | ND<0.0050 | U | ND<0.0050 | U | ND<0.0050 | U |

## Appendix D.1: Screen of Historical Groundwater Long-Term Monitoring Analytical Results for COPCs (cont'd)
## WP/SOW, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, RHSF, JBPHH, O‘ahu, HI

|  |  | Analytical Method | 8015 |  |  |  |  |  | 8260B |  |  |  |  |  |  |  |  |  |  |  | 8270B |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | TPH-d |  | TPH-g |  | TPH-o |  | TPH-g |  | Benzene |  | Ethylbenzene |  | Naphthalene |  | Toluene |  | Xylenes, Total (p/m-, o-xylene) |  | 1-Methylnaphthalene |  | 2-Methylnaphthalene |  | Naphthalene |  |
| Well Name | Sample ID | Date Sampled | (µg/l) |  | (µg/l) |  | (µg/l) |  | (µg/l) |  | (µg/l) |  | (µg/l) |  | (µg/l) |  | (µg/l) |  | (µg/l) |  | (µg/l) |  | (µg/l) |  | (µg/l) |  |
|  |  | **EAL** | **100** |  | **100** |  | **100** |  | **100** |  | **5** |  | **30** |  | **17** |  | **40** |  | **20** |  | **4.7** |  | **10** |  | **17** |  |
|  |  | **SSRBL** | **4500** |  | **NA** |  | **750** |  | **NA** |  | **NA** |  | **NA** |  | **NA** |  | **NA** |  | **NA** |  | **NA** |  | **NA** |  | **NA** |  |
| RHMW06 | RHMW06-GW-01 | 10/21/2014 | ND<86 | U | ND<20 | U | ND<86 | U | — |  | ND<0.200 | U | ND<0.50 | U | — |  | ND<0.30 | U | ND<0.30 | U | ND<0.011 | U | 0.0064 | J | ND<0.053 | U |
| RHMW06 | RHMW06-GW-02 | 1/23/2015$^{d}$ | ND<76 | U | ND<20 | U | ND<76 | U | — |  | ND<0.200 | U | ND<0.50 | U | — |  | ND<0.30 | U | ND<0.30 | U | ND<0.010 | U | ND<0.010 | U | ND<0.052 | U |
| RHMW06 | ES140 | 4/23/2015 | 20 | J | ND<25 | U | 47 | B,J | — |  | ND<0.10 | U | ND<0.10 | U | — |  | ND<0.10 | U | ND<0.20 | U | ND<0.0052 | U | ND<0.0052 | U | ND<0.0052 | U |
| RHMW06 | ES155 | 7/28/2015 | ND<20 | U | ND<25 | U | ND<50 | U | — |  | ND<0.10 | U | ND<0.10 | U | — |  | ND<0.10 | U | ND<0.20 | U | ND<0.0050 | U | ND<0.0050 | U | ND<0.0050 | U |
| RHMW06 | ERH005 | 10/19/2015 | ND<21 | B,U | ND<25 | U | ND<53 | B,U | — |  | ND<0.10 | U,** | ND<0.10 | U,** | — |  | 0.5 | ** | ND<0.20 | U,** | ND<0.0050 | U | ND<0.0050 | B,U | ND<0.0050 | B,U |
| RHMW06 | ERH018 | 1/19/2016 | 21 | B,J | ND<25 | U | ND<54 | B,U | — |  | ND<0.10 | U | ND<0.10 | U | — |  | 0.100 | Tb,J | ND<0.20 | U | ND<0.0050 | U | ND<0.0050 | U | ND<0.0050 | U |
| RHMW07 | RHMW07-GW-01 | 10/20/2014 | 57 | J | ND<20 | U | ND<78 | U | — |  | ND<0.200 | U | ND<0.50 | U | — |  | ND<0.30 | U | ND<0.30 | U | ND<0.0096 | U | 0.0084 | J | ND<0.048 | U |
| RHMW07 | RHMW07-GW-01FD | 10/20/2014 | 66 | J | ND<20 | U | ND<77 | U | — |  | ND<0.200 | U | ND<0.50 | U | — |  | ND<0.30 | U | ND<0.30 | U | ND<0.010 | U | 0.0060 | J | ND<0.050 | U |
| RHMW07 | RHMW07-GW-02 | 1/22/2015$^{d}$ | ND<75 | U | ND<20 | U | ND<75 | U | — |  | ND<0.200 | U | ND<0.50 | U | — |  | ND<0.30 | U | ND<0.30 | U | ND<0.011 | U | ND<0.011 | U | ND<0.055 | U |
| RHMW07 | RHMW07-GW-02FD | 1/22/2015$^{d*}$ | ND<81 | U | ND<20 | U | ND<81 | U | — |  | ND<0.200 | U | ND<0.50 | U | — |  | ND<0.30 | U | ND<0.30 | U | ND<0.010 | U | ND<0.010 | U | ND<0.050 | U |
| RHMW07 | ES141 | 4/23/2015 | 26 | J | ND<25 | U | 47 | B,J | — |  | ND<0.10 | U | ND<0.10 | U | — |  | ND<0.10 | U | ND<0.20 | U | ND<0.0052 | U | ND<0.0052 | U | ND<0.0052 | U |
| RHMW07 | ES154 | 7/27/2015 | 22 | J | ND<25 | U | 48 | J | — |  | ND<0.10 | U | ND<0.10 | U | — |  | ND<0.10 | U | ND<0.20 | U | 0.0051 | J | 0.0095 | J | 0.0060 | J |
| RHMW07 | ERH003 | 10/19/2015 | 26 | B,J | ND<25 | U | ND<59 | B,U | — |  | ND<0.10 | U,** | ND<0.10 | U,** | — |  | 0.64 | ** | ND<0.20 | U,** | ND<0.005 | U | 0.010 | B,J | 0.010 | B,J |
| RHMW07 | ERH017 | 1/19/2016 | 28 | B,J | ND<25 | U | 44 | B,J | — |  | ND<0.10 | U | ND<0.10 | U | — |  | ND<0.10 | U | ND<0.20 | U | 0.0046 | J | 0.0077 | J | 0.0038 | J |

**Notes:**

Background historical data are from February 2005 to July 2012.

Non-detects (from October 2012 and on) are the LOD values.

SSRBLs only apply to monitoring wells RHMW01, RHMW02, and RHMW03.

* = duplicate samples

** = Samples analyzed beyond the EPA recommended holding time.

*** = Samples ES087 (OWDFMW01) and ES088 (HDMW2253-03) possibly switched prior to analysis.

[1] The holding time until analysis was exceeded by one day; the results may be biased low.

a = MDL values were used for non-detects

b = MRL values were used for non-detects

c = no analytical lab reports found, could not verify results

d = no analytical lab reports available, used summary table from DOH Quarterly GW Reports

e = results from stilling basin, pumps offline

f = results from stilling basin, pumps online

µg/l = micrograms per liter

Light blue highlight = exceeds EAL

**Dark blue highlight = exceeds SSRBL**

*Light yellow highlight = non-detect above EAL*

B = analyte was present in the associated method blank

BU = sample analyzed after holding time expired

D = the reported result is from a dilution

EAL = Hawaii State Department of Health Environmental Action Level

F = indicates that the compound was identified but the concentration was above the MDL and below the RL

HD, Y, L, O, Z, ++ = the chromatographic pattern was inconsistent with the profile of the reference fuel standard

J = indicates an estimated value

LOD = laboratory limit of detection

MDL = laboratory method detection limit

MRL, RL = laboratory reporting limit

ND = non-detect

SSRBL = site specific risk-based level

U = indicates that the compound was analyzed for but not detected at or above the stated limit. The stated limit is the LOD unless otherwise specified.

X = possible high bias due to matrix interference

Tb - The analyte was also detected in the associated trip blank at a similar concentration

| Well Name | Sample ID | Date Sampled | 8015 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | TPH-d | | TPH-g | | TPH-o | | TPH-g | | 1,1,1-Trichloroethane | | 1,1,2-Trichloroethane | | 1,1-Dichloroethane | | 1,1-Dichloroethylene | | 1,2,3-Trichloropropane | | 1,2,4-Tricholorobenzene | | 1,2-Dibromo-3-chloropropane | | 1,2-Dibromoethane | | 1,2-Dichlorobenzene | | 1,2-Dichloroethane | | 1,2-Dichloropropane | | 1,3-Dichlorobenzene | | 1,3-Dichloropropene (total of cis/trans) | | 1,4-Dichlorobenzene | | Acetone | | Benzene | | Bromodichloromethane | |
| | | | (µg/l) | | (µg/l) | | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| **For wells > 150 m from surface water** | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations > 150m from surface water)** | - | - | **100** | | **100** | | **100** | | **100** | | **200** | | **5.0** | | **2.4** | | **7.0** | | **0.6** | | **70** | | **0.04** | | **0.04** | | **10** | | **0.5** | | **5.0** | | **5.0** | | **0.43** | | **5.0** | | **1500** | | **5.0** | | **0.12** | |
| **RHMW01<br>102.27' TOC ELEV** | RH-W-001 | 2/17/2005[b] | **1,400** | **Y** | < 50[b] | U | **770** | **O** | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0083[b] | U | - | | < 0.50[b] | U | - | | - | | - | | - | | - | | < 0.50[b] | U | - | |
| | RH-W-002 | 2/17/2005*[b] | **1,500** | | < 50[b] | U | **890** | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0082[b] | U | - | | < 0.50[b] | U | - | | - | | - | | - | | - | | < 0.50[b] | U | - | |
| | RH-W-003 | 6/28/2005[a] | **1,300** | **Z** | <13 | U | **-** | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.00096 | U | - | | < 0.50[b] | U | - | | - | | - | | - | | - | | < 0.50[b] | U | - | |
| | RH-W-004 | 6/28/2005*[a] | **1,100** | **Z** | <13 | U | **-** | | - | | - | | - | | - | | - | | - | | - | | - | | <0.00095[d] | U | - | | < 0.50[b] | U | - | | - | | - | | - | | - | | < 0.50[b] | U | - | |
| | RH-W-005 | 9/8/2005[a] | **950** | **Y** | < 13 | U | **540** | **O** | - | | - | | - | | - | | - | | - | | - | | - | | < 0.00096 | U | - | | < 0.12 | U | - | | - | | - | | - | | - | | < 0.14 | U | - | |
| | RH-W-006 | 9/8/2005*[a] | **1,100** | **Y** | < 13 | U | **720** | **O** | - | | - | | - | | - | | - | | - | | - | | - | | < 0.00096 | U | - | | < 0.12 | U | - | | - | | - | | - | | - | | < 0.14 | U | - | |
| | RHMW01W01 | 9/20/2005[b] | **-** | | - | | - | | - | | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.30 | U | <0.50 | U | <5.0 | U | < 0.50 | U | <0.50 | U |
| | RH-W-007 | 12/6/2005[a] | **670** | **Z** | < 13 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0096 | U | - | | < 0.12 | U | - | | - | | - | | - | | - | | < 0.14 | U | - | |
| | RH-W-008 | 12/6/2005*[a] | **740** | **Z** | < 13 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0095 | U | - | | < 0.12 | U | - | | - | | - | | - | | - | | < 0.14 | U | - | |
| | RHMW01-GW02 | 7/10/2006[ad] | **509** | | < 50 | U | - | | - | | < 0.50 | U | <0.50 | U | <0.50 | U | < 0.50 | U | <1.0 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.30 | U | <0.50 | U | <5.0 | U | < 0.50 | U | <0.50 | U |
| | RHMW01-GW06 | 12/5/2006[ad] | **303** | | < 50 | U | - | | - | | < 0.50 | U | <0.50 | U | <0.50 | U | < 0.50 | U | <1.0 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.30 | U | <0.50 | U | <5.0 | U | < 0.50 | U | <0.50 | U |
| | RHMW01-WG07 | 3/27/2007[ad] | **307** | | < 50 | U | - | | - | | < 0.50 | U | < 0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | < 0.50 | U | < 1.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | < 0.50 | U | < 0.50 | U | <0.30 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U |
| | RHMW01-WG08 | 6/12/2007[ad] | **274** | | < 50 | U | - | | - | | < 0.50 | U | < 0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | < 0.50 | U | < 1.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | < 0.50 | U | < 0.50 | U | <0.30 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U |
| | RHMW01-WG09 | 9/10/2007[a] | **261** | | < 50 | U | - | | - | | <0.29 | U | < 0.30 | U | <0.25 | U | <0.23 | U | <0.50 | U | < 0.22 | U | < 0.41 | U | <0.20 | U | <0.20 | U | <0.20 | U | < 0.25 | U | < 0.23 | U | <0.24 | U | < 0.22 | U | < 10 | U | < 0.20 | U | < 0.29 | U |
| | RHMW01-WG10 | 1/15/2008[a] | **574** | | < 10.0 | U | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | - | | < 0.120 | U | < 0.150 | U |
| | RHMW01-WG11 | 4/15/2008[a] | **427** | **J** | **13.6** | **J** | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | < 0.120 | U | < 0.150 | U |
| | RHMW01-WG12 | 7/29/2008[a] | **327** | **J** | < 10.0 | U | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | < 0.120 | U | < 0.150 | U |
| | RHMW01-WG13 | 10/22/2008[a] | **459** | | < 10.0 | U | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | < 0.120 | U | < 0.150 | U |
| | RHMW01-WG14 | 2/4/2009[a] | **387** | **J** | **14.4** | **J** | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | < 0.120 | U | < 0.150 | U |
| | RHMW01-WG15 | 5/13/2009[a] | **373** | **J** | **16.6** | **J** | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | < 0.120 | U | < 0.150 | U |
| | RHMW01-WG16 | 7/15/2009[a] | **248** | **J** | < 30.0 | U | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | < 0.120 | U | < 0.150 | U |
| | RHMW01-WG17 | 10/14/2009[a] | **299** | **F** | < 30 | U | - | | - | | < 0.31 | U | < 0.31 | U | < 0.31 | U | <0.31 | U | < 0.31 | U | < 0.31 | U | < 0.62 | U | < 0.31 | U | < 0.31 | U | < 0.15 | U | < 0.31 | U | < 0.31 | U | < 0.15 | U | < 0.15 | U | < 3.1 | U | < 0.12 | U | < 0.15 | U |
| | RHMW01-WG18 | 1/27/2010 | **312** | **J** | < 60.0 | U | - | | - | | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 6.20 | U | < 0.240 | U | < 0.300 | U |
| | RHMW01-WG19 | 4/13/2010 | **377** | **J** | < 60.0 | U | - | | - | | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 6.20 | U | < 0.240 | U | < 0.300 | U |
| | RHMW01-WG20 | 7/13/2010 | **228** | **J** | < 60.0 | U | - | | - | | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | - | | < 0.240 | U | < 0.300 | U |
| | ES009 | 11/3/2010 | < 80.8 | U | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | **2.4** | **J** | < 0.32 | U | < 0.28 | U |
| | ES015 | 1/20/2011 | < 80.8 | U | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES033 | 4/28/2011 | **300** | | - | | **-** | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES041 | 7/20/2011 | **290** | | - | | < 212.0 | U | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES057 | 11/2/2011 | **210** | | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES069 | 2/14/2012 | **210** | **++** | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES075 | 4/17/2012 | < 80.8 | U | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES088 | 7/20/2012 | < 80.8 | U | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | <0.50 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES001 | 10/22/2012 | **85** | **J,HD** | - | | - | | **20** | **B,J** | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U | < 0.50 | U | < 0.50 | U |
| | ES010 | 2/4/2013 | **79** | | - | | - | | **13** | **J** | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | IJ,ICH,U | < 0.50 | U | < 0.50 | U |
| | ES019 | 4/22/2013 | **340** | **HD** | - | | - | | <30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U | < 0.50 | U | < 0.50 | U |
| | ES028 | 7/22/2013 | **99** | **HD** | - | | - | | <30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U | < 0.50[1] | U | < 0.50 | U |
| | ES037 | 10/21/2013 | **92** | **HD** | - | | - | | **15** | **B,J** | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U,ICH | < 0.50 | U | < 0.50 | U |
| | ES048 | 1/15/2014 | **250** | **HD** | - | | - | | **-** | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | **15** | **J,ICH** | < 0.50 | U | < 0.50 | U |
| | ES056 | 1/28/2014 | **130** | **HD** | - | | - | | **26** | **B,J** | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | <10 | U | < 0.50 | U | < 0.50 | U |
| | ES062 | 2/24/2014 | **89** | **HD** | - | | - | | <30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U,IJ | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | <10 | U | < 0.50 | U | < 0.50 | U |
| | ES064 | 3/5/2014 | **93** | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | - | |
| | ES069 | 3/10/2014 | **38** | **HD** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | - | |
| | ES072 | 3/25/2014 | **82** | **HD** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | - | |
| | ES077 | 4/7/2014 | **140** | **HD** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | - | |
| | ES080 | 4/21/2014 | **88** | **HD** | - | | - | | <30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U,ICH | < 0.50 | U | < 0.50 | U |
| | ES091 | 5/27/2014 | **66** | **HD** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | - | |
| | ES098 | 6/23/2014 | **77** | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | - | |
| | ES103 | 7/21/2014 | **67** | **HD** | - | | - | | <30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U,ICH | < 0.50 | U | < 0.50 | U |
| | ES113 | 10/27/2014 | **120** | **J,HD** | - | | - | | <30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U,IH | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U,ICH | < 0.50 | U | < 0.50 | U |
| | ES120X | 1/27/2015 | **33** | **HD** | - | | - | | <30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U | < 0.50 | U | < 0.50 | U |
| | ES130 | 4/20/2015 | **170** | **Y** | <25 | U | **23** | **B,J** | - | | <0.20 | U | <0.40 | U | <0.20 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.80 | U | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <10 | U | <0.10 | U | - | |
| | ES143 | 6/25/2015 | **130** | **Y** | - | | **40** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES145 | 7/20/2015 | **150** | **Y** | <25 | U | **21** | **J** | - | | <0.20 | U | <0.40 | U | <0.20 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.80 | U | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <10 | U | <0.10 | U | - | |
| | ERH011 | 10/20/2015 | **330** | **B,Y** | <25 | U | <54 | B,U | - | | <0.20 | U,** | <0.40 | U,** | <0.20 | U,** | <0.20 | U,** | <0.50 | U,** | <0.30 | U,** | <0.80 | U,** | <0.20 | U,** | <0.20 | U,** | - | | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <10 | U,** | <0.10 | U,** | - | |
| | ERH024 | 1/20/2016 | **430** | **B,Y** | < 25 | U | **60** | **B,J** | - | | - | < 0.20 | U | < 0.40 | U | < 0.20 | U | < 0.20 | U | < 0.50 | U | < 0.30 | U | < 0.80 | U | < 0.004 | U | < 0.20 | U | <0.020 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 10 | U | < 0.10 | U | - | - |

| Well Name | Sample ID | Date Sampled | 8260B | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Bromoform | | Bromomethane | | Carbon Tetrachloride | | Chlorobenzene | | Chloroethane | | Chloroform | | Chloromethane | | cis-1,2-Dichloroethylene | | Dibromochloromethane | | Ethylbenzene | | Hexachlorobutadiene | | Methyl ethyl ketone (2-Butanone) | | Methyl isobutyl ketone (4-Methyl-2-Pentanone) | | Methyl tert-butyl Ether | | Methylene chloride | | Naphthalene | | Styrene | | Tetrachloroethane, 1,1,1,2- | | Tetrachloroethane, 1,1,2,2- | | Tetrachloroethylene | | Toluene | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| **For wells > 150 m from surface water** | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations > 150m from surface water)** | - | - | **80** | | **8.7** | | **5.0** | | **50** | | **16** | | **70** | | **1.8** | | **70** | | **0.16** | | **30** | | **0.86** | | **7,100** | | **170** | | **5.0** | | **4.8** | | **17** | | **10** | | **0.52** | | **0.067** | | **5.0** | | **40** | |
| **RHMW01<br>102.27' TOC ELEV** | RH-W-001 | 2/17/2005[b] | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50[b] | U | - | | - | | - | | < 0.50[b] | U | - | | - | | - | | - | | - | | - | | < 0.50[b] | U |
| | RH-W-002 | 2/17/2005*[b] | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50[b] | U | - | | - | | - | | < 0.50[b] | U | - | | - | | - | | - | | - | | - | | < 0.50[b] | U |
| | RH-W-003 | 6/28/2005[a] | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50[b] | U | - | | - | | - | | < 0.50[b] | U | - | | - | | - | | - | | - | | - | | < 0.50[b] | U |
| | RH-W-004 | 6/28/2005*[a] | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50[b] | U | - | | - | | - | | < 0.50[b] | U | - | | - | | - | | - | | - | | - | | < 0.50[b] | U |
| | RH-W-005 | 9/8/2005[a] | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.13 | U | - | | - | | - | | < 0.20 | U | - | | - | | - | | - | | - | | - | | **0.15** | **J** |
| | RH-W-006 | 9/8/2005*[a] | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.13 | U | - | | - | | - | | < 0.20 | U | - | | - | | - | | - | | - | | - | | **0.15** | **J** |
| | RHMW01W01 | 9/20/2005[b] | <0.50 | U | <1.0 | U | <0.50 | U | <0.50 | U | <1.0 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.40 | U | < 0.50 | U | <0.50 | U | <2.5 | U | <2.5 | U | < 0.50 | U | <1.0 | U | <1.0 | U | <0.50 | U | <0.50 | U | <0.40 | U | <0.50 | U | < 0.50 | U |
| | RH-W-007 | 12/6/2005[a] | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.13 | U | - | | - | | - | | < 0.20 | U | - | | - | | - | | - | | - | | - | | **0.12** | **J** |
| | RH-W-008 | 12/6/2005*[a] | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.13 | U | - | | - | | - | | < 0.20 | U | - | | - | | - | | - | | - | | - | | < 11 | U |
| | RHMW01-GW02 | 7/10/2006[ad] | <0.50 | U | <1.0 | U | <0.50 | U | <0.50 | U | <1.0 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.40 | U | < 0.50 | U | <0.50 | U | <2.5 | U | <2.5 | U | < 0.50 | U | <1.0 | U | < 1.0 | U | <0.50 | U | <0.50 | U | <0.40 | U | < 0.50 | U | < 0.50 | U |
| | RHMW01-GW06 | 12/5/2006[ad] | <0.50 | U | <1.0 | U | <0.50 | U | <0.50 | U | <1.0 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.40 | U | < 0.50 | U | <0.50 | U | <2.5 | U | <2.5 | U | < 0.50 | U | <1.0 | U | < 1.0 | U | <0.50 | U | <0.50 | U | <0.40 | U | < 0.50 | U | < 0.50 | U |
| | RHMW01-WG07 | 3/27/2007[ad] | < 0.50 | U | < 1.0 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 0.50 | U | < 1.0 | U | < 0.50 | U | <0.40 | U | < 0.50 | U | < 0.50 | U | < 2.5 | U | < 2.5 | U | <0.50 | U | < 1.0 | U | < 1.0 | U | < 0.50 | U | < 0.50 | U | < 0.40 | U | < 0.50 | U | < 0.50 | U |
| | RHMW01-WG08 | 6/12/2007[ad] | < 0.50 | U | < 1.0 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 0.50 | U | < 1.0 | U | < 0.50 | U | <0.40 | U | < 0.50 | U | < 0.50 | U | < 2.5 | U | < 2.5 | U | <0.50 | U | < 1.0 | U | < 1.0 | U | < 0.50 | U | < 0.50 | U | < 0.40 | U | < 0.50 | U | < 0.50 | U |
| | RHMW01-WG09 | 9/10/2007[a] | < 0.28 | U | < 0.54 | U | < 0.29 | U | < 0.20 | U | < 0.46 | U | < 0.21 | U | < 0.38 | U | < 0.28 | U | <0.20 | U | < 0.20 | U | < 0.57 | U | < 2.0 | U | < 2.2 | U | <0.25 | U | < 1.0 | U | < 0.44 | U | < 0.20 | U | < 0.25 | U | < 0.37 | U | < 0.25 | U | < 0.27 | U |
| | RHMW01-WG10 | 1/15/2008[a] | < 0.500 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.180 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 0.310 | U | **5.98** | | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW01-WG11 | 4/15/2008[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | < 0.620 | U | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW01-WG12 | 7/29/2008[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | < 0.620 | U | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW01-WG13 | 10/22/2008[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | < 0.620 | U | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW01-WG14 | 2/4/2009[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | < 0.620 | U | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW01-WG15 | 5/13/2009[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | < 0.620 | U | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW01-WG16 | 7/15/2009[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | < 0.620 | U | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW01-WG17 | 10/14/2009[a] | < 0.31 | U | < 0.94 | U | < 0.31 | U | < 0.15 | U | < 0.31 | U | < 0.3 | U | < 0.31 | U | < 0.31 | U | < 0.150 | U | < 0.31 | U | < 0.31 | U | **4.27** | **F** | < 3.1 | U | - | | < 1 | U | < 0.62 | U | < 0.31 | U | < 0.15 | U | < 0.15 | U | < 0.31 | U | < 0.31 | U |
| | RHMW01-WG18 | 1/27/2010 | < 0.620 | U | < 1.88 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.600 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 6.20 | U | < 6.20 | U | < 3.00 | U | < 2.00 | U | < 1.24 | U | < 0.620 | U | < 0.300 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U |
| | RHMW01-WG19 | 4/13/2010 | < 0.620 | U | < 1.88 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.600 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 6.20 | U | < 6.20 | U | < 3.00 | U | < 2.00 | U | < 1.24 | U | < 0.620 | U | < 0.300 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U |
| | RHMW01-WG20 | 7/13/2010 | < 0.620 | U | < 1.88 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.600 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 6.20 | U | < 6.20 | U | < 3.00 | U | < 2.00 | U | < 1.24 | U | < 0.620 | U | < 0.300 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U |
| | ES009 | 11/3/2010 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.62 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.38 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.30 | U | < 0.34 | U |
| | ES015 | 1/20/2011 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.62 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.38 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.30 | U | < 0.34 | U |
| | ES033 | 4/28/2011 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.62 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.38 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.30 | U | < 0.34 | U |
| | ES041 | 7/20/2011 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.62 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.38 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.30 | U | < 0.34 | U |
| | ES057 | 11/2/2011 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | **0.13** | **J** | < 0.84 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.52 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.48 | U | < 0.34 | U |
| | ES069 | 2/14/2012 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.84 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.52 | U | **0.59** | **B,J** | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.48 | U | < 0.34 | U |
| | ES075 | 4/17/2012 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.84 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.52 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.48 | U | < 0.34 | U |
| | ES088 | 7/20/2012 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.84 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.52 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.48 | U | < 0.34 | U |
| | ES001 | 10/22/2012 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 5.0 | IH,U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES010 | 2/4/2013 | < 2.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES019 | 4/22/2013 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES028 | 7/22/2013 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50[1] | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50[1] | U |
| | ES037 | 10/21/2013 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U,IJ | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U,ICH | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES048 | 1/15/2014 | < 1.0 | U | < 5.0 | U,ICJ | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | **2.5** | |
| | ES056 | 1/28/2014 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | **1.3** | |
| | ES062 | 2/24/2014 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U,IJ | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES064 | 3/5/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U |
| | ES069 | 3/10/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U |
| | ES072 | 3/25/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U |
| | ES077 | 4/7/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U |
| | ES080 | 4/21/2014 | < 1.0 | U | < 5.0 | U,ICJ | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES091 | 5/27/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U |
| | ES098 | 6/23/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U |
| | ES103 | 7/21/2014 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U,IJ | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES113 | 10/27/2014 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U,IJ | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U,ICH | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES120X | 1/27/2015 | < 1.0 | U | < 5.0 | U,IH | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES130 | 4/20/2015 | <0.50 | U | <0.30 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | - | | <0.10 | U | <0.30 | U | <4.0 | U | <10 | U | <0.30 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.10 | U |
| | ES143 | 6/25/2015 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES145 | 7/20/2015 | <0.50 | U | <0.30 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | - | | <0.10 | U | <0.30 | U | <4.0 | U | <10 | U | <0.30 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.10 | U |
| | ERH011 | 10/20/2015 | <0.50 | U,** | <0.30 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | - | | <0.10 | U,** | <0.30 | U,** | <4.0 | U,** | <10 | U,** | <0.30 | U,** | <0.20 | B,U | - | | <0.20 | U,** | <0.20 | U,** | - | | <0.20 | U,** | **0.42** | **J,**,Tb** |
| | ERH024 | 1/20/2016 | < 0.50 | U | < 0.30 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | - | - | < 0.10 | U | < 0.30 | U | < 4.0 | U | < 10 | U | < 0.30 | U | < 0.20 | B,U | - | - | < 0.20 | U | < 0.20 | U | < 15 | U | < 0.20 | U | **0.17** | **J,Tb** |

| Well Name | Sample ID | Date Sampled | | | | | | | | | 504.1 | | 8260SIM | | | | | | | | | | | | 8011 | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | trans-1,2-Dichloroethylene | | Trichloroethylene | | Vinyl chloride | | Xylenes, Total (p/m-, o-xylene) | | 1,2-Dibromoethane | | 1,2-Dibromoethane | | 1,2-Dichloroethane | | Bromodichloromethane | | Dibromochloromethane | | Tetrachloroethane, 1,1,2,2- | | 1,2-Dibromo-3-chloropropane | | 1,2-Dibromoethane | | Acenaphthene | | Acenaphthylene | | Anthracene | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| **For wells > 150 m from surface water** | **-** | **-** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations > 150m from surface water)** | **-** | **-** | **100** | | **5.0** | | **2.0** | | **20** | | **0.04** | | **0.04** | | **0.15** | | **0.12** | | **0.16** | | **0.067** | | **0.04** | | **0.04** | | **20** | | **240** | | **22** | |
| **RHMW01 102.27' TOC ELEV** | RH-W-001 | 2/17/2005[b] | - | | - | | - | | < 0.50[b] | U | <0.0083 | U | - | | - | | - | | - | | - | | - | | - | | **0.052** | | < 0.020[b] | U | < 0.020[b] | U |
| | RH-W-002 | 2/17/2005*[b] | - | | - | | - | | < 0.50[b] | U | <0.0082 | U | - | | - | | - | | - | | - | | - | | - | | **0.054** | | < 0.020[b] | U | < 0.020[b] | U |
| | RH-W-003 | 6/28/2005[a] | - | | - | | - | | < 0.50[b] | U | <0.0095 | U | - | | - | | - | | - | | - | | - | | - | | **0.061** | | < 0.020[b] | U | < 0.020[b] | U |
| | RH-W-004 | 6/28/2005*[a] | - | | - | | - | | < 0.50[b] | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.061** | | < 0.020[b] | U | < 0.020[b] | U |
| | RH-W-005 | 9/8/2005[a] | - | | - | | - | | < 0.22 | U | <0.0096 | U | - | | - | | - | | - | | - | | - | | - | | **0.054** | | < 0.020[b] | U | < 0.020[b] | U |
| | RH-W-006 | 9/8/2005*[a] | - | | - | | - | | < 0.22 | U | <0.0094 | U | - | | - | | - | | - | | - | | - | | - | | **0.056** | | < 0.020[b] | U | < 0.020[b] | U |
| | RHMW01W01 | 9/20/2005[b] | <0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | **-** | | - | | - | |
| | RH-W-007 | 12/6/2005[a] | - | | - | | - | | < 0.33 | U | <0.0096 | U | - | | - | | - | | - | | - | | - | | - | | **0.061** | | < 0.0018 | U | **0.012** | **J** |
| | RH-W-008 | 12/6/2005*[a] | - | | - | | - | | < 0.33 | U | <0.0095 | U | - | | - | | - | | - | | - | | - | | - | | **0.058** | | < 0.0018 | U | < 0.0011 | U |
| | RHMW01-GW02 | 7/10/2006[ad] | <0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | <0.50 | U | <0.50 | U |
| | RHMW01-GW06 | 12/5/2006[ad] | <0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | <0.50 | U | <0.50 | U |
| | RHMW01-WG07 | 3/27/2007[ad] | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | RHMW01-WG08 | 6/12/2007[ad] | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.51 | U | < 0.51 | U | < 0.51 | U |
| | RHMW01-WG09 | 9/10/2007[a] | < 0.20 | U | < 0.38 | U | < 0.34 | U | < 0.36 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | RHMW01-WG10 | 1/15/2008[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.0310** | **J** | < 0.0158 | U | < 0.0158 | U |
| | RHMW01-WG11 | 4/15/2008[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.0406** | **J** | < 0.0160 | U | < 0.0160 | U |
| | RHMW01-WG12 | 7/29/2008[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U |
| | RHMW01-WG13 | 10/22/2008[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U |
| | RHMW01-WG14 | 2/4/2009[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U |
| | RHMW01-WG15 | 5/13/2009[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.0243** | **J** | < 0.0150 | U | < 0.0150 | U |
| | RHMW01-WG16 | 7/15/2009[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.180** | | < 0.0158 | U | < 0.0158 | U |
| | RHMW01-WG17 | 10/14/2009[a] | < 0.31 | U | < 0.31 | U | < 0.31 | U | < 1 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.0177** | **F** | < 0.0174 | U | < 0.0174 | U |
| | RHMW01-WG18 | 1/27/2010 | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.0372** | **J** | < 0.0334 | U | < 0.0334 | U |
| | RHMW01-WG19 | 4/13/2010 | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.0450** | **J** | < 0.0322 | U | < 0.0322 | U |
| | RHMW01-WG20 | 7/13/2010 | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.0321** | **J** | < 0.0316 | U | < 0.0316 | U |
| | ES009 | 11/3/2010 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES015 | 1/20/2011 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES033 | 4/28/2011 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES041 | 7/20/2011 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES057 | 11/2/2011 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES069 | 2/14/2012 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES075 | 4/17/2012 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES088 | 7/20/2012 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES001 | 10/22/2012 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.050 | U | < 0.050 | U | < 0.050 | U |
| | ES010 | 2/4/2013 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.050 | U | < 0.050 | U | < 0.050 | U |
| | ES019 | 4/22/2013 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.052 | U | < 0.052 | U | < 0.052 | U |
| | ES028 | 7/22/2013 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0[1] | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.050 | U | < 0.050 | U | < 0.050 | U |
| | ES037 | 10/21/2013 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.052 | U | < 0.052 | U | < 0.052 | U |
| | ES048 | 1/15/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES056 | 1/28/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | <0.050 | U | <0.050 | U | <0.050 | U |
| | ES062 | 2/24/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.027** | **J** | <0.050 | U | <0.050 | U |
| | ES064 | 3/5/2014 | - | | - | | - | | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES069 | 3/10/2014 | - | | - | | - | | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES072 | 3/25/2014 | - | | - | | - | | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES077 | 4/7/2014 | - | | - | | - | | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES080 | 4/21/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | <0.050 | U | <0.050 | U | <0.050 | U |
| | ES091 | 5/27/2014 | - | | - | | - | | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES098 | 6/23/2014 | - | | - | | - | | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES103 | 7/21/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | <0.051 | U | <0.051 | U | <0.051 | U |
| | ES113 | 10/27/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | <0.052 | U | <0.052 | U | <0.052 | U |
| | ES120X | 1/27/2015 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | <0.054 | U | <0.054 | U | <0.054 | U |
| | ES130 | 4/20/2015 | <0.20 | U | <0.10 | U | <0.10 | U | <0.20 | U | - | | <0.010 | U | <0.015 | U | <0.010 | U | <0.010 | U | <0.015 | U | <0.0040 | U | <0.0040 | U | **0.0094** | **J** | **0.0041** | **J** | <0.0050 | U |
| | ES143 | 6/25/2015 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES145 | 7/20/2015 | <0.20 | U | <0.10 | U | <0.10 | U | <0.20 | U | - | | - | | <0.015 | U | <0.010 | U | <0.010 | U | <0.015 | U | <0.0040 | U | <0.0040 | U | **0.0053** | **J** | <0.0050 | Ui | <0.0050 | U |
| | ERH011 | 10/20/2015 | <0.20 | U,** | <0.10 | U,** | <0.10 | U,** | <0.20 | U,** | - | | - | | <0.015 | U | - | | <0.010 | U | <0.015 | U | <0.0040 | | <0.0040 | U | **0.027** | | <0.0050 | U,i | <0.0050 | U |
| | ERH024 | 1/20/2016 | < 0.20 | U | < 0.10 | U | < 0.10 | U | < 0.20 | U | - | - | - | - | < 0.015 | U | < 0.010 | U | < 0.010 | U | - | - | - | - | < 0.0040 | U | **0.028** | | **0.0077** | **JX** | < 0.0050 | U |

# Cumulative Groundwater Measurements and Analytical Results for Tunnel Wells
# Red Hill Bulk Fuel Storage Facility

| Well Name | Sample ID | Date Sampled | 8270C | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 6020 | | 6010B/6020/200.8 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Benzo[a]anthracene | | Benzo[g,h,i]perylene | | Benzo[a]pyrene | | Benzo[b]fluoranthene | | Benzo[k]fluoranthene | | Chrysene | | Dibenz[a,h]anthracene | | Fluoranthene | | Fluorene | | Indeno[1,2,3-cd]pyrene | | 1-Methylnaphthalene | | 2-Methylnaphthalene | | Naphthalene | | Phenanthrene | | Pyrene | | Dissolved Lead (filtered) | | Total Lead (unfiltered) | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| **For wells > 150 m from surface water** | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations > 150m from surface water)** | - | - | **0.092** | | **0.13** | | **0.20** | | **0.092** | | **0.40** | | **1.0** | | **0.0092** | | **130** | | **240** | | **0.092** | | **4.7** | | **10** | | **17** | | **240** | | **68** | | **15** | | - | |
| **RHMW01<br>102.27' TOC ELEV** | RH-W-001 | 2/17/2005[b] | < 0.020[b] | U | < 0.020[b] | U | **0.022** | | **0.025** | | < 0.020[b] | U | **0.020** | | < 0.020[b] | U | **0.035** | | **0.053** | | < 0.020[b] | U | - | | **0.14** | | **0.25** | | **0.12** | | **0.056** | | **10.2** | | - | |
| | RH-W-002 | 2/17/2005*[b] | < 0.020[b] | U | < 0.020[b] | U | < 0.020[b] | U | < 0.020[b] | U | < 0.020[b] | U | < 0.020[b] | U | < 0.020[b] | U | **0.021** | | **0.043** | | < 0.020[b] | U | - | | **0.057** | | **0.21** | | **0.082** | | **0.029** | | **11.9** | | - | |
| | RH-W-003 | 6/28/2005[a] | **0.047** | | **0.034** | | **0.045** | | **0.040** | | **0.051** | | **0.062** | | < 0.020[b] | U | **0.093** | | **0.041** | | **0.037** | | - | | **0.054** | | **0.073** | | **0.14** | | **0.11** | | **6.700** | | - | |
| | RH-W-004 | 6/28/2005*[a] | **0.033** | | **0.022** | | **0.031** | | **0.028** | | **0.035** | | **0.044** | | < 0.020[b] | U | **0.064** | | **0.039** | | **0.024** | | - | | **0.051** | | **0.055** | | **0.10** | | **0.072** | | **6.980** | | - | |
| | RH-W-005 | 9/8/2005[a] | < 0.020[b] | U | < 0.020[b] | U | < 0.020[b] | U | < 0.020[b] | U | < 0.020[b] | U | **0.022** | | < 0.020[b] | U | **0.025** | | **0.064** | | < 0.020[b] | U | - | | **0.038** | | **0.83** | | **0.11** | | **0.030** | | **0.21** | | - | |
| | RH-W-006 | 9/8/2005*[a] | **0.025** | | < 0.020[b] | U | < 0.020[b] | U | < 0.020[b] | U | < 0.020[b] | U | **0.036** | | < 0.020 | U | **0.049** | | **0.064** | | < 0.020[b] | U | - | | **0.038** | | **0.78** | | **0.12** | | **0.058** | | **0.05** | | - | |
| | RHMW01W01 | 9/20/2005[b] | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | **19.6[g]** | |
| | RH-W-007 | 12/6/2005[a] | **0.027** | | **0.015** | **J** | **0.024** | | **0.020** | **J** | **0.017** | **J** | **0.036** | | < 0.0017 | U | **0.062** | | **0.058** | | **0.017** | **J** | - | | **0.098** | | **0.51** | | **0.10** | | **0.072** | | **0.06** | | - | |
| | RH-W-008 | 12/6/2005*[a] | **0.0077** | **J** | **0.0057** | **J** | **0.0086** | **J** | **0.0072** | **J** | **0.0068** | **J** | **0.014** | **J** | < 0.0017 | U | **0.026** | | **0.050** | | **0.0075** | **J** | - | | **0.11** | | **0.48** | | **0.059** | | **0.026** | | **0.04** | | - | |
| | RHMW01-GW02 | 7/10/2006[ad] | <0.050 | U | <0.10 | U | < 0.10 | U | <0.050 | U | <0.10 | U | <0.10 | U | <0.050 | U | < 0.25 | U | <0.25 | U | <0.050 | U | <0.25 | U | <0.25 | U | < 0.25 | U | <0.50 | U | <0.25 | U | < 1.7 | U | - | |
| | RHMW01-GW06 | 12/5/2006[ad] | <0.050 | U | <0.099 | U | < 0.099 | U | <0.050 | U | <0.099 | U | <0.099 | U | <0.050 | U | < 0.25 | U | <0.25 | U | <0.050 | U | <0.25 | U | <0.25 | U | <0.25 | U | <0.50 | U | <0.25 | U | < 1.7 | U | - | |
| | RHMW01-WG07 | 3/27/2007[ad] | <0.050 | U | < 0.099 | U | < 0.099 | U | < 0.050 | U | < 0.099 | U | < 0.099 | U | < 0.050 | U | < 0.25 | U | < 0.25 | U | < 0.050 | U | < 0.25 | U | < 0.25 | U | < 0.25 | U | < 0.50 | U | < 0.25 | U | **1.7** | **J** | - | |
| | RHMW01-WG08 | 6/12/2007[ad] | <0.051 | U | < 0.10 | U | < 0.10 | U | < 0.051 | U | < 0.10 | U | < 0.10 | U | < 0.051 | U | < 0.25 | U | < 0.25 | U | < 0.051 | U | < 0.25 | U | < 0.25 | U | < 0.25 | U | < 0.51 | U | < 0.25 | U | < 3.4 | U | - | |
| | RHMW01-WG09 | 9/10/2007[a] | <0.050 | U | < 0.10 | U | < 0.10 | U | < 0.050 | U | < 0.10 | U | < 0.10 | U | < 0.050 | U | < 0.25 | U | < 0.25 | U | < 0.050 | U | < 0.25 | U | < 0.25 | U | < 0.25 | U | < 0.50 | U | < 0.25 | U | < 2.1 | U | - | |
| | RHMW01-WG10 | 1/15/2008[a] | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | **0.0371** | **J** | < 0.0158 | U | **0.0640** | | **0.0478** | **J** | **0.210** | | < 0.0158 | U | < 0.0158 | U | < 0.310 | U | - | |
| | RHMW01-WG11 | 4/15/2008[a] | < 0.0160 | U | < 0.0160 | U | < 0.0160 | U | < 0.0160 | U | < 0.0160 | U | < 0.0160 | U | < 0.0160 | U | < 0.0160 | U | **0.0375** | **J** | < 0.0160 | U | **0.101** | | **0.0789** | | **0.216** | | < 0.0160 | U | < 0.0160 | U | < 0.310 | U | - | |
| | RHMW01-WG12 | 7/29/2008[a] | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | **0.0206** | **J** | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | **0.114** | | < 0.0150 | U | < 0.0150 | U | < 0.310 | U | - | |
| | RHMW01-WG13 | 10/22/2008[a] | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | **0.0207** | **J** | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | **0.103** | | < 0.0150 | U | < 0.0150 | U | **0.966** | **J** | - | |
| | RHMW01-WG14 | 2/4/2009[a] | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | **0.0235** | **J** | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | **0.173** | | < 0.0165 | U | < 0.0165 | U | < 0.310 | U | - | |
| | RHMW01-WG15 | 5/13/2009[a] | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | **0.0246** | **J** | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | **0.182** | | < 0.0150 | U | < 0.0150 | U | < 0.310 | U | - | |
| | RHMW01-WG16 | 7/15/2009[a] | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | **0.0159** | **J** | < 0.0158 | U | **0.0263** | **J** | **0.0952** | | < 0.0158 | U | **9.44** | | **3.07** | | **5.61** | | **0.0349** | **J** | **0.0270** | **J** | < 0.310 | U | - | |
| | RHMW01-WG17 | 10/14/2009[a] | < 0.0174 | U | < 0.0174 | U | < 0.0174 | U | < 0.0174 | U | < 0.0174 | U | < 0.0174 | U | < 0.0174 | U | < 0.0174 | U | **0.0288** | **F** | < 0.0174 | U | < 0.0174 | U | < 0.0174 | U | **0.193** | | < 0.0174 | U | < 0.0174 | U | < 0.31 | U | - | |
| | RHMW01-WG18 | 1/27/2010 | < 0.0334 | U | < 0.0334 | U | < 0.0334 | U | < 0.0334 | U | < 0.0334 | U | < 0.0334 | U | < 0.0334 | U | < 0.0334 | U | **0.0384** | **J** | < 0.0334 | U | < 0.0334 | U | **0.0559** | | **0.330** | | **0.0204** | **J** | < 0.0334 | U | < 0.620 | U | - | |
| | RHMW01-WG19 | 4/13/2010 | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | **0.0455** | **J** | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0666 | U | < 0.0322 | U | < 0.0322 | U | < 0.620 | U | - | |
| | RHMW01-WG20 | 7/13/2010 | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U | **0.0350** | **J** | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U | **0.184** | | < 0.0316 | U | < 0.0316 | U | < 0.620 | U | - | |
| | ES009 | 11/3/2010 | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | **0.17** | **J** | < 0.14 | U | < 0.16 | U | **0.47** | **J** | - | |
| | ES015 | 1/20/2011 | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | < 0.22 | U | - | |
| | ES033 | 4/28/2011 | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | < 0.22 | U | - | |
| | ES041 | 7/20/2011 | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | **0.12** | **J** | < 0.14 | U | < 0.16 | U | **0.17** | **J** | - | |
| | ES057 | 11/2/2011 | < 0.14 | U | < 0.16 | U | < 0.12 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | < 0.22 | U | - | |
| | ES069 | 2/14/2012 | < 0.14 | U | < 0.16 | U | < 0.12 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | < 0.22 | U | - | |
| | ES075 | 4/17/2012 | < 0.14 | U | < 0.16 | U | < 0.12 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | < 0.22 | U | - | |
| | ES088 | 7/20/2012 | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | **0.13** | **J** | < 0.14 | U | < 0.16 | U | **0.60** | | - | |
| | ES001 | 10/22/2012 | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | **0.178** | **J** | - | |
| | ES010 | 2/4/2013 | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | **0.10** | **J** | < 0.050 | U | < 0.050 | U | **0.846** | **J** | - | |
| | ES019 | 4/22/2013 | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | **0.641** | **J** | - | |
| | ES028 | 7/22/2013 | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.052 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | **0.048** | **J** | < 0.050 | U | < 0.050 | U | < 0.200 | U | - | |
| | ES037 | 10/21/2013 | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | **0.027** | **J** | **2.06** | | - | |
| | ES048 | 1/15/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | **0.040** | **J** | **0.039** | **J** | **0.062** | **J** | - | | - | | - | | - | |
| | ES056 | 1/28/2014 | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | **0.045** | **J** | <0.050 | U | <0.050 | U | **0.205** | **J** | - | |
| | ES062 | 2/24/2014 | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | **0.035** | **J** | <0.050 | U | <0.050 | U | <0.050 | U | **0.037** | **J** | <0.050 | U | <0.050 | U | **0.195** | **J** | - | |
| | ES064 | 3/5/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.050 | U | **0.038** | **J** | <0.050 | U | - | | - | | **0.112** | **J** | | |
| | ES069 | 3/10/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.052 | U | <0.052 | U | <0.052 | U | - | | - | | <0.200 | U | - | |
| | ES072 | 3/25/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.051 | U | <0.051 | U | <0.051 | U | - | | - | | **0.110** | **J** | - | |
| | ES077 | 4/7/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.050 | U | <0.050 | U | <0.050 | U | - | | - | | <0.200 | U | - | |
| | ES080 | 4/21/2014 | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.200 | U | - | |
| | ES091 | 5/27/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.051 | U | <0.051 | U | <0.051 | U | - | | - | | **0.0901** | **J** | - | |
| | ES098 | 6/23/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.050 | U | <0.050 | U | <0.050 | U | - | | - | | <0.200 | U | - | |
| | ES103 | 7/21/2014 | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.200 | U | - | |
| | ES113 | 10/27/2014 | <0.052 | U | <0.10 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.10 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | **0.0976** | **J** | - | |
| | ES120X | 1/27/2015 | <0.054 | U | <0.11 | U | <0.054 | U | <0.054 | U | <0.054 | U | <0.054 | U | <0.054 | U | <0.054 | U | <0.054 | U | <0.054 | U | <0.11 | U | <0.054 | U | <0.054 | U | <0.054 | U | <0.054 | U | **0.631** | | - | |
| | ES130 | 4/20/2015 | **0.0026** | **B,J** | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.020 | U | **0.0096** | **J** | <0.0050 | U | **0.014** | **J** | **0.0093** | **J** | **0.056** | **J** | **0.011** | **J** | <0.010 | U | **0.624** | | - | |
| | ES143 | 6/25/2015 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | **0.0068** | **JX** | **0.0058** | **JX** | **0.040** | **X** | - | | - | | - | | - | |
| | ES145 | 7/20/2015 | **0.0029** | **J** | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.020 | U | **0.0098** | **J** | <0.0050 | U | **0.014** | **JX** | **0.013** | **J** | **0.057** | | **0.012** | **J** | <0.010 | U | **0.132** | | - | |
| | ERH011 | 10/20/2015 | <0.0050 | B,U | <0.0050 | B,U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | B,U | <0.020 | U | **0.026** | | <0.0050 | B,U | **0.037** | | **0.024** | **B** | **0.20** | **B** | <0.005 | U | <0.010 | U | **0.166** | | | |
| | ERH024 | 1/20/2016 | **0.0082** | **J** | **0.0034** | **J** | **0.0061** | **J** | **0.0063** | **J** | < 0.0050 | U | **0.0089** | **J** | < 0.0050 | U | **0.018** | **J** | **0.031** | | **0.0042** | **J** | **0.029** | **X** | **0.023** | **X** | **0.18** | | **0.020** | | **0.015** | **JX** | **0.035** | | - | - |

| | | | 8015 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Well Name | Sample ID | Date Sampled | TPH-d | | TPH-g | | TPH-o | | TPH-g | | 1,1,1-Trichloroethane | | 1,1,2-Trichloroethane | | 1,1-Dichloroethane | | 1,1-Dichloroethylene | | 1,2,3-Trichloropropane | | 1,2,4-Tricholorobenzene | | 1,2-Dibromo-3-chloropropane | | 1,2-Dibromoethane | | 1,2-Dichlorobenzene | | 1,2-Dichloroethane | | 1,2-Dichloropropane | | 1,3-Dichlorobenzene | | 1,3-Dichloropropene (total of cis/trans) | | 1,4-Dichlorobenzene | | Acetone | | Benzene | | Bromodichloromethane | |
| | | | (µg/l) | | (µg/l) | | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| **For wells > 150 m from surface water** | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations > 150m from surface water)** | - | - | **100** | | **100** | | **100** | | **100** | | **200** | | **5.0** | | **2.4** | | **7.0** | | **0.6** | | **70** | | **0.04** | | **0.04** | | **10** | | **0.15** | | **5.0** | | **5.0** | | **0.43** | | **5.0** | | **1500** | | **5.0** | | **0.12** | |
| **RHMW02<br>104.76' TOC ELEV** | RHMW02W01 | 9/20/2005[b] | **2,660** | | < 50 | U | - | | - | | <2.5 | U | <2.5 | U | <2.5 | U | <2.5 | U | <5.0 | U | <2.5 | U | <5.0 | U | <2.5 | U | <2.5 | U | <2.5 | U | <2.5 | U | <2.5 | U | <1.5 | U | <2.5 | U | <25 | U | < 2.5 | U | <2.5 | U |
| | RHMW02Q01 | 9/20/2005*[b] | **2,500** | | < 50 | U | - | | - | | <2.5 | U | <2.5 | U | <2.5 | U | <2.5 | U | <5.0 | U | <2.5 | U | <5.0 | U | <2.5 | U | <2.5 | U | <2.5 | U | <2.5 | U | <2.5 | U | <1.5 | U | <2.5 | U | <25 | U | < 2.5 | U | <2.5 | U |
| | RHMW02-GW02 | 7/10/2006[a] | **2,800** | | **124** | | - | | - | | < 0.50 | U | <0.50 | U | <0.50 | U | < 0.50 | U | <1.0 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.30 | U | <0.50 | U | **6.2** | **J** | < 0.50 | U | <0.50 | U |
| | RHMW05-GW02 | 7/10/2006*[a] | **2,790** | | **119** | | - | | - | | < 2.5 | U | <2.5 | U | <2.5 | U | < 2.5 | U | <5.0 | U | <2.5 | U | <5.0 | U | <2.5 | U | <2.5 | U | <2.5 | U | <2.5 | U | <2.5 | U | <1.5 | U | <2.5 | U | <25 | U | < 2.5 | U | <2.5 | U |
| | RHMW02-GW06 | 12/5/2006[a] | **2,600** | | **110** | | - | | - | | < 0.50 | U | <0.50 | U | <0.50 | U | < 0.50 | U | <1.0 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.30 | U | <0.50 | U | <5.0 | U | < 0.50 | U | <0.50 | U |
| | RHMWA01-GW06 | 12/5/2006*[a] | **2,690** | | **138** | | - | | - | | < 0.50 | U | <0.50 | U | <0.50 | U | < 0.50 | U | <1.0 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.30 | U | <0.50 | U | <5.0 | U | < 0.50 | U | <0.50 | U |
| | RHMW02-WG07 | 3/27/2007[a] | **2,750** | **O** | **122** | **O** | - | | - | | <0.50 | U | < 0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | < 0.50 | U | < 1.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | < 0.50 | U | < 0.50 | U | <0.30 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U |
| | RHMWA01-WG07 | 3/27/2007*[a] | **2,250** | **O** | **148** | **O** | - | | - | | < 0.50 | U | < 0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | < 0.50 | U | < 1.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | < 0.50 | U | < 0.50 | U | <0.30 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U |
| | RHMW02-WG08 | 6/12/2007[a] | **2750** | | **52.5** | **J** | - | | - | | < 0.50 | U | < 0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | < 0.50 | U | < 1.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | < 0.50 | U | < 0.50 | U | <0.30 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U |
| | RHMWA01-WG08 | 6/12/2007*[a] | **2900** | | **56.5** | **J** | - | | - | | < 0.50 | U | < 0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | < 0.50 | U | < 1.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | < 0.50 | U | < 0.50 | U | <0.30 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U |
| | RHMW02-WG09 | 9/10/2007[a] | **2,810** | | **76** | **J** | - | | - | | <0.29 | U | < 0.30 | U | <0.25 | U | <0.23 | U | <0.50 | U | < 0.22 | U | < 0.41 | U | <0.20 | U | <0.20 | U | <0.20 | U | < 0.25 | U | < 0.23 | U | <0.24 | U | < 0.22 | U | < 10 | U | < 0.20 | U | < 0.29 | U |
| | RHMWA01-WG09 | 9/10/2007*[a] | **3,180** | | **78.2** | **J** | - | | - | | <0.29 | U | < 0.30 | U | <0.25 | U | <0.23 | U | <0.50 | U | < 0.22 | U | < 0.41 | U | <0.20 | U | <0.20 | U | <0.20 | U | < 0.25 | U | < 0.23 | U | <0.24 | U | < 0.22 | U | < 10 | U | < 0.2 | U | < 0.29 | U |
| | RHMW02-WG10 | 1/15/2008[a] | **2,310** | | **64.3** | **J** | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | - | | **0.170** | **J** | < 0.150 | U |
| | RHMWA01-WG10 | 1/15/2008*[a] | **3,230** | | **66.2** | **J** | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | - | | **0.170** | **J** | < 0.150 | U |
| | RHMW02-WG11 | 4/15/2008[a] | **3,120** | | **58.9** | **J** | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | < 0.120 | U | < 0.150 | U |
| | RHMWA01-WG11 | 4/15/2008*[a] | **3,020** | | **58.9** | **J** | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | **0.150** | **J** | < 0.150 | U |
| | RHMW02-WG12 | 7/29/2008[a] | **4,470** | | **61.7** | **J** | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | < 0.120 | U | < 0.150 | U |
| | RHMWA01-WG12 | 7/29/2008*[a] | **3,640** | | **61.2** | **J** | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | **0.120** | **J** | < 0.150 | U |
| | RHMW02-WG13 | 10/22/2008[a] | **4,540** | | **52.8** | **J** | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | **0.140** | **J** | < 0.150 | U |
| | RHMWA01-WG13 | 10/22/2008*[a] | **6,300** | | **52.9** | **J** | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | **0.150** | **J** | < 0.150 | U |
| | RHMW02-WG14 | 2/4/2009[a] | **2,840** | | **52.3** | **J** | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | **8.51** | **J** | **0.260** | **J** | < 0.150 | U |
| | RHMWA01-WG14 | 2/4/2009*[a] | **2,840** | | **54.3** | **J** | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | **8.59** | **J** | **0.240** | **J** | < 0.150 | U |
| | RHMW02-WG15 | 5/13/2009[a] | **1,620** | | **39.1** | **J** | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | < 0.120 | U | < 0.150 | U |
| | RHMWA01-WG15 | 5/13/2009*[a] | **2,000** | | **36.7** | **J** | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | < 0.120 | U | < 0.150 | U |
| | RHMW02-WG16 | 7/15/2009[a] | **1,450** | | < 30.0 | U | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | < 0.120 | U | < 0.150 | U |
| | RHMWA01-WG16 | 7/15/2009*[a] | **1,300** | | < 30.0 | U | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | < 0.120 | U | < 0.150 | U |
| | RHMW02-WG17 | 10/13/2009[ad] | **2,570** | | **36.9** | **F** | - | | - | | < 0.31 | U | < 0.31 | U | < 0.31 | U | - | | < 0.31 | U | < 0.31 | U | < 0.62 | U | < 0.31 | U | < 0.31 | U | < 0.15 | U | < 0.31 | U | < 0.31 | U | < 0.15 | U | < 0.15 | U | < 3.1 | U | < 0.12 | U | < 0.15 | U |
| | RHMWA01-WG17 | 10/13/2009*[a] | **2,570** | | < 30 | U | - | | - | | < 0.31 | U | < 0.31 | U | < 0.31 | U | - | | < 0.31 | U | < 0.31 | U | < 0.62 | U | < 0.31 | U | < 0.31 | U | < 0.15 | U | < 0.31 | U | < 0.31 | U | < 0.15 | U | < 0.15 | U | < 3.1 | U | < 0.12 | U | < 0.15 | U |
| | RHMW02-WG18 | 1/26/2010 | **2,130** | | **42.3** | **J** | - | | - | | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 6.20 | U | < 0.240 | U | < 0.300 | U |
| | RHMWA01-WG18 | 1/26/2010* | **3,410** | | **38.1** | **J** | - | | - | | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 6.20 | U | < 0.240 | U | < 0.300 | U |
| | RHMW02-WG19 | 4/13/2010 | **2,350** | | **39.3** | **J** | - | | - | | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 6.20 | U | < 0.240 | U | < 0.300 | U |
| | RHMWA01-WG19 | 4/13/2010* | **2,080** | | **39.0** | **J** | - | | - | | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 6.20 | U | < 0.240 | U | < 0.300 | U |
| | RHMW02-WG20 | 7/13/2010 | **3,060** | | **46.5** | **J** | - | | - | | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | - | | < 0.240 | U | < 0.300 | U |
| | RHMWA01-WG20 | 7/13/2010* | **3,110** | | **45.4** | **J** | - | | - | | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | - | | < 0.240 | U | < 0.300 | U |
| | ES002 | 10/18/2010 | **1,700** | **++** | - | | - | | **150** | **++** | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES003 | 10/18/2010* | **1,700** | **++** | - | | - | | **160** | **++** | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES010 | 1/18/2011 | **1,100** | **++** | - | | - | | **17** | **J, ++** | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES011 | 1/18/2011* | **1,100** | **++** | - | | - | | **20** | **++** | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES020 | 4/19/2011 | **1,100** | **++** | - | | - | | **24** | **++** | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES021 | 4/19/2011* | **1,100** | **++** | - | | - | | **29** | **++** | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES037 | 7/19/2011 | **1,100** | | - | | < 212.0 | U | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES038 | 7/19/2011* | **1,800** | | - | | < 212.0 | U | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES046 | 10/24/2011 | **750** | | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES047 | 10/24/2011* | **730** | | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |

| Well Name | Sample ID | Date Sampled | 8260B | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Bromoform | | Bromomethane | | Carbon Tetrachloride | | Chlorobenzene | | Chloroethane | | Chloroform | | Chloromethane | | cis-1,2-Dichloroethylene | | Dibromochloromethane | | Ethylbenzene | | Hexachlorobutadiene | | Methyl ethyl ketone (2-Butanone) | | Methyl isobutyl ketone (4-Methyl-2-Pentanone) | | Methyl tert-butyl Ether | | Methylene chloride | | Naphthalene | | Styrene | | Tetrachloroethane, 1,1,1,2- | | Tetrachloroethane, 1,1,2,2- | | Tetrachloroethylene | | Toluene | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| **For wells > 150 m from surface water** | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations > 150m from surface water)** | - | - | **80** | | **8.7** | | **5.0** | | **50** | | **16** | | **70** | | **1.8** | | **70** | | **0.16** | | **30** | | **0.86** | | **7,100** | | **170** | | **5.0** | | **4.8** | | **17** | | **10** | | **0.52** | | **0.067** | | **5.0** | | **40** | |
| **RHMW02<br>104.76' TOC ELEV** | RHMW02W01 | 9/20/2005[b] | <2.5 | U | <2.5 | U | <2.5 | U | <2.5 | U | <5.0 | U | <2.5 | U | <5.0 | U | <2.5 | U | <2.0 | U | < 2.5 | U | <2.5 | U | <13 | U | <13 | U | < 2.5 | U | <5.0 | U | **283** | **J** | <2.5 | U | <2.5 | U | <2.0 | U | <2.5 | U | < 2.5 | U |
| | RHMW02Q01 | 9/20/2005*[b] | <2.5 | U | <2.5 | U | <2.5 | U | <2.5 | U | <5.0 | U | <2.5 | U | <5.0 | U | <2.5 | U | <2.0 | U | < 2.5 | U | <2.5 | U | <13 | U | <13 | U | < 2.5 | U | <5.0 | U | **319** | | <2.5 | U | <2.5 | U | <2.0 | U | <2.5 | U | < 2.5 | U |
| | RHMW02-GW02 | 7/10/2006[a] | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.40 | U | **1.3** | | <0.50 | U | <2.5 | U | <2.5 | U | < 0.50 | U | <1.0 | U | **343** | | <0.50 | U | <0.50 | U | <0.40 | U | < 0.50 | U | < 0.50 | U |
| | RHMW05-GW02 | 7/10/2006*[a] | <2.5 | U | <5.0 | U | <2.5 | U | <2.5 | U | <5.0 | U | <2.5 | U | <5.0 | U | <2.5 | U | <2.0 | U | < 2.5 | U | <2.5 | U | <13 | U | <13 | U | < 2.5 | U | **24.9** | **JB** | **335** | | <2.5 | U | <2.5 | U | <2.0 | U | < 2.5 | U | < 2.5 | U |
| | RHMW02-GW06 | 12/5/2006[a] | <0.50 | U | <1.0 | U | <0.50 | U | <0.50 | U | <1.0 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.40 | U | **1.2** | | <0.50 | U | <2.5 | U | <2.5 | U | < 0.50 | U | <1.0 | U | **257** | | <0.50 | U | <0.50 | U | <0.40 | U | < 0.50 | U | < 0.50 | U |
| | RHMWA01-GW06 | 12/5/2006*[a] | <0.50 | U | <1.0 | U | <0.50 | U | <0.50 | U | <1.0 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.40 | U | **1.1** | | <0.50 | U | <2.5 | U | <2.5 | U | < 0.50 | U | <1.0 | U | **269** | | <0.50 | U | <0.50 | U | <0.40 | U | < 0.50 | U | < 0.50 | U |
| | RHMW02-WG07 | 3/27/2007[a] | < 0.50 | U | < 1.0 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 0.50 | U | < 1.0 | U | < 0.50 | U | <0.40 | U | < 0.50 | U | < 0.50 | U | < 2.5 | U | < 2.5 | U | <0.50 | U | < 1.0 | U | **196** | **O** | < 0.50 | U | < 0.50 | U | < 0.40 | U | < 0.50 | U | < 0.50 | U |
| | RHMWA01-WG07 | 3/27/2007*[a] | < 0.50 | U | < 1.0 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 0.50 | U | < 1.0 | U | < 0.50 | U | <0.40 | U | < 0.50 | U | < 0.50 | U | < 2.5 | U | < 2.5 | U | <0.50 | U | < 1.0 | U | **207** | **O** | < 0.50 | U | < 0.50 | U | < 0.40 | U | < 0.50 | U | < 0.50 | U |
| | RHMW02-WG08 | 6/12/2007[a] | < 0.50 | U | < 1.0 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 0.50 | U | < 1.0 | U | < 0.50 | U | <0.40 | U | < 0.50 | U | < 0.50 | U | < 2.5 | U | < 2.5 | U | <0.50 | U | < 1.0 | U | **209** | | < 0.50 | U | < 0.50 | U | < 0.40 | U | < 0.50 | U | < 0.50 | U |
| | RHMWA01-WG08 | 6/12/2007*[a] | < 0.50 | U | < 1.0 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 0.50 | U | < 1.0 | U | < 0.50 | U | <0.40 | U | < 0.50 | U | < 0.50 | U | < 2.5 | U | < 2.5 | U | <0.50 | U | < 1.0 | U | **207** | | < 0.50 | U | < 0.50 | U | < 0.40 | U | < 0.50 | U | < 0.50 | U |
| | RHMW02-WG09 | 9/10/2007[a] | < 0.28 | U | < 0.54 | U | < 0.29 | U | < 0.20 | U | < 0.46 | U | < 0.21 | U | < 0.38 | U | < 0.28 | U | <0.20 | U | < 0.20 | U | < 0.57 | U | < 2.0 | U | < 2.2 | U | <0.25 | U | < 1.0 | U | **206** | | < 0.20 | U | < 0.25 | U | < 0.37 | U | < 0.25 | U | < 0.27 | U |
| | RHMWA01-WG09 | 9/10/2007*[a] | < 0.28 | U | < 0.54 | U | < 0.29 | U | < 0.2 | U | < 0.46 | U | < 0.21 | U | < 0.38 | U | < 0.28 | U | <0.20 | U | < 0.20 | U | < 0.57 | U | < 2.0 | U | < 2.2 | U | <0.25 | U | < 1.0 | U | **264** | | < 0.20 | U | < 0.25 | U | < 0.37 | U | < 0.25 | U | < 0.27 | U |
| | RHMW02-WG10 | 1/15/2008[a] | < 0.500 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.180 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 0.310 | U | **195** | | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMWA01-WG10 | 1/15/2008*[a] | < 0.500 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | **0.350** | **J** | < 0.180 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 0.310 | U | **194** | | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW02-WG11 | 4/15/2008[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | **290** | | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMWA01-WG11 | 4/15/2008*[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | **293** | | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW02-WG12 | 7/29/2008[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | **0.580** | **J** | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | **320** | | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMWA01-WG12 | 7/29/2008*[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | **0.560** | **J** | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | **309** | | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW02-WG13 | 10/22/2008[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | **0.450** | **J** | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | **239** | | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMWA01-WG13 | 10/22/2008*[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | **0.420** | **J** | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | **245** | | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW02-WG14 | 2/4/2009[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | **0.490** | **J** | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | **42.8** | | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMWA01-WG14 | 2/4/2009*[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | **0.520** | **J** | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | **43.0** | | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW02-WG15 | 5/13/2009[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | < 0.620 | U | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMWA01-WG15 | 5/13/2009*[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | < 0.620 | U | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW02-WG16 | 7/15/2009[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | **10.1** | | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMWA01-WG16 | 7/15/2009*[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | **11.2** | | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW02-WG17 | 10/13/2009[ad] | < 0.31 | U | < 0.94 | U | < 0.31 | U | < 0.15 | U | < 0.31 | U | < 0.3 | U | < 0.31 | U | < 0.31 | U | < 0.15 | U | < 0.31 | U | < 0.31 | U | < 3.1 | U | < 3.1 | U | - | | < 1 | U | **23.3** | | < 0.31 | U | < 0.15 | U | < 0.15 | U | < 0.31 | U | < 0.31 | U |
| | RHMWA01-WG17 | 10/13/2009*[a] | < 0.31 | U | < 0.94 | U | < 0.31 | U | < 0.15 | U | < 0.31 | U | < 0.3 | U | < 0.31 | U | < 0.31 | U | < 0.15 | U | < 0.31 | U | < 0.31 | U | < 3.1 | U | < 3.1 | U | - | | < 1 | U | **20.0** | | < 0.31 | U | < 0.15 | U | < 0.15 | U | < 0.31 | U | < 0.31 | U |
| | RHMW02-WG18 | 1/26/2010 | < 0.620 | U | < 1.88 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.600 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 6.20 | U | < 6.20 | U | < 3.00 | U | < 2.00 | U | **31.5** | | < 0.620 | U | < 0.300 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U |
| | RHMWA01-WG18 | 1/26/2010* | < 0.620 | U | < 1.88 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.600 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 6.20 | U | < 6.20 | U | < 3.00 | U | < 2.00 | U | **9.30** | | < 0.620 | U | < 0.300 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U |
| | RHMW02-WG19 | 4/13/2010 | < 0.620 | U | < 1.88 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.600 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 6.20 | U | < 6.20 | U | < 3.00 | U | < 2.00 | U | **20.6** | | < 0.620 | U | < 0.300 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U |
| | RHMWA01-WG19 | 4/13/2010* | < 0.620 | U | < 1.88 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.600 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 6.20 | U | < 6.20 | U | < 3.00 | U | < 2.00 | U | **21.4** | | < 0.620 | U | < 0.300 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U |
| | RHMW02-WG20 | 7/13/2010 | < 0.620 | U | < 1.88 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.600 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 6.20 | U | < 6.20 | U | < 3.00 | U | < 2.00 | U | **107** | | < 0.620 | U | < 0.300 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U |
| | RHMWA01-WG20 | 7/13/2010* | < 0.620 | U | < 1.88 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.600 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 6.20 | U | < 6.20 | U | < 3.00 | U | < 2.00 | U | **102** | | < 0.620 | U | < 0.300 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U |
| | ES002 | 10/18/2010 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.62 | U | < 0.32 | U | < 0.38 | U | **0.25** | **J** | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.38 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.30 | U | < 0.34 | U |
| | ES003 | 10/18/2010* | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.62 | U | < 0.32 | U | < 0.38 | U | **0.32** | **J** | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.38 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.30 | U | < 0.34 | U |
| | ES010 | 1/18/2011 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.62 | U | < 0.32 | U | < 0.38 | U | **0.29** | **J** | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.38 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.30 | U | < 0.34 | U |
| | ES011 | 1/18/2011* | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.62 | U | < 0.32 | U | < 0.38 | U | **0.25** | **J** | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.38 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.30 | U | < 0.34 | U |
| | ES020 | 4/19/2011 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.62 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.38 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.30 | U | < 0.34 | U |
| | ES021 | 4/19/2011* | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.62 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.38 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.30 | U | < 0.34 | U |
| | ES037 | 7/19/2011 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.62 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.38 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.30 | U | < 0.34 | U |
| | ES038 | 7/19/2011* | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.62 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.38 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.30 | U | < 0.34 | U |
| | ES046 | 10/24/2011 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.84 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.52 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.48 | U | < 0.34 | U |
| | ES047 | 10/24/2011* | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.84 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.52 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.48 | U | < 0.34 | U |

| Well Name | Sample ID | Date Sampled | | | | | | | | | 504.1 | | 8260SIM | | | | | | | | | | 8011 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | trans-1,2-Dichloroethylene | | Trichloroethylene | | Vinyl chloride | | Xylenes, Total (p/m-, o-xylene) | | 1,2-Dibromoethane | | 1,2-Dibromoethane | | 1,2-Dichloroethane | | Bromodichloromethane | | Dibromochloromethane | | Tetrachloroethane, 1,1,2,2- | | 1,2-Dibromo-3-chloropropane | | 1,2-Dibromoethane | | Acenaphthene | | Acenaphthylene | | Anthracene | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| **For wells > 150 m from surface water** | **-** | **-** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations > 150m from surface water)** | **-** | **-** | **100** | | **5.0** | | **2.0** | | **20** | | **0.04** | | **0.04** | | **0.15** | | **0.12** | | **0.16** | | **0.067** | | **0.04** | | **0.04** | | **20** | | **240** | | **22** | |
| **RHMW02<br>104.76' TOC ELEV** | RHMW02W01 | 9/20/2005[b] | <2.5 | U | **8.2** | | <2.5 | U | < 2.5 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.52 | U | < 0.52 | U | < 0.52 | U |
| | RHMW02Q01 | 9/20/2005*[b] | <2.5 | U | < 2.5 | U | <2.5 | U | < 2.5 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.52 | U | < 0.52 | U | < 0.52 | U |
| | RHMW02-GW02 | 7/10/2006[a] | <0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.63** | **J** | <0.54 | U | <0.54 | U |
| | RHMW05-GW02 | 7/10/2006*[a] | <2.5 | U | < 2.5 | U | < 2.5 | U | < 2.5 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.58** | **J** | <0.50 | U | <0.50 | U |
| | RHMW02-GW06 | 12/5/2006[a] | <0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.53** | **J** | <0.49 | U | <0.49 | U |
| | RHMWA01-GW06 | 12/5/2006*[a] | <0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.51** | **J** | <0.48 | U | <0.48 | U |
| | RHMW02-WG07 | 3/27/2007[a] | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.66** | **J** | < 0.48 | U | < 0.48 | U |
| | RHMWA01-WG07 | 3/27/2007*[a] | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.56** | **J** | < 0.48 | U | < 0.48 | U |
| | RHMW02-WG08 | 6/12/2007[a] | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.5 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.49 | U | < 0.49 | U | < 0.49 | U |
| | RHMWA01-WG08 | 6/12/2007*[a] | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.86** | **J** | < 0.49 | U | < 0.49 | U |
| | RHMW02-WG09 | 9/10/2007[a] | < 0.20 | U | < 0.38 | U | < 0.34 | U | < 0.36 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.60** | **J** | < 0.50 | U | < 0.50 | U |
| | RHMWA01-WG09 | 9/10/2007*[a] | < 0.20 | U | < 0.38 | U | < 0.34 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.59** | **J** | < 0.50 | U | < 0.50 | U |
| | RHMW02-WG10 | 1/15/2008[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | **1.06** | | - | | - | | - | | - | | - | | - | | - | | - | | **0.308** | | < 0.0158 | U | < 0.0158 | U |
| | RHMWA01-WG10 | 1/15/2008*[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | **1.10** | | - | | - | | - | | - | | - | | - | | - | | - | | **0.303** | | < 0.0155 | U | < 0.0155 | U |
| | RHMW02-WG11 | 4/15/2008[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | **0.740** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.404** | | < 0.0155 | U | < 0.0155 | U |
| | RHMWA01-WG11 | 4/15/2008*[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | **0.750** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.346** | | < 0.0155 | U | < 0.0155 | U |
| | RHMW02-WG12 | 7/29/2008[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.470** | **J** | < 0.155 | U | < 0.155 | U |
| | RHMWA01-WG12 | 7/29/2008*[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.450** | **J** | < 0.155 | U | < 0.155 | U |
| | RHMW02-WG13 | 10/22/2008[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | **0.450** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.365** | | < 0.0156 | U | < 0.0156 | U |
| | RHMWA01-WG13 | 10/22/2008*[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | **0.490** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.208** | | < 0.0150 | U | < 0.0150 | U |
| | RHMW02-WG14 | 2/4/2009[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | **0.400** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | < 0.161 | U | < 0.161 | U | < 0.161 | U |
| | RHMWA01-WG14 | 2/4/2009*[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | **0.470** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0163 | U | < 0.0163 | U | < 0.0163 | U |
| | RHMW02-WG15 | 5/13/2009[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | **0.310** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U |
| | RHMWA01-WG15 | 5/13/2009*[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U |
| | RHMW02-WG16 | 7/15/2009[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.235** | | < 0.0156 | U | < 0.0156 | U |
| | RHMWA01-WG16 | 7/15/2009*[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.213** | | < 0.0165 | U | < 0.0165 | U |
| | RHMW02-WG17 | 10/13/2009[ad] | < 0.31 | U | < 0.31 | U | < 0.31 | U | < 1 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.200** | | < 0.017 | U | < 0.017 | U |
| | RHMWA01-WG17 | 10/13/2009*[a] | < 0.31 | U | < 0.31 | U | < 0.31 | U | < 1 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.210** | | < 0.0179 | U | < 0.0179 | U |
| | RHMW02-WG18 | 1/26/2010 | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.247** | | < 0.0330 | U | < 0.0330 | U |
| | RHMWA01-WG18 | 1/26/2010* | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.231** | | < 0.0340 | U | < 0.0340 | U |
| | RHMW02-WG19 | 4/13/2010 | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.426** | | < 0.0322 | U | < 0.0322 | U |
| | RHMWA01-WG19 | 4/13/2010* | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.429** | | < 0.0330 | U | < 0.0330 | U |
| | RHMW02-WG20 | 7/13/2010 | < 0.620 | U | < 0.620 | U | < 0.620 | U | **0.690** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.287** | | < 0.0322 | U | < 0.0322 | U |
| | RHMWA01-WG20 | 7/13/2010* | < 0.620 | U | < 0.620 | U | < 0.620 | U | **0.660** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.309** | | < 0.0314 | U | < 0.0314 | U |
| | ES002 | 10/18/2010 | < 0.38 | U | < 0.32 | U | < 0.46 | U | **0.60** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.28** | | **0.14** | **J** | < 0.10 | U |
| | ES003 | 10/18/2010* | < 0.38 | U | < 0.32 | U | < 0.46 | U | **0.51** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.27** | | **0.13** | **J** | < 0.10 | U |
| | ES010 | 1/18/2011 | < 0.38 | U | < 0.32 | U | < 0.46 | U | **0.48** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.29** | | **0.13** | **J** | < 0.10 | U |
| | ES011 | 1/18/2011* | < 0.38 | U | < 0.32 | U | < 0.46 | U | **0.58** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.25** | | **0.14** | **J** | < 0.10 | U |
| | ES020 | 4/19/2011 | < 0.38 | U | < 0.32 | U | < 0.46 | U | **0.41** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.18** | **J** | **0.071** | **J** | < 0.10 | U |
| | ES021 | 4/19/2011* | < 0.38 | U | < 0.32 | U | < 0.46 | U | **0.41** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.17** | **J** | **0.070** | **J** | < 0.10 | U |
| | ES037 | 7/19/2011 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.31** | | < 0.12 | U | < 0.10 | U |
| | ES038 | 7/19/2011* | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.46** | | **0.099** | **J** | < 0.10 | U |
| | ES046 | 10/24/2011 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.17** | **J** | < 0.12 | U | < 0.10 | U |
| | ES047 | 10/24/2011* | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.16** | **J** | < 0.12 | U | < 0.10 | U |

| Well Name | Sample ID | Date Sampled | 8270C | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 6020 | | 6010B/6020/200.8 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Benzo[a]anthracene** | | **Benzo[g,h,i]perylene** | | **Benzo[a]pyrene** | | **Benzo[b]fluoranthene** | | **Benzo[k]fluoranthene** | | **Chrysene** | | **Dibenz[a,h]anthracene** | | **Fluoranthene** | | **Fluorene** | | **Indeno[1,2,3-cd]pyrene** | | **1-Methylnaphthalene** | | **2-Methylnaphthalene** | | **Naphthalene** | | **Phenanthrene** | | **Pyrene** | | **Dissolved Lead (filtered)** | | **Total Lead (unfiltered)** | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| **For wells > 150 m from surface water** | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations > 150m from surface water)** | - | - | **0.092** | | **0.13** | | **0.20** | | **0.092** | | **0.40** | | **1.0** | | **0.0092** | | **130** | | **240** | | **0.092** | | **4.7** | | **10** | | **17** | | **240** | | **68** | | **15** | | - | |
| **RHMW02<br>104.76' TOC ELEV** | RHMW02W01 | 9/20/2005[b] | < 0.52 | U | < 0.10 | U | < 0.10 | U | < 0.052 | U | < 0.10 | U | < 0.10 | U | < 0.052 | U | < 0.26 | U | < 0.26 | U | < 0.052 | U | **104** | | **88.5** | | **120** | | < 0.52 | U | < 0.26 | U | < 5 | U | < 5.0[g] | U |
| | RHMW02Q01 | 9/20/2005*[b] | **0.071** | **J** | < 0.10 | U | < 0.10 | U | **0.069** | **J** | < 0.10 | U | < 0.10 | U | < 0.052 | U | < 0.26 | U | < 0.26 | U | < 0.052 | U | **102** | | **87.2** | | **123** | | < 0.52 | U | < 0.26 | U | < 5 | U | < 5.0[g] | U |
| | RHMW02-GW02 | 7/10/2006[a] | <0.054 | U | <0.11 | U | < 0.11 | U | <0.054 | U | <0.11 | U | <0.11 | U | <0.054 | U | < 0.27 | U | **0.33** | **J** | <0.054 | U | **142** | | **65.8** | | **171** | | <0.54 | U | <0.27 | U | < 1.7 | U | < 10[g] | U |
| | RHMW05-GW02 | 7/10/2006*[a] | <0.050 | U | <0.10 | U | < 0.10 | U | <0.050 | U | <0.10 | U | <0.10 | U | <0.050 | U | < 0.25 | U | **0.32** | **J** | <0.050 | U | **133** | | **67.1** | | **180** | | <0.50 | U | <0.25 | U | < 1.7 | U | < 10[g] | U |
| | RHMW02-GW06 | 12/5/2006[a] | <0.049 | U | <0.097 | U | < 0.097 | U | <0.049 | U | <0.097 | U | <0.097 | U | <0.049 | U | < 0.24 | U | **0.34** | **J** | <0.049 | U | **124** | | **45.1** | | **160** | | <0.49 | U | <0.24 | U | < 1.7 | U | - | |
| | RHMWA01-GW06 | 12/5/2006*[a] | <0.048 | U | <0.096 | U | < 0.096 | U | <0.048 | U | <0.096 | U | <0.096 | U | <0.048 | U | < 0.24 | U | **0.35** | **J** | <0.048 | U | **114** | | **51.1** | | **147** | | <0.48 | U | <0.24 | U | < 1.7 | U | **-** | |
| | RHMW02-WG07 | 3/27/2007[a] | <0.048 | U | < 0.096 | U | < 0.096 | U | < 0.048 | U | < 0.096 | U | < 0.096 | U | < 0.048 | U | < 0.24 | U | **0.26** | **J** | < 0.048 | U | **72.1** | **O** | **30.3** | **O** | **105** | **O** | < 0.48 | U | < 0.24 | U | **1.7** | **J** | - | |
| | RHMWA01-WG07 | 3/27/2007*[a] | <0.048 | U | < 0.096 | U | < 0.096 | U | < 0.048 | U | < 0.096 | U | < 0.096 | U | < 0.048 | U | < 0.24 | U | **0.26** | **J** | < 0.048 | U | **59.4** | **O** | **26.2** | **O** | **90.1** | **O** | < 0.48 | U | < 0.24 | U | **1.7** | **J** | - | |
| | RHMW02-WG08 | 6/12/2007[a] | <0.049 | U | < 0.098 | U | < 0.098 | U | < 0.049 | U | < 0.098 | U | < 0.098 | U | < 0.049 | U | < 0.25 | U | **0.31** | **J** | < 0.049 | U | **67.3** | | **26.5** | | **87.2** | | < 0.49 | U | < 0.25 | U | < 3.4 | U | - | |
| | RHMWA01-WG08 | 6/12/2007*[a] | <0.049 | U | < 0.098 | U | < 0.098 | U | < 0.049 | U | < 0.098 | U | < 0.098 | U | < 0.049 | U | < 0.25 | U | **0.37** | **J** | < 0.049 | U | **88.3** | | **33** | | **128** | | < 0.49 | U | < 0.25 | U | < 3.4 | U | - | |
| | RHMW02-WG09 | 9/10/2007[a] | <0.050 | U | < 0.10 | U | < 0.10 | U | < 0.050 | U | < 0.10 | U | < 0.10 | U | < 0.050 | U | < 0.25 | U | **0.39** | **J** | < 0.050 | U | **109** | | **21.5** | | **144** | | < 0.50 | U | < 0.25 | U | < 2.1 | U | - | |
| | RHMWA01-WG09 | 9/10/2007*[a] | <0.050 | U | < 0.10 | U | < 0.10 | U | < 0.050 | U | < 0.10 | U | < 0.10 | U | < 0.050 | U | < 0.25 | U | **0.34** | **J** | < 0.050 | U | **102** | | **19.7** | | **136** | | < 0.50 | U | < 0.25 | U | < 2.1 | U | - | |
| | RHMW02-WG10 | 1/15/2008[a] | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | **0.161** | | < 0.0158 | U | **67.0** | | **23.8** | | **93.6** | | < 0.0158 | U | < 0.0158 | U | < 0.310 | U | - | |
| | RHMWA01-WG10 | 1/15/2008*[a] | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | **0.161** | | < 0.0155 | U | **73.2** | | **27.6** | | **102** | | < 0.0155 | U | < 0.0155 | U | < 0.310 | U | - | |
| | RHMW02-WG11 | 4/15/2008[a] | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | **0.220** | | < 0.0155 | U | **75.8** | | **34.5** | | **73.0** | | < 0.0155 | U | < 0.0155 | U | < 0.310 | U | - | |
| | RHMWA01-WG11 | 4/15/2008*[a] | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | **0.187** | | < 0.0155 | U | **71.9** | | **40.8** | | **105** | | < 0.0155 | U | < 0.0155 | U | < 0.310 | U | - | |
| | RHMW02-WG12 | 7/29/2008[a] | < 0.155 | U | < 0.155 | U | < 0.155 | U | < 0.155 | U | < 0.155 | U | < 0.155 | U | < 0.155 | U | < 0.155 | U | **0.324** | **J** | < 0.155 | U | **102** | | **31.5** | | **140** | | < 0.155 | U | < 0.155 | U | < 0.310 | U | - | |
| | RHMWA01-WG12 | 7/29/2008*[a] | < 0.155 | U | < 0.155 | U | < 0.155 | U | < 0.155 | U | < 0.155 | U | < 0.155 | U | < 0.155 | U | < 0.155 | U | **0.304** | **J** | < 0.155 | U | **96.0** | | **42.2** | | **132** | | < 0.155 | U | < 0.155 | U | < 0.310 | U | - | |
| | RHMW02-WG13 | 10/22/2008[a] | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | **0.214** | | < 0.0156 | U | **72.1** | | **13.7** | | **97.4** | | < 0.0156 | U | < 0.0156 | U | < 0.310 | U | - | |
| | RHMWA01-WG13 | 10/22/2008*[a] | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | **0.122** | | < 0.0150 | U | **62.4** | | **12.7** | | **82.3** | | < 0.0150 | U | < 0.0150 | U | < 0.310 | U | - | |
| | RHMW02-WG14 | 2/4/2009[a] | < 0.161 | U | < 0.161 | U | < 0.161 | U | < 0.161 | U | < 0.161 | U | < 0.161 | U | < 0.161 | U | < 0.161 | U | < 0.161 | U | < 0.161 | U | **21.2** | | **10.5** | | **15.2** | | < 0.161 | U | < 0.161 | U | < 0.310 | U | - | |
| | RHMWA01-WG14 | 2/4/2009*[a] | < 0.0163 | U | < 0.0163 | U | < 0.0163 | U | < 0.0163 | U | < 0.0163 | U | < 0.0163 | U | < 0.0163 | U | < 0.0163 | U | < 0.0163 | U | < 0.0163 | U | **22.8** | | **11.1** | | **16.6** | | < 0.0163 | U | < 0.0163 | U | < 0.310 | U | - | |
| | RHMW02-WG15 | 5/13/2009[a] | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | **17.9** | | **0.136** | | **1.17** | | **0.0162** | **J** | < 0.0150 | U | < 0.310 | U | - | |
| | RHMWA01-WG15 | 5/13/2009*[a] | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | **24.6** | | **0.107** | | **1.08** | | **0.0171** | **J** | < 0.0155 | U | < 0.310 | U | - | |
| | RHMW02-WG16 | 7/15/2009[a] | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | **0.0162** | **J** | < 0.0156 | U | **0.0247** | **J** | **0.115** | | < 0.0156 | U | **13.2** | | **3.66** | | **8.37** | | **0.0304** | **J** | **0.0272** | **J** | < 0.310 | U | - | |
| | RHMWA01-WG16 | 7/15/2009*[a] | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | **0.0199** | **J** | **0.108** | | < 0.0165 | U | **10.6** | | **2.58** | | **6.71** | | **0.0291** | **J** | **0.0189** | **J** | < 0.310 | U | - | |
| | RHMW02-WG17 | 10/13/2009[ad] | < 0.017 | U | < 0.017 | U | < 0.017 | U | < 0.017 | U | < 0.017 | U | < 0.017 | U | < 0.017 | U | < 0.017 | U | **0.0979** | | < 0.017 | U | **2.46** | | **0.486** | | **6.77** | | < 0.017 | U | < 0.017 | U | < 0.31 | U | - | |
| | RHMWA01-WG17 | 10/13/2009*[a] | < 0.0179 | U | < 0.0179 | U | < 0.0179 | U | < 0.0179 | U | < 0.0179 | U | < 0.0179 | U | < 0.0179 | U | < 0.0179 | U | **0.0935** | | < 0.0179 | U | **4.03** | | **0.783** | | **7.82** | | < 0.0179 | U | < 0.0179 | U | < 0.31 | U | - | |
| | RHMW02-WG18 | 1/26/2010 | < 0.0330 | U | < 0.0330 | U | < 0.0330 | U | < 0.0330 | U | < 0.0330 | U | < 0.0330 | U | < 0.0330 | U | < 0.0330 | U | **0.144** | | < 0.0330 | U | **9.03** | | **3.85** | | **17.3** | | < 0.0330 | U | < 0.0330 | U | **1.53** | | - | |
| | RHMWA01-WG18 | 1/26/2010* | < 0.0340 | U | < 0.0340 | U | < 0.0340 | U | < 0.0340 | U | < 0.0340 | U | < 0.0340 | U | < 0.0340 | U | **0.0209** | **J** | **0.122** | | < 0.0340 | U | **8.26** | | **2.65** | | **15.7** | | < 0.0340 | U | < 0.0340 | U | < 0.620 | U | - | |
| | RHMW02-WG19 | 4/13/2010 | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | **0.224** | | < 0.0322 | U | **6.61** | | **1.69** | | **14.3** | | < 0.0322 | U | < 0.0322 | U | < 0.620 | U | - | |
| | RHMWA01-WG19 | 4/13/2010* | < 0.0330 | U | < 0.0330 | U | < 0.0330 | U | < 0.0330 | U | < 0.0330 | U | < 0.0330 | U | < 0.0330 | U | < 0.0330 | U | **0.230** | | < 0.0330 | U | **5.90** | | **1.90** | | **12.7** | | < 0.0330 | U | < 0.0330 | U | < 0.620 | U | - | |
| | RHMW02-WG20 | 7/13/2010 | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | **0.159** | | < 0.0322 | U | **7.43** | | **1.06** | | **59.9** | | < 0.0322 | U | < 0.0322 | U | < 0.620 | U | - | |
| | RHMWA01-WG20 | 7/13/2010* | < 0.0314 | U | < 0.0314 | U | < 0.0314 | U | < 0.0314 | U | < 0.0314 | U | < 0.0314 | U | < 0.0314 | U | < 0.0314 | U | **0.165** | | < 0.0314 | U | **7.05** | | **0.937** | | **61.1** | | < 0.0314 | U | < 0.0314 | U | < 0.620 | U | - | |
| | ES002 | 10/18/2010 | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | **0.16** | **J** | < 0.14 | U | **15** | | **5.0** | | **59** | | < 0.14 | U | < 0.16 | U | **0.32** | **J** | - | |
| | ES003 | 10/18/2010* | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | **0.15** | **J** | < 0.14 | U | **15** | | **6.3** | | **54** | | < 0.14 | U | < 0.16 | U | **1.2** | | - | |
| | ES010 | 1/18/2011 | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | **0.15** | **J** | < 0.14 | U | **19** | | **3.6** | | **57** | | < 0.14 | U | < 0.16 | U | < 0.22 | U | - | |
| | ES011 | 1/18/2011* | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | **0.16** | **J** | < 0.14 | U | **23** | | **5.6** | | **63** | | < 0.14 | U | < 0.16 | U | < 0.22 | U | - | |
| | ES020 | 4/19/2011 | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | **0.086** | **J** | < 0.14 | U | **5.1** | | **0.43** | | **3.5** | | < 0.14 | U | < 0.16 | U | < 0.22 | U | - | |
| | ES021 | 4/19/2011* | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | **0.085** | **J** | < 0.14 | U | **5.2** | | **0.53** | | **4.2** | | < 0.14 | U | < 0.16 | U | < 0.22 | U | - | |
| | ES037 | 7/19/2011 | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | **0.088** | **J** | < 0.14 | U | **0.85** | | **0.16** | **J** | **2.2** | | < 0.14 | U | < 0.16 | U | **1.2** | | - | |
| | ES038 | 7/19/2011* | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | **0.11** | **J** | < 0.14 | U | **0.90** | | **0.12** | **J** | **2.7** | | < 0.14 | U | < 0.16 | U | **0.49** | **J** | - | |
| | ES046 | 10/24/2011 | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | **0.082** | **J** | < 0.14 | U | **0.53** | | **0.15** | **J** | **0.80** | | < 0.14 | U | < 0.16 | U | < 0.22 | U | - | |
| | ES047 | 10/24/2011* | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | **0.083** | **J** | < 0.14 | U | **0.62** | | **0.20** | | **1.0** | | < 0.14 | U | < 0.16 | U | < 0.22 | U | - | |

| Well Name | Sample ID | Date Sampled | 8015 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | TPH-d | | TPH-g | | TPH-o | | TPH-g | | 1,1,1-Trichloroethane | | 1,1,2-Trichloroethane | | 1,1-Dichloroethane | | 1,1-Dichloroethylene | | 1,2,3-Trichloropropane | | 1,2,4-Tricholorobenzene | | 1,2-Dibromo-3-chloropropane | | 1,2-Dibromoethane | | 1,2-Dichlorobenzene | | 1,2-Dichloroethane | | 1,2-Dichloropropane | | 1,3-Dichlorobenzene | | 1,3-Dichloropropene (total of cis/trans) | | 1,4-Dichlorobenzene | | Acetone | | Benzene | | Bromodichloromethane | |
| | | | (µg/l) | | (µg/l) | | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| For wells > 150 m from surface water | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| DOH Tier 1 EALs (for locations > 150m from surface water) | - | - | 100 | | 100 | | 100 | | 100 | | 200 | | 5.0 | | 2.4 | | 7.0 | | 0.6 | | 70 | | 0.04 | | 0.04 | | 10 | | 0.15 | | 5.0 | | 5.0 | | 0.43 | | 5.0 | | 1500 | | 5.0 | | 0.12 | |
| RHMW02<br>104.76' TOC ELEV | ES061 | 1/26/2012 | **1,700** | | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES071 | 4/16/2012 | **1,200** | | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES072 | 4/16/2012* | **1,100** | | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES082 | 7/18/2012 | **1,700** | ++ | - | | < 212.0 | U | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | <0.50 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES002 | 10/22/2012 | **2,200** | HD | - | | - | | **320** | B | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U | < 0.50 | U | < 0.50 | U |
| | ES003 | 10/22/2012* | **1,800** | HD | - | | - | | **360** | B | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U | < 0.50 | U | < 0.50 | U |
| | ES011 | 1/28/2013 | **1,700** | HD | - | | - | | **660** | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 10 | IJ,ICH,U | < 0.50 | U | < 0.50 | U |
| | ES012 | 1/28/2013* | **1,500** | HD | - | | - | | **650** | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 10 | IJ,ICH,U | < 0.50 | U | < 0.50 | U |
| | ES020 | 4/22/2013 | **2,600** | HD | - | | - | | **54** | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U | < 0.50 | U | < 0.50 | U |
| | ES021 | 4/22/2013* | **3,300** | HD | - | | - | | **56** | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | IJ,ICH,U | < 0.50 | U | < 0.50 | U |
| | ES029 | 7/22/2013 | **2,500** | HD | - | | - | | **55** | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U | < 0.50[1] | U | < 0.50 | U |
| | ES030 | 7/22/2013* | **2,600** | HD | - | | - | | **61** | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U | < 0.50[1] | U | < 0.50 | U |
| | ES038 | 10/21/2013 | **2,400** | HD | - | | - | | **48** | B,J | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U,ICH | < 0.50 | U | < 0.50 | U |
| | ES039 | 10/21/2013* | **2,400** | HD | - | | - | | **63** | B | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U,ICH | < 0.50 | U | < 0.50 | U |
| | ES046 | 1/15/2014 | **5,000** | | - | | - | | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U,ICH | < 0.50 | U | < 0.50 | U |
| | ES047 | 1/15/2014* | **5,200** | | - | | - | | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U,ICH | < 0.50 | U | < 0.50 | U |
| | ES057 | 1/28/2014 | **2,300** | HD | - | | - | | **50** | B | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U | **0.14** | J | < 0.50 | U |
| | ES058 | 1/28/2014* | **2,100** | HD | - | | - | | **52** | B | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U | **0.15** | J | < 0.50 | U |
| | ES063 | 2/24/2014 | **2,200** | HD | - | | - | | **40** | J | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U,IJ | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | <10 | U | < 0.50 | U | < 0.50 | U |
| | ES065 | 3/5/2014 | **2,100** | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | - | |
| | ES066 | 3/5/2014* | **2,200** | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | - | |
| | ES070 | 3/10/2014 | **930** | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | - | |
| | ES071 | 3/10/2014* | **890** | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | - | |
| | ES073 | 3/25/2014 | **1,700** | HD | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | - | |
| | ES074 | 3/25/2014* | **1,700** | HD | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | - | |
| | ES078 | 4/7/2014 | **3,500** | HD | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | - | |
| | ES079 | 4/7/2014* | **3,300** | HD | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | - | |
| | ES081 | 4/21/2014 | **1,900** | | - | | - | | **53** | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | <10 | U,ICH | < 0.50 | U | < 0.50 | U |
| | ES082 | 4/21/2014* | **1,500** | | - | | - | | **50** | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | <10 | U,ICH | < 0.50 | U | < 0.50 | U |
| | ES092 | 5/27/2014 | **1,500** | HD | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | - | |
| | ES093 | 5/27/2014* | **1,300** | HD | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | - | |
| | ES099 | 6/23/2014 | **1,800** | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | - | |
| | ES100 | 6/23/2014* | **1,600** | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | - | |
| | ES104 | 7/21/2014 | **1,200** | HD | - | | - | | **48** | J | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | <10 | U,ICH | < 0.50 | U | < 0.50 | U |
| | ES105 | 7/21/2014* | **1,300** | HD | - | | - | | **49** | J | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | <10 | U,ICH | < 0.50 | U | < 0.50 | U |
| | ES114 | 10/27/2014 | **2,000** | J,HD | - | | - | | **57** | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U,IH | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | <10 | U,ICH | < 0.50 | U | < 0.50 | U |
| | ES115 | 10/27/2014 | **2,000** | J,HD | - | | - | | **53** | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U,IH | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | <10 | U,ICH | < 0.50 | U | < 0.50 | U |
| | ES126 | 1/28/2015 | **1,100** | HD | - | | - | | **54** | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | <10 | U,IJ | < 0.50 | U | < 0.50 | U |
| | ES127 | 1/28/2015* | **1,700** | HD | - | | - | | **59** | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | <10 | U,IJ | < 0.50 | U | < 0.50 | U |
| | ES131 | 4/20/2015 | **5,200** | Y | **46** | J | **360** | L | - | | <0.20 | U | <0.40 | U | <0.20 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.80 | U | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <10 | U | **0.090** | J | - | |
| | ES132 | 4/20/2015* | **5,400** | Y | **47** | J | **360** | L | - | | <0.20 | U | <0.40 | U | <0.20 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.80 | U | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <10 | U | **0.080** | J | - | |
| | ES144 | 6/25/2015 | **3,800** | Y | - | | **250** | L | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES146 | 7/20/2015 | **3,900** | Y | **40** | J | **240** | L | - | | <0.20 | U | <0.40 | U | <0.20 | U | <0.20 | U | **0.27** | J | <0.30 | U | <0.80 | U | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <10 | U | <0.10 | U | - | |
| | ES147 | 7/20/2015* | **3,200** | Y | **41** | J | **260** | L | - | | <0.20 | U | <0.40 | U | <0.20 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.80 | U | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <10 | U | **0.10** | J | - | |
| | ERH012 | 10/20/2015 | **6,100** | B,Y | **47** | J | **310** | B,L | - | | <0.20 | U,** | <0.40 | U,** | <0.20 | U,** | <0.20 | U,** | <0.50 | U,** | <0.30 | U,** | <0.80 | U,** | <0.20 | U,** | <0.20 | U,** | - | | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <10 | U,** | **0.090** | J,** | - | |
| | ERH013 | 10/20/2015 | **6,200** | B,Y | **47** | J | **320** | B,L | - | | <0.20 | U,** | <0.40 | U,** | <0.20 | U,** | <0.20 | U,** | <0.50 | U,** | <0.30 | U,** | <0.80 | U,** | <0.20 | U,** | <0.20 | U,** | - | | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <10 | U,** | **0.090** | J,** | - | |
| | ERH025 | 1/20/2016 | **6,500** | B,Y | **36** | J | **340** | B,L | - | - | < 0.20 | U | < 0.40 | U | < 0.20 | U | < 0.20 | U | < 0.50 | U | < 0.30 | U | < 0.80 | U | < 0.20 | U | < 0.20 | U | - | - | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 10 | U | **0.080** | J | - | - |

| Well Name | Sample ID | Date Sampled | 8260B | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Bromoform | | Bromomethane | | Carbon Tetrachloride | | Chlorobenzene | | Chloroethane | | Chloroform | | Chloromethane | | cis-1,2-Dichloroethylene | | Dibromochloromethane | | Ethylbenzene | | Hexachlorobutadiene | | Methyl ethyl ketone (2-Butanone) | | Methyl isobutyl ketone (4-Methyl-2-Pentanone) | | Methyl tert-butyl Ether | | Methylene chloride | | Naphthalene | | Styrene | | Tetrachloroethane, 1,1,1,2- | | Tetrachloroethane, 1,1,2,2- | | Tetrachloroethylene | | Toluene | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| **For wells > 150 m from surface water** | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations > 150m from surface water)** | - | - | **80** | | **8.7** | | **5.0** | | **50** | | **16** | | **70** | | **1.8** | | **70** | | **0.16** | | **30** | | **0.86** | | **7,100** | | **170** | | **5.0** | | **4.8** | | **17** | | **10** | | **0.52** | | **0.067** | | **5.0** | | **40** | |
| **RHMW02<br>104.76' TOC ELEV** | ES061 | 1/26/2012 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.84 | U | < 0.32 | U | < 0.38 | U | **0.30** | **J** | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.52 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.48 | U | < 0.34 | U |
| | ES071 | 4/16/2012 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.84 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.52 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.48 | U | < 0.34 | U |
| | ES072 | 4/16/2012* | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.84 | U | < 0.32 | U | < 0.38 | U | **0.23** | **J** | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.52 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.48 | U | < 0.34 | U |
| | ES082 | 7/18/2012 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.84 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.52 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.48 | U | < 0.34 | U |
| | ES002 | 10/22/2012 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 5.0 | IH,U | < 0.50 | U | < 0.50 | U | **0.18** | **J** | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.59** | **J** |
| | ES003 | 10/22/2012* | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 5.0 | IH,U | < 0.50 | U | < 0.50 | U | **0.18** | **J** | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.60** | **J** |
| | ES011 | 1/28/2013 | < 2.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | **0.21** | **J** | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES012 | 1/28/2013* | < 2.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | **0.24** | **J** | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES020 | 4/22/2013 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | **0.21** | **J** | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES021 | 4/22/2013* | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | **0.21** | **J** | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES029 | 7/22/2013 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | **0.17**[1] | **J** | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50[1] | U |
| | ES030 | 7/22/2013* | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | **0.19**[1] | **J** | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50[1] | U |
| | ES038 | 10/21/2013 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U,IJ | < 0.50 | U | < 0.50 | U | **0.14** | **J** | < 0.50 | U | < 5.0 | U,ICH | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES039 | 10/21/2013* | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U,IJ | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U,ICH | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES046 | 1/15/2014 | < 1.0 | U | < 5.0 | U,ICJ | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | **0.17** | **J** | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES047 | 1/15/2014* | < 1.0 | U | < 5.0 | U,ICJ | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | **0.17** | **J** | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES057 | 1/28/2014 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | **0.20** | **J** | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES058 | 1/28/2014* | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | **0.20** | **J** | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES063 | 2/24/2014 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U,IJ | < 0.50 | U | < 0.50 | U | **0.15** | **J** | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES065 | 3/5/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | **0.15** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U |
| | ES066 | 3/5/2014* | - | | - | | - | | - | | - | | - | | - | | - | | - | | **0.15** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U |
| | ES070 | 3/10/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U |
| | ES071 | 3/10/2014* | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U |
| | ES073 | 3/25/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | **0.15** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U |
| | ES074 | 3/25/2014* | - | | - | | - | | - | | - | | - | | - | | - | | - | | **0.16** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U |
| | ES078 | 4/7/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | **0.18** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U |
| | ES079 | 4/7/2014* | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U |
| | ES081 | 4/21/2014 | < 1.0 | U | < 5.0 | U,ICJ | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | **0.17** | **J** | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES082 | 4/21/2014* | < 1.0 | U | < 5.0 | U,ICJ | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | **0.16** | **J** | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES092 | 5/27/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U |
| | ES093 | 5/27/2014* | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U |
| | ES099 | 6/23/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | **0.16** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U |
| | ES100 | 6/23/2014* | - | | - | | - | | - | | - | | - | | - | | - | | - | | **0.18** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U |
| | ES104 | 7/21/2014 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U,IJ | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES105 | 7/21/2014* | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U,IJ | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES114 | 10/27/2014 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U,IJ | < 0.50 | U | < 0.50 | U | **0.15** | **J** | < 0.50 | U | < 5.0 | U,ICH | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES115 | 10/27/2014 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U,IJ | < 0.50 | U | < 0.50 | U | **0.14** | **J** | < 0.50 | U | < 5.0 | U,ICH | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES126 | 1/28/2015 | < 1.0 | U | < 5.0 | U,IH | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | **0.16** | **J** | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES127 | 1/28/2015* | < 1.0 | U | < 5.0 | U,IH | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | **0.17** | **J** | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES131 | 4/20/2015 | <0.50 | U | <0.30 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | - | | **0.18** | **J** | <0.30 | U | <4.0 | U | <10 | U | <0.30 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.10 | U |
| | ES132 | 4/20/2015* | <0.50 | U | <0.30 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | - | | **0.19** | **J** | <0.30 | U | <4.0 | U | <10 | U | <0.30 | U | **0.10** | **J** | - | | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.10 | U |
| | ES144 | 6/25/2015 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES146 | 7/20/2015 | <0.50 | U | <0.30 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | - | | **0.16** | **J** | <0.30 | U | <4.0 | U | <10 | U | <0.30 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | - | | <0.20 | U | **0.060** | **J** |
| | ES147 | 7/20/2015* | <0.50 | U | <0.30 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | - | | **0.17** | **J** | <0.30 | U | <4.0 | U | <10 | U | <0.30 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.10 | U |
| | ERH012 | 10/20/2015 | <0.50 | U,** | <0.30 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | - | | **0.29** | **J,**** | <0.30 | U,** | <4.0 | U,** | <10 | U,** | <0.30 | U,** | <0.20 | B,U,** | - | | <0.20 | U,** | <0.20 | U,** | - | | <0.20 | U,** | **0.30** | **J,**,Tb** |
| | ERH013 | 10/20/2015 | <0.50 | U,** | <0.30 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | - | | **0.26** | **J,**** | <0.30 | U,** | <4.0 | U,** | <10 | U,** | <0.30 | U,** | <0.20 | B,U,** | - | | <0.20 | U,** | <0.20 | U,** | - | | <0.20 | U,** | **0.49** | **J,**,Tb** |
| | ERH025 | 1/20/2016 | < 0.50 | U | < 0.30 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | - | - | **0.014** | **J** | < 0.30 | U | < 4.0 | U | < 10 | U | < 0.30 | U | < 0.20 | B,U | - | - | < 0.20 | U | < 0.20 | U | < 15 | U | < 0.20 | U | **0.070** | **Tb,J** |

| Well Name | Sample ID | Date Sampled | | | | | | | | | 504.1 | | 8260SIM | | | | | | | | | | 8011 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | trans-1,2-Dichloroethylene | | Trichloroethylene | | Vinyl chloride | | Xylenes, Total (p/m-, o-xylene) | | 1,2-Dibromoethane | | 1,2-Dibromoethane | | 1,2-Dichloroethane | | Bromodichloromethane | | Dibromochloromethane | | Tetrachloroethane, 1,1,2,2- | | 1,2-Dibromo-3-chloropropane | | 1,2-Dibromoethane | | Acenaphthene | | Acenaphthylene | | Anthracene | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| For wells > 150 m from surface water | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| DOH Tier 1 EALs (for locations > 150m from surface water) | - | - | 100 | | 5.0 | | 2.0 | | 20 | | 0.04 | | 0.04 | | 0.15 | | 0.12 | | 0.16 | | 0.067 | | 0.04 | | 0.04 | | 20 | | 240 | | 22 | |
| **RHMW02**<br>**104.76' TOC ELEV** | ES061 | 1/26/2012 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.29** | | **0.089** | **J** | < 0.10 | U |
| | ES071 | 4/16/2012 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.26** | | < 0.12 | U | < 0.10 | U |
| | ES072 | 4/16/2012* | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | **0.23** | | < 0.12 | U | < 0.10 | U |
| | ES082 | 7/18/2012 | < 0.38 | U | < 0.32 | U | < 0.46 | U | **0.43** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.23** | | < 0.12 | U | < 0.10 | U |
| | ES002 | 10/22/2012 | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.51** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.58** | | < 0.050 | U | < 0.050 | U |
| | ES003 | 10/22/2012* | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.47** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.59** | | < 0.050 | U | < 0.050 | U |
| | ES011 | 1/28/2013 | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.65** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.57** | | < 0.050 | U | < 0.050 | U |
| | ES012 | 1/28/2013* | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.69** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.54** | | < 0.050 | U | < 0.050 | U |
| | ES020 | 4/22/2013 | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.58** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.58** | | < 0.051 | U | < 0.051 | U |
| | ES021 | 4/22/2013* | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.58** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.65** | | < 0.048 | U | < 0.048 | U |
| | ES029 | 7/22/2013 | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.45**[1] | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.52** | | < 0.050 | U | < 0.050 | U |
| | ES030 | 7/22/2013* | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.50**[1] | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.51** | | < 0.050 | U | < 0.050 | U |
| | ES038 | 10/21/2013 | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.37** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.54** | | < 0.053 | U | < 0.053 | U |
| | ES039 | 10/21/2013* | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.37** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.57** | | < 0.052 | U | < 0.052 | U |
| | ES046 | 1/15/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.48** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES047 | 1/15/2014* | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.45** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES057 | 1/28/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.38** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.37** | | <0.049 | U | <0.049 | U |
| | ES058 | 1/28/2014* | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.34** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.32** | | <0.050 | U | <0.050 | U |
| | ES063 | 2/24/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.29** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.32** | | <0.050 | U | <0.050 | U |
| | ES065 | 3/5/2014 | - | | - | | - | | **0.29** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES066 | 3/5/2014* | - | | - | | - | | **0.32** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES070 | 3/10/2014 | - | | - | | - | | **0.30** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES071 | 3/10/2014* | - | | - | | - | | **0.31** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES073 | 3/25/2014 | - | | - | | - | | **0.38** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES074 | 3/25/2014* | - | | - | | - | | **0.41** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES078 | 4/7/2014 | - | | - | | - | | **0.40** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES079 | 4/7/2014* | - | | - | | - | | **0.33** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES081 | 4/21/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.43** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.47** | | <0.051 | U | <0.051 | U |
| | ES082 | 4/21/2014* | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.42** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.49** | | <0.050 | U | <0.050 | U |
| | ES092 | 5/27/2014 | - | | - | | - | | **0.31** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES093 | 5/27/2014* | - | | - | | - | | **0.32** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES099 | 6/23/2014 | - | | - | | - | | **0.40** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES100 | 6/23/2014* | - | | - | | - | | **0.37** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES104 | 7/21/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.36** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.52** | | <0.048 | U | <0.048 | U |
| | ES105 | 7/21/2014* | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.33** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.50** | | <0.051 | U | <0.051 | U |
| | ES114 | 10/27/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.32** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.53** | | <0.047 | U | <0.047 | U |
| | ES115 | 10/27/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.29** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.53** | | <0.047 | U | <0.047 | U |
| | ES126 | 1/28/2015 | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.35** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.59** | | <0.050 | U | <0.050 | U |
| | ES127 | 1/28/2015* | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.35** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | **0.55** | | <0.049 | U | <0.049 | U |
| | ES131 | 4/20/2015 | <0.20 | U | <0.10 | U | <0.10 | U | **0.26** | **J** | - | | <0.010 | U | <0.015 | U | <0.010 | U | <0.010 | U | **0.059** | | <0.0040 | U | <0.0040 | U | **0.24** | | **0.10** | **X** | <0.0050 | U |
| | ES132 | 4/20/2015* | <0.20 | U | <0.10 | U | <0.10 | U | **0.30** | **J** | - | | <0.010 | U | <0.015 | U | <0.010 | U | <0.010 | U | **0.065** | | <0.0040 | U | <0.0040 | U | **0.51** | | **0.26** | **X** | <0.0050 | U |
| | ES144 | 6/25/2015 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES146 | 7/20/2015 | <0.20 | U | <0.10 | U | <0.10 | U | **0.26** | **J** | - | | - | | <0.015 | U | <0.010 | U | <0.010 | U | <0.13 | Ui | <0.0040 | U | <0.0040 | U | **0.57** | | <0.24 | Ui | <0.0050 | U |
| | ES147 | 7/20/2015* | <0.20 | U | <0.10 | U | <0.10 | U | **0.27** | **J** | - | | - | | <0.015 | U | <0.010 | U | <0.010 | U | <0.12 | Ui | <0.0040 | U | <0.0040 | U | **0.53** | | <0.24 | Ui | <0.0050 | U |
| | ERH012 | 10/20/2015 | <0.20 | U,** | <0.10 | U,** | <0.10 | U,** | **0.32** | **J,**** | - | | - | | - | U | - | U | <0.010 | U | <0.02 | U | - | U | <0.0040 | U | **0.33** | | <0.20 | U,i | <0.021 | U,i |
| | ERH013 | 10/20/2015 | <0.20 | U,** | <0.10 | U,** | <0.10 | U,** | **0.30** | **J,**** | - | | - | | - | U | - | U | <0.010 | U | <0.02 | U | - | U | <0.0040 | U | **0.36** | | <0.20 | U,i | <0.021 | U,i |
| | ERH025 | 1/20/2016 | < 0.20 | U | < 0.10 | U | < 0.10 | U | **0.21** | **J** | - | - | - | - | <0.015 | U | < 0.010 | U | < 0.010 | U | - | - | - | - | < 0.0040 | U | **0.51** | **D** | <0.25 | Ui | < 0.0050 | U |

| Well Name | Sample ID | Date Sampled | 8270C | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 6020 | | 6010B/6020/200.8 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Benzo[a]anthracene | | Benzo[g,h,i]perylene | | Benzo[a]pyrene | | Benzo[b]fluoranthene | | Benzo[k]fluoranthene | | Chrysene | | Dibenz[a,h]anthracene | | Fluoranthene | | Fluorene | | Indeno[1,2,3-cd]pyrene | | 1-Methylnaphthalene | | 2-Methylnaphthalene | | Naphthalene | | Phenanthrene | | Pyrene | | Dissolved Lead (filtered) | | Total Lead (unfiltered) | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| **For wells > 150 m from surface water** | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations > 150m from surface water)** | - | - | **0.092** | | **0.13** | | **0.20** | | **0.092** | | **0.40** | | **1.0** | | **0.0092** | | **130** | | **240** | | **0.092** | | **4.7** | | **10** | | **17** | | **240** | | **68** | | **15** | | **-** | |
| **RHMW02 104.76' TOC ELEV** | ES061 | 1/26/2012 | < 0.14 | U | < 0.16 | U | < 0.12 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | **0.21** | | < 0.14 | U | **0.57** | | **0.17** | **J** | **1.7** | | < 0.14 | U | < 0.16 | U | **0.17** | **J** | - | |
| | ES071 | 4/16/2012 | < 0.14 | U | < 0.16 | U | < 0.12 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | **0.14** | **J** | < 0.14 | U | **0.30** | | < 0.12 | U | **0.86** | | < 0.14 | U | < 0.16 | U | **0.44** | **J** | - | |
| | ES072 | 4/16/2012* | < 0.14 | U | < 0.16 | U | < 0.12 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | **0.12** | **J** | < 0.14 | U | **1.2** | | **0.61** | | **2.9** | | < 0.14 | U | < 0.16 | U | < 0.22 | U | - | |
| | ES082 | 7/18/2012 | < 0.14 | U | < 0.16 | U | < 0.12 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | **4.7** | | **0.88** | | **17** | | < 0.14 | U | < 0.16 | U | **0.42** | **J** | - | |
| | ES002 | 10/22/2012 | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | **0.29** | | < 0.050 | U | **24** | | **14** | | **63** | | < 0.050 | U | < 0.050 | U | < 0.200 | U | - | |
| | ES003 | 10/22/2012* | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | **0.30** | | < 0.050 | U | **21** | | **12** | | **61** | | < 0.050 | U | < 0.050 | U | < 0.200 | U | - | |
| | ES011 | 1/28/2013 | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | **0.30** | | < 0.050 | U | **47** | | **35** | | **110** | | < 0.050 | U | < 0.050 | U | < 0.200 | U | - | |
| | ES012 | 1/28/2013* | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | **0.27** | | < 0.050 | U | **41** | | **31** | | **100** | | < 0.050 | U | < 0.050 | U | **0.171** | **J** | - | |
| | ES020 | 4/22/2013 | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | **0.24** | | < 0.051 | U | **16** | | **13** | | **53** | | < 0.051 | U | < 0.051 | U | < 0.200 | U | - | |
| | ES021 | 4/22/2013* | < 0.048 | U | < 0.048 | U | < 0.048 | U | < 0.048 | U | < 0.048 | U | < 0.048 | U | < 0.048 | U | < 0.048 | U | **0.28** | | < 0.048 | U | **20** | | **16** | | **61** | | < 0.048 | U | < 0.048 | U | <0.200 | U | - | |
| | ES029 | 7/22/2013 | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | **0.23** | | < 0.050 | U | **21** | | **9.1** | | **73** | | < 0.050 | U | < 0.050 | U | **0.135** | **J** | - | |
| | ES030 | 7/22/2013* | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | **0.22** | | < 0.050 | U | **18** | | **6.6** | | **67** | | < 0.050 | U | < 0.050 | U | < 0.200 | U | - | |
| | ES038 | 10/21/2013 | < 0.053 | U | < 0.053 | U | < 0.053 | U | < 0.053 | U | < 0.053 | U | < 0.053 | U | < 0.053 | U | < 0.053 | U | **0.27** | | < 0.053 | U | **9.0** | | **9.0** | | **30** | | < 0.053 | U | < 0.053 | U | < 0.200 | U | - | |
| | ES039 | 10/21/2013* | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | < 0.052 | U | **0.31** | | < 0.052 | U | **7.5** | | **7.5** | | **25** | | < 0.052 | U | < 0.052 | U | < 0.200 | U | - | |
| | ES046 | 1/15/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | **6.0** | | **4.9** | | **18** | | - | | - | | - | | - | |
| | ES047 | 1/15/2014* | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | **5.3** | | **4.3** | | **17** | | - | | - | | - | | - | |
| | ES057 | 1/28/2014 | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | **0.19** | **J** | <0.049 | U | **8.8** | | **5.4** | | **18** | | <0.049 | U | <0.049 | U | <0.200 | U | - | |
| | ES058 | 1/28/2014* | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | **0.17** | **J** | <0.050 | U | **9.0** | | **5.9** | | **18** | | <0.050 | U | <0.050 | U | <0.200 | U | - | |
| | ES063 | 2/24/2014 | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | **0.19** | **J** | <0.050 | U | **5.2** | | **2.5** | | **15** | | <0.050 | U | <0.050 | U | <0.200 | U | - | |
| | ES065 | 3/5/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | **2.6** | | **1.5** | | **10** | | - | | - | | <0.200 | U | - | |
| | ES066 | 3/5/2014* | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | **3.9** | | **2.9** | | **13** | | - | | - | | <0.200 | U | - | |
| | ES070 | 3/10/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | **3.7** | | **2.5** | | **11** | | - | | - | | <0.200 | U | - | |
| | ES071 | 3/10/2014* | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | **4.2** | | **3.0** | | **12** | | - | | - | | <0.200 | U | - | |
| | ES073 | 3/25/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | **9.0** | | **4.9** | | **33** | | - | | - | | <0.200 | U | - | |
| | ES074 | 3/25/2014* | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | **8.1** | | **4.0** | | **33** | | - | | - | | **0.116** | **J** | - | |
| | ES078 | 4/7/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | **6.2** | | **4.4** | | **25** | | - | | - | | **0.200** | **J** | - | |
| | ES079 | 4/7/2014* | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | **9.0** | | **7.6** | | **31** | | - | | - | | <0.200 | U | - | |
| | ES081 | 4/21/2014 | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | **0.22** | | <0.051 | U | **8.7** | | **8.1** | | **31** | | <0.051 | U | <0.051 | U | <0.200 | U | - | |
| | ES082 | 4/21/2014* | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | **0.23** | | <0.050 | U | **8.3** | | **7.7** | | **32** | | <0.050 | U | <0.050 | U | <0.200 | U | - | |
| | ES092 | 5/27/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | **9.3** | | **2.7** | | **34** | | - | | - | | <0.200 | U | - | |
| | ES093 | 5/27/2014* | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | **7.8** | | **1.5** | | **28** | | - | | - | | **0.418** | **J** | - | |
| | ES099 | 6/23/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | **11** | | **3.4** | | **38** | | - | | - | | **0.149** | **J** | | |
| | ES100 | 6/23/2014* | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | **12** | | **4.5** | | **41** | | - | | - | | <0.200 | U | | |
| | ES104 | 7/21/2014 | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | **0.24** | | <0.048 | U | **25** | | **20** | | **71** | | <0.048 | U | <0.048 | U | <0.200 | U | - | |
| | ES105 | 7/21/2014* | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | **0.23** | | <0.051 | U | **26** | | **22** | | **76** | | <0.051 | U | <0.051 | U | **0.170** | **J** | - | |
| | ES114 | 10/27/2014 | <0.047 | U | <0.095 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | **59** | | **43** | | **140** | | <0.047 | U | <0.047 | U | <0.200 | U | - | |
| | ES115 | 10/27/2014 | <0.047 | U | <0.095 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | **54** | | **36** | | **130** | | <0.047 | U | <0.047 | U | **0.165** | **J** | - | |
| | ES126 | 1/28/2015 | <0.050 | U | <0.099 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | **0.30** | | <0.050 | U | **34** | | **7.6** | **J** | **90** | | <0.050 | U | <0.050 | U | <0.200 | U | - | |
| | ES127 | 1/28/2015* | <0.049 | U | <0.098 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | **0.22** | | <0.049 | U | **25** | | **2.7** | **J** | **63** | | <0.049 | U | <0.049 | U | <0.200 | U | - | |
| | ES131 | 4/20/2015 | **0.0047** | **B,J** | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.020 | U | **0.14** | | <0.0050 | U | **31** | **JD** | **15** | **JD** | **39** | **JD** | <0.0050 | U | **0.0058** | **JX** | **0.016** | **J** | - | |
| | ES132 | 4/20/2015* | **0.0030** | **B,J** | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.020 | U | **0.31** | | <0.0050 | U | **68** | **JD** | **37** | **JD** | **140** | **JD** | <0.0050 | U | <0.010 | U | **0.025** | | - | |
| | ES144 | 6/25/2015 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | **71** | **JD** | **48** | **JD** | **150** | **JD** | - | | - | | - | | - | |
| | ES146 | 7/20/2015 | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.020 | U | **0.32** | | <0.0050 | U | **65** | **JD** | **43** | **JD** | **150** | **JD** | <0.0050 | U | <0.010 | U | **0.071** | | - | |
| | ES147 | 7/20/2015* | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.020 | U | **0.29** | | <0.0050 | U | **66** | **D** | **43** | **D** | **160** | **D** | <0.0050 | U | <0.010 | U | **0.027** | | - | |
| | ERH012 | 10/20/2015 | <0.0050 | B,U | <0.0050 | B,U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | B,U | <0.020 | U | **0.19** | | <0.0050 | B,U | **60** | **D** | **27** | **B,D** | **120** | **B,D** | **0.017** | **J** | <0.010 | U | **0.080** | | - | |
| | ERH013 | 10/20/2015 | <0.0050 | B,U | <0.0050 | B,U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | B,U | <0.020 | U | **0.22** | | <0.0050 | B,U | **57** | **D** | **24** | **B,D** | **88** | **B,D** | **0.019** | **J** | <0.010 | U | **0.039** | | - | |
| | ERH025 | 1/20/2016 | **0.0029** | **J** | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.020 | U | **0.28** | **D** | < 0.0050 | U | **48** | **D** | **7.9** | **D** | **120** | **D** | < 0.0050 | U | < 0.010 | U | **0.030** | | - | - |

Cumulative Groundwater Measurements and Analytical Results for Tunnel Wells
Red Hill Bulk Fuel Storage Facility

| | | | 8015 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Well Name | Sample ID | Date Sampled | TPH-d | | TPH-g | | TPH-o | | TPH-g | | 1,1,1-Trichloroethane | | 1,1,2-Trichloroethane | | 1,1-Dichloroethane | | 1,1-Dichloroethylene | | 1,2,3-Trichloropropane | | 1,2,4-Tricholorobenzene | | 1,2-Dibromo-3-chloropropane | | 1,2-Dibromoethane | | 1,2-Dichlorobenzene | | 1,2-Dichloroethane | | 1,2-Dichloropropane | | 1,3-Dichlorobenzene | | 1,3-Dichloropropene (total of cis/trans) | | 1,4-Dichlorobenzene | | Acetone | | Benzene | | Bromodichloromethane | |
| | | | (µg/l) | | (µg/l) | | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| For wells > 150 m from surface water | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| DOH Tier 1 EALs (for locations > 150m from surface water) | - | - | 100 | | 100 | | 100 | | 100 | | 200 | | 5.0 | | 2.4 | | 7.0 | | 0.6 | | 70 | | 0.04 | | 0.04 | | 10 | | 0.15 | | 5.0 | | 5.0 | | 0.43 | | 5.0 | | 1500 | | 5.0 | | 0.12 | |
| **RHMW03<br>121.06' TOC ELEV** | RHMW03W01 | 9/20/2005[b] | **162** | J | < 0.50 | U | - | | - | | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | | <1.0 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.30 | U | <0.50 | U | <5.0 | U | < 0.50 | U | <0.50 | U |
| | RHMW03-GW02 | 7/10/2006[ad] | **142** | J | < 50 | U | - | | - | | < 0.50 | U | <0.50 | U | <0.50 | U | < 0.50 | U | <1.0 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.30 | U | <0.50 | U | <5.0 | U | < 0.50 | U | <0.50 | U |
| | RHMW03-GW06 | 12/5/2006[ad] | < 100 | U | < 50 | U | - | | - | | < 0.50 | U | <0.50 | U | <0.50 | U | < 0.50 | U | <1.0 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.30 | U | <0.50 | U | <5.0 | U | < 0.50 | U | <0.50 | U |
| | RHMW03-WG07 | 3/27/2007[a] | **95.7** | J | < 50 | U | - | | - | | < 0.50 | U | < 0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | < 0.50 | U | < 1.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | < 0.5 | U | < 0.50 | U | <0.30 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U |
| | RHMW03-WG08 | 6/12/2007[a] | **123** | J | < 50 | U | - | | - | | < 0.50 | U | < 0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | < 0.50 | U | < 1.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | < 0.50 | U | < 0.50 | U | <0.30 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U |
| | RHMW03-WG09 | 9/10/2007[a] | < 96 | U | < 50 | U | - | | - | | <0.29 | U | < 0.30 | U | <0.25 | U | <0.23 | U | <0.50 | U | < 0.22 | U | < 0.41 | U | <0.20 | U | <0.20 | U | <0.20 | U | < 0.25 | U | < 0.25 | U | <0.24 | U | < 0.22 | U | < 10 | U | < 0.20 | U | < 0.29 | U |
| | RHMW03-WG10 | 1/15/2008[a] | **242** | J | < 10.0 | U | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | - | | < 0.120 | U | < 0.150 | U |
| | RHMW03-WG11 | 4/15/2008[a] | **190** | J | < 10.0 | U | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | < 0.120 | U | < 0.150 | U |
| | RHMW03-WG12 | 7/29/2008[a] | **199** | J | < 10.0 | U | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | < 0.120 | U | < 0.150 | U |
| | RHMW03-WG13 | 10/22/2008[a] | **244** | J | < 10.0 | U | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | < 0.120 | U | < 0.150 | U |
| | RHMW03-WG14 | 2/4/2009[a] | **207** | J | **16.1** | J | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | < 0.120 | U | < 0.150 | U |
| | RHMW03-WG15 | 5/13/2009[a] | < 161 | U | **14.8** | J | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | < 0.120 | U | < 0.150 | U |
| | RHMW03-WG16 | 7/15/2009[a] | < 150 | U | < 30.0 | U | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | < 0.120 | U | < 0.150 | U |
| | RHMW03-WG17 | 10/14/2009[a] | < 163 | U | < 30 | U | - | | - | | < 0.31 | U | < 0.31 | U | < 0.31 | U | <0.31 | U | < 0.31 | U | < 0.31 | U | < 0.62 | U | < 0.31 | U | < 0.31 | U | < 0.15 | U | < 0.31 | U | < 0.31 | U | < 0.15 | U | < 0.15 | U | < 3.1 | U | < 0.12 | U | < 0.15 | U |
| | RHMW03-WG18 | 1/27/2010 | < 330 | U | < 60.0 | U | - | | - | | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 6.20 | U | < 0.240 | U | < 0.300 | U |
| | RHMW03-WG19 | 4/13/2010 | < 320 | U | < 60.0 | U | - | | - | | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 6.20 | U | < 0.240 | U | < 0.300 | U |
| | RHMW03-WG20 | 7/13/2010 | < 324 | U | < 60.0 | U | - | | - | | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | - | | < 0.240 | U | < 0.300 | U |
| | ES001 | 10/18/2010 | **330** | ++ | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES012 | 1/19/2011 | < 80.8 | U | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES025 | 4/20/2011 | < 80.8 | U | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES035 | 7/19/2011 | < 80.8 | U | - | | < 212.0 | U | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES049 | 10/24/2011 | < 80.8 | U | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES060 | 1/26/2012 | < 80.8 | U | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES073 | 4/16/2012 | < 80.8 | U | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES081 | 7/18/2012 | < 80.8 | U | - | | < 212.0 | U | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | <0.50 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES004 | 10/22/2012 | **45** | J,HD | - | | - | | < 30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U | < 0.50 | U | < 0.50 | U |
| | ES013 | 1/28/2013 | **59** | HD | - | | - | | < 30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 10 | IJ,ICH,U | < 0.50 | U | < 0.50 | U |
| | ES022 | 4/22/2013 | **69** | HD | - | | - | | < 30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U | < 0.50 | U | < 0.50 | U |
| | ES031 | 7/22/2013 | **48** | J,HD | - | | - | | < 30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U | < 0.50[1] | U | < 0.50 | U |
| | ES040 | 10/21/2013 | **54** | HD | - | | - | | **23** | B,J | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U,ICH | < 0.50 | U | < 0.50 | U |
| | ES059 | 1/28/2014 | **74** | | - | | - | | **20** | B,J | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U | < 0.50 | U | < 0.50 | U |
| | ES083 | 4/21/2014 | **39** | HD | - | | - | | < 30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U,ICH | < 0.50 | U | < 0.50 | U |
| | ES106 | 7/22/2014 | **37** | HD | - | | - | | < 30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U,ICH | < 0.50 | U | < 0.50 | U |
| | ES116 | 10/27/2014 | **80** | J,HD | - | | - | | < 30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U,IH | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U,ICH | < 0.50 | U | < 0.50 | U |
| | ES123 | 1/28/2015 | **39** | HD | - | | - | | < 30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U,IJ | < 0.50 | U | < 0.50 | U |
| | ES133 | 4/20/2015 | **100** | B,Y | <25 | U | **110** | B,L | - | | <0.20 | U | <0.40 | U | <0.20 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.80 | U | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <10 | U | <0.10 | U | - | |
| | ES148 | 7/20/2015 | **130** | Y | <25 | U | **150** | L | - | | <0.20 | U | <0.40 | U | <0.20 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.80 | U | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <10 | U | <0.10 | U | - | |
| | ERH014 | 10/20/2015 | **130** | B,Y | <25 | U | **160** | B,L | - | | <0.20 | U,** | <0.40 | U,** | <0.20 | U,** | <0.20 | U,** | <0.50 | U,** | <0.30 | U,** | <0.80 | U,** | <0.20 | U,** | <0.20 | U,** | - | | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <10 | U,** | <0.10 | U,** | - | |
| | ERH026 | 1/20/2016 | **150** | B,Y | < 25 | U | **160** | B,L | - | - | < 0.20 | U | < 0.40 | U | < 0.20 | U | < 0.20 | U | < 0.50 | U | < 0.30 | U | < 0.80 | U | < 0.20 | U | < 0.20 | U | - | - | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | **3.4** | **J** | < 0.10 | U | - | - |

| Well Name | Sample ID | Date Sampled | 8260B | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Bromoform | | Bromomethane | | Carbon Tetrachloride | | Chlorobenzene | | Chloroethane | | Chloroform | | Chloromethane | | cis-1,2-Dichloroethylene | | Dibromochloromethane | | Ethylbenzene | | Hexachlorobutadiene | | Methyl ethyl ketone (2-Butanone) | | Methyl isobutyl ketone (4-Methyl-2-Pentanone) | | Methyl tert-butyl Ether | | Methylene chloride | | Naphthalene | | Styrene | | Tetrachloroethane, 1,1,1,2- | | Tetrachloroethane, 1,1,2,2- | | Tetrachloroethylene | | Toluene | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| For wells > 150 m from surface water | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| DOH Tier 1 EALs (for locations > 150m from surface water) | - | - | 80 | | 8.7 | | 5.0 | | 50 | | 16 | | 70 | | 1.8 | | 70 | | 0.16 | | 30 | | 0.86 | | 7,100 | | 170 | | 5.0 | | 4.8 | | 17 | | 10 | | 0.52 | | 0.067 | | 5.0 | | 40 | |
| RHMW03<br>121.06' TOC ELEV | RHMW03W01 | 9/20/2005[b] | <0.50 | U | <1.0 | U | <0.50 | U | <0.50 | U | <1.0 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.40 | U | < 0.50 | U | <0.50 | U | <2.5 | U | <2.5 | U | < 0.50 | U | <1.0 | U | <1.0 | U | <0.50 | U | <0.50 | U | <0.40 | U | <0.50 | U | < 0.50 | U |
| | RHMW03-GW02 | 7/10/2006[ad] | <0.50 | U | <1.0 | U | <0.50 | U | <0.50 | U | <1.0 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.40 | U | < 0.50 | U | <0.50 | U | <2.5 | U | <2.5 | U | < 0.50 | U | <1.0 | U | < 1.0 | U | <0.50 | U | <0.50 | U | <0.40 | U | < 0.50 | U | < 0.50 | U |
| | RHMW03-GW06 | 12/5/2006[ad] | <0.50 | U | <1.0 | U | <0.50 | U | <0.50 | U | <1.0 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.40 | U | < 0.50 | U | <0.50 | U | <2.5 | U | <2.5 | U | < 0.50 | U | <1.0 | U | < 1.0 | U | <0.50 | U | <0.50 | U | <0.40 | U | < 0.50 | U | < 0.50 | U |
| | RHMW03-WG07 | 3/27/2007[a] | < 0.50 | U | < 1.0 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 0.50 | U | < 1.0 | U | < 0.50 | U | <0.40 | U | < 0.50 | U | < 0.50 | U | < 2.5 | U | < 2.5 | U | <0.50 | U | < 1.0 | U | < 1.0 | U | < 0.50 | U | < 0.50 | U | < 0.40 | U | < 0.50 | U | < 0.50 | U |
| | RHMW03-WG08 | 6/12/2007[a] | < 0.50 | U | < 1.0 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 0.50 | U | < 1.0 | U | < 0.50 | U | <0.40 | U | < 0.50 | U | < 0.50 | U | < 2.5 | U | < 2.5 | U | <0.50 | U | < 1.0 | U | < 1.0 | U | < 0.50 | U | < 0.50 | U | < 0.40 | U | < 0.50 | U | < 0.50 | U |
| | RHMW03-WG09 | 9/10/2007[a] | < 0.28 | U | < 0.54 | U | < 0.29 | U | < 0.20 | U | < 0.46 | U | < 0.21 | U | < 0.38 | U | < 0.28 | U | <0.20 | U | < 0.20 | U | < 0.57 | U | < 2.0 | U | < 2.2 | U | <0.25 | U | < 1.0 | U | < 0.44 | U | < 0.20 | U | < 0.25 | U | < 0.37 | U | < 0.25 | U | < 0.27 | U |
| | RHMW03-WG10 | 1/15/2008[a] | < 0.500 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.180 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW03-WG11 | 4/15/2008[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | < 0.620 | U | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW03-WG12 | 7/29/2008[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | < 0.620 | U | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW03-WG13 | 10/22/2008[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | < 0.620 | U | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW03-WG14 | 2/4/2009[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | < 0.620 | U | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW03-WG15 | 5/13/2009[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | < 0.620 | U | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW03-WG16 | 7/15/2009[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | < 0.620 | U | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW03-WG17 | 10/14/2009[a] | < 0.31 | U | < 0.94 | U | < 0.31 | U | < 0.15 | U | < 0.31 | U | < 0.3 | U | < 0.31 | U | < 0.31 | U | < 0.15 | U | < 0.31 | U | < 0.31 | U | < 3.1 | U | < 3.1 | U | - | | < 1 | U | < 0.62 | U | < 0.31 | U | < 0.15 | U | < 0.15 | U | < 0.31 | U | < 0.31 | U |
| | RHMW03-WG18 | 1/27/2010 | < 0.620 | U | < 1.88 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.600 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 6.20 | U | < 6.20 | U | < 3.00 | U | < 2.00 | U | < 1.24 | U | < 0.620 | U | < 0.300 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U |
| | RHMW03-WG19 | 4/13/2010 | < 0.620 | U | < 1.88 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.600 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 6.20 | U | < 6.20 | U | < 3.00 | U | < 2.00 | U | < 1.24 | U | < 0.620 | U | < 0.300 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U |
| | RHMW03-WG20 | 7/13/2010 | < 0.620 | U | < 1.88 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.600 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 6.20 | U | < 6.20 | U | < 3.00 | U | < 2.00 | U | < 1.24 | U | < 0.620 | U | < 0.300 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U |
| | ES001 | 10/18/2010 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.62 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.38 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.30 | U | < 0.34 | U |
| | ES012 | 1/19/2011 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.62 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.38 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.30 | U | < 0.34 | U |
| | ES025 | 4/20/2011 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.62 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.38 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.30 | U | < 0.34 | U |
| | ES035 | 7/19/2011 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.62 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.38 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.30 | U | < 0.34 | U |
| | ES049 | 10/24/2011 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.84 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.52 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.48 | U | < 0.34 | U |
| | ES060 | 1/26/2012 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.84 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.52 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.48 | U | < 0.34 | U |
| | ES073 | 4/16/2012 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.84 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.52 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.48 | U | < 0.34 | U |
| | ES081 | 7/18/2012 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.84 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.38 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.48 | U | < 0.34 | U |
| | ES004 | 10/22/2012 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 5.0 | IH,U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.54** | **J** |
| | ES013 | 1/28/2013 | < 2.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES022 | 4/22/2013 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES031 | 7/22/2013 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50[1] | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50[1] | U |
| | ES040 | 10/21/2013 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U,IJ | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U,ICH | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES059 | 1/28/2014 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES083 | 4/21/2014 | < 1.0 | U | < 5.0 | U,ICJ | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES106 | 7/22/2014 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U,IJ | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES116 | 10/27/2014 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U,IJ | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U,ICH | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES123 | 1/28/2015 | < 1.0 | U | < 5.0 | U,IH | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES133 | 4/20/2015 | <0.50 | U | <0.30 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | - | | <0.10 | U | <0.30 | U | <4.0 | U | <10 | U | <0.30 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.10 | U |
| | ES148 | 7/20/2015 | <0.50 | U | <0.30 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | - | | <0.10 | U | <0.30 | U | <4.0 | U | <10 | U | <0.30 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.10 | U |
| | ERH014 | 10/20/2015 | <0.50 | U,** | <0.30 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | - | | <0.10 | U,** | <0.30 | U,** | <4.0 | U,** | <10 | U,** | <0.30 | U,** | <0.20 | B,U,** | - | | <0.20 | U,** | <0.20 | U,** | - | | <0.20 | U,** | **0.40** | J,**,Tb |
| | ERH026 | 1/20/2016 | < 0.50 | U | < 0.30 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | - | - | < 0.10 | U | < 0.30 | U | < 4.0 | U | < 10 | U | < 0.30 | U | < 0.20 | B,U | - | - | < 0.20 | U | < 0.20 | U | < 15 | U | < 0.20 | U | **0.14** | **Tb,J** |

| Well Name | Sample ID | Date Sampled | | | | | | | | | 504.1 | | 8260SIM | | | | | | | | | | 8011 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | trans-1,2-Dichloroethylene | | Trichloroethylene | | Vinyl chloride | | Xylenes, Total (p/m-, o-xylene) | | 1,2-Dibromoethane | | 1,2-Dibromoethane | | 1,2-Dichloroethane | | Bromodichloromethane | | Dibromochloromethane | | Tetrachloroethane, 1,1,2,2- | | 1,2-Dibromo-3-chloropropane | | 1,2-Dibromoethane | | Acenaphthene | | Acenaphthylene | | Anthracene | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| **For wells > 150 m from surface water** | **-** | **-** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations > 150m from surface water)** | **-** | **-** | **100** | | **5.0** | | **2.0** | | **20** | | **0.04** | | **0.04** | | **0.15** | | **0.12** | | **0.16** | | **0.067** | | **0.04** | | **0.04** | | **20** | | **240** | | **22** | |
| **RHMW03<br>121.06' TOC ELEV** | RHMW03W01 | 9/20/2005[b] | <0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.48 | U | < 0.48 | U | < 0.48 | U |
| | RHMW03-GW02 | 7/10/2006[ad] | <0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | <0.50 | U | <0.50 | U |
| | RHMW03-GW06 | 12/5/2006[ad] | <0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.49 | U | <0.49 | U | <0.49 | U |
| | RHMW03-WG07 | 3/27/2007[a] | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.49 | U | < 0.49 | U | < 0.49 | U |
| | RHMW03-WG08 | 6/12/2007[a] | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | RHMW03-WG09 | 9/10/2007[a] | < 0.20 | U | < 0.38 | U | < 0.34 | U | < 0.36 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | RHMW03-WG10 | 1/15/2008[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U |
| | RHMW03-WG11 | 4/15/2008[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U |
| | RHMW03-WG12 | 7/29/2008[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U |
| | RHMW03-WG13 | 10/22/2008[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U |
| | RHMW03-WG14 | 2/4/2009[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0161 | U | < 0.0161 | U | < 0.0161 | U |
| | RHMW03-WG15 | 5/13/2009[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0152 | U | < 0.0152 | U | < 0.0152 | U |
| | RHMW03-WG16 | 7/15/2009[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U |
| | RHMW03-WG17 | 10/14/2009[a] | < 0.31 | U | < 0.31 | U | < 0.31 | U | < 1 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0169 | U | < 0.0169 | U | < 0.0169 | U |
| | RHMW03-WG18 | 1/27/2010 | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U |
| | RHMW03-WG19 | 4/13/2010 | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U |
| | RHMW03-WG20 | 7/13/2010 | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U |
| | ES001 | 10/18/2010 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES012 | 1/19/2011 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES025 | 4/20/2011 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES035 | 7/19/2011 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES049 | 10/24/2011 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES060 | 1/26/2012 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES073 | 4/16/2012 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES081 | 7/18/2012 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES004 | 10/22/2012 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.050 | U | < 0.050 | U | < 0.050 | U |
| | ES013 | 1/28/2013 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.050 | U | < 0.050 | U | < 0.050 | U |
| | ES022 | 4/22/2013 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.053 | U | < 0.053 | U | < 0.053 | U |
| | ES031 | 7/22/2013 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0[1] | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.050 | U | < 0.050 | U | < 0.050 | U |
| | ES040 | 10/21/2013 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.050 | U | < 0.050 | U | < 0.050 | U |
| | ES059 | 1/28/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | <0.050 | U | <0.050 | U | <0.050 | U |
| | ES083 | 4/21/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | <0.049 | U | <0.049 | U | <0.049 | U |
| | ES106 | 7/22/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | <0.047 | U | <0.047 | U | <0.047 | U |
| | ES116 | 10/27/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | <0.054 | U | <0.054 | U | <0.054 | U |
| | ES123 | 1/28/2015 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | <0.048 | U | <0.048 | U | <0.048 | U |
| | ES133 | 4/20/2015 | <0.20 | U | <0.10 | U | <0.10 | U | <0.20 | U | - | | <0.010 | U | <0.015 | U | <0.010 | U | <0.010 | U | <0.015 | U | <0.0040 | U | <0.0040 | U | <0.0053 | U | <0.0053 | U | <0.0053 | U |
| | ES148 | 7/20/2015 | <0.20 | U | <0.10 | U | <0.10 | U | <0.20 | U | - | | - | | <0.015 | U | <0.010 | U | <0.010 | U | <0.015 | U | <0.0040 | U | <0.0040 | U | <0.0052 | U | <0.0052 | U | <0.0052 | U |
| | ERH014 | 10/20/2015 | <0.20 | U,** | <0.10 | U,** | <0.10 | U,** | <0.20 | U,** | - | | - | | <0.015 | U | - | U | <0.010 | U | <0.015 | U | - | U | <0.0040 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U |
| | ERH026 | 1/20/2016 | < 0.20 | U | < 0.10 | U | < 0.10 | U | < 0.20 | U | - | - | - | - | < 0.015 | U | < 0.010 | U | < 0.010 | U | - | - | - | - | < 0.0040 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U |

| Well Name | Sample ID | Date Sampled | 8270C | | | | | | | | | | | | | | | | | | | | | | | | | | | | 6020 | | 6010B/6020/200.8 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Benzo[a]anthracene | | Benzo[g,h,i]perylene | | Benzo[a]pyrene | | Benzo[b]fluoranthene | | Benzo[k]fluoranthene | | Chrysene | | Dibenz[a,h]anthracene | | Fluoranthene | | Fluorene | | Indeno[1,2,3-cd]pyrene | | 1-Methylnaphthalene | | 2-Methylnaphthalene | | Naphthalene | | Phenanthrene | | Pyrene | | Dissolved Lead (filtered) | | Total Lead (unfiltered) | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| **For wells > 150 m from surface water** | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations > 150m from surface water)** | - | - | **0.092** | | **0.13** | | **0.20** | | **0.092** | | **0.40** | | **1.0** | | **0.0092** | | **130** | | **240** | | **0.092** | | **4.7** | | **10** | | **17** | | **240** | | **68** | | **15** | | **-** | |
| **RHMW03<br>121.06' TOC ELEV** | RHMW03W01 | 9/20/2005[b] | < 0.48 | U | < 0.096 | U | < 0.096 | U | < 0.048 | U | < 0.096 | U | < 0.096 | U | < 0.048 | U | < 0.24 | U | < 0.24 | U | < 0.048 | U | < 0.24 | U | < 0.24 | U | < 0.24 | U | < 0.48 | U | < 0.24 | U | < 5 | U | **8.5[g]** | |
| | RHMW03-GW02 | 7/10/2006[ad] | <0.050 | U | <0.10 | U | < 0.10 | U | <0.050 | U | <0.10 | U | <0.10 | U | <0.050 | U | < 0.25 | U | <0.25 | U | <0.050 | U | <0.25 | U | <0.25 | U | < 0.25 | U | <0.50 | U | <0.25 | U | < 1.7 | U | - | |
| | RHMW03-GW06 | 12/5/2006[ad] | <0.049 | U | <0.098 | U | < 0.098 | U | <0.049 | U | <0.098 | U | <0.098 | U | <0.049 | U | < 0.25 | U | <0.25 | U | <0.049 | U | <0.25 | U | <0.25 | U | < 0.25 | U | <0.49 | U | 0.25 | U | < 1.7 | U | - | |
| | RHMW03-WG07 | 3/27/2007[a] | <0.049 | U | < 0.098 | U | < 0.098 | U | < 0.049 | U | < 0.098 | U | < 0.098 | U | < 0.049 | U | < 0.25 | U | < 0.25 | U | < 0.049 | U | < 0.25 | U | < 0.25 | U | < 0.25 | U | < 0.49 | U | < 0.25 | U | **3.0** | **J** | - | |
| | RHMW03-WG08 | 6/12/2007[a] | <0.050 | U | < 0.099 | U | < 0.099 | U | < 0.050 | U | < 0.099 | U | < 0.099 | U | < 0.050 | U | < 0.25 | U | < 0.25 | U | < 0.050 | U | < 0.25 | U | < 0.25 | U | < 0.25 | U | < 0.50 | U | < 0.25 | U | < 3.4 | U | - | |
| | RHMW03-WG09 | 9/10/2007[a] | <0.050 | U | < 0.10 | U | < 0.10 | U | < 0.050 | U | < 0.10 | U | < 0.10 | U | < 0.050 | U | < 0.25 | U | < 0.25 | U | < 0.05 | U | < 0.25 | U | < 0.25 | U | < 0.25 | U | < 0.50 | U | < 0.25 | U | < 2.1 | U | - | |
| | RHMW03-WG10 | 1/15/2008[a] | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0323 | U | < 0.0156 | U | < 0.0156 | U | < 0.310 | U | - | |
| | RHMW03-WG11 | 4/15/2008[a] | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | **0.0268** | **J** | **0.0279** | **J** | < 0.0341 | U | < 0.0165 | U | < 0.0165 | U | < 0.310 | U | - | |
| | RHMW03-WG12 | 7/29/2008[a] | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | **0.0294** | **J** | < 0.0156 | U | **0.0689** | **J** | < 0.0156 | U | < 0.0156 | U | < 0.310 | U | - | |
| | RHMW03-WG13 | 10/22/2008[a] | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | < 0.0155 | U | **0.0658** | | **0.0937** | | **0.219** | | < 0.0155 | U | < 0.0155 | U | < 0.310 | U | - | |
| | RHMW03-WG14 | 2/4/2009[a] | < 0.0161 | U | < 0.0161 | U | < 0.0161 | U | < 0.0161 | U | < 0.0161 | U | < 0.0161 | U | < 0.0161 | U | < 0.0161 | U | < 0.0161 | U | < 0.0161 | U | < 0.0161 | U | < 0.0161 | U | < 0.0333 | U | < 0.0161 | U | < 0.0161 | U | < 0.310 | U | - | |
| | RHMW03-WG15 | 5/13/2009[a] | < 0.0152 | U | < 0.0152 | U | < 0.0152 | U | < 0.0152 | U | < 0.0152 | U | < 0.0152 | U | < 0.0152 | U | < 0.0152 | U | < 0.0152 | U | < 0.0152 | U | < 0.0152 | U | < 0.0152 | U | < 0.0313 | U | < 0.0152 | U | < 0.0152 | U | < 0.310 | U | - | |
| | RHMW03-WG16 | 7/15/2009[a] | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0326 | U | < 0.0158 | U | < 0.0158 | U | < 0.310 | U | - | |
| | RHMW03-WG17 | 10/14/2009[a] | < 0.0169 | U | < 0.0169 | U | < 0.0169 | U | < 0.0169 | U | < 0.0169 | U | < 0.0169 | U | < 0.0169 | U | < 0.0169 | U | < 0.0169 | U | < 0.0169 | U | < 0.0169 | U | < 0.0169 | U | < 0.0348 | U | < 0.0169 | U | < 0.0169 | U | < 0.31 | U | - | |
| | RHMW03-WG18 | 1/27/2010 | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0666 | U | < 0.0322 | U | < 0.0322 | U | < 0.620 | U | - | |
| | RHMW03-WG19 | 4/13/2010 | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0666 | U | < 0.0322 | U | < 0.0322 | U | < 0.620 | U | - | |
| | RHMW03-WG20 | 7/13/2010 | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0322 | U | < 0.0666 | U | < 0.0322 | U | < 0.0322 | U | < 0.620 | U | - | |
| | ES001 | 10/18/2010 | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | **0.28** | **J** | - | |
| | ES012 | 1/19/2011 | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | < 0.22 | U | - | |
| | ES025 | 4/20/2011 | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | < 0.22 | U | - | |
| | ES035 | 7/19/2011 | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | **0.33** | **J** | - | |
| | ES049 | 10/24/2011 | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | **0.22** | **J** | - | |
| | ES060 | 1/26/2012 | < 0.14 | U | < 0.16 | U | < 0.12 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | **0.14** | **J** | - | |
| | ES073 | 4/16/2012 | < 0.14 | U | < 0.16 | U | < 0.12 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | **1.4** | | - | |
| | ES081 | 7/18/2012 | < 0.14 | U | < 0.16 | U | < 0.12 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | < 0.22 | U | - | |
| | ES004 | 10/22/2012 | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | **0.029** | **J** | < 0.050 | U | < 0.050 | U | < 0.200 | U | - | |
| | ES013 | 1/28/2013 | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | **0.10** | **J** | **0.069** | **J** | **0.32** | | < 0.050 | U | < 0.050 | U | < 0.200 | U | - | |
| | ES022 | 4/22/2013 | < 0.053 | U | < 0.053 | U | < 0.053 | U | < 0.053 | U | < 0.053 | U | < 0.053 | U | < 0.053 | U | < 0.053 | U | < 0.053 | U | < 0.053 | U | < 0.053 | U | < 0.053 | U | < 0.053 | U | < 0.053 | U | < 0.053 | U | < 0.200 | U | - | |
| | ES031 | 7/22/2013 | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | **0.064** | **J** | < 0.050 | U | < 0.050 | U | < 0.200 | U | - | |
| | ES040 | 10/21/2013 | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.200 | U | - | |
| | ES059 | 1/28/2014 | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | **0.15** | **J** | <0.050 | U | <0.050 | U | <0.200 | U | - | |
| | ES083 | 4/21/2014 | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | **0.11** | **J** | <0.049 | U | <0.049 | U | <0.200 | U | - | |
| | ES106 | 7/22/2014 | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.200 | U | - | |
| | ES116 | 10/27/2014 | <0.054 | U | <0.11 | U | <0.054 | U | <0.054 | U | <0.054 | U | <0.054 | U | <0.054 | U | <0.054 | U | <0.054 | U | <0.054 | U | <0.11 | U | <0.054 | U | <0.054 | U | <0.054 | U | <0.054 | U | <0.200 | U | - | |
| | ES123 | 1/28/2015 | <0.048 | U | <0.097 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.097 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.200 | U | - | |
| | ES133 | 4/20/2015 | **0.0037** | **B,J** | <0.0053 | U | <0.0053 | U | <0.0053 | U | <0.0053 | U | <0.0053 | U | <0.0053 | U | <0.021 | U | <0.0053 | U | <0.0053 | U | **0.015** | **J** | **0.0083** | **J** | **0.035** | **J** | **0.0058** | **J** | <0.011 | U | **0.011** | **J** | - | |
| | ES148 | 7/20/2015 | **0.0043** | **J** | <0.0052 | U | <0.0052 | U | <0.0052 | U | <0.0052 | U | <0.0052 | U | <0.0052 | U | <0.021 | U | <0.0052 | U | <0.0052 | U | <0.0052 | U | <0.0052 | U | <0.0052 | U | **0.0057** | **J** | <0.011 | U | **0.030** | | - | |
| | ERH014 | 10/20/2015 | <0.0050 | B,U | <0.0050 | B,U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | B,U | <0.020 | U | <0.0050 | U | <0.0050 | B,U | **0.0039** | **J** | **0.0034** | **B,J** | **0.0094** | **B,J** | <0.0057 | U | <0.011 | U | **0.122** | | - | |
| | ERH026 | 1/20/2016 | **0.0064** | **J** | < 0.0050 | U | < 0.0050 | U | **0.0042** | **J** | < 0.0050 | U | **0.0065** | **J** | < 0.0050 | U | < 0.020 | U | < 0.0050 | U | **0.0026** | **J** | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | **0.0074** | **J** | **0.0086** | **J** | **0.093** | | - | - |

| Well Name | Sample ID | Date Sampled | 8015 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | TPH-d | | TPH-g | | TPH-o | | TPH-g | | 1,1,1-Trichloroethane | | 1,1,2-Trichloroethane | | 1,1-Dichloroethane | | 1,1-Dichloroethylene | | 1,2,3-Trichloropropane | | 1,2,4-Tricholorobenzene | | 1,2-Dibromo-3-chloropropane | | 1,2-Dibromoethane | | 1,2-Dichlorobenzene | | 1,2-Dichloroethane | | 1,2-Dichloropropane | | 1,3-Dichlorobenzene | | 1,3-Dichloropropene (total of cis/trans) | | 1,4-Dichlorobenzene | | Acetone | | Benzene | | Bromodichloromethane | |
| | | | (µg/l) | | (µg/l) | | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| **For wells > 150 m from surface water** | **-** | **-** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations > 150m from surface water)** | **-** | **-** | **100** | | **100** | | **100** | | **100** | | **200** | | **5.0** | | **2.4** | | **7.0** | | **0.6** | | **70** | | **0.04** | | **0.04** | | **10** | | **0.15** | | **5.0** | | **5.0** | | **0.43** | | **5.0** | | **1500** | | **5.0** | | **0.12** | |
| **RHMW05 101.55' TOC ELEV** | RHMW05-WG15 | 5/13/2009[a] | **200** | **J** | **13.2** | **J** | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | **10.4** | | < 0.120 | U | < 0.150 | U |
| | RHMW05-WG16 | 7/15/2009[a] | **491** | | < 30.0 | U | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | **65.0** | | < 0.120 | U | < 0.150 | U |
| | RHMW05-WG17 | 10/13/2009[ad] | **673** | | < 30 | U | - | | - | | < 0.31 | U | < 0.31 | U | < 0.31 | U | <0.31 | U | < 0.31 | U | < 0.31 | U | < 0.62 | U | < 0.31 | U | < 0.31 | U | < 0.15 | U | < 0.31 | U | < 0.31 | U | < 0.15 | U | < 0.15 | U | < 3.1 | U | < 0.12 | U | < 0.15 | U |
| | RHMW05-WG18 | 1/26/2010 | **2,060** | | < 60.0 | U | - | | - | | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 6.20 | U | < 0.240 | U | < 0.300 | U |
| | RHMW05-WG19 | 4/13/2010 | < 300 | U | < 60.0 | U | - | | - | | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 6.20 | U | < 0.240 | U | < 0.300 | U |
| | RHMW05-WG20 | 7/13/2010 | < 320 | U | < 60.0 | U | - | | - | | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | - | | < 0.240 | U | < 0.300 | U |
| | ES005 | 10/20/2010 | < 80.8 | U | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES013 | 1/19/2011 | < 80.8 | U | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES024 | 4/20/2011 | < 80.8 | U | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES039 | 7/19/2011 | < 80.8 | U | - | | < 212.0 | U | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES051 | 10/25/2011 | < 80.8 | U | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES063 | 2/1/2012 | < 80.8 | U | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES070 | 4/16/2012 | < 80.8 | U | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES079 | 7/17/2012 | < 80.8 | U | - | | < 212.0 | U | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | <0.50 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES080 | 7/17/2012* | < 80.8 | U | - | | < 212.0 | U | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | <0.50 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES005 | 10/22/2012 | **17** | **J,HD** | - | | - | | **15** | **B,J** | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U | < 0.50 | U | < 0.50 | U |
| | ES015 | 1/29/2013 | **62** | **HD** | - | | - | | < 30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 10 | IJ,ICH,U | < 0.50 | U | < 0.50 | U |
| | ES024 | 4/23/2013 | **27** | **J** | - | | - | | **15** | **J** | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U | < 0.50 | U | < 0.50 | U |
| | ES033 | 7/23/2013 | < 20 | U | - | | - | | < 30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U | < 0.50 | U | < 0.50 | U |
| | ES042 | 10/22/2013 | < 20 | U | - | | - | | **17** | **B,J** | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U,ICH | < 0.50 | U | < 0.50 | U |
| | ES049 | 1/16/2014 | < 20 | U | - | | - | | **-** | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U,ICH | < 0.50 | U | < 0.50 | U |
| | ES061 | 1/29/2014 | **16** | **J,HD** | - | | - | | **23** | **B,J** | <0.50 | U,IH | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U,IH | < 0.50 | U | < 0.50 | U |
| | ES068 | 3/6/2014 | <21 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U | - | |
| | ES076 | 3/26/2014 | **17** | **J,HD** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U | - | |
| | ES084 | 4/22/2014 | <10 | U | - | | - | | < 30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U,ICH | < 0.50 | U | < 0.50 | U |
| | ES095 | 5/28/2014 | <12 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U | - | |
| | ES101 | 6/24/2014 | <12 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U | - | |
| | ES108 | 7/22/2014 | <12 | U | - | | - | | < 30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U,ICH | < 0.50 | U | < 0.50 | U |
| | ES118 | 10/28/2014 | **16** | **J,HD** | - | | - | | < 30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U,ICH | < 0.50 | U | < 0.50 | U |
| | ES124 | 1/27/2015 | <13 | U | - | | - | | < 30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U | < 0.50 | U | < 0.50 | U |
| | ES135 | 4/21/2015 | **17** | **B,J** | <25 | U | **34** | **B,J** | - | | <0.20 | U | <0.40 | U | <0.20 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.80 | U | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <10 | U | <0.10 | U | - | |
| | ES142 | 6/25/2015 | **15** | **J** | - | | **41** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES150 | 7/21/2015 | **18** | **J** | <25 | U | **44** | **J** | - | | <0.20 | U | <0.40 | U | <0.20 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.80 | U | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <10 | U | <0.10 | U | - | |
| | ERH010 | 10/20/2015 | **20** | **B,J** | <25 | U | <54 | B,U | - | | <0.20 | U,** | <0.40 | U,** | <0.20 | U,** | <0.20 | U,** | <0.50 | U,** | <0.30 | U,** | <0.80 | U,** | <0.20 | U,** | <0.20 | U,** | - | | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <10 | U,** | <0.10 | U,** | - | |
| | ERH022 | 1/20/2016 | **27** | **B,J** | < 25 | U | **45** | **B,J** | - | - | < 0.20 | U | < 0.40 | U | < 0.20 | U | < 0.20 | U | < 0.50 | U | < 0.30 | U | < 0.80 | U | < 0.20 | U | < 0.20 | U | - | - | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | **3.9** | **J** | < 0.10 | U | - | - |
| | ERH023 | 1/20/2016 | **26** | **B,J** | < 25 | U | **44** | **B,J** | - | - | < 0.20 | U | < 0.40 | U | < 0.20 | U | < 0.20 | U | < 0.50 | U | < 0.30 | U | < 0.80 | U | < 0.20 | U | < 0.20 | U | - | - | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 10 | U | < 0.10 | U | - | - |

| Well Name | Sample ID | Date Sampled | 8260B | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Bromoform | | Bromomethane | | Carbon Tetrachloride | | Chlorobenzene | | Chloroethane | | Chloroform | | Chloromethane | | cis-1,2-Dichloroethylene | | Dibromochloromethane | | Ethylbenzene | | Hexachlorobutadiene | | Methyl ethyl ketone (2-Butanone) | | Methyl isobutyl ketone (4-Methyl-2-Pentanone) | | Methyl tert-butyl Ether | | Methylene chloride | | Naphthalene | | Styrene | | Tetrachloroethane, 1,1,1,2- | | Tetrachloroethane, 1,1,2,2- | | Tetrachloroethylene | | Toluene | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| For wells > 150 m from surface water | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| DOH Tier 1 EALs (for locations > 150m from surface water) | - | - | 80 | | 8.7 | | 5.0 | | 50 | | 16 | | 70 | | 1.8 | | 70 | | 0.16 | | 30 | | 0.86 | | 7,100 | | 170 | | 5.0 | | 4.8 | | 17 | | 10 | | 0.52 | | 0.067 | | 5.0 | | 40 | |
| RHMW05<br>101.55' TOC ELEV | RHMW05-WG15 | 5/13/2009[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | < 0.620 | U | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW05-WG16 | 7/15/2009[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | < 0.620 | U | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW05-WG17 | 10/13/2009[ad] | < 0.31 | U | < 0.94 | U | < 0.31 | U | < 0.15 | U | < 0.31 | U | < 0.3 | U | < 0.31 | U | < 0.31 | U | < 0.15 | U | < 0.31 | U | < 0.31 | U | < 3.1 | U | < 3.1 | U | - | | < 1 | U | < 0.62 | U | < 0.31 | U | < 0.15 | U | < 0.15 | U | < 0.31 | U | < 0.31 | U |
| | RHMW05-WG18 | 1/26/2010 | < 0.620 | U | < 1.88 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.600 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 6.20 | U | < 6.20 | U | < 3.00 | U | < 2.00 | U | < 1.24 | U | < 0.620 | U | < 0.300 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U |
| | RHMW05-WG19 | 4/13/2010 | < 0.620 | U | < 1.88 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.600 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 6.20 | U | < 6.20 | U | < 3.00 | U | < 2.00 | U | < 1.24 | U | < 0.620 | U | < 0.300 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U |
| | RHMW05-WG20 | 7/13/2010 | < 0.620 | U | < 1.88 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.600 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 6.20 | U | < 6.20 | U | < 3.00 | U | < 2.00 | U | < 1.24 | U | < 0.620 | U | < 0.300 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U |
| | ES005 | 10/20/2010 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.62 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.38 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.30 | U | < 0.34 | U |
| | ES013 | 1/19/2011 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.62 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.38 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.30 | U | < 0.34 | U |
| | ES024 | 4/20/2011 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.62 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.38 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.30 | U | < 0.34 | U |
| | ES039 | 7/19/2011 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.62 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.38 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.30 | U | < 0.34 | U |
| | ES051 | 10/25/2011 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.84 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.52 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.48 | U | < 0.34 | U |
| | ES063 | 2/1/2012 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.84 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.52 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.48 | U | < 0.34 | U |
| | ES070 | 4/16/2012 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.84 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.52 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.48 | U | < 0.34 | U |
| | ES079 | 7/17/2012 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.84 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.52 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.48 | U | < 0.34 | U |
| | ES080 | 7/17/2012* | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.84 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.52 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.48 | U | < 0.34 | U |
| | ES005 | 10/22/2012 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 5.0 | IH,U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.31** | **J** |
| | ES015 | 1/29/2013 | < 2.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES024 | 4/23/2013 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES033 | 7/23/2013 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES042 | 10/22/2013 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U,IJ | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U,ICH | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES049 | 1/16/2014 | < 1.0 | U | < 5.0 | U,ICJ | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U,IJ | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U,IJ | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES061 | 1/29/2014 | < 1.0 | U | < 5.0 | U | < 0.50 | U,IH | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES068 | 3/6/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U |
| | ES076 | 3/26/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U |
| | ES084 | 4/22/2014 | < 1.0 | U | < 5.0 | U,ICJ | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES095 | 5/28/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U |
| | ES101 | 6/24/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U |
| | ES108 | 7/22/2014 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U,IJ | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES118 | 10/28/2014 | < 1.0 | U | < 5.0 | U,IJ | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES124 | 1/27/2015 | < 1.0 | U | < 5.0 | U,IH | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES135 | 4/21/2015 | <0.50 | U | <0.30 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | - | | <0.10 | U | <0.30 | U | <4.0 | U | <10 | U | <0.30 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.10 | U |
| | ES142 | 6/25/2015 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES150 | 7/21/2015 | <0.50 | U | <0.30 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | - | | <0.10 | U | <0.30 | U | <4.0 | U | <10 | U | <0.30 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.10 | U |
| | ERH010 | 10/20/2015 | <0.50 | U,** | <0.30 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | - | | <0.10 | U,** | <0.30 | U,** | <4.0 | U,** | <10 | U,** | <0.30 | U,** | <0.20 | U,J,** | - | | <0.20 | U,** | <0.20 | U,** | - | | <0.20 | U,** | **0.59** | **, Tb |
| | ERH022 | 1/20/2016 | < 0.50 | U | < 0.30 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | - | - | < 0.10 | U | < 0.30 | U | < 4.0 | U | < 10 | U | < 0.30 | U | < 0.20 | B,U | - | - | < 0.20 | U | < 0.20 | U | < 15 | U | < 0.20 | U | **0.18** | **Tb,J** |
| | ERH023 | 1/20/2016 | < 0.50 | U | < 0.30 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | - | - | < 0.10 | U | < 0.30 | U | < 4.0 | U | < 10 | U | < 0.30 | U | < 0.20 | B,U | - | - | < 0.20 | U | < 0.20 | U | < 15 | U | < 0.20 | U | **0.12** | **Tb,J** |

| Well Name | Sample ID | Date Sampled | | | | | | | | | 504.1 | | 8260SIM | | | | | | | | | | 8011 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | trans-1,2-Dichloroethylene | | Trichloroethylene | | Vinyl chloride | | Xylenes, Total (p/m-, o-xylene) | | 1,2-Dibromoethane | | 1,2-Dibromoethane | | 1,2-Dichloroethane | | Bromodichloromethane | | Dibromochloromethane | | Tetrachloroethane, 1,1,2,2- | | 1,2-Dibromo-3-chloropropane | | 1,2-Dibromoethane | | Acenaphthene | | Acenaphthylene | | Anthracene | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| **For wells > 150 m from surface water** | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations > 150m from surface water)** | - | - | **100** | | **5.0** | | **2.0** | | **20** | | **0.04** | | **0.04** | | **0.15** | | **0.12** | | **0.16** | | **0.067** | | **0.04** | | **0.04** | | **20** | | **240** | | **22** | |
| **RHMW05<br>101.55' TOC ELEV** | RHMW05-WG15 | 5/13/2009[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U |
| | RHMW05-WG16 | 7/15/2009[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U |
| | RHMW05-WG17 | 10/13/2009[ad] | < 0.31 | U | < 0.31 | U | < 0.31 | U | < 1 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.017 | U | < 0.017 | U | < 0.017 | U |
| | RHMW05-WG18 | 1/26/2010 | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0344 | U | < 0.0344 | U | < 0.0344 | U |
| | RHMW05-WG19 | 4/13/2010 | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0326 | U | < 0.0326 | U | < 0.0326 | U |
| | RHMW05-WG20 | 7/13/2010 | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U |
| | ES005 | 10/20/2010 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES013 | 1/19/2011 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES024 | 4/20/2011 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES039 | 7/19/2011 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES051 | 10/25/2011 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES063 | 2/1/2012 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES070 | 4/16/2012 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES079 | 7/17/2012 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES080 | 7/17/2012* | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES005 | 10/22/2012 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.050 | U | < 0.050 | U | < 0.050 | U |
| | ES015 | 1/29/2013 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.050 | U | < 0.050 | U | < 0.050 | U |
| | ES024 | 4/23/2013 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.048 | U | < 0.048 | U | < 0.048 | U |
| | ES033 | 7/23/2013 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.051 | U | < 0.051 | U | < 0.051 | U |
| | ES042 | 10/22/2013 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.051 | U | < 0.051 | U | < 0.051 | U |
| | ES049 | 1/16/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES061 | 1/29/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | <0.050 | U | <0.050 | U | <0.050 | U |
| | ES068 | 3/6/2014 | - | | - | | - | | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES076 | 3/26/2014 | - | | - | | - | | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES084 | 4/22/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | <0.051 | U | <0.051 | U | <0.051 | U |
| | ES095 | 5/28/2014 | - | | - | | - | | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES101 | 6/24/2014 | - | | - | | - | | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES108 | 7/22/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | <0.049 | U | <0.049 | U | <0.049 | U |
| | ES118 | 10/28/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | <0.048 | U | <0.048 | U | <0.048 | U |
| | ES124 | 1/27/2015 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | <0.048 | U | <0.048 | U | <0.048 | U |
| | ES135 | 4/21/2015 | <0.20 | U | <0.10 | U | <0.10 | U | <0.20 | U | - | | <0.010 | U | <0.015 | U | <0.010 | U | <0.010 | U | <0.015 | U | <0.0040 | U | <0.0040 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U |
| | ES142 | 6/25/2015 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES150 | 7/21/2015 | <0.20 | U | <0.10 | U | <0.10 | U | <0.20 | U | - | | - | | <0.015 | U | <0.010 | U | <0.010 | U | <0.015 | U | <0.0040 | U | <0.0040 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U |
| | ERH010 | 10/20/2015 | <0.20 | U,** | <0.10 | U,** | <0.10 | U,** | <0.20 | U,** | - | | - | | <0.015 | U | - | U | <0.010 | U | <0.015 | U | - | U | <0.0040 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U |
| | ERH022 | 1/20/2016 | < 0.20 | U | < 0.10 | U | < 0.10 | U | < 0.20 | U | - | - | - | - | < 0.015 | U | < 0.010 | U | < 0.010 | U | - | - | - | - | < 0.0040 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U |
| | ERH023 | 1/20/2016 | < 0.20 | U | < 0.10 | U | < 0.10 | U | < 0.20 | U | - | - | - | - | < 0.015 | U | < 0.010 | U | < 0.010 | U | - | - | - | - | < 0.0040 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U |

| | | | 8270C | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 6020 | | 6010B/6020/200.8 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Well Name** | **Sample ID** | **Date Sampled** | **Benzo[a]anthracene** | | **Benzo[g,h,i]perylene** | | **Benzo[a]pyrene** | | **Benzo[b]fluoranthene** | | **Benzo[k]fluoranthene** | | **Chrysene** | | **Dibenz[a,h]anthracene** | | **Fluoranthene** | | **Fluorene** | | **Indeno[1,2,3-cd]pyrene** | | **1-Methylnaphthalene** | | **2-Methylnaphthalene** | | **Naphthalene** | | **Phenanthrene** | | **Pyrene** | | **Dissolved Lead (filtered)** | | **Total Lead (unfiltered)** | |
| | | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | |
| **For wells > 150 m from surface water** | **-** | **-** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations > 150m from surface water)** | **-** | **-** | **0.092** | | **0.13** | | **0.20** | | **0.092** | | **0.40** | | **1.0** | | **0.0092** | | **130** | | **240** | | **0.092** | | **4.7** | | **10** | | **17** | | **240** | | **68** | | **15** | | **-** | |
| **RHMW05<br>101.55' TOC ELEV** | RHMW05-WG15 | 5/13/2009[a] | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0158 | U | < 0.0326 | U | < 0.0158 | U | < 0.0158 | U | < 0.310 | U | - | |
| | RHMW05-WG16 | 7/15/2009[a] | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0341 | U | < 0.0165 | U | < 0.0165 | U | < 0.310 | U | - | |
| | RHMW05-WG17 | 10/13/2009[ad] | < 0.017 | U | < 0.017 | U | < 0.017 | U | < 0.017 | U | < 0.017 | U | < 0.017 | U | < 0.017 | U | < 0.017 | U | < 0.017 | U | < 0.017 | U | < 0.017 | U | < 0.017 | U | < 0.0352 | U | < 0.017 | U | **0.0173** | **F** | < 0.31 | U | - | |
| | RHMW05-WG18 | 1/26/2010 | < 0.0344 | U | < 0.0344 | U | < 0.0344 | U | < 0.0344 | U | < 0.0344 | U | < 0.0344 | U | < 0.0344 | U | **0.0190** | **J** | < 0.0344 | U | < 0.0344 | U | **0.0207** | **J** | **0.0246** | **J** | < 0.0712 | U | **0.0182** | **J** | < 0.0344 | U | < 0.620 | U | - | |
| | RHMW05-WG19 | 4/13/2010 | < 0.0326 | U | < 0.0326 | U | < 0.0326 | U | < 0.0326 | U | < 0.0326 | U | < 0.0326 | U | < 0.0326 | U | < 0.0326 | U | < 0.0326 | U | < 0.0326 | U | **0.0335** | **J** | < 0.0326 | U | **0.0752** | **J** | < 0.0326 | U | < 0.0326 | U | < 0.620 | U | - | |
| | RHMW05-WG20 | 7/13/2010 | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U | **0.0643** | **J** | < 0.0316 | U | < 0.0316 | U | < 0.620 | U | - | |
| | ES005 | 10/20/2010 | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | < 0.22 | U | - | |
| | ES013 | 1/19/2011 | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | < 0.22 | U | - | |
| | ES024 | 4/20/2011 | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | < 0.22 | U | - | |
| | ES039 | 7/19/2011 | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | **0.24** | **J** | - | |
| | ES051 | 10/25/2011 | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | < 0.22 | U | - | |
| | ES063 | 2/1/2012 | < 0.14 | U | < 0.16 | U | < 0.12 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | < 0.22 | U | - | |
| | ES070 | 4/16/2012 | < 0.14 | U | < 0.16 | U | < 0.12 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | < 0.22 | U | - | |
| | ES079 | 7/17/2012 | < 0.14 | U | < 0.16 | U | < 0.12 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | **0.17** | **J** | - | |
| | ES080 | 7/17/2012* | < 0.14 | U | < 0.16 | U | < 0.12 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | **0.21** | **J** | - | |
| | ES005 | 10/22/2012 | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | **0.038** | **J** | < 0.050 | U | < 0.050 | U | < 0.200 | U | - | |
| | ES015 | 1/29/2013 | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | **0.075** | **J** | < 0.050 | U | < 0.050 | U | < 0.200 | U | - | |
| | ES024 | 4/23/2013 | < 0.048 | U | < 0.048 | U | < 0.048 | U | < 0.048 | U | < 0.048 | U | < 0.048 | U | < 0.048 | U | < 0.048 | U | < 0.048 | U | < 0.048 | U | < 0.048 | U | < 0.048 | U | **0.033** | **J** | < 0.048 | U | < 0.048 | U | < 0.200 | U | - | |
| | ES033 | 7/23/2013 | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | **0.033** | **J** | < 0.051 | U | < 0.051 | U | < 0.200 | U | - | |
| | ES042 | 10/22/2013 | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | **0.17** | **J** | < 0.051 | U | < 0.051 | U | < 0.200 | U | - | |
| | ES049 | 1/16/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.050 | U | < 0.050 | U | < 0.050 | U | - | | - | | **-** | | - | |
| | ES061 | 1/29/2014 | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | **0.064** | **J** | <0.050 | U | <0.050 | U | <0.200 | U | - | |
| | ES068 | 3/6/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.050 | U | <0.050 | U | **0.038** | **J** | - | | - | | <0.200 | U | - | |
| | ES076 | 3/26/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.050 | U | <0.050 | U | **0.092** | **J** | - | | - | | **0.286** | **J** | - | |
| | ES084 | 4/22/2014 | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | **0.066** | **J** | <0.051 | U | <0.051 | U | **0.123** | **J** | - | |
| | ES095 | 5/28/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.049 | U | <0.049 | U | <0.049 | U | - | | - | | <0.200 | U | - | |
| | ES101 | 6/24/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.051 | U | <0.051 | U | <0.051 | U | - | | - | | <0.200 | U | - | |
| | ES108 | 7/22/2014 | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.200 | U | - | |
| | ES118 | 10/28/2014 | <0.048 | U | <0.096 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.096 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.200 | U | - | |
| | ES124 | 1/27/2015 | <0.048 | U | <0.096 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.096 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.200 | U | - | |
| | ES135 | 4/21/2015 | **0.0038** | **B,J** | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.020 | U | <0.0050 | U | <0.0050 | U | <0.0050 | UJ | <0.0050 | UJ | <0.0050 | UJ | **0.0052** | **J** | <0.010 | U | **0.032** | | - | |
| | ES142 | 6/25/2015 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | **0.0046** | **J** | **0.0029** | **J** | <0.0050 | U | - | | - | | - | | - | |
| | ES150 | 7/21/2015 | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.020 | U | <0.0050 | U | <0.0050 | U | **0.0041** | **J** | **0.0036** | **J** | **0.0058** | **J** | <0.0050 | U | <0.010 | U | **0.050** | | - | |
| | ERH010 | 10/20/2015 | <0.0050 | B,U | <0.0050 | B,U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | B,U | <0.020 | U | <0.0050 | U | <0.0050 | B,U | **0.0050** | **J** | **0.0066** | **B,J** | **0.0074** | **B,J** | <0.0050 | U | <0.010 | U | **0.103** | | - | |
| | ERH022 | 1/20/2016 | **0.0028** | **J** | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.020 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | **0.0031** | **J** | < 0.0050 | U | < 0.0050 | U | < 0.010 | U | **0.018** | | - | - |
| | ERH023 | 1/20/2016 | **0.0028** | **J** | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.020 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | **0.0039** | **J** | **0.0046** | **J** | < 0.0050 | U | < 0.010 | U | **0.026** | | - | - |

| | | | 8015 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Well Name** | **Sample ID** | **Date Sampled** | **TPH-d** | | **TPH-g** | | **TPH-o** | | **TPH-g** | | **1,1,1-Trichloroethane** | | **1,1,2-Trichloroethane** | | **1,1-Dichloroethane** | | **1,1-Dichloroethylene** | | **1,2,3-Trichloropropane** | | **1,2,4-Tricholorobenzene** | | **1,2-Dibromo-3-chloropropane** | | **1,2-Dibromoethane** | | **1,2-Dichlorobenzene** | | **1,2-Dichloroethane** | | **1,2-Dichloropropane** | | **1,3-Dichlorobenzene** | | **1,3-Dichloropropene (total of cis/trans)** | | **1,4-Dichlorobenzene** | | **Acetone** | | **Benzene** | | **Bromodichloromethane** | |
| | | | **(µg/l)** | | **(µg/l)** | | | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | |
| **For wells < 150 m from surface water** | **-** | **-** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations < 150m from surface water)** | **-** | **-** | **100** | | **100** | | **100** | | **100** | | **62** | | **5.0** | | **2.4** | | **7.0** | | **0.6** | | **25** | | **0.04** | | **0.04** | | **10** | | **0.15** | | **5.0** | | **5.0** | | **0.43** | | **5.0** | | **1500** | | **5.0** | | **0.12** | |
| **RHMW2254-01** | RH-B-001 | 2/16/2005[be] | <50 | U | <50 | U | <100 | U | - | | - | | - | | - | | - | | - | | - | | - | | <0.0083 | U | - | | <0.50 | U | - | | - | | - | | - | | - | | <0.50 | U | - | |
| | RH-B-002 | 2/16/2005[bf] | <53 | U | <50 | U | <110 | U | - | | - | | - | | - | | - | | - | | - | | - | | <0.0081 | U | - | | <0.50 | U | - | | - | | - | | - | | - | | <0.50 | U | - | |
| | RH-B-003 | 2/16/2005*[bf] | <50 | U | <50 | U | <100 | U | - | | - | | - | | - | | - | | - | | - | | - | | <0.0082 | U | - | | <0.50 | U | - | | - | | - | | - | | - | | <0.50 | U | - | |
| | RH-B-004 | 6/28/2005[ae] | **43** | **J** | <13 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | 0.00096 | U | - | | <0.50[b] | U | - | | - | | - | | - | | - | | <0.50[b] | U | - | |
| | RH-B-005 | 6/28/2005*[ae] | **67** | **Z** | <13 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | 0.00096 | U | - | | <0.50[b] | U | - | | - | | - | | - | | - | | <0.50[b] | U | - | |
| | RH-B-006 | 6/28/2005*[af] | **58** | **Z** | <13 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | 0.00096 | U | - | | <0.50[b] | U | - | | - | | - | | - | | - | | <0.50[b] | U | - | |
| | RH-B-007 | 9/8/2005[ae] | **45** | **J** | <13 | U | **59** | **J** | - | | - | | - | | - | | - | | - | | - | | - | | 0.00096 | U | - | | <0.12 | U | - | | - | | - | | - | | - | | <0.14 | U | - | |
| | RH-B-008 | 9/8/2005[af] | <50 | U | <13 | U | <28 | U | - | | - | | - | | - | | - | | - | | - | | - | | 0.00096 | U | - | | <0.12 | U | - | | - | | - | | - | | - | | <0.14 | U | - | |
| | RH-B-009 | 9/8/2005*[af] | <50[d] | U | <13 | U | <100[d] | U | - | | - | | - | | - | | - | | - | | - | | - | | 0.00096 | U | - | | <0.12 | U | - | | - | | - | | - | | - | | <0.14 | U | - | |
| | RHMW2254W01 | 9/20/2005[bd] | - | | - | | - | | - | | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.30 | U | <0.50 | U | <5.0 | U | < 0.50 | U | <0.50 | U |
| | RH-B-010 | 12/6/2005[ae] | **38** | **J** | <13 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.0096[b] | U | - | | <0.12 | U | - | | - | | - | | - | | - | | <0.14 | U | - | |
| | RH-B-011 | 12/6/2005*[ae] | **24** | **J** | <13 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.0094[b] | U | - | | <0.12 | U | - | | - | | - | | - | | - | | <0.14 | U | - | |
| | RH-B-012 | 12/7/2005[af] | <20 | U | <13 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.0095[b] | U | - | | <0.12 | U | - | | - | | - | | - | | - | | <0.14 | U | - | |
| | RHMW2254-01-GW02 | 7/10/2006[ad] | < 110 | U | < 50 | U | - | | - | | < 0.50 | U | <0.50 | U | <0.50 | U | < 0.50 | U | <1.0 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.30 | U | <0.50 | U | <5.0 | U | < 0.50 | U | <0.50 | U |
| | RHMW2254-01-GW06 | 12/5/2006[ad] | < 100 | U | < 50 | U | - | | - | | < 0.50 | U | <0.50 | U | <0.50 | U | < 0.50 | U | <1.0 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.30 | U | <0.50 | U | <5.0 | U | < 0.50 | U | <0.50 | U |
| | RHMW2254-01-WG07 | 3/27/2007[a] | < 98 | U | < 50 | U | - | | - | | < 0.50 | U | < 0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | < 0.5 | U | <1.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | < 0.50 | U | <0.50 | U | <0.30 | U | <0.50 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U |
| | RHMW2254-01-WG08 | 6/12/2007[a] | < 98 | U | < 50 | U | - | | - | | < 0.50 | U | < 0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | < 0.5 | U | <1.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | < 0.50 | U | <0.50 | U | <0.30 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U |
| | RHMW2254-01-WG0 | 9/10/2007[a] | < 97 | U | < 50 | U | - | | - | | <0.29 | U | < 0.30 | U | <0.25 | U | <0.23 | U | <0.50 | U | **0.24** | **J** | < 0.41 | U | <0.20 | U | <0.20 | U | <0.20 | U | < 0.25 | U | < 0.23 | U | <0.24 | U | < 0.22 | U | < 10.0 | U | < 0.20 | U | < 0.29 | U |
| | RHMW2254-01-WG10 | 1/15/2008[a] | < 102 | U | < 10.0 | U | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | - | | < 0.120 | U | < 0.150 | U |
| | RHMW2254-01-WG10.1 | 2/6/2008[a] | < 100 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | RHMW2254-01-WG10.1 | 2/6/2008[a] | < 10.3 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | RHMW2254-01-WG11 | 4/15/2008[a] | < 86.0 | U | < 10.0 | U | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | < 0.120 | U | < 0.150 | U |
| | RHMW2254-01-WG12 | 7/29/2008[a] | < 83.3 | U | < 10.0 | U | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | < 0.120 | U | < 0.150 | U |
| | RHMW2254-01-WG13 | 10/22/2008[a] | < 84.2 | U | < 10.0 | U | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | < 0.120 | U | < 0.150 | U |
| | RHMW2254-WG13B | 12/16/2008[c] | - | | - | | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.46 | U | < 0.150 | U | < 3.10 | U | < 0.120 | U | < 0.150 | U |
| | RHMWA01-WG13B | 12/16/2008*[c] | - | | - | | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.46 | U | < 0.150 | U | < 3.10 | U | < 0.120 | U | < 0.150 | U |
| | RHMW2254-01-WG14 | 2/4/2009[a] | < 92.0 | U | **14.0** | **J** | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | < 0.120 | U | < 0.150 | U |
| | RHMW2254-01-WG15 | 5/13/2009[a] | < 169 | U | **19.1** | **J** | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | < 0.120 | U | < 0.150 | U |
| | RHMW2254-01-WG16 | 7/15/2009[a] | < 163 | U | < 30.0 | U | - | | - | | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 3.10 | U | < 0.120 | U | < 0.150 | U |
| | RHMW2254-WG17 | 10/14/2009[a] | < 158 | U | < 30 | U | - | | - | | < 0.31 | U | < 0.31 | U | < 0.31 | U | <0.31 | U | < 0.31 | U | < 0.31 | U | < 0.62 | U | < 0.31 | U | < 0.31 | U | < 0.15 | U | < 0.31 | U | < 0.31 | U | < 0.15 | U | < 0.15 | U | < 3.1 | U | < 0.12 | U | < 0.15 | U |
| | RHMW2254-01-WG18 | 1/27/2010 | < 320 | U | < 60.0 | U | - | | - | | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 6.20 | U | < 0.240 | U | < 0.300 | U |
| | RHMW2254-01-WG19 | 4/13/2010 | < 320 | U | < 60.0 | U | - | | - | | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 6.20 | U | < 0.240 | U | < 0.300 | U |
| | RHMW2254-01-WG20 | 7/13/2010 | < 320 | U | < 60.0 | U | - | | - | | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | - | | < 0.240 | U | < 0.300 | U |
| | ES004 | 10/19/2010 | < 80.0 | U | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES014 | 1/20/2011 | < 80.8 | U | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES019 | 4/19/2011 | < 80.8 | U | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES040 | 7/20/2011 | < 80.8 | U | - | | < 212.0 | U | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES050 | 10/25/2011 | < 80.8 | U | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES062 | 2/1/2012 | < 80.8 | U | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES074 | 4/17/2012 | < 80.8 | U | - | | - | | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | < 0.36 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES077 | 7/17/2012 | < 80.8 | U | - | | < 212.0 | U | < 12.12 | U | < 0.28 | U | < 0.40 | U | < 0.38 | U | < 0.60 | U | < 0.78 | U | < 0.42 | U | < 1.52 | U | < 0.40 | U | < 0.34 | U | < 0.28 | U | < 0.34 | U | < 0.22 | U | <0.50 | U | < 0.38 | U | < 1.90 | U | < 0.32 | U | < 0.28 | U |
| | ES006 | 10/22/2012 | < 20 | U | - | | - | | **18** | **B,J** | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U | < 0.50 | U | < 0.50 | U |
| | ES014 | 1/29/2013 | **22** | **J,HD** | - | | - | | < 30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 10 | IJ,ICH,U | < 0.50 | U | < 0.50 | U |
| | ES023 | 4/23/2013 | <20 | U | - | | - | | < 30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U | < 0.50 | U | < 0.50 | U |
| | ES032 | 7/23/2013 | < 20 | U | - | | - | | < 30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U | < 0.50 | U | < 0.50 | U |
| | ES041 | 10/22/2013 | < 20 | U | - | | - | | **13** | **B,J** | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U,ICH | < 0.50 | U | < 0.50 | U |

| Well Name | Sample ID | Date Sampled | 8260B | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Bromoform | | Bromomethane | | Carbon Tetrachloride | | Chlorobenzene | | Chloroethane | | Chloroform | | Chloromethane | | cis-1,2-Dichloroethylene | | Dibromochloromethane | | Ethylbenzene | | Hexachlorobutadiene | | Methyl ethyl ketone (2-Butanone) | | Methyl isobutyl ketone (4-Methyl-2-Pentanone) | | Methyl tert-butyl Ether | | Methylene chloride | | Naphthalene | | Styrene | | Tetrachloroethane, 1,1,1,2- | | Tetrachloroethane, 1,1,2,2- | | Tetrachloroethylene | | Toluene | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| **For wells < 150 m from surface water** | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations < 150m from surface water)** | - | - | **80** | | **8.7** | | **5.0** | | **25** | | **16** | | **70** | | **1.8** | | **70** | | **0.16** | | **30** | | **0.86** | | **7,100** | | **170** | | **5.0** | | **4.8** | | **17** | | **10** | | **0.52** | | **0.067** | | **5.0** | | **40** | |
| **RHMW2254-01** | RH-B-001 | 2/16/2005[be] | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U | - | | - | | - | | <0.50 | U | - | | - | | - | | - | | - | | - | | **1.0** | |
| | RH-B-002 | 2/16/2005[bf] | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U | - | | - | | - | | <0.50 | U | - | | - | | - | | - | | - | | - | | **1.2** | |
| | RH-B-003 | 2/16/2005*[bf] | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U | - | | - | | - | | <0.50 | U | - | | - | | - | | - | | - | | - | | **0.81** | |
| | RH-B-004 | 6/28/2005[ae] | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50[b] | U | - | | - | | - | | <0.50[b] | U | - | | - | | - | | - | | - | | - | | <0.50[b] | U |
| | RH-B-005 | 6/28/2005*[ae] | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50[b] | U | - | | - | | - | | <0.50[b] | U | - | | - | | - | | - | | - | | - | | <0.50[b] | U |
| | RH-B-006 | 6/28/2005*[af] | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50[b] | U | - | | - | | - | | <0.50[b] | U | - | | - | | - | | - | | - | | - | | <0.50[b] | U |
| | RH-B-007 | 9/8/2005[ae] | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.13 | U | - | | - | | - | | <0.20 | U | - | | - | | - | | - | | - | | - | | <0.11 | U |
| | RH-B-008 | 9/8/2005[af] | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.13 | U | - | | - | | - | | <0.20 | U | - | | - | | - | | - | | - | | - | | <0.11 | U |
| | RH-B-009 | 9/8/2005*[af] | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.13 | U | - | | - | | - | | <0.20 | U | - | | - | | - | | - | | - | | - | | <0.11 | U |
| | RHMW2254W01 | 9/20/2005[bd] | <0.50 | U | <1.0 | U | <0.50 | U | <0.50 | U | <1.0 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.40 | U | < 0.50 | U | <0.50 | U | <2.5 | U | <2.5 | U | < 0.50 | U | <1.0 | U | <1.0 | U | <0.50 | U | <0.50 | U | <0.40 | U | <0.50 | U | < 0.50 | U |
| | RH-B-010 | 12/6/2005[ae] | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.13 | U | - | | - | | - | | <0.20 | U | - | | - | | - | | - | | - | | - | | <0.11 | U |
| | RH-B-011 | 12/6/2005*[ae] | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.13 | U | - | | - | | - | | <0.20 | U | - | | - | | - | | - | | - | | - | | <0.11 | U |
| | RH-B-012 | 12/7/2005[af] | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.13 | U | - | | - | | - | | <0.20 | U | - | | - | | - | | - | | - | | - | | <0.11 | U |
| | RHMW2254-01-GW02 | 7/10/2006[ad] | <0.50 | U | <1.0 | U | <0.50 | U | <0.50 | U | <1.0 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.40 | U | < 0.50 | U | <0.50 | U | <2.5 | U | <2.5 | U | < 0.50 | U | <1.0 | U | < 1.0 | U | <0.50 | U | <0.50 | U | <0.40 | U | < 0.50 | U | < 0.50 | U |
| | RHMW2254-01-GW06 | 12/5/2006[ad] | <0.50 | U | <1.0 | U | <0.50 | U | <0.50 | U | <1.0 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.40 | U | < 0.50 | U | <0.50 | U | <2.5 | U | <2.5 | U | < 0.50 | U | <1.0 | U | < 1.0 | U | <0.50 | U | <0.50 | U | <0.40 | U | < 0.50 | U | < 0.50 | U |
| | RHMW2254-01-WG07 | 3/27/2007[a] | < 0.50 | U | < 1.0 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 0.50 | U | <1.0 | U | < 0.50 | U | <0.40 | U | < 0.50 | U | < 0.50 | U | < 2.5 | U | < 2.5 | U | <0.50 | U | < 1.0 | U | < 1.0 | U | < 0.50 | U | < 0.50 | U | < 0.40 | U | < 0.50 | U | < 0.50 | U |
| | RHMW2254-01-WG08 | 6/12/2007[a] | < 0.50 | U | < 1.0 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 0.50 | U | < 1.0 | U | < 0.50 | U | <0.40 | U | < 0.50 | U | < 0.50 | U | < 2.5 | U | < 2.5 | U | <0.50 | U | < 1.0 | U | < 1.0 | U | < 0.50 | U | < 0.50 | U | < 0.40 | U | < 0.50 | U | < 0.50 | U |
| | RHMW2254-01-WG0 | 9/10/2007[a] | < 0.28 | U | < 0.54 | U | < 0.29 | U | < 0.20 | U | < 0.46 | U | < 0.21 | U | < 0.38 | U | < 0.28 | U | <0.20 | U | < 0.20 | U | < 0.57 | U | < 2.0 | U | < 2.2 | U | <0.25 | U | < 1.0 | U | < 0.44 | U | < 0.20 | U | < 0.25 | U | < 0.37 | U | < 0.25 | U | < 0.27 | U |
| | RHMW2254-01-WG10 | 1/15/2008[a] | < 0.500 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.180 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 0.310 | U | < 0.620 | U | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW2254-01-WG10.1 | 2/6/2008[a] | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | RHMW2254-01-WG10.1 | 2/6/2008[a] | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | RHMW2254-01-WG11 | 4/15/2008[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | < 0.620 | U | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW2254-01-WG12 | 7/29/2008[a] | < 0.310 | U | **1.26** | **J** | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | < 0.620 | U | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW2254-01-WG13 | 10/22/2008[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | < 0.620 | U | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW2254-WG13B | 12/16/2008[c] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | < 0.620 | U | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMWA01-WG13B | 12/16/2008*[c] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | < 0.620 | U | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW2254-01-WG14 | 2/4/2009[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | < 0.620 | U | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW2254-01-WG15 | 5/13/2009[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | < 0.620 | U | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW2254-01-WG16 | 7/15/2009[a] | < 0.310 | U | < 0.940 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.300 | U | < 0.310 | U | < 0.310 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U | < 3.10 | U | < 3.10 | U | < 1.50 | U | < 1.00 | U | < 0.620 | U | < 0.310 | U | < 0.150 | U | < 0.150 | U | < 0.310 | U | < 0.310 | U |
| | RHMW2254-WG17 | 10/14/2009[a] | < 0.31 | U | < 0.94 | U | < 0.31 | U | < 0.15 | U | < 0.31 | U | < 0.3 | U | < 0.31 | U | < 0.31 | U | < 0.15 | U | < 0.31 | U | < 0.31 | U | < 3.1 | U | < 3.1 | U | - | | < 1 | U | < 0.62 | U | < 0.31 | U | < 0.15 | U | < 0.15 | U | < 0.31 | U | < 0.31 | U |
| | RHMW2254-01-WG18 | 1/27/2010 | < 0.620 | U | < 1.88 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.600 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 6.20 | U | < 6.20 | U | < 3.00 | U | < 2.00 | U | < 1.24 | U | < 0.620 | U | < 0.300 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U |
| | RHMW2254-01-WG19 | 4/13/2010 | < 0.620 | U | < 1.88 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.600 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 6.20 | U | < 6.20 | U | < 3.00 | U | < 2.00 | U | < 1.24 | U | < 0.620 | U | < 0.300 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U |
| | RHMW2254-01-WG20 | 7/13/2010 | < 0.620 | U | < 1.88 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.600 | U | < 0.620 | U | < 0.620 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U | < 6.20 | U | < 6.20 | U | < 3.00 | U | < 2.00 | U | < 1.24 | U | < 0.620 | U | < 0.300 | U | < 0.300 | U | < 0.620 | U | < 0.620 | U |
| | ES004 | 10/19/2010 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.62 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.38 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.30 | U | < 0.34 | U |
| | ES014 | 1/20/2011 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.62 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.38 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.30 | U | < 0.34 | U |
| | ES019 | 4/19/2011 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.62 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.38 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.30 | U | < 0.34 | U |
| | ES040 | 7/20/2011 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.62 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.38 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.30 | U | < 0.34 | U |
| | ES050 | 10/25/2011 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.84 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.52 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.48 | U | < 0.34 | U |
| | ES062 | 2/1/2012 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.84 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.52 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.48 | U | < 0.34 | U |
| | ES074 | 4/17/2012 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.84 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.52 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.48 | U | < 0.34 | U |
| | ES077 | 7/17/2012 | < 0.28 | U | < 0.48 | U | < 0.20 | U | < 0.42 | U | < 0.42 | U | < 0.14 | U | < 0.84 | U | < 0.32 | U | < 0.38 | U | < 0.46 | U | < 0.38 | U | < 1.20 | U | < 3.80 | U | < 0.52 | U | < 0.70 | U | - | | < 0.50 | U | < 0.26 | U | < 0.20 | U | < 0.48 | U | < 0.34 | U |
| | ES006 | 10/22/2012 | < 1.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 5.0 | IH,U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 5.0 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | **0.71** | **J** |
| | ES014 | 1/29/2013 | < 2.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES023 | 4/23/2013 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES032 | 7/23/2013 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES041 | 10/22/2013 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U,IJ | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U,ICH | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |

| Well Name | Sample ID | Date Sampled | | | | | | | | | 504.1 | | 8260SIM | | | | | | | | | | 8011 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | trans-1,2-Dichloroethylene | | Trichloroethylene | | Vinyl chloride | | Xylenes, Total (p/m-, o-xylene) | | 1,2-Dibromoethane | | 1,2-Dibromoethane | | 1,2-Dichloroethane | | Bromodichloromethane | | Dibromochloromethane | | Tetrachloroethane, 1,1,2,2- | | 1,2-Dibromo-3-chloropropane | | 1,2-Dibromoethane | | Acenaphthene | | Acenaphthylene | | Anthracene | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| **For wells < 150 m from surface water** | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations < 150m from surface water)** | - | - | **100** | | **5.0** | | **2.0** | | **20** | | **0.04** | | **0.04** | | **0.15** | | **0.12** | | **0.16** | | **0.067** | | **0.04** | | **0.04** | | **20** | | **30** | | **0.73** | |
| **RHMW2254-01** | RH-B-001 | 2/16/2005[be] | - | | - | | - | | <0.50 | U | <0.0083 | U | - | | - | | - | | - | | - | | - | | - | | <0.020 | U | <0.020 | U | <0.020 | U |
| | RH-B-002 | 2/16/2005[bf] | - | | - | | - | | <0.50 | U | <0.0081 | U | - | | - | | - | | - | | - | | - | | - | | <0.022 | U | <0.022 | U | <0.022 | U |
| | RH-B-003 | 2/16/2005*[bf] | - | | - | | - | | <0.50 | U | <0.0082 | U | - | | - | | - | | - | | - | | - | | - | | <0.021 | U | <0.021 | U | <0.021 | U |
| | RH-B-004 | 6/28/2005[ae] | - | | - | | - | | <0.50[b] | U | <0.0095 | U | - | | - | | - | | - | | - | | - | | - | | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U |
| | RH-B-005 | 6/28/2005*[ae] | - | | - | | - | | <0.50[b] | U | <0.0097 | U | - | | - | | - | | - | | - | | - | | - | | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U |
| | RH-B-006 | 6/28/2005*[af] | - | | - | | - | | <0.50[b] | U | <0.0095 | U | - | | - | | - | | - | | - | | - | | - | | <0.021[b] | U | <0.021[b] | U | <0.021[b] | U |
| | RH-B-007 | 9/8/2005[ae] | - | | - | | - | | <0.22 | U | <0.0095 | U | - | | - | | - | | - | | - | | - | | - | | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U |
| | RH-B-008 | 9/8/2005[af] | - | | - | | - | | <0.22 | U | <0.0095 | U | - | | - | | - | | - | | - | | - | | - | | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U |
| | RH-B-009 | 9/8/2005*[af] | - | | - | | - | | <0.22 | U | <0.0095 | U | - | | - | | - | | - | | - | | - | | - | | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U |
| | RHMW2254W01 | 9/20/2005[bd] | <0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | RH-B-010 | 12/6/2005[ae] | - | | - | | - | | <0.22 | U | <0.0096 | U | - | | - | | - | | - | | - | | - | | - | | <0.0020 | U | **0.0023** | **J** | <0.0011 | U |
| | RH-B-011 | 12/6/2005*[ae] | - | | - | | - | | <0.22 | U | <0.0094 | U | - | | - | | - | | - | | - | | - | | - | | <0.0020 | U | **0.0024** | **J** | <0.0011 | U |
| | RH-B-012 | 12/7/2005[af] | - | | - | | - | | <0.22 | U | <0.0095 | U | - | | - | | - | | - | | - | | - | | - | | <0.0020 | U | <0.0018 | U | <0.0011 | U |
| | RHMW2254-01-GW02 | 7/10/2006[ad] | <0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.51 | U | <0.51 | U | <0.51 | U |
| | RHMW2254-01-GW06 | 12/5/2006[ad] | <0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.49 | U | <0.49 | U | <0.49 | U |
| | RHMW2254-01-WG07 | 3/27/2007[a] | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.49 | U | < 0.49 | U | < 0.49 | U |
| | RHMW2254-01-WG08 | 6/12/2007[a] | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.49 | U | < 0.49 | U | < 0.49 | U |
| | RHMW2254-01-WG0 | 9/10/2007[a] | < 0.20 | U | < 0.38 | U | < 0.34 | U | < 0.36 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | RHMW2254-01-WG10 | 1/15/2008[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U |
| | RHMW2254-01-WG10.1 | 2/6/2008[a] | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | RHMW2254-01-WG10.1 | 2/6/2008[a] | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | RHMW2254-01-WG11 | 4/15/2008[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0160 | U | < 0.0160 | U | < 0.0160 | U |
| | RHMW2254-01-WG12 | 7/29/2008[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U |
| | RHMW2254-01-WG13 | 10/22/2008[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U |
| | RHMW2254-WG13B | 12/16/2008[c] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.93 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | RHMWA01-WG13B | 12/16/2008*[c] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.93 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | RHMW2254-01-WG14 | 2/4/2009[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0161 | U | < 0.0161 | U | < 0.0161 | U |
| | RHMW2254-01-WG15 | 5/13/2009[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U |
| | RHMW2254-01-WG16 | 7/15/2009[a] | < 0.310 | U | < 0.310 | U | < 0.310 | U | < 0.620 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U |
| | RHMW2254-WG17 | 10/14/2009[a] | < 0.31 | U | < 0.31 | U | < 0.31 | U | < 1 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.017 | U | < 0.017 | U | < 0.017 | U |
| | RHMW2254-01-WG18 | 1/27/2010 | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U |
| | RHMW2254-01-WG19 | 4/13/2010 | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0330 | U | < 0.0330 | U | < 0.0330 | U |
| | RHMW2254-01-WG20 | 7/13/2010 | < 0.620 | U | < 0.620 | U | < 0.620 | U | < 1.24 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.0320 | U | < 0.0320 | U | < 0.0320 | U |
| | ES004 | 10/19/2010 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES014 | 1/20/2011 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES019 | 4/19/2011 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES040 | 7/20/2011 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES050 | 10/25/2011 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES062 | 2/1/2012 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES074 | 4/17/2012 | < 0.38 | U | **0.17** | **J** | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES077 | 7/17/2012 | < 0.38 | U | < 0.32 | U | < 0.46 | U | < 0.38 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.12 | U | < 0.12 | U | < 0.10 | U |
| | ES006 | 10/22/2012 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.050 | U | < 0.050 | U | < 0.050 | U |
| | ES014 | 1/29/2013 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.050 | U | < 0.050 | U | < 0.050 | U |
| | ES023 | 4/23/2013 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.051 | U | < 0.051 | U | < 0.051 | U |
| | ES032 | 7/23/2013 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.050 | U | < 0.050 | U | < 0.050 | U |
| | ES041 | 10/22/2013 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | < 0.050 | U | < 0.050 | U | < 0.050 | U |

| Well Name | Sample ID | Date Sampled | 8270C | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 6020 | | 6010B/6020/200.8 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Benzo[a]anthracene | | Benzo[g,h,i]perylene | | Benzo[a]pyrene | | Benzo[b]fluoranthene | | Benzo[k]fluoranthene | | Chrysene | | Dibenz[a,h]anthracene | | Fluoranthene | | Fluorene | | Indeno[1,2,3-cd]pyrene | | 1-Methylnaphthalene | | 2-Methylnaphthalene | | Naphthalene | | Phenanthrene | | Pyrene | | Dissolved Lead (filtered) | | Total Lead (unfiltered) | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| **For wells < 150 m from surface water** | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations < 150m from surface water)** | - | - | **0.027** | | **0.10** | | **0.014** | | **0.092** | | **0.40** | | **0.35** | | **0.0092** | | **8.0** | | **3.9** | | **0.092** | | **2.1** | | **2.1** | | **17** | | **4.6** | | **2.0** | | **5.6** | | - | |
| **RHMW2254-01** | RH-B-001 | 2/16/2005[be] | <0.020 | U | <0.020 | U | <0.020 | U | <0.020 | U | <0.020 | U | <0.020 | U | <0.020 | U | <0.020 | U | <0.020 | U | <0.020 | U | - | | <0.020 | U | <0.020 | U | <0.020 | U | <0.020 | U | - | | **0.33** | |
| | RH-B-002 | 2/16/2005[bf] | <0.022 | U | <0.022 | U | <0.022 | U | <0.022 | U | <0.022 | U | <0.022 | U | <0.022 | U | <0.022 | U | <0.022 | U | <0.022 | U | - | | <0.022 | U | <0.022 | U | <0.022 | U | <0.022 | U | - | | **0.06** | |
| | RH-B-003 | 2/16/2005*[bf] | <0.021 | U | <0.021 | U | <0.021 | U | <0.021 | U | <0.021 | U | <0.021 | U | <0.021 | U | <0.021 | U | <0.021 | U | <0.021 | U | - | | <0.021 | U | <0.021 | U | <0.021 | U | <0.021 | U | - | | **0.05** | |
| | RH-B-004 | 6/28/2005[ae] | <0.020[b] | U | <0.024[b] | Ui | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | - | | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | - | | **0.952** | |
| | RH-B-005 | 6/28/2005*[ae] | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.026[b] | Ui | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | - | | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | - | | **0.549** | |
| | RH-B-006 | 6/28/2005*[af] | <0.021[b] | U | <0.021[b] | U | <0.021[b] | U | <0.021[b] | U | <0.021[b] | U | <0.021[b] | U | <0.021[b] | U | <0.021[b] | U | <0.021[b] | U | <0.021[b] | U | - | | <0.021[b] | U | <0.021[b] | U | <0.021[b] | U | <0.021[b] | U | - | | **0.129** | |
| | RH-B-007 | 9/8/2005[ae] | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | - | | <0.020[b] | U | **0.085** | | <0.020[b] | U | <0.020[b] | U | **0.05** | | - | |
| | RH-B-008 | 9/8/2005[af] | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | - | | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | **0.03** | | - | |
| | RH-B-009 | 9/8/2005*[af] | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | <0.020[b] | U | - | | <0.020[b] | U | **0.045** | | <0.020[b] | U | <0.020[b] | U | **0.27** | | - | |
| | RHMW2254W01 | 9/20/2005[bd] | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | **-** | | **-** | | **-** | | - | |
| | RH-B-010 | 12/6/2005[ae] | **0.0022** | **J** | <0.0037 | U | <0.0016 | U | <0.0020 | U | <0.0014 | U | **0.0038** | **J** | <0.0017 | U | **0.0084** | **J** | <0.0026 | U | <0.0021 | U | - | | **0.038** | | **0.036** | | **0.0078** | **J** | **0.0075** | **J** | **0.14** | | - | |
| | RH-B-011 | 12/6/2005*[ae] | **0.0033** | **J** | <0.0037 | U | <0.0016 | U | <0.0020 | U | <0.0014 | U | **0.0041** | **J** | <0.0017 | U | **0.0092** | **J** | <0.0026 | U | <0.0021 | U | - | | **0.022** | | **0.024** | | **0.0073** | **J** | **0.0070** | **J** | **0.04** | | - | |
| | RH-B-012 | 12/7/2005[af] | <0.0021 | U | <0.0037 | U | <0.0016 | U | <0.0020 | U | <0.0014 | U | <0.0013 | U | <0.0017 | U | <0.0024 | U | <0.0026 | U | <0.0021 | U | - | | **0.0071** | **J** | **0.011** | **J** | <0.0032 | U | <0.0023 | U | **0.02** | **B** | - | |
| | RHMW2254-01-GW02 | 7/10/2006[ad] | <0.051 | U | <0.10 | U | < 0.10 | U | <0.051 | U | <0.10 | U | <0.10 | U | <0.051 | U | < 0.26 | U | <0.26 | U | <0.051 | U | <0.26 | U | <0.26 | U | < 0.26 | U | <0.51 | U | <0.26 | U | < 1.7 | U | - | |
| | RHMW2254-01-GW06 | 12/5/2006[ad] | <0.049 | U | <0.098 | U | < 0.098 | U | <0.049 | U | <0.098 | U | <0.098 | U | <0.049 | U | < 0.25 | U | <0.25 | U | <0.049 | U | <0.25 | U | <0.25 | U | < 0.25 | U | <0.49 | U | <0.25 | U | < 1.7 | U | - | |
| | RHMW2254-01-WG07 | 3/27/2007[a] | <0.049 | U | < 0.097 | U | < 0.097 | U | < 0.049 | U | < 0.097 | U | < 0.097 | U | < 0.049 | U | < 0.24 | U | < 0.24 | U | < 0.049 | U | < 0.24 | U | < 0.24 | U | < 0.24 | U | < 0.49 | U | < 0.24 | U | < 1.7 | U | - | |
| | RHMW2254-01-WG08 | 6/12/2007[a] | <0.049 | U | < 0.098 | U | < 0.098 | U | < 0.049 | U | < 0.098 | U | < 0.098 | U | < 0.049 | U | < 0.25 | U | < 0.25 | U | < 0.049 | U | < 0.25 | U | < 0.25 | U | < 0.25 | U | < 0.49 | U | < 0.25 | U | < 3.4 | U | - | |
| | RHMW2254-01-WG0 | 9/10/2007[a] | <0.050 | U | < 0.10 | U | < 0.10 | U | < 0.050 | U | < 0.10 | U | < 0.10 | U | < 0.050 | U | < 0.25 | U | < 0.25 | U | < 0.050 | U | < 0.25 | U | < 0.25 | U | < 0.25 | U | < 0.50 | U | < 0.25 | U | < 2.1 | U | - | |
| | RHMW2254-01-WG10 | 1/15/2008[a] | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0310 | U | < 0.0150 | U | < 0.0150 | U | < 0.310 | U | - | |
| | RHMW2254-01-WG10.1 | 2/6/2008[a] | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | RHMW2254-01-WG10.1 | 2/6/2008[a] | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | RHMW2254-01-WG11 | 4/15/2008[a] | < 0.0160 | U | < 0.0160 | U | < 0.0160 | U | < 0.0160 | U | < 0.0160 | U | < 0.0160 | U | < 0.0160 | U | < 0.0160 | U | < 0.0160 | U | < 0.0160 | U | **0.0435** | **J** | **0.0561** | | < 0.0332 | U | < 0.0160 | U | < 0.0160 | U | < 0.310 | U | - | |
| | RHMW2254-01-WG12 | 7/29/2008[a] | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0323 | U | < 0.0156 | U | < 0.0156 | U | < 0.310 | U | - | |
| | RHMW2254-01-WG13 | 10/22/2008[a] | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | < 0.0150 | U | **0.0276** | **J** | < 0.0150 | U | **0.0466** | **J** | < 0.0150 | U | < 0.0150 | U | < 0.310 | U | - | |
| | RHMW2254-WG13B | 12/16/2008[c] | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | RHMWA01-WG13B | 12/16/2008*[c] | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | RHMW2254-01-WG14 | 2/4/2009[a] | < 0.0161 | U | < 0.0161 | U | < 0.0161 | U | < 0.0161 | U | < 0.0161 | U | < 0.0161 | U | < 0.0161 | U | < 0.0161 | U | < 0.0161 | U | < 0.0161 | U | < 0.0161 | U | < 0.0161 | U | < 0.0333 | U | < 0.0161 | U | < 0.0161 | U | < 0.310 | U | - | |
| | RHMW2254-01-WG15 | 5/13/2009[a] | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | < 0.0156 | U | **0.0180** | **J** | < 0.0323 | U | < 0.0156 | U | < 0.0156 | U | < 0.310 | U | - | |
| | RHMW2254-01-WG16 | 7/15/2009[a] | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0165 | U | < 0.0341 | U | < 0.0165 | U | < 0.0165 | U | < 0.310 | U | - | |
| | RHMW2254-WG17 | 10/14/2009[a] | < 0.017 | U | < 0.017 | U | < 0.017 | U | < 0.017 | U | < 0.017 | U | < 0.017 | U | < 0.017 | U | < 0.017 | U | < 0.017 | U | < 0.017 | U | < 0.017 | U | < 0.017 | U | < 0.0352 | U | < 0.017 | U | < 0.017 | U | < 0.31 | U | - | |
| | RHMW2254-01-WG18 | 1/27/2010 | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U | < 0.0316 | U | **0.0375** | **J** | < 0.0316 | U | < 0.0316 | U | < 0.620 | U | - | |
| | RHMW2254-01-WG19 | 4/13/2010 | < 0.0330 | U | < 0.0330 | U | < 0.0330 | U | < 0.0330 | U | < 0.0330 | U | < 0.0330 | U | < 0.0330 | U | < 0.0330 | U | < 0.0330 | U | < 0.0330 | U | < 0.0330 | U | < 0.0330 | U | < 0.0682 | U | < 0.0330 | U | < 0.0330 | U | < 0.620 | U | - | |
| | RHMW2254-01-WG20 | 7/13/2010 | < 0.0320 | U | < 0.0320 | U | < 0.0320 | U | < 0.0320 | U | < 0.0320 | U | < 0.0320 | U | < 0.0320 | U | < 0.0320 | U | < 0.0320 | U | < 0.0320 | U | < 0.0320 | U | < 0.0320 | U | < 0.0664 | U | < 0.0320 | U | < 0.0320 | U | < 0.620 | U | - | |
| | ES004 | 10/19/2010 | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | **3.3** | | - | |
| | ES014 | 1/20/2011 | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | < 0.22 | U | - | |
| | ES019 | 4/19/2011 | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | < 0.22 | U | - | |
| | ES040 | 7/20/2011 | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | **1.9** | | - | |
| | ES050 | 10/25/2011 | < 0.14 | U | < 0.16 | U | < 0.14 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | < 0.22 | U | - | |
| | ES062 | 2/1/2012 | < 0.14 | U | < 0.16 | U | < 0.12 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | < 0.22 | U | - | |
| | ES074 | 4/17/2012 | < 0.14 | U | < 0.16 | U | < 0.12 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | < 0.22 | U | - | |
| | ES077 | 7/17/2012 | < 0.14 | U | < 0.16 | U | < 0.12 | U | < 0.12 | U | < 0.14 | U | < 0.10 | U | < 0.10 | U | < 0.16 | U | < 0.12 | U | < 0.14 | U | < 0.12 | U | < 0.12 | U | < 0.10 | U | < 0.14 | U | < 0.16 | U | **2.2** | | - | |
| | ES006 | 10/22/2012 | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | **0.037** | **J** | < 0.050 | U | < 0.050 | U | < 0.200 | U | **0.169[h]** | **J** |
| | ES014 | 1/29/2013 | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | **0.052** | **J** | < 0.050 | U | < 0.050 | U | **-** | | **0.242[k]** | **J** |
| | ES023 | 4/23/2013 | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | < 0.051 | U | **-** | | **0.828[k]** | **J** |
| | ES032 | 7/23/2013 | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | **0.099** | **J** | < 0.050 | U | < 0.050 | U | **-** | | **0.300[k]** | **J** |
| | ES041 | 10/22/2013 | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | **0.036** | **J** | < 0.050 | U | < 0.050 | U | **-** | | <0.0898[k] | U |

| Well Name | Sample ID | Date Sampled | 8015 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | TPH-d | | TPH-g | | TPH-o | | TPH-g | | 1,1,1-Trichloroethane | | 1,1,2-Trichloroethane | | 1,1-Dichloroethane | | 1,1-Dichloroethylene | | 1,2,3-Trichloropropane | | 1,2,4-Tricholorobenzene | | 1,2-Dibromo-3-chloropropane | | 1,2-Dibromoethane | | 1,2-Dichlorobenzene | | 1,2-Dichloroethane | | 1,2-Dichloropropane | | 1,3-Dichlorobenzene | | 1,3-Dichloropropene (total of cis/trans) | | 1,4-Dichlorobenzene | | Acetone | | Benzene | | Bromodichloromethane | |
| | | | (μg/l) | | (μg/l) | | | | (μg/l) | | (μg/l) | | (μg/l) | | (μg/l) | | (μg/l) | | (μg/l) | | (μg/l) | | (μg/l) | | (μg/l) | | (μg/l) | | (μg/l) | | (μg/l) | | (μg/l) | | (μg/l) | | (μg/l) | | (μg/l) | | (μg/l) | | (μg/l) | |
| **For wells < 150 m from surface water** | **-** | **-** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations < 150m from surface water)** | **-** | **-** | **100** | | **100** | | **100** | | **100** | | **62** | | **5.0** | | **2.4** | | **7.0** | | **0.6** | | **25** | | **0.04** | | **0.04** | | **10** | | **0.15** | | **5.0** | | **5.0** | | **0.43** | | **5.0** | | **1500** | | **5.0** | | **0.12** | |
| **RHMW2254-01** | ES050 | 1/16/2014 | < 20 | U | - | | - | | **-** | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U,ICH | < 0.50 | U | < 0.50 | U |
| | ES060 | 1/29/2014 | <20 | U | - | | - | | **16** | **B,J** | <0.50 | U,IH | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U,IH | < 0.50 | U | < 0.50 | U |
| | ES067 | 3/6/2014 | <20 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U | - | |
| | ES075 | 3/26/2014 | <10 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U | - | |
| | ES085 | 4/22/2014 | <10 | U | - | | - | | < 30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U,ICH | < 0.50 | U | < 0.50 | U |
| | ES094 | 5/28/2014 | <12 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U | - | |
| | ES102 | 6/24/2014 | <12 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U | - | |
| | ES107 | 7/22/2014 | <12 | U | - | | - | | < 30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U,ICH | < 0.50 | U | < 0.50 | U |
| | ES117 | 10/28/2014 | **22** | **J,HD** | - | | - | | < 30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U,ICH | < 0.50 | U | < 0.50 | U |
| | ES125 | 1/27/2015 | <12 | U | - | | - | | < 30 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U | < 0.50 | U | < 0.50 | U |
| | ES134 | 4/21/2015 | **14** | **B,J** | <25 | U | **37** | **B,J** | - | | <0.20 | U | <0.40 | U | <0.20 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.80 | U | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <10 | U | <0.10 | U | - | |
| | ES149 | 7/21/2015 | **17** | **J** | <25 | U | **42** | **J** | - | | <0.20 | U | <0.40 | U | <0.20 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.80 | U | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <10 | U | <0.10 | U | - | |
| | ERH009 | 10/20/2015 | **16** | **B,J** | <25 | U | <53 | B,U | - | | <0.20 | U,** | <0.40 | U,** | <0.20 | U,** | <0.20 | U,** | <0.50 | U,** | <0.30 | U,** | <0.80 | U,** | <0.20 | U,** | <0.20 | U,** | - | | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <10 | U,** | <0.10 | U,** | - | |
| | ERH021 | 1/20/2016 | **21** | **B,J** | < 25 | U | < 54 | B,U | - | - | < 0.20 | U | < 0.40 | U | < 0.20 | U | < 0.20 | U | < 0.50 | U | < 0.30 | U | < 0.80 | U | < 0.20 | U | < 0.20 | U | - | - | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | **3.6** | **J** | < 0.10 | U | - | - |

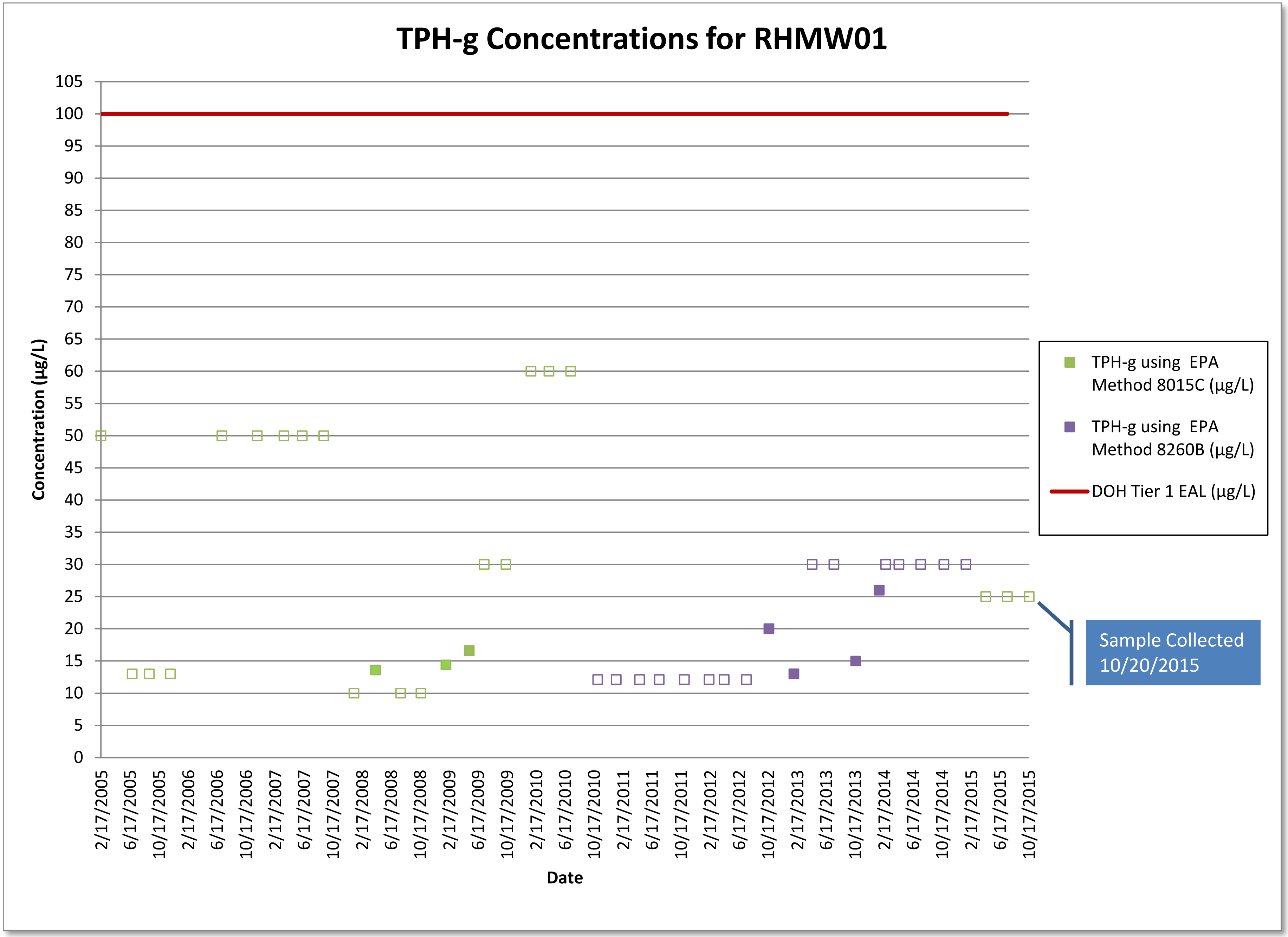
| Well Name | Sample ID | Date Sampled | 8260B | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Bromoform | | Bromomethane | | Carbon Tetrachloride | | Chlorobenzene | | Chloroethane | | Chloroform | | Chloromethane | | cis-1,2-Dichloroethylene | | Dibromochloromethane | | Ethylbenzene | | Hexachlorobutadiene | | Methyl ethyl ketone (2-Butanone) | | Methyl isobutyl ketone (4-Methyl-2-Pentanone) | | Methyl tert-butyl Ether | | Methylene chloride | | Naphthalene | | Styrene | | Tetrachloroethane, 1,1,1,2- | | Tetrachloroethane, 1,1,2,2- | | Tetrachloroethylene | | Toluene | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| **For wells < 150 m from surface water** | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations < 150m from surface water)** | - | - | **80** | | **8.7** | | **5.0** | | **25** | | **16** | | **70** | | **1.8** | | **70** | | **0.16** | | **30** | | **0.86** | | **7,100** | | **170** | | **5.0** | | **4.8** | | **17** | | **10** | | **0.52** | | **0.067** | | **5.0** | | **40** | |
| **RHMW2254-01** | ES050 | 1/16/2014 | < 1.0 | U | < 5.0 | U,ICJ | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U,IJ | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U,IJ | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES060 | 1/29/2014 | < 1.0 | U | < 5.0 | U | < 0.50 | U,IH | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES067 | 3/6/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U |
| | ES075 | 3/26/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U |
| | ES085 | 4/22/2014 | < 1.0 | U | < 5.0 | U,ICJ | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES094 | 5/28/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U |
| | ES102 | 6/24/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.50 | U |
| | ES107 | 7/22/2014 | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U,IJ | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES117 | 10/28/2014 | < 1.0 | U | < 5.0 | U,IJ | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES125 | 1/27/2015 | < 1.0 | U | < 5.0 | U,IH | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U |
| | ES134 | 4/21/2015 | <0.50 | U | <0.30 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | - | | <0.10 | U | <0.30 | U | <4.0 | U | <10 | U | <0.30 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.10 | U |
| | ES149 | 7/21/2015 | <0.50 | U | <0.30 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | - | | <0.10 | U | <0.30 | U | <4.0 | U | <10 | U | <0.30 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.10 | U |
| | ERH009 | 10/20/2015 | <0.50 | U,** | <0.30 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | - | | <0.10 | U,** | <0.30 | U,** | <4.0 | U,** | <10 | U,** | <0.30 | U,** | <0.20 | B,U,** | - | | <0.20 | U,** | <0.20 | U,** | - | | <0.20 | U,** | **0.990** | **Tb, **** |
| | ERH021 | 1/20/2016 | < 0.50 | U | < 0.30 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | - | - | < 0.10 | U | < 0.30 | U | < 4.0 | U | < 10 | U | < 0.30 | U | < 0.20 | B,U | - | - | < 0.20 | U | < 0.20 | U | < 15 | U | < 0.20 | U | **0.16** | **Tb,J** |

| Well Name | Sample ID | Date Sampled | | | | | | | | | 504.1 | | 8260SIM | | | | | | | | | | 8011 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | trans-1,2-Dichloroethylene | | Trichloroethylene | | Vinyl chloride | | Xylenes, Total (p/m-, o-xylene) | | 1,2-Dibromoethane | | 1,2-Dibromoethane | | 1,2-Dichloroethane | | Bromodichloromethane | | Dibromochloromethane | | Tetrachloroethane, 1,1,2,2- | | 1,2-Dibromo-3-chloropropane | | 1,2-Dibromoethane | | Acenaphthene | | Acenaphthylene | | Anthracene | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| For wells < 150 m from surface water | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| DOH Tier 1 EALs (for locations < 150m from surface water) | - | - | 100 | | 5.0 | | 2.0 | | 20 | | 0.04 | | 0.04 | | 0.15 | | 0.12 | | 0.16 | | 0.067 | | 0.04 | | 0.04 | | 20 | | 30 | | 0.73 | |
| RHMW2254-01 | ES050 | 1/16/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES060 | 1/29/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | <0.050 | U | <0.050 | U | <0.050 | U |
| | ES067 | 3/6/2014 | - | | - | | - | | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES075 | 3/26/2014 | - | | - | | - | | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES085 | 4/22/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | <0.049 | U | <0.049 | U | <0.049 | U |
| | ES094 | 5/28/2014 | - | | - | | - | | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES102 | 6/24/2014 | - | | - | | - | | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | |
| | ES107 | 7/22/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | <0.048 | U | <0.048 | U | <0.048 | U |
| | ES117 | 10/28/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | <0.049 | U | <0.049 | U | <0.049 | U |
| | ES125 | 1/27/2015 | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | | - | | <0.050 | U | <0.050 | U | <0.050 | U |
| | ES134 | 4/21/2015 | <0.20 | U | <0.10 | U | <0.10 | U | <0.20 | U | - | | <0.010 | U | <0.015 | U | <0.010 | U | <0.010 | U | <0.015 | U | <0.0040 | U | <0.0040 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U |
| | ES149 | 7/21/2015 | <0.20 | U | <0.10 | U | <0.10 | U | <0.20 | U | - | | - | | <0.015 | U | <0.010 | U | <0.010 | U | <0.015 | U | <0.0040 | U | <0.0040 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U |
| | ERH009 | 10/20/2015 | <0.20 | U,** | <0.10 | U,** | <0.10 | U,** | <0.20 | U,** | - | | - | | <0.015 | U | - | U | <0.010 | U | <0.015 | U | - | U | <0.0040 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U |
| | ERH021 | 1/20/2016 | < 0.20 | U | < 0.10 | U | < 0.10 | U | < 0.20 | U | - | - | - | - | < 0.015 | U | < 0.010 | U | < 0.010 | U | - | - | - | - | < 0.0040 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U |

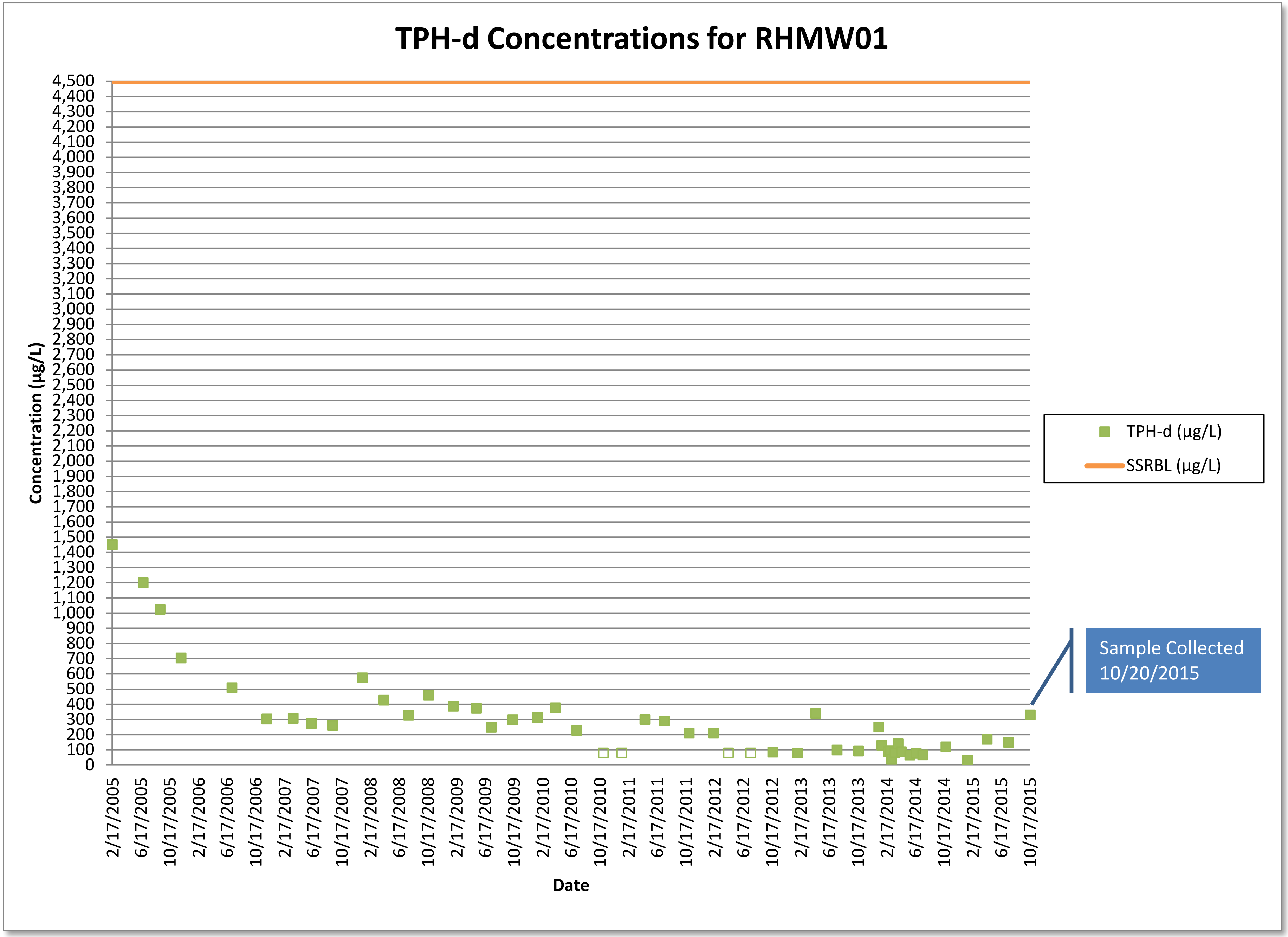
| Well Name | Sample ID | Date Sampled | 8270C | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 6020 | | 6010B/6020/200.8 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Benzo[a]anthracene | | Benzo[g,h,i]perylene | | Benzo[a]pyrene | | Benzo[b]fluoranthene | | Benzo[k]fluoranthene | | Chrysene | | Dibenz[a,h]anthracene | | Fluoranthene | | Fluorene | | Indeno[1,2,3-cd]pyrene | | 1-Methylnaphthalene | | 2-Methylnaphthalene | | Naphthalene | | Phenanthrene | | Pyrene | | Dissolved Lead (filtered) | | Total Lead (unfiltered) | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| **For wells < 150 m from surface water** | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations < 150m from surface water)** | - | - | **0.027** | | **0.10** | | **0.014** | | **0.092** | | **0.40** | | **0.35** | | **0.0092** | | **8.0** | | **3.9** | | **0.092** | | **2.1** | | **2.1** | | **17** | | **4.6** | | **2.0** | | **5.6** | | **-** | |
| **RHMW2254-01** | ES050 | 1/16/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.049 | U | < 0.049 | U | **0.046** | **J** | - | | - | | **-** | | - | |
| | ES060 | 1/29/2014 | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | **0.049** | **J** | <0.050 | U | <0.050 | U | **-** | | <0.0898$^{k}$ | U |
| | ES067 | 3/6/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.050 | U | <0.050 | U | **0.081** | **J** | - | | - | | <0.200 | U | **0.155$^{k}$** | **J** |
| | ES075 | 3/26/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.050 | U | <0.050 | U | <0.050 | U | - | | - | | **0.207** | **J** | **0.140$^{k}$** | **J** |
| | ES085 | 4/22/2014 | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | **-** | | <0.0898$^{k}$ | U |
| | ES094 | 5/28/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.050 | U | <0.050 | U | <0.050 | U | - | | - | | <0.200 | U | <0.0898$^{k}$ | U |
| | ES102 | 6/24/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.049 | U | <0.049 | U | <0.049 | U | - | | - | | <0.200 | U | <0.0898$^{k}$ | U |
| | ES107 | 7/22/2014 | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | **-** | | <0.0898$^{k}$ | U |
| | ES117 | 10/28/2014 | <0.049 | U | <0.097 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.097 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | **-** | | **0.211** | **J** |
| | ES125 | 1/27/2015 | <0.050 | U | <0.10 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.10 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | **-** | | <0.0898$^{k}$ | U |
| | ES134 | 4/21/2015 | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.020 | U | <0.0050 | U | <0.0050 | U | <0.0050 | UJ | <0.0050 | UJ | <0.0050 | UJ | <0.0050 | U | <0.010 | U | **-** | | **0.202$^{k}$** | |
| | ES149 | 7/21/2015 | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.020 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.010 | U | **-** | | **0.166k** | |
| | ERH009 | 10/20/2015 | <0.0050 | B,U | <0.0050 | B,U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | B,U | <0.020 | U | <0.0050 | U | <0.0050 | B,U | <0.0050 | U | <0.0050 | B,U | <0.0050 | B,U | <0.0050 | U | <0.010 | U | **-** | | **0.253** | |
| | ERH021 | 1/20/2016 | **0.0030** | **J** | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.020 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.010 | U | - | - | **0.036** | |

**Notes:**

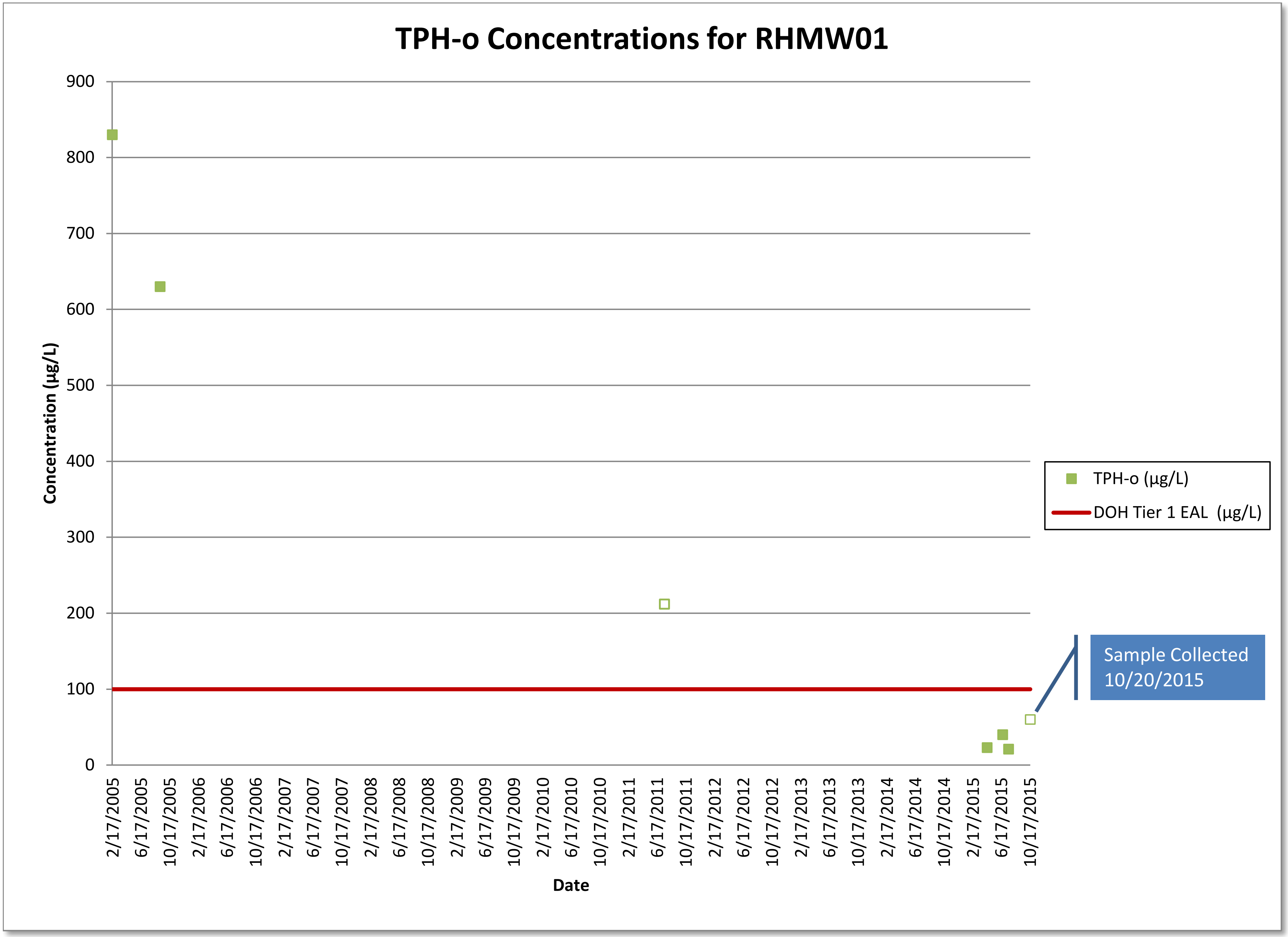
* duplicate samples
January 2008 to November 2009 depth to water measurements were entered in previous reports a tenth of a foot to high, adjustments were made to correct.
HDOH, Tier 1 Environmental Action Levels, Table D-1a. Groundwater Action Levels (Groundwater IS a current or potential drinking water resource, surface water body IS located within 150 meters of release site)
HDOH, Tier 1 Environmental Action Levels, Table D-1b. Groundwater Action Levels (Groundwater IS a current or potential drinking water resource, surface water body IS NOT located within 150 meters of release site)
Background historical data are from February 2005 to July 2012.
Non-detects (from October 2012 and on) are the LOD values.
Results for October 2015 sampling have been adjusted to reflect corrections from hits in the laboratory blank.
[1] - The holding time until analysis was exceeded by one day; the results may be biased low.
** - Samples analyzed passed the EPA reccomended holding time
a - MDL values were used for non-detects
b - MRL values were used for non-detects
c - no analytical lab reports found, could not verify results
d - no analytical lab reports available, used summary table from DOH Quarterly GW Reports
e - results from stilling basin, pumps offline
f - results from stilling basin, pumps online
g - analyzed by Method 6010B
h - analyzed by Method 6020
i - the MRL/MDL has been elevated due to a chromatographic interference
k - analyzed by Method 200.8
µg/l - micrograms per liter
Grey highlight - exceeds EALs
Bold - detected values
B - analyte was present in the associated method blank
D - the reported result is from a dilution
F - indicates that the compound was identified but the concentration was above the MDL and below the RL
ICH - Initial calibrtn. verif. recov. above method CL for this analyte
ICJ - Initial calibrtn. verif. recov. below method CL for this analyte
IH - Calibrtn. verif. recov. below method CL for this analyte
IJ - Calibrtn. verif. recov. above method CL for this analyte
J - indicates an estimated value
U - indicates that the compound was analyzed for but not detected at or above the stated limit. The stated limit is the LOD unless otherwise specified.
HD, Y, L, O, Z, H, ++ - the chromatographic pattern was inconsistent with the profile of the reference fuel standard
X - possible high bias due to matrix interference
Tb - The analyte was also detected in the associated trip blank at a similar concentration



Unfilled boxes indicate non-detections. Data points for 2/17/2005 through 9/8/2005 and 12/6/2005 are the average of the primary and duplicate samples. Possible laboratory contamination for 10/22/2012, 10/21/2013, and 1/28/2014 sampling events. Method reporting limits (MRLs) are shown for February 2005, method detection limits (MDLs) are shown for June 2005 through October 2009, and limits of detection (LODs) are shown from January 2010 on.



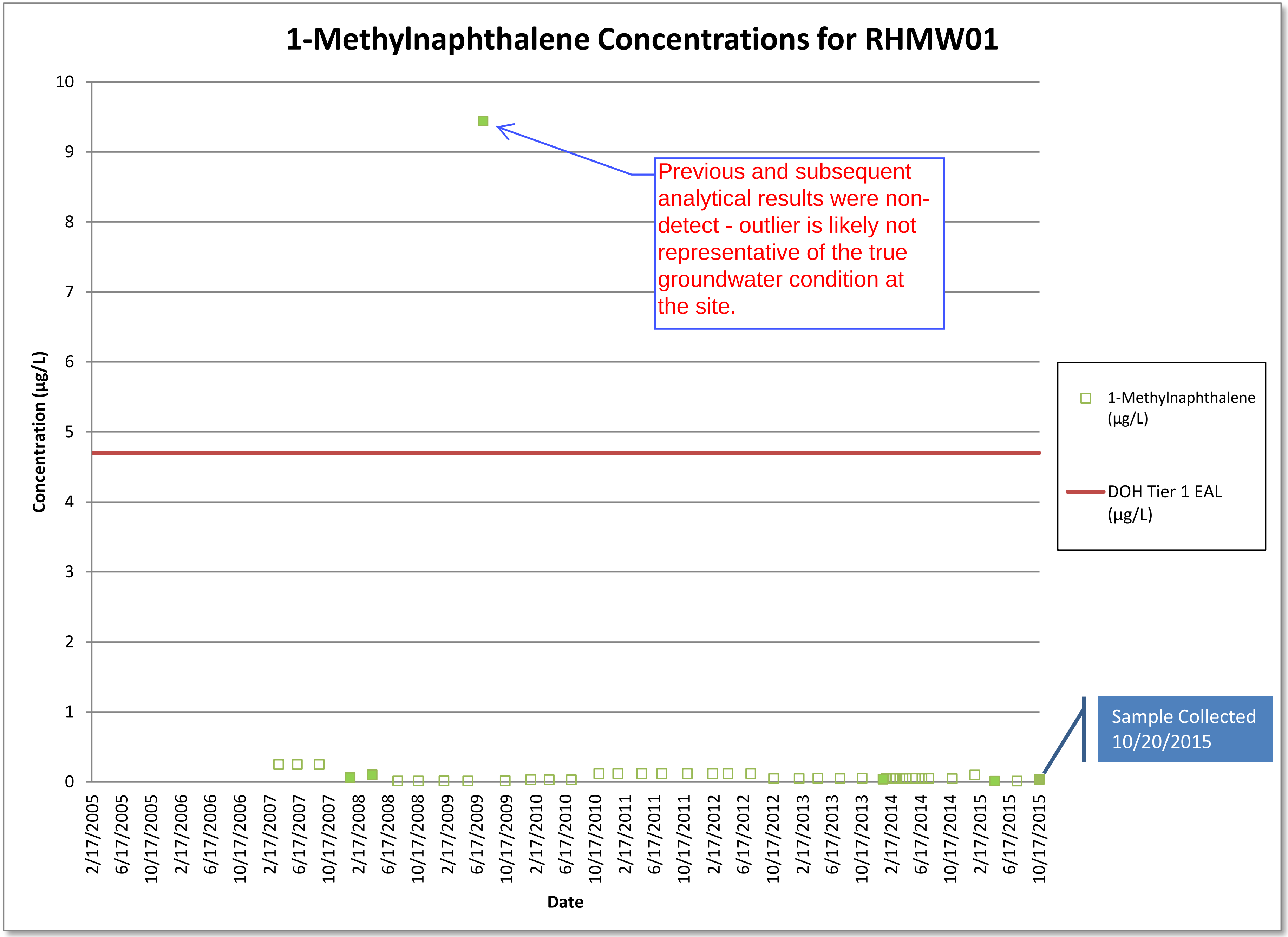
Unfilled boxes indicate non-detections. LODs are shown. Numerous sample results had a chromatographic pattern that did not match the calibration standard. The relatively high TPH-d values may not necessarily be indicative that there is diesel fuel or other petroleum products in the well. Data points for 2/17/2005 through 9/8/2005 and 12/6/2005 are the average of the primary and duplicate samples.



TPH-o Concentrations for RHMW01

Sample Collected 10/20/2015

Unfilled boxes indicate non-detections.

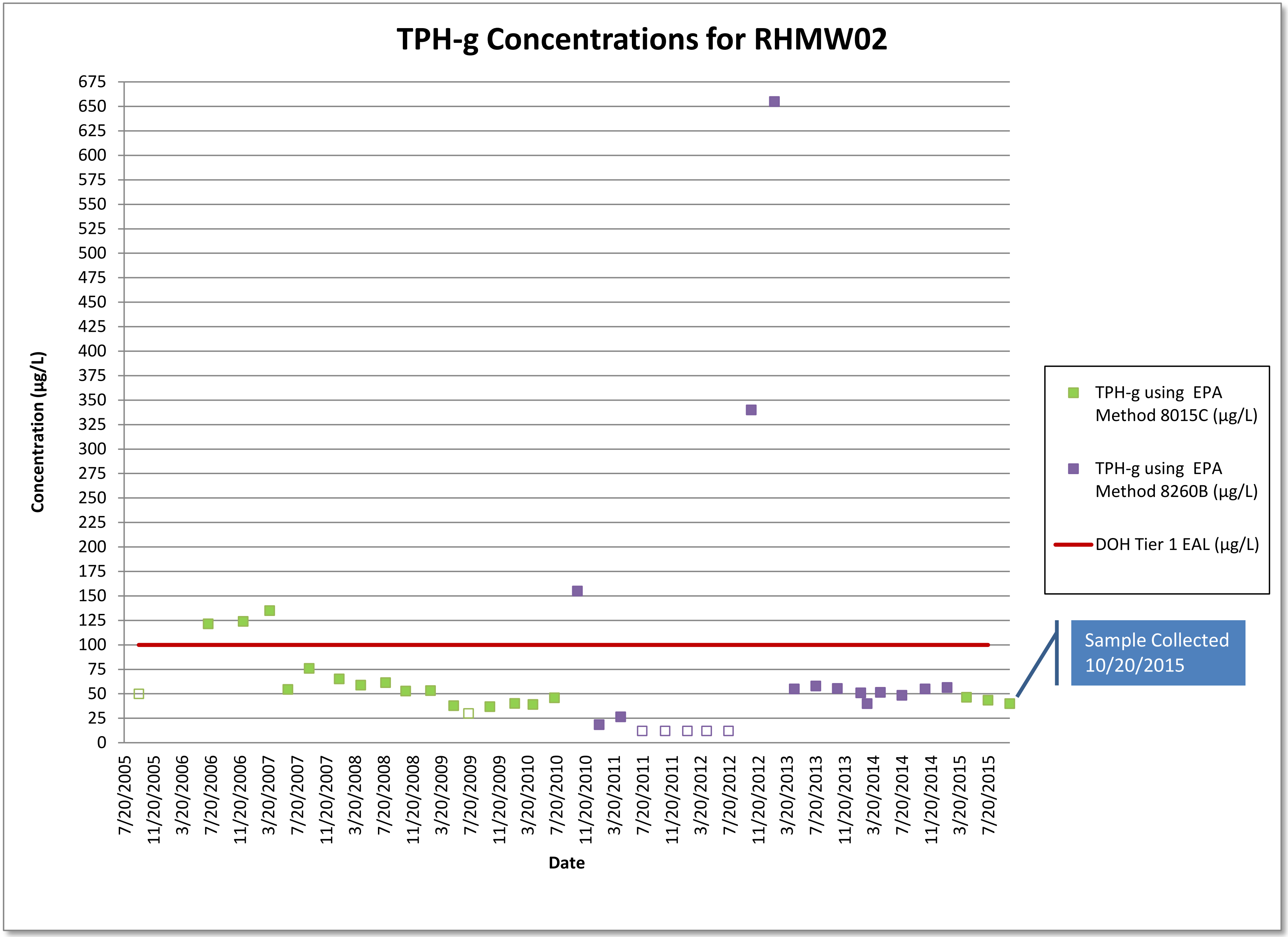


1-Methylnaphthalene Concentrations for RHMW01

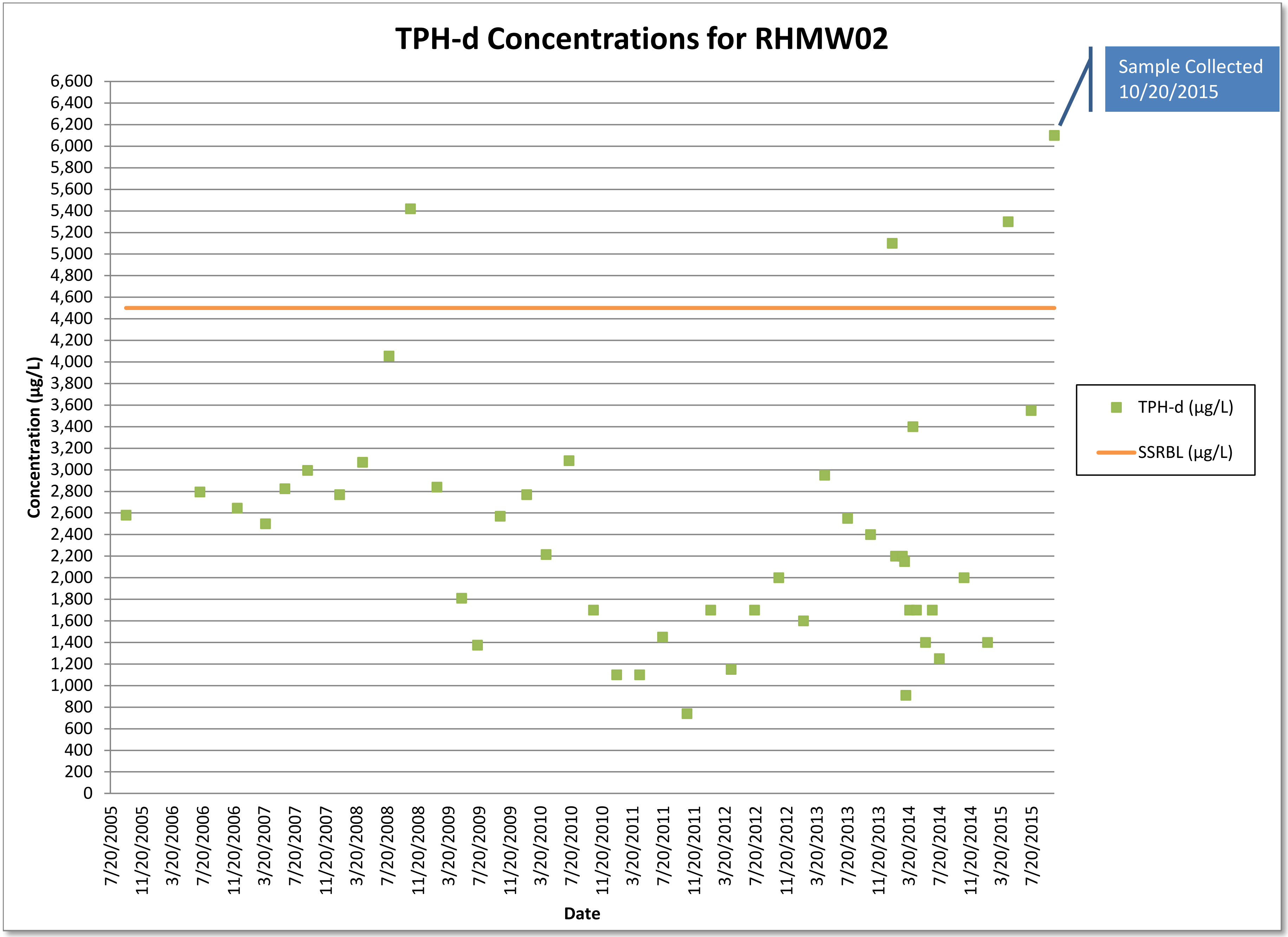
Previous and subsequent analytical results were non-detect - outlier is likely not representative of the true groundwater condition at the site.

Sample Collected 10/20/2015

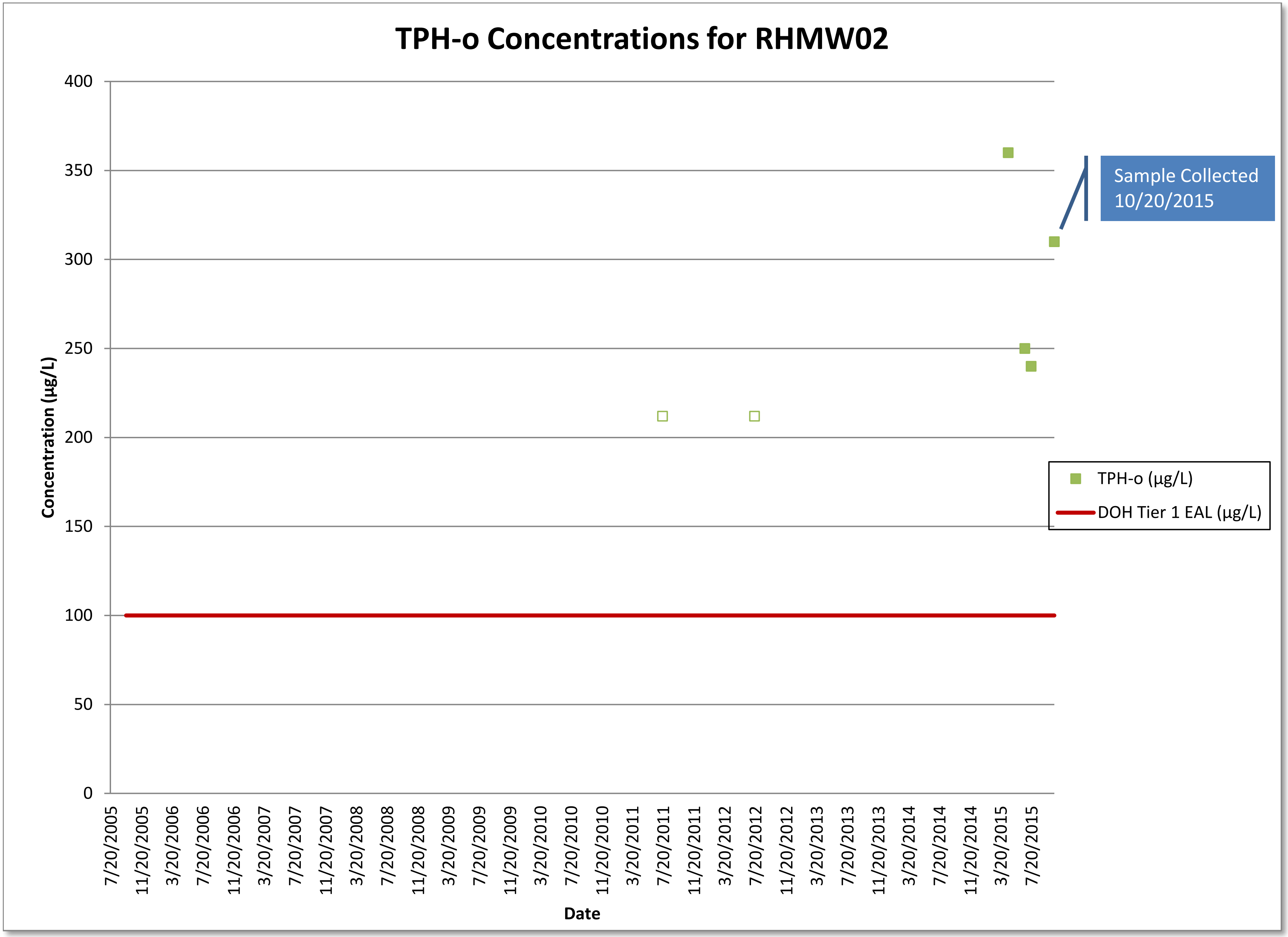
Unfilled boxes indicate non-detections. MDLs are shown for June 2005 through October 2009, and LODs are shown from January 2010 on.



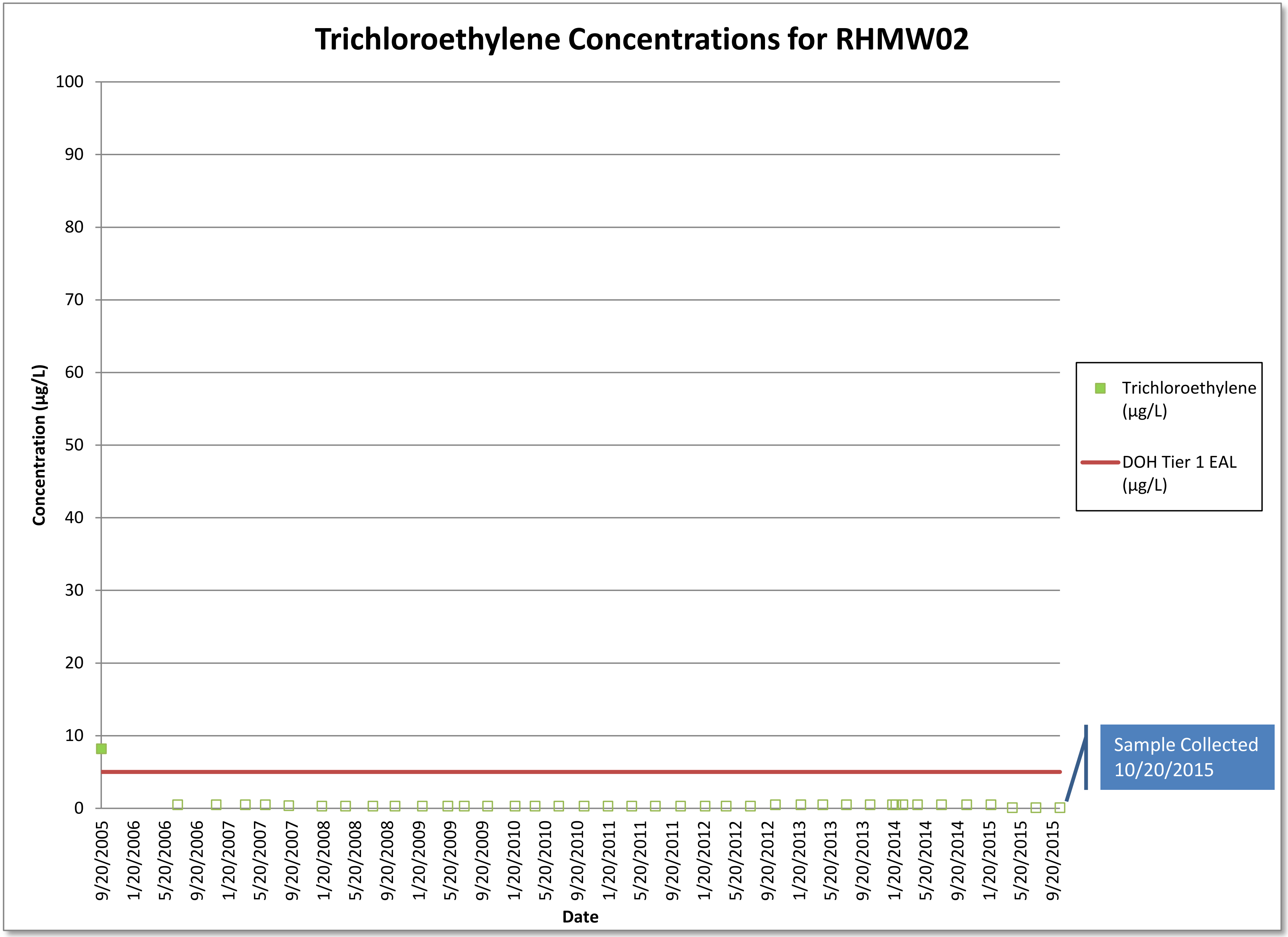
Unfilled boxes indicate non-detections. Data points for 9/20/2005 through 4/21/2014 are the average of the primary and duplicate samples. Possible laboratory contamination for 10/21/2013 and 1/28/2014 sampling events. MDLs are shown for July 2009, and LODs are shown for September 2005 and from July 2011 on. Primary sample results are shown for 1/26/2012 and 7/18/2012; all other concentrations are the average of the primary and duplicate sample results.



Data points for 9/20/2005 through 4/21/2014 are the average of the primary and duplicate samples.
Numerous sample results had a chromatographic pattern that did not match the calibration standard.
The relatively high TPH-d values may not necessarily be indicative that there is diesel fuel or other petroleum products in the well.

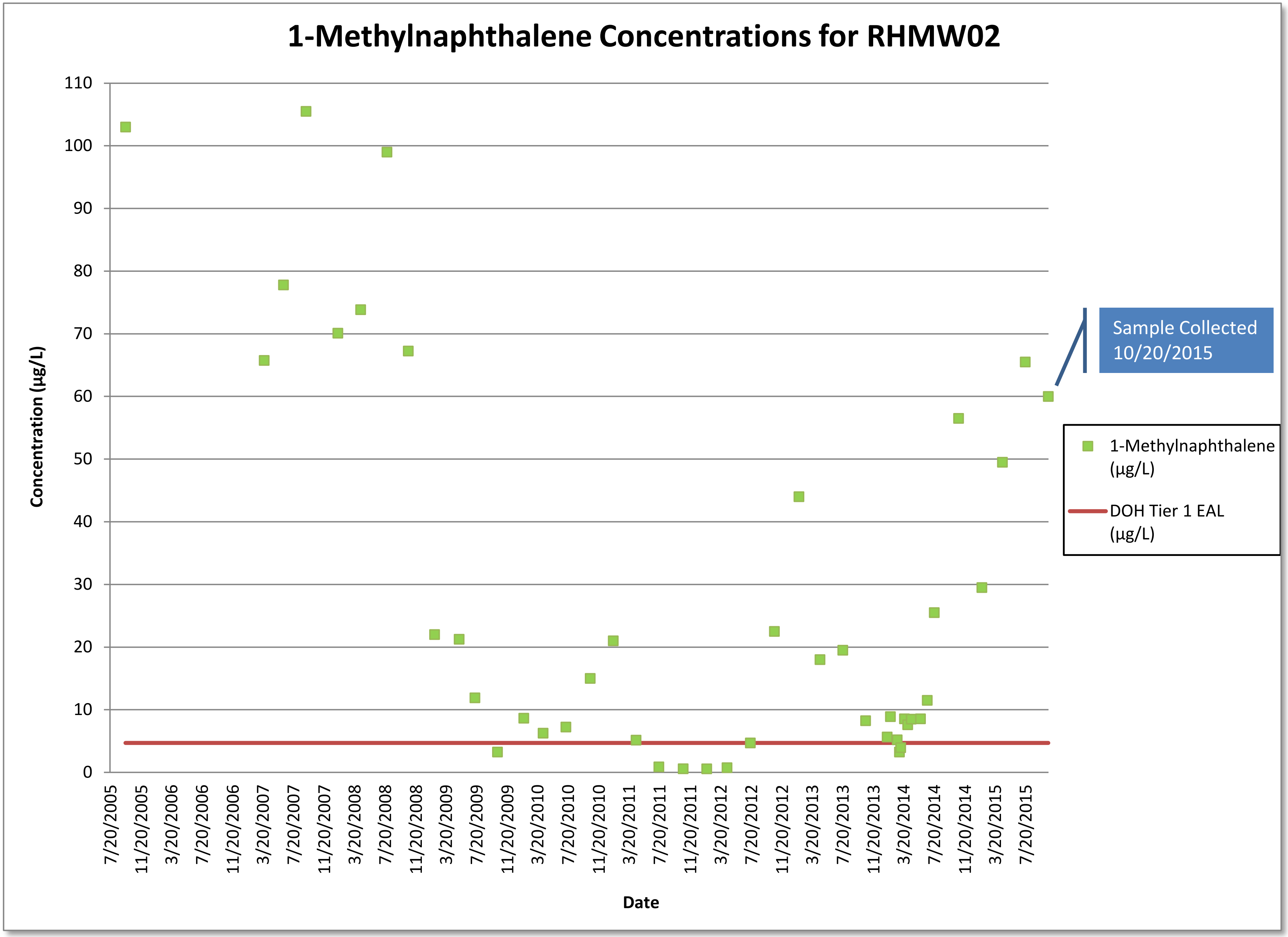


Unfilled boxes indicate non-detections.

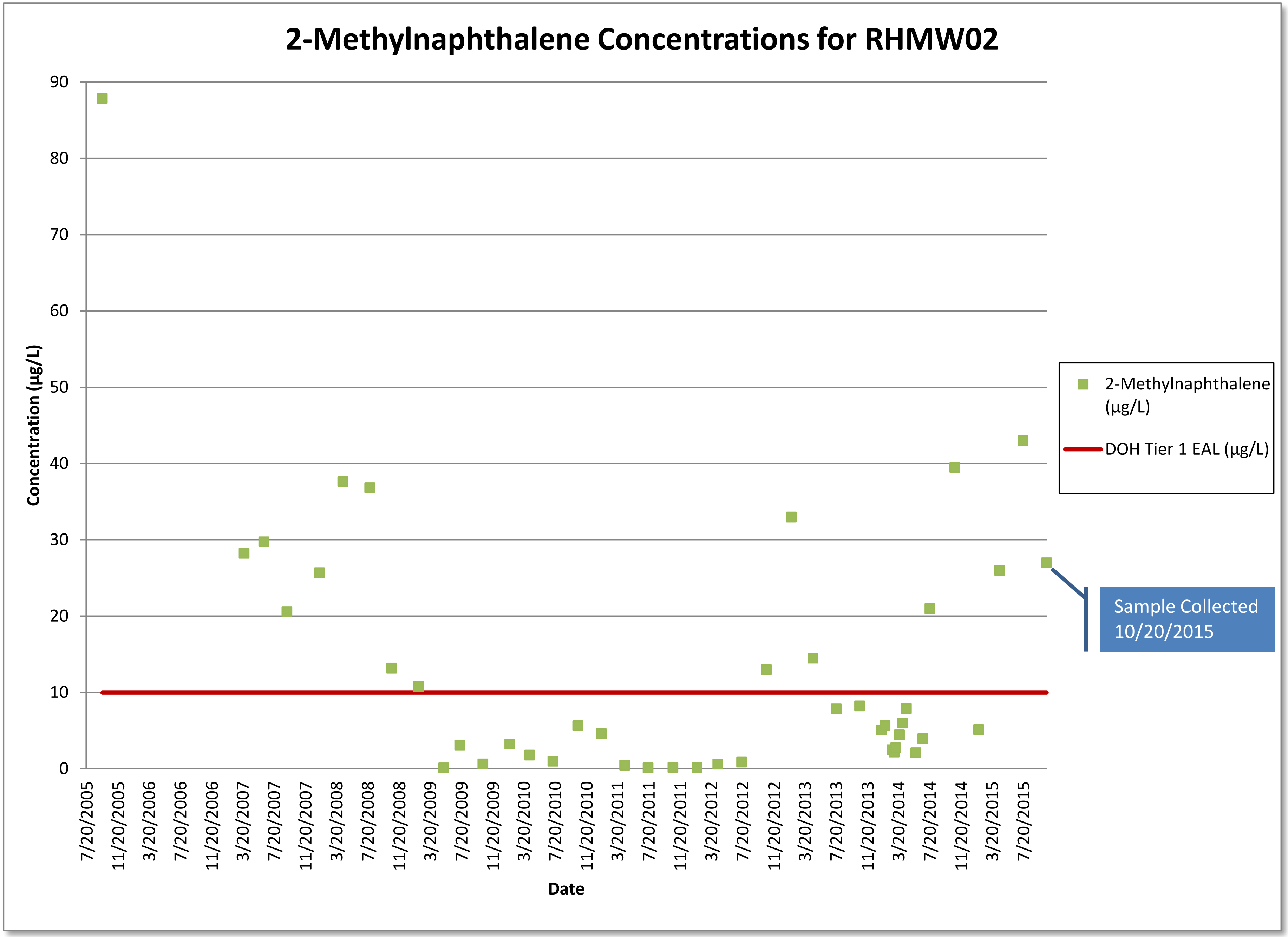


Data points for 9/20/2005 through 4/21/2014 are the average of the primary and duplicate samples.

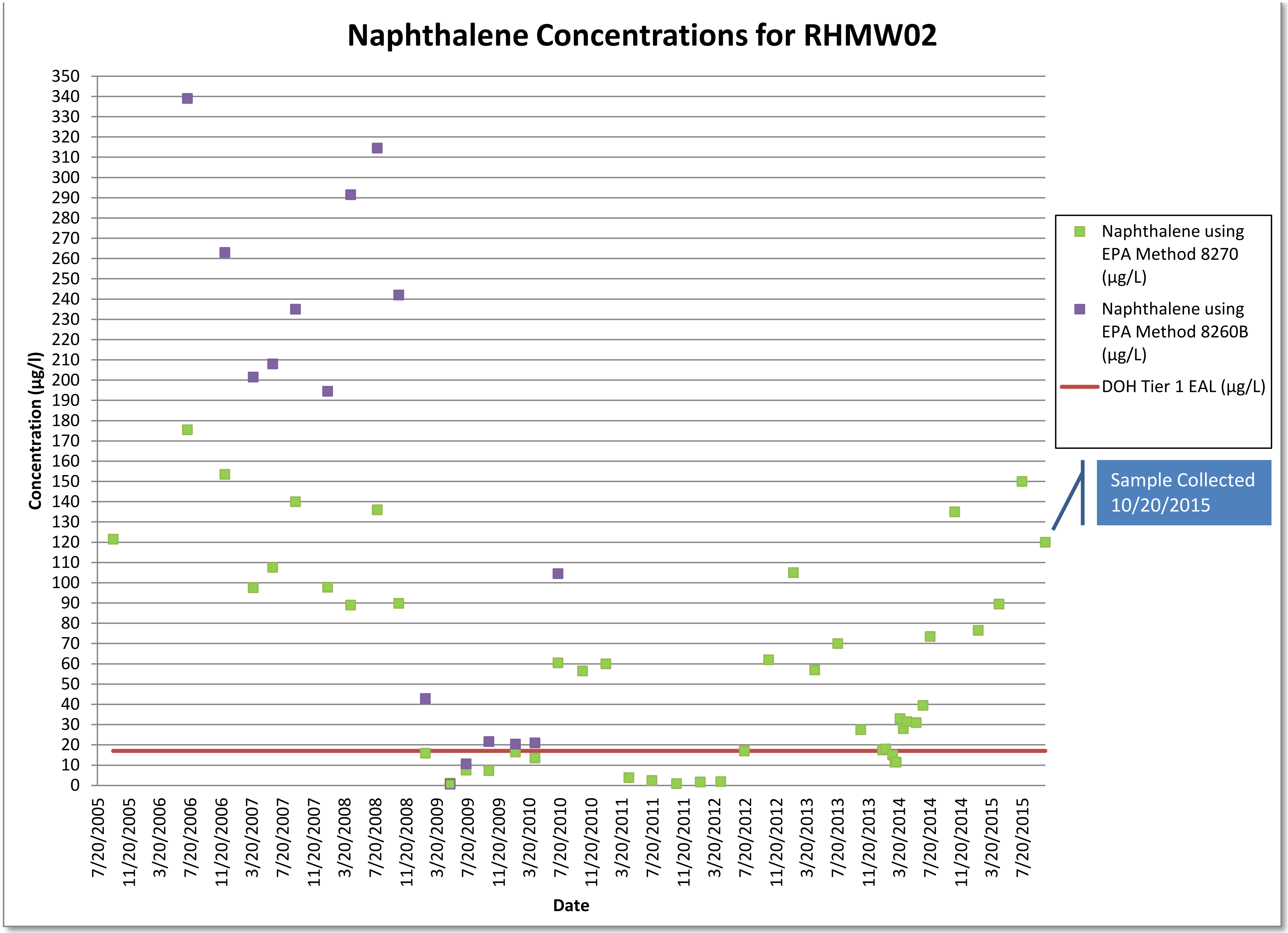
Unfilled boxes indicate non-detections. MDLs are shown for July 2006 through October 2009, and LODs are shown from January 2010 on.



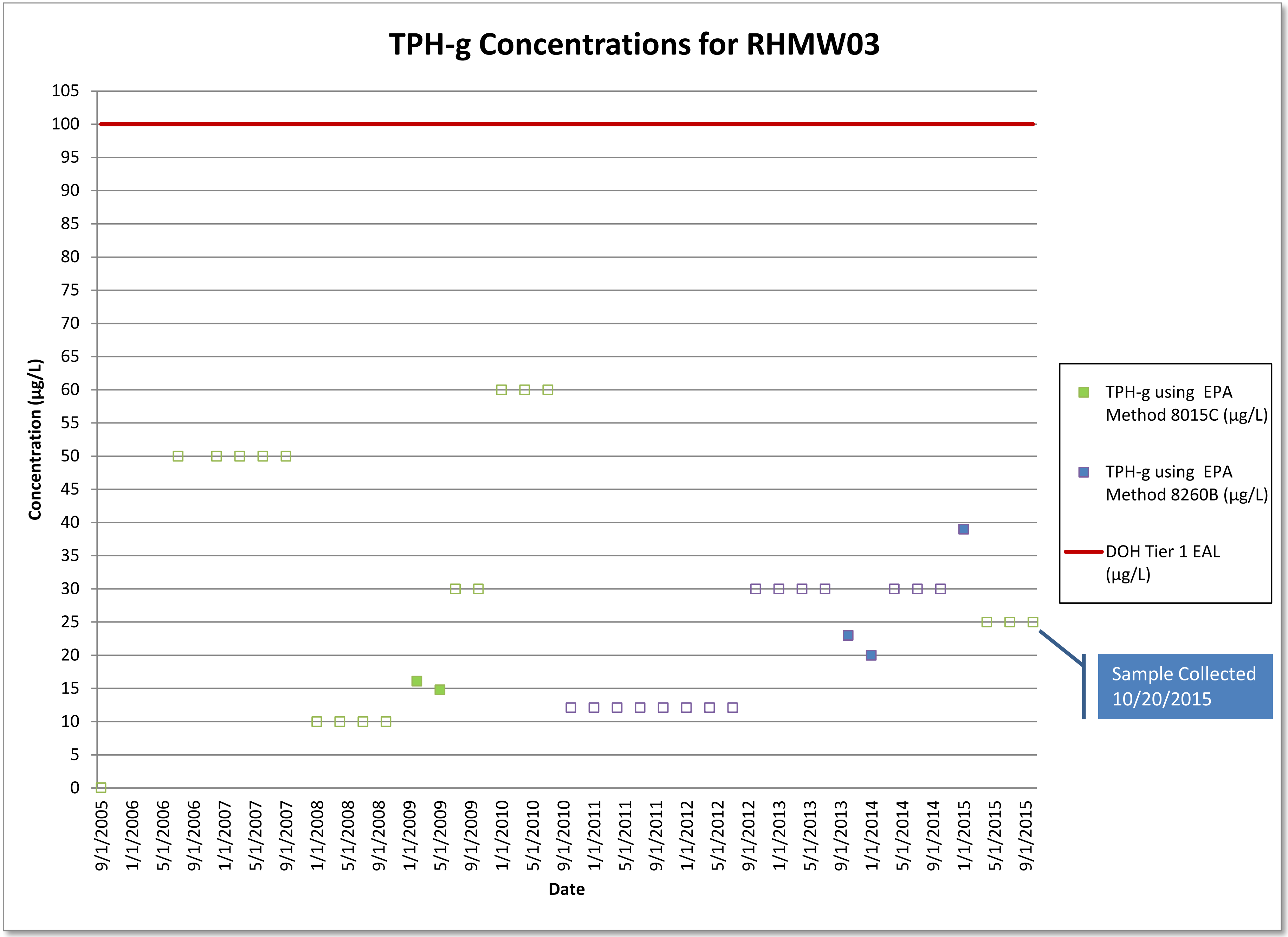
Data points for 9/20/2005 and 3/27/2007 through 4/21/2014 are the average of the primary and duplicate samples.



Data points for 9/20/2005 and 3/27/2007 through 4/21/2014 are the average of the primary and duplicate samples.

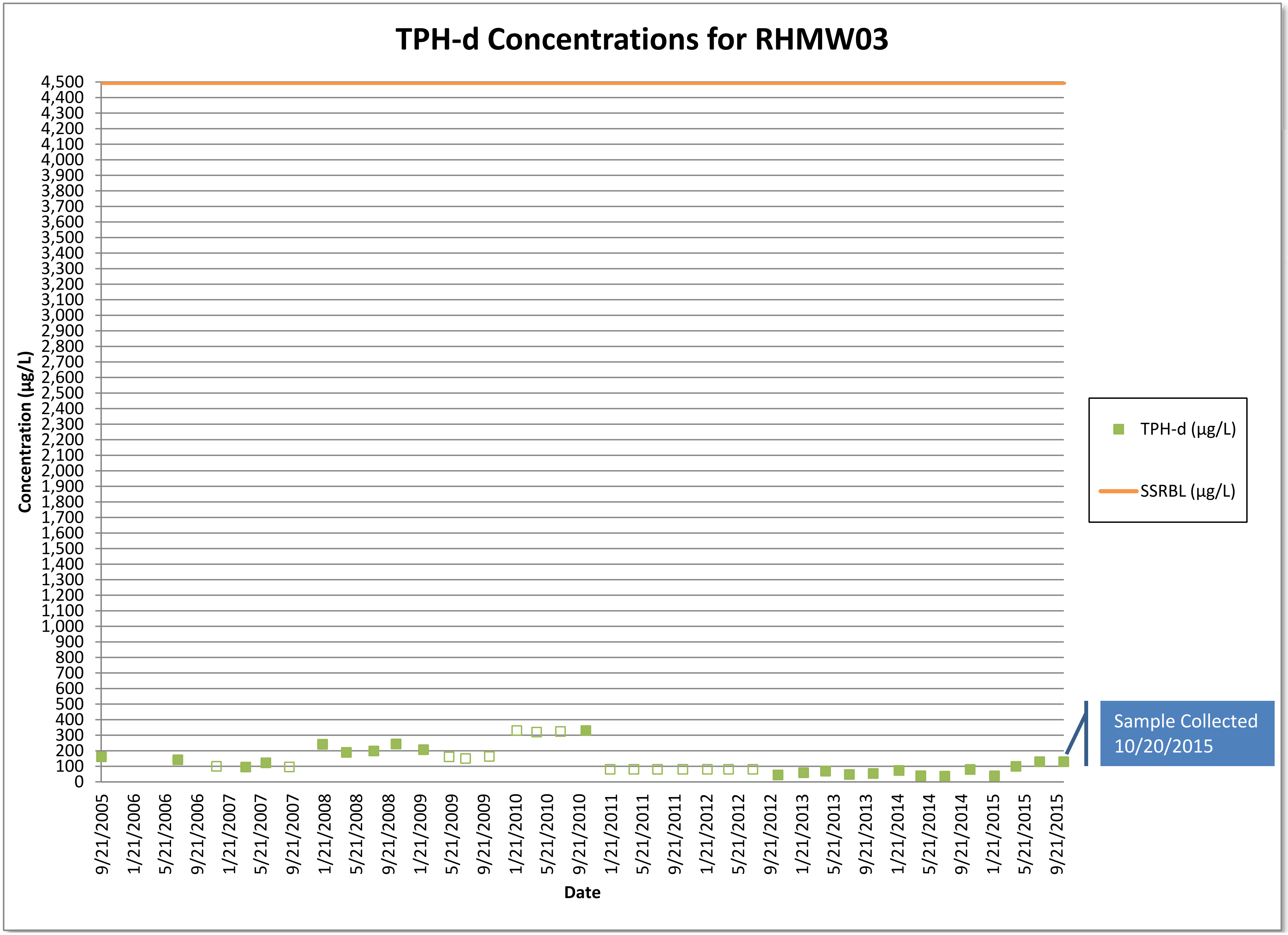


Possible laboratory contamination for 10/21/2013 and 1/28/2014 sampling events.
Unfilled boxes indicate non-detections. LODs are shown.

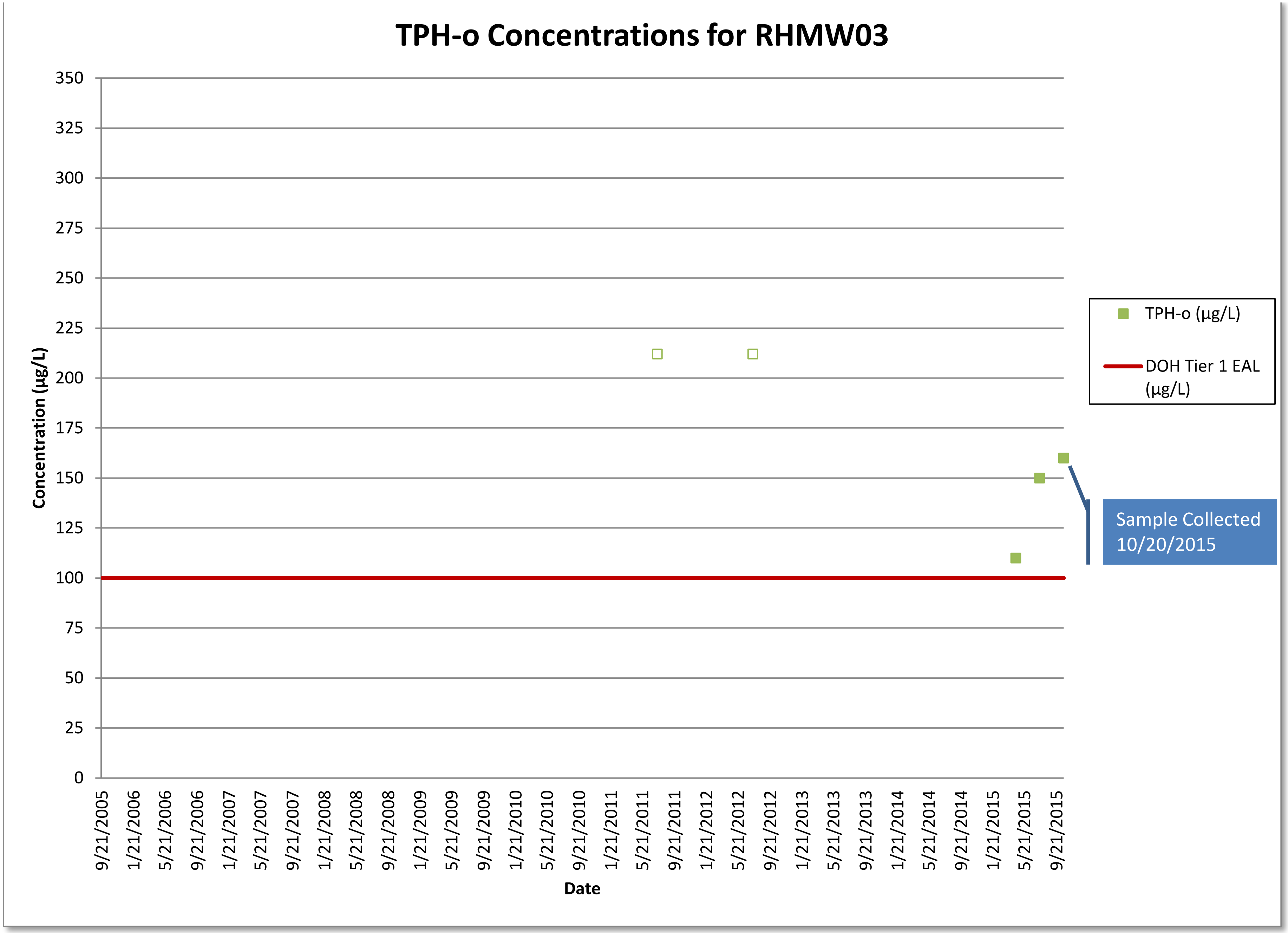


Possible laboratory contamination for 10/21/2013 and 1/28/2014 sampling events.

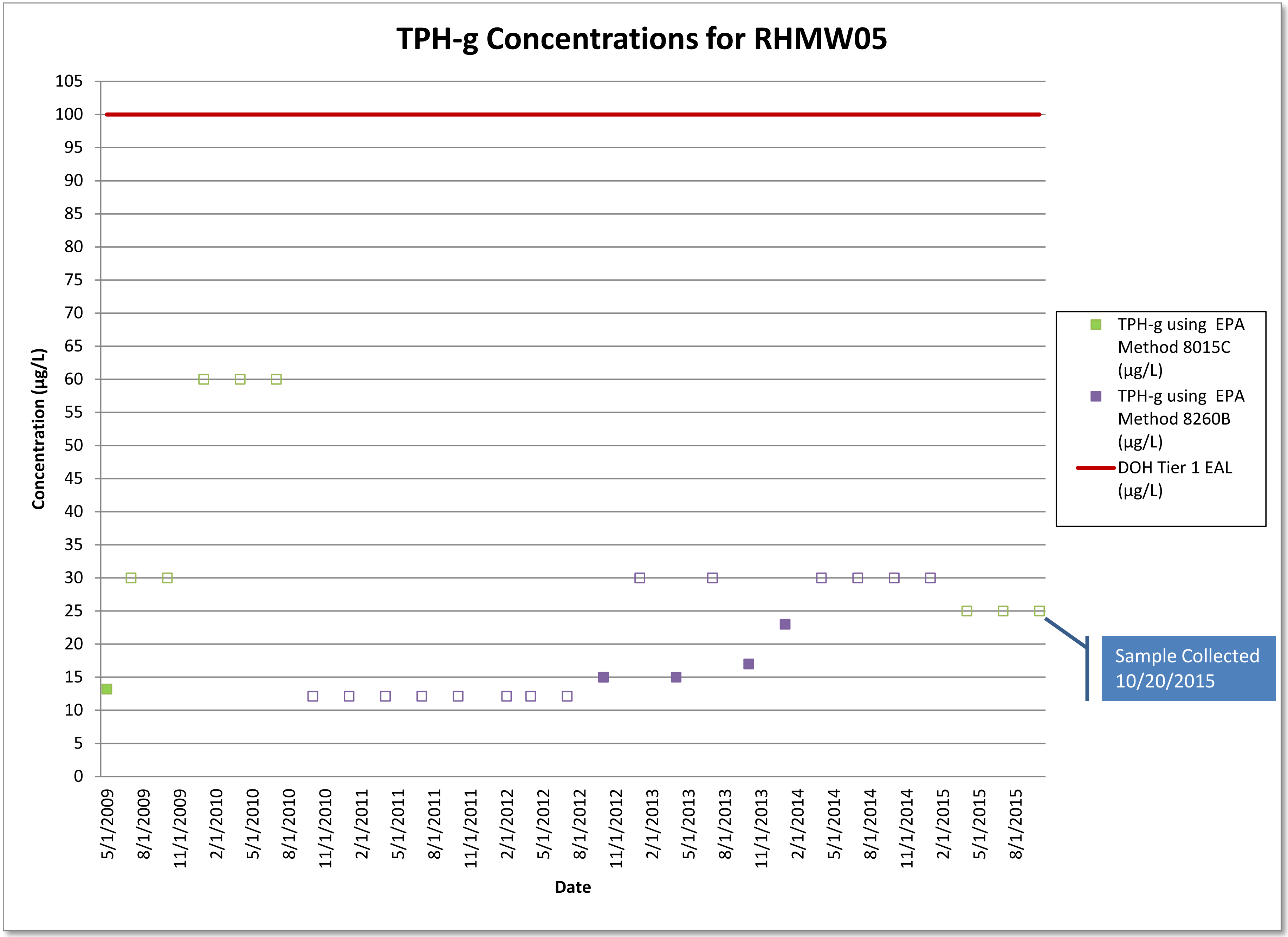
Unfilled boxes indicate non-detections. MDLs are shown for July 2006 through October 2009, and LODs are shown for September 2005 and from January 2010 on.



Unfilled boxes indicate non-detections. MDLs are shown for December 2006 through October 2009, and LODs are shown for September 2005 and from January 2010 on. Numerous sample results had a chromatographic pattern that didn't match the calibration standard. The relatively high TPH-d values may not necessarily be indicative that there is diesel fuel or other petroleum products in the well.

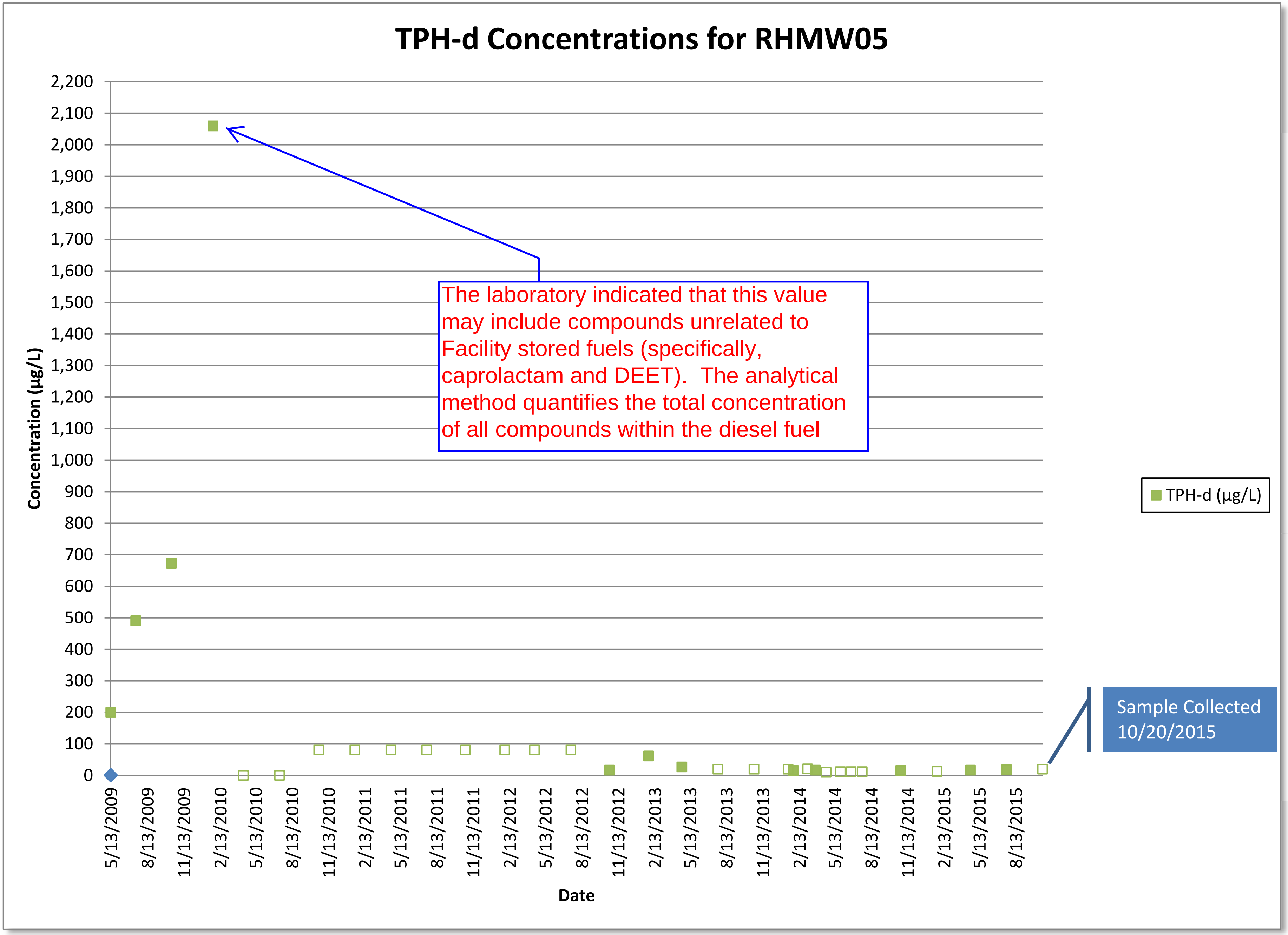


Unfilled boxes indicate non-detections.

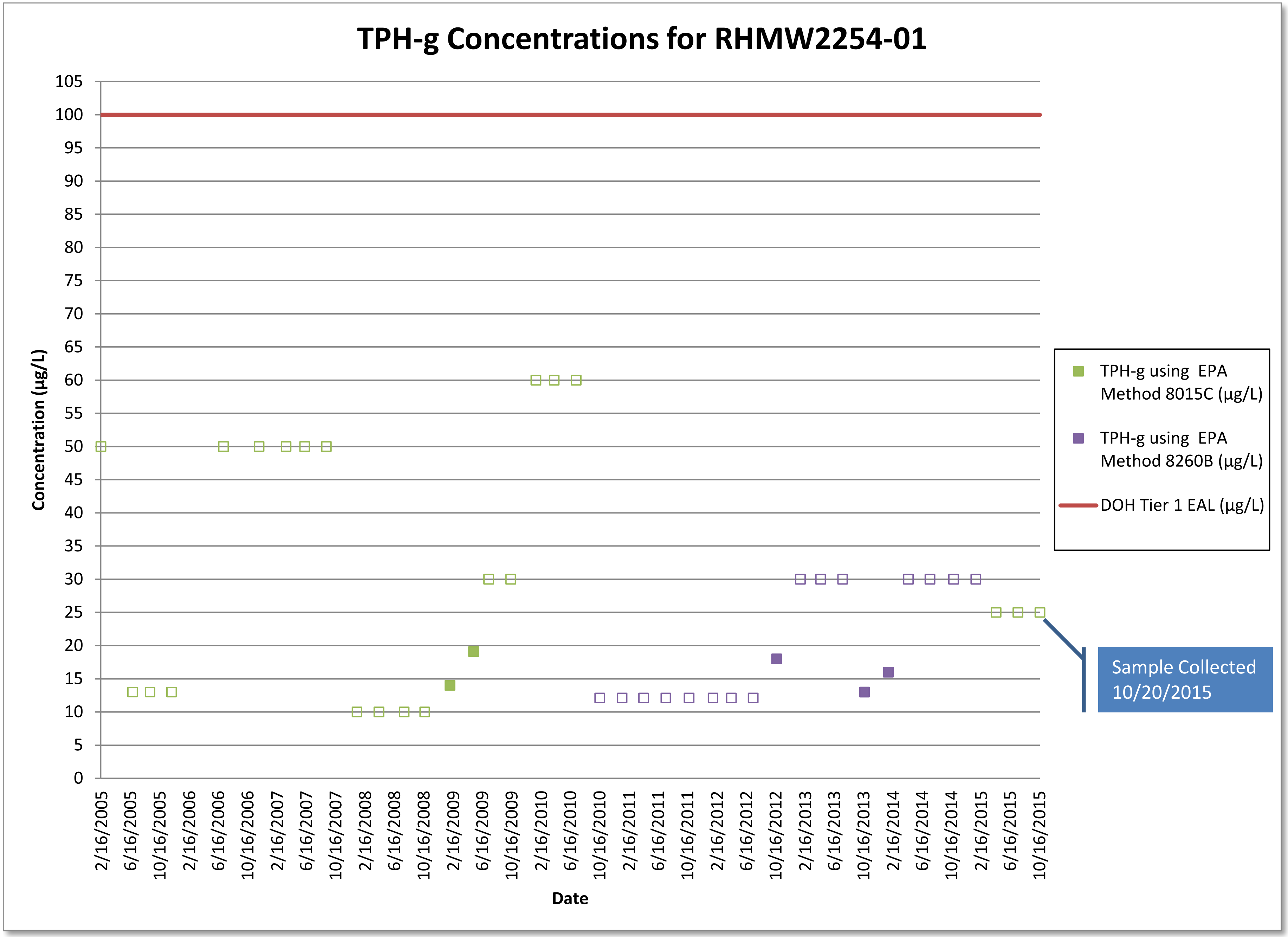


Unfilled boxes indicate non-detections. Data point for 7/17/2012 is the average of the primary and duplicate samples. MDLs are shown for July and October 2009, and LODs are shown from January 2010 on.

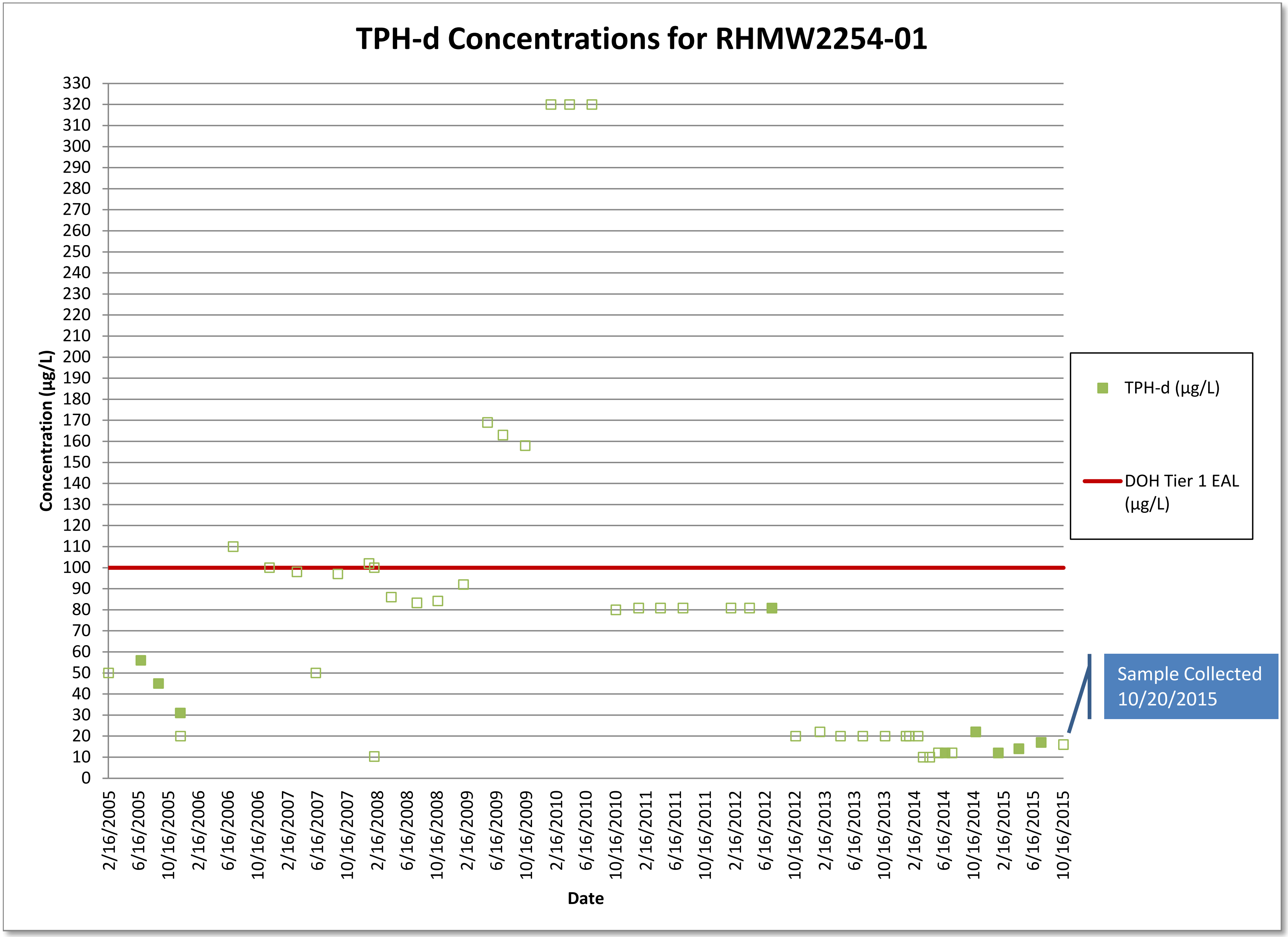
Possible laboratory contamination for 10/22/2012, 10/22/2013, and 1/29/2014 sampling events.



Unfilled boxes indicate non-detections. LODs are shown. Data point for 7/17/2012 is the average of the primary and duplicate samples. Numerous sample results had a chromatographic pattern that did not match the calibration standard. The relatively high TPH-d values may not necessarily be indicative that there is diesel fuel or other petroleum products in the well.



Unfilled boxes indicate non-detections. MRLs are shown for February 2005, MDLs are shown for June 2005 through October 2009, and LODs are shown from January 2010 on. Possible laboratory contamination for 10/22/2012, 10/22/2013, and 1/29/2014 sampling events.



Unfilled boxes indicate non-detections. MRLs are shown for February 2005, MDLs are shown for December 2005 through October 2009, and LODs are shown from January 2010 on. Laboratory data rejected for 1/15/2008 sampling event. Numerous sample results had a chromatographic pattern that did not match the calibration standard. The relatively high TPH-d values may not necessarily be indicative that there is diesel fuel or other petroleum products in the well.

Cumulative Groundwater Measurements and Analytical Results for Outside-Tunnel Wells
Red Hill Bulk Fuel Storage Facility

| Well Name | Sample ID | Date Sampled | 8015C |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | TPH-d (µg/l) |  | TPH-g (µg/l) |  | TPH-o (µg/l) |  | TPH-g (µg/l) |  | 1,1,1-Trichloroethane (µg/l) |  | 1,1,2-Trichloroethane (µg/l) |  | 1,1-Dichloroethane (µg/l) |  | 1,1-Dichloroethylene (µg/l) |  | 1,2,3-Trichloropropane (µg/l) |  | 1,2,4-Tricholorobenzene (µg/l) |  | 1,2-Dibromo-3-chloropropane (µg/l) |  | 1,2-Dibromoethane (µg/l) |  | 1,2-Dichlorobenzene (µg/l) |  | 1,2-Dichloroethane (µg/l) |  | 1,2-Dichloropropane (µg/l) |  | 1,3-Dichlorobenzene (µg/l) |  | 1,3-Dichloropropene (total of cis/trans) (µg/l) |  | 1,4-Dichlorobenzene (µg/l) |  | Acetone (µg/l) |  |
| **For wells < 150 m from surface water** | - | - |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **DOH Tier 1 EALs (for locations < 150m from surface water)** | - | - | **100** |  | **100** |  | **100** |  | **100** |  | **62** |  | **5.0** |  | **2.4** |  | **7.0** |  | **0.6** |  | **25** |  | **0.04** |  | **0.04** |  | **10** |  | **0.5** |  | **5.0** |  | **5.0** |  | **0.43** |  | **5.0** |  | **1500** |  |
| **OWDFMW01** | OWDFMW01-WG-01 | 8/4/2009[a] | <171 | U | <30.0 | U | - |  | - |  | <0.310 | U | <0.310 | U | <0.310 | U | <0.310 | U | <0.310 | U | <0.310 | U | <0.620 | U | <0.310 | U | <0.310 | U | <0.150 | U | <0.310 | U | <0.310 | U | <0.310 | U | <0.150 | U | <3.10 | U |
|  | OWDFMW01-WG-02 | 10/13/2009[ab] | <167 | U | <30 | U | - |  | - |  | <0.31 | U | <0.31 | U | <0.31 | U | - | U | <0.31 | U | <0.31 | U | <0.62 | U | <0.31 | U | <0.31 | U | <0.15 | U | <0.31 | U | <0.31 | U | <0.15 | U | <0.15 | U | <3.1 | U |
|  | OWDFMW01-WG-03 | 1/26/2010 | **1,490** |  | <60.0 | U | **-** |  | - |  | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <1.24 | U | <0.620 | U | <0.620 | U | <0.300 | U | <0.620 | U | <0.620 | U | <0.620 |  | <0.300 | U | <6.20 | U |
|  | OWDFMW01-WG-04 | 4/26/2010 | **288** | **J** | <60.0 | U | **-** |  | - |  | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <1.24 | U | <0.620 | U | <0.620 | U | <0.300 | U | <0.620 | U | <0.620 | U | <0.620 |  | <0.300 | U | <6.20 | U |
|  | ES007 | 10/21/2010 | <80.8 | U | - |  | - |  | <12.12 | U | <0.28 | U | <0.40 | U | <0.38 | U | <0.60 | U | <0.78 | U | <0.42 | U | <1.52 | U | <0.40 | U | <0.34 | U | <0.28 | U | <0.34 | U | <0.22 | U | <0.36 | U | <0.38 | U | **1.4** | **J** |
|  | ES008 | 10/21/2010* | <80.8 | U | - |  | - |  | <12.12 | U | <0.28 | U | <0.40 | U | <0.38 | U | <0.60 | U | <0.78 | U | <0.42 | U | <1.52 | U | <0.40 | U | <0.34 | U | <0.28 | U | <0.34 | U | <0.22 | U | <0.36 | U | <0.38 | U | <1.90 | U |
|  | ES017 | 1/21/2011 | <80.8 | U | - |  | - |  | <12.12 | U | <0.28 | U | <0.40 | U | <0.38 | U | <0.60 | U | <0.78 | U | <0.42 | U | <1.52 | U | <0.40 | U | <0.34 | U | <0.28 | U | <0.34 | U | <0.22 | U | <0.36 | U | <0.38 | U | <1.90 | U |
|  | ES018 | 1/21/2011* | <80.8 | U | - |  | - |  | <12.12 | U | <0.28 | U | <0.40 | U | <0.38 | U | <0.60 | U | <0.78 | U | <0.42 | U | <1.52 | U | <0.40 | U | <0.34 | U | <0.28 | U | <0.34 | U | <0.22 | U | <0.36 | U | <0.38 | U | <1.90 | U |
|  | ES029 | 4/21/2011 | <80.8 | U | - |  | - |  | <12.12 | U | <0.28 | U | <0.40 | U | <0.38 | U | <0.60 | U | <0.78 | U | <0.42 | U | <1.52 | U | <0.40 | U | <0.34 | U | <0.28 | U | <0.34 | U | <0.22 | U | <0.36 | U | <0.38 | U | <1.90 | U |
|  | ES031 | 4/21/2011* | <80.8 | U | - |  | - |  | <12.12 | U | <0.28 | U | <0.40 | U | <0.38 | U | <0.60 | U | <0.78 | U | <0.42 | U | <1.52 | U | <0.40 | U | <0.34 | U | <0.28 | U | <0.34 | U | <0.22 | U | <0.36 | U | <0.38 | U | <1.90 | U |
|  | ES044 | 7/21/2011 | <80.8 | U | - |  | < 212.0 | U | <12.12 | U | <0.28 | U | <0.40 | U | <0.38 | U | <0.60 | U | <0.78 | U | <0.42 | U | <1.52 | U | <0.40 | U | <0.34 | U | <0.28 | U | <0.34 | U | <0.22 | U | <0.36 | U | <0.38 | U | <1.90 | U |
|  | ES045 | 7/21/2011* | <80.8 | U | - |  | < 212.0 | U | <12.12 | U | <0.28 | U | <0.40 | U | <0.38 | U | <0.60 | U | <0.78 | U | <0.42 | U | <1.52 | U | <0.40 | U | <0.34 | U | <0.28 | U | <0.34 | U | <0.22 | U | <0.36 | U | <0.38 | U | <1.90 | U |
|  | ES055 | 10/26/2011 | <80.8 | U | - |  | - |  | <12.12 | U | <0.28 | U | <0.40 | U | <0.38 | U | <0.60 | U | <0.78 | U | <0.42 | U | <1.52 | U | <0.40 | U | <0.34 | U | <0.28 | U | <0.34 | U | <0.22 | U | <0.36 | U | <0.38 | U | <1.90 | U |
|  | ES056 | 10/26/2011* | <80.8 | U | - |  | - |  | <12.12 | U | <0.28 | U | <0.40 | U | <0.38 | U | <0.60 | U | <0.78 | U | <0.42 | U | <1.52 | U | <0.40 | U | <0.34 | U | <0.28 | U | <0.34 | U | <0.22 | U | <0.36 | U | <0.38 | U | <1.90 | U |
|  | ES058 | 1/24/2012 | <80.8 | U | - |  | < 212.0 | U | <12.12 | U | <0.28 | U | <0.40 | U | <0.38 | U | <0.60 | U | <0.78 | U | <0.42 | U | <1.52 | U | <0.40 | U | <0.34 | U | <0.28 | U | <0.34 | U | <0.22 | U | <0.36 | U | <0.38 | U | <1.90 | U |
|  | ES059 | 1/24/2012* | <80.8 | U | - |  | < 212.0 | U | <12.12 | U | <0.28 | U | <0.40 | U | <0.38 | U | <0.60 | U | <0.78 | U | <0.42 | U | <1.52 | U | <0.40 | U | <0.34 | U | <0.28 | U | <0.34 | U | <0.22 | U | <0.36 | U | <0.38 | U | <1.90 | U |
|  | ES077 | 4/26/2012 | **220** | **++** | - |  | - |  | <12.12 | U | <0.28 | U | <0.40 | U | <0.38 | U | <0.60 | U | <0.78 | U | <0.42 | U | <1.52 | U | <0.40 | U | <0.34 | U | <0.28 | U | <0.34 | U | <0.22 | U | <0.36 | U | <0.38 | U | **2.8** | **J** |
|  | ES084 | 7/19/2012 | <80.8 | U | - |  | - |  | <12.12 | U | <0.28 | U | <0.40 | U | <0.38 | U | <0.60 | U | <0.78 | U | <0.42 | U | <1.52 | U | <0.40 | U | <0.34 | U | <0.28 | U | <0.34 | U | <0.22 | U | <0.36 | U | <0.38 | U | **2.3** | **J** |
|  | ES008 | 11/7/2012 | **2,500** | **HD** | - |  | **-** |  | **17** | **BU,B** | <0.50 | BU,U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <10 | U |
|  | ES007 | 11/7/2012* | **2,500** | **HD** | - |  | **-** |  | <30 | BU,U | <0.50 | BU,U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <10 | U |
|  | ES016 | 1/30/2013 | **1,000** |  | - |  | **-** |  | <30 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | **17** | **J,ICH** |
|  | ES017 | 1/30/2013* | **1,000** |  | - |  | **-** |  | <30 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <10 | U,ICH |
|  | ES025 | 4/24/2013 | **1,900** | **HD** | - |  | **-** |  | <30 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <1.0 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | **84** | **ICH** |
|  | ES026 | 4/24/2013* | **1,600** | **HD** | - |  | **-** |  | <30 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <1.0 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | **86** | **ICH** |
|  | ES034 | 7/24/2013 | **470** | **HD** | - |  | **-** |  | <30 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <1.0 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | **88** |  |
|  | ES035 | 7/24/2013* | **340** | **HD** | - |  | **-** |  | <30 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <1.0 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | **83** |  |
|  | ES043 | 10/23/2013 | **170** | **HD** | - |  | **-** |  | **17** | **B,J** | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | **44** | **ICH** |
|  | ES044 | 10/23/2013* | **200** | **HD** | - |  | **-** |  | **14** | **B,J** | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | **38** | **ICH** |
|  | ES053 | 1/27/2014 | **170** | **HD** | - |  | **-** |  | **26** | **B,J** | < 0.50 | U,IH | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U,IH | < 0.50 | U | **19** | **J** |
|  | ES054 | 1/27/2014* | **140** | **HD** | - |  | **-** |  | **23** | **B,J** | < 0.50 | U,IH | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U,IH | < 0.50 | U | **18** | **J** |
|  | ES086 | 4/23/2014 | **270** | **HD** | - |  | **-** |  | <30 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <1.0 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U,ICH | <0.50 | U | **11** | **J,IH,ICH** |
|  | ES087*** | 4/23/2014* | **32** | **HD** | - |  | **-** |  | **31** | **B,J** | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <1.0 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U,ICH | <0.50 | U | **12** | **J,IH,ICH** |
|  | ES109 | 7/24/2014 | **17** | **HD,J** | - |  | **-** |  | <30 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <1.0 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | **6.4** | **J,IH,ICH** |
|  | ES110 | 7/24/2014* | **15** | **HD,J** | - |  | **-** |  | <30 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <1.0 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | **9.8** | **J,IH,ICH** |
|  | ES121 | 10/22/2014 | **19** | **HD,J** | - |  | **-** |  | <30 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <1.0 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | **7.7** | **J,ICH** |
|  | ES122 | 10/22/2014* | **19** | **HD,J** | - |  | **-** |  | <30 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <1.0 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U,IH | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | **8.6** | **J,ICH** |
|  | ES121X | 1/26/2015 | **24** | **HD,J** | - |  | **-** |  | <30 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <1.0 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | **13** | **J** |
|  | ES122X | 1/26/2015* | **16** | **HD,J** | - |  | **-** |  | <30 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <1.0 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | **13** | **J** |
|  | ES137 | 4/22/2015 | **120** | **Z** | <25 | U | **110** | **B,Z** | **-** |  | <0.20 | U | <0.40 | U | <0.20 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.80 | U | <0.20 | U | <0.20 | U | **-** |  | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | **25** |  |
|  | ES138 | 4/22/2015* | **120** | **Z** | <25 | U | **140** | **B,Z** | **-** |  | <0.20 | U | <0.40 | U | <0.20 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.80 | U | <0.20 | U | <0.20 | U | **-** |  | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | **25** |  |
|  | ES152 | 7/22/2015 | **3,100** | **Z** | <25 | U | **390** | **Z** | **-** |  | <0.20 | U | <0.40 | U | <0.20 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.80 | U | <0.20 | U | <0.20 | U | **-** |  | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | **150** |  |
|  | ES153 | 7/22/2015* | **3,000** | **Z** | <25 | U | **330** | **Z** | **-** |  | <0.20 | U | <0.40 | U | <0.20 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.80 | U | <0.20 | U | <0.20 | U | **-** |  | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | **150** |  |
|  | ERH002 | 10/19/2015 | **680** | **B,Z** | <25 | U | **100** | **B,J** | **-** |  | <0.20 | U,** | <0.40 | U,** | <0.20 | U,** | <0.20 | J,* | <0.50 | J,* | <0.30 | J,* | <0.80 | U,** | <0.20 | J,* | <0.20 | J,* | **-** |  | <0.20 | J,* | <0.20 | J,* | <0.20 | U,** | <0.20 | U,** | **56** | ** |
|  | ERH016 | 1/19/2016 | **320** | **B,Z** | < 25 | U | **69** | **B,J** | - | - | < 0.20 | U | < 0.40 | U | < 0.20 | U | < 0.20 | U | < 0.50 | U | < 0.30 | U | < 0.80 | U | < 0.20 | U | < 0.20 | U | - | - | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | **34** |  |

| Well Name | Sample ID | Date Sampled | 8260B | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Benzene | | Bromodichloromethane | | Bromoform | | Bromomethane | | Carbon Tetrachloride | | Chlorobenzene | | Chloroethane | | Chloroform | | Chloromethane | | cis-1,2-Dichloroethylene | | Dibromochloromethane | | Ethylbenzene | | Hexachlorobutadiene | | Methyl ethyl ketone (2-Butanone) | | Methyl isobutyl ketone (4-Methyl-2-Pentanone) | | Methyl tert-butyl Ether | | Methylene chloride | | Napthalene | | Styrene | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| **For wells < 150 m from surface water** | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations < 150m from surface water)** | - | - | **5.0** | | **0.12** | | **80** | | **8.7** | | **5.0** | | **25** | | **16** | | **70** | | **1.8** | | **70** | | **0.16** | | **30** | | **0.86** | | **7,100** | | **170** | | **5.0** | | **4.8** | | **17** | | **10** | |
| **OWDFMW01** | OWDFMW01-WG-01 | 8/4/2009[a] | **0.470** | | <0.150 | U | <0.310 | U | <0.940 | U | <0.310 | U | <0.150 | U | <0.310 | U | <0.300 | U | <0.310 | U | <0.310 | U | <0.150 | U | <0.310 | U | <0.310 | U | <3.10 | U | <3.10 | U | <1.50 | U | <1.00 | U | <0.620 | U | <0.310 | U |
| | OWDFMW01-WG-02 | 10/13/2009[ab] | <0.12 | U | <0.15 | U | <0.31 | U | <0.94 | U | <0.31 | U | <0.15 | U | <0.31 | U | <0.30 | U | <0.31 | U | <0.31 | U | <0.15 | U | <0.31 | U | <0.31 | U | <3.1 | U | <3.1 | U | - | | <1 | U | <0.62 | U | <0.31 | U |
| | OWDFMW01-WG-03 | 1/26/2010 | <0.240 | U | <0.300 | U | <0.620 | U | <1.88 | U | <0.620 | U | <0.300 | U | <0.620 | U | <0.600 | U | <0.620 | U | <0.620 | U | <0.300 | U | <0.620 | U | <0.620 | U | <6.20 | U | <6.20 | U | <3.00 | U | <2.00 | U | <1.24 | U | <0.620 | U |
| | OWDFMW01-WG-04 | 4/26/2010 | <0.240 | U | <0.300 | U | <0.620 | U | <1.88 | U | <0.620 | U | <0.300 | U | <0.620 | U | <0.600 | U | <0.620 | U | <0.620 | U | <0.300 | U | <0.620 | U | <0.620 | U | <6.20 | U | <6.20 | U | <3.00 | U | <2.00 | U | <1.24 | U | <0.620 | U |
| | ES007 | 10/21/2010 | <0.32 | U | <0.28 | U | <0.28 | U | <0.48 | U | <0.20 | U | <0.42 | U | <0.42 | U | <0.14 | U | <0.62 | U | <0.32 | U | <0.38 | U | <0.46 | U | <0.38 | U | <1.20 | U | <3.80 | U | <0.38 | U | <0.70 | U | - | | <0.50 | U |
| | ES008 | 10/21/2010* | <0.32 | U | <0.28 | U | <0.28 | U | <0.48 | U | <0.20 | U | <0.42 | U | <0.42 | U | <0.14 | U | <0.62 | U | <0.32 | U | <0.38 | U | <0.46 | U | <0.38 | U | <1.20 | U | <3.80 | U | <0.38 | U | <0.70 | U | - | | <0.50 | U |
| | ES017 | 1/21/2011 | **0.54** | **J** | <0.28 | U | <0.28 | U | <0.48 | U | <0.20 | U | <0.42 | U | <0.42 | U | <0.14 | U | <0.62 | U | <0.32 | U | <0.38 | U | <0.46 | U | <0.38 | U | <1.20 | U | <3.80 | U | <0.38 | U | <0.70 | U | - | | <0.50 | U |
| | ES018 | 1/21/2011* | **0.69** | **J** | <0.28 | U | <0.28 | U | <0.48 | U | <0.20 | U | <0.42 | U | <0.42 | U | <0.14 | U | <0.62 | U | <0.32 | U | <0.38 | U | <0.46 | U | <0.38 | U | <1.20 | U | <3.80 | U | <0.38 | U | <0.70 | U | - | | <0.50 | U |
| | ES029 | 4/21/2011 | <0.32 | U | <0.28 | U | <0.28 | U | <0.48 | U | <0.20 | U | <0.42 | U | <0.42 | U | <0.14 | U | <0.62 | U | <0.32 | U | <0.38 | U | <0.46 | U | <0.38 | U | <1.20 | U | <3.80 | U | <0.38 | U | <0.70 | U | - | | <0.50 | U |
| | ES031 | 4/21/2011* | **0.29** | **J** | <0.28 | U | <0.28 | U | <0.48 | U | <0.20 | U | <0.42 | U | <0.42 | U | <0.14 | U | <0.62 | U | <0.32 | U | <0.38 | U | <0.46 | U | <0.38 | U | <1.20 | U | <3.80 | U | <0.38 | U | <0.70 | U | - | | <0.50 | U |
| | ES044 | 7/21/2011 | <0.32 | U | <0.28 | U | <0.28 | U | <0.48 | U | <0.20 | U | <0.42 | U | <0.42 | U | <0.14 | U | <0.62 | U | <0.32 | U | <0.38 | U | <0.46 | U | <0.38 | U | <1.20 | U | <3.80 | U | <0.38 | U | <0.70 | U | - | | <0.50 | U |
| | ES045 | 7/21/2011* | <0.32 | U | <0.28 | U | <0.28 | U | <0.48 | U | <0.20 | U | <0.42 | U | <0.42 | U | <0.14 | U | <0.62 | U | <0.32 | U | <0.38 | U | <0.46 | U | <0.38 | U | <1.20 | U | <3.80 | U | <0.38 | U | <0.70 | U | - | | <0.50 | U |
| | ES055 | 10/26/2011 | <0.32 | U | <0.28 | U | <0.28 | U | <0.48 | U | <0.20 | U | <0.42 | U | <0.42 | U | <0.14 | U | <0.84 | U | <0.32 | U | <0.38 | U | <0.46 | U | <0.38 | U | <1.20 | U | <3.80 | U | <0.52 | U | <0.70 | U | - | | <0.50 | U |
| | ES056 | 10/26/2011* | **0.28** | **J** | <0.28 | U | <0.28 | U | <0.48 | U | <0.20 | U | <0.42 | U | <0.42 | U | <0.14 | U | <0.84 | U | <0.32 | U | <0.38 | U | <0.46 | U | <0.38 | U | <1.20 | U | <3.80 | U | <0.52 | U | <0.70 | U | - | | <0.50 | U |
| | ES058 | 1/24/2012 | **0.70** | **J** | <0.28 | U | <0.28 | U | <0.48 | U | <0.20 | U | <0.42 | U | <0.42 | U | <0.14 | U | <0.84 | U | <0.32 | U | <0.38 | U | <0.46 | U | <0.38 | U | <1.20 | U | <3.80 | U | <0.52 | U | <0.70 | U | - | | <0.50 | U |
| | ES059 | 1/24/2012* | **0.58** | **J** | <0.28 | U | <0.28 | U | <0.48 | U | <0.20 | U | <0.42 | U | <0.42 | U | <0.14 | U | <0.84 | U | <0.32 | U | <0.38 | U | <0.46 | U | <0.38 | U | <1.20 | U | <3.80 | U | <0.52 | U | <0.70 | U | - | | <0.50 | U |
| | ES077 | 4/26/2012 | **0.71** | **J** | <0.28 | U | <0.28 | U | <0.48 | U | <0.20 | U | <0.42 | U | <0.42 | U | <0.14 | U | <0.84 | U | <0.32 | U | <0.38 | U | <0.46 | U | <0.38 | U | <1.20 | U | <3.80 | U | <0.52 | U | <0.70 | U | - | | <0.50 | U |
| | ES084 | 7/19/2012 | **1.3** | | <0.28 | U | <0.28 | U | <0.48 | U | <0.20 | U | <0.42 | U | <0.42 | U | <0.14 | U | <0.62 | U | <0.32 | U | <0.38 | U | <0.46 | U | <0.38 | U | **1.0** | **J** | <3.80 | U | <0.38 | U | <0.70 | U | - | | <0.50 | U |
| | ES008 | 11/7/2012 | **0.38** | **BU,J** | <0.50 | U | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <5.0 | U | <0.50 | U | <5.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <5.0 | U | <5.0 | U | <0.50 | U | <1.0 | U | - | | <0.50 | U |
| | ES007 | 11/7/2012* | **0.49** | **BU,J** | <0.50 | BU,J | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <5.0 | U | <0.50 | U | <5.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <5.0 | U | <5.0 | U | <0.50 | U | <1.0 | U | - | | <0.50 | U |
| | ES016 | 1/30/2013 | **0.39** | **J** | <0.50 | U | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <5.0 | U | <0.50 | U | <5.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <5.0 | U | <5.0 | U | <0.50 | U | <1.0 | U | - | | <0.50 | U |
| | ES017 | 1/30/2013* | **0.17** | **J** | <0.50 | U | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <5.0 | U | <0.50 | U | <5.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <5.0 | U | <5.0 | U | <0.50 | U | <1.0 | U | - | | <0.50 | U |
| | ES025 | 4/24/2013 | **0.82** | **J** | <0.50 | U | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <5.0 | U | <0.50 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <5.0 | U | <5.0 | U | <0.50 | U | <1.0 | U | - | | <0.50 | U |
| | ES026 | 4/24/2013* | **0.67** | **J** | <0.50 | U | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <5.0 | U | <0.50 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <5.0 | U | <5.0 | U | <0.50 | U | <1.0 | U | - | | <0.50 | U |
| | ES034 | 7/24/2013 | **0.42** | **J** | <0.50 | U | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <5.0 | U | <0.50 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <5.0 | U | <5.0 | U | <0.50 | U | <1.0 | U | - | | <0.50 | U |
| | ES035 | 7/24/2013* | **0.44** | **J** | <0.50 | U | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <5.0 | U | <0.50 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <5.0 | U | <5.0 | U | <0.50 | U | <1.0 | U | - | | <0.50 | U |
| | ES043 | 10/23/2013 | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U,IJ | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U,ICH | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U |
| | ES044 | 10/23/2013* | **0.17** | **J** | < 0.50 | U | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U,IJ | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U,ICH | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U |
| | ES053 | 1/27/2014 | **0.15** | **J** | < 0.50 | U | < 1.0 | U | < 5.0 | U,IH | < 0.50 | U,IH | < 0.50 | U | < 5.0 | U,IH | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U |
| | ES054 | 1/27/2014* | <0.50 | U | < 0.50 | U | < 1.0 | U | < 5.0 | U,IH | < 0.50 | U,IH | < 0.50 | U | < 5.0 | U,IH | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U |
| | ES086 | 4/23/2014 | <0.50 | U | <0.50 | U | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <5.0 | U | <0.50 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <5.0 | U,ICH | <5.0 | U | <0.50 | U | <1.0 | U | - | | <0.50 | U |
| | ES087*** | 4/23/2014* | <0.50 | U | <0.50 | U | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <5.0 | U | <0.50 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <5.0 | U,ICH | <5.0 | U | <0.50 | U | <1.0 | U | - | | <0.50 | U |
| | ES109 | 7/24/2014 | <0.50 | U | <0.50 | U | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <5.0 | U | <0.50 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <5.0 | U | <5.0 | U | <0.50 | U | <1.0 | U | - | | <0.50 | U |
| | ES110 | 7/24/2014* | <0.50 | U | <0.50 | U | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <5.0 | U | <0.50 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <5.0 | U | <5.0 | U | <0.50 | U | <1.0 | U | - | | <0.50 | U |
| | ES121 | 10/22/2014 | <0.50 | U | <0.50 | U | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <5.0 | U | <0.50 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <5.0 | U,ICH | <5.0 | U | <0.50 | U | <1.0 | U | - | | <0.50 | U |
| | ES122 | 10/22/2014* | <0.50 | U | <0.50 | U | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <5.0 | U | <0.50 | U | <2.0 | U,IJ | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <5.0 | U,ICH | <5.0 | U | <0.50 | U | <1.0 | U | - | | <0.50 | U |
| | ES121X | 1/26/2015 | <0.50 | U | <0.50 | U | <1.0 | U | <5.0 | U,IH | <0.50 | U | <0.50 | U | <5.0 | U | <0.50 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <5.0 | U | <5.0 | U | <0.50 | U | <1.0 | U | - | | <0.50 | U |
| | ES122X | 1/26/2015* | <0.50 | U | <0.50 | U | <1.0 | U | <5.0 | U,IH | <0.50 | U | <0.50 | U | <5.0 | U | <0.50 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <5.0 | U | <5.0 | U | <0.50 | U | <1.0 | U | - | | <0.50 | U |
| | ES137 | 4/22/2015 | **0.070** | **J** | - | | <0.50 | U | <0.30 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | **0.070** | **J** | <0.20 | U | - | | <0.10 | U | <0.30 | U | <4.0 | U | <10 | U | <0.30 | U | <0.20 | U | - | | <0.20 | U |
| | ES138 | 4/22/2015* | <0.10 | U | - | | <0.50 | U | <0.30 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | - | | <0.10 | U | <0.30 | U | <4.0 | U | <10 | U | <0.30 | U | <0.20 | U | - | | <0.20 | U |
| | ES152 | 7/22/2015 | <0.10 | U | - | | <0.50 | U | <0.30 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | **0.080** | **J** | <0.20 | U | - | | <0.10 | U | <0.30 | U | <4.0 | U | <10 | U | <0.30 | U | **0.20** | **J** | - | | <0.20 | U |
| | ES153 | 7/22/2015* | <0.10 | U | - | | <0.50 | U | <0.30 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | **0.090** | **J** | <0.20 | U | - | | <0.10 | U | <0.30 | U | <4.0 | U | <10 | U | <0.30 | U | **0.20** | **J** | - | | <0.20 | U |
| | ERH002 | 10/19/2015 | <0.10 | U,** | - | | <0.50 | U,** | <0.30 | U,** | <0.20 | U,** | <0.20 | U,* | <0.20 | U,** | <0.20 | U,** | **0.12** | **J,**** | <0.20 | U,* | - | | <0.10 | U,** | <0.30 | U,* | <4.0 | U,** | <10 | U,* | <0.30 | U,* | <0.20 | B,U,** | - | | <0.20 | U,** |
| | ERH016 | 1/19/2016 | < 0.10 | U | - | - | < 0.50 | U | < 0.30 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | **0.17** | **J** | < 0.20 | U | - | - | < 0.10 | U | < 0.30 | U | < 4.0 | U | < 10 | U | < 0.30 | U | < 0.20 | B,U | - | - | < 0.20 | U |

## Cumulative Groundwater Measurements and Analytical Results for Outside-Tunnel Wells
## Red Hill Bulk Fuel Storage Facility

| Well Name | Sample ID | Date Sampled | | | | | | | | | | | | | | | | | 8260SIM | | | | | | | | | | 8011 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Tetrachloroethane, 1,1,1,2- | | Tetrachloroethane, 1,1,2,2- | | Tetrachloroethylene | | Toluene | | trans-1,2- Dichloroethylene | | Trichloroethylene | | Vinyl chloride | | Xylenes (total) | | 1,2-Dibromoethane | | 1,2-Dichloroethane | | Bromodichloromethane | | Dibromochloromethane | | Tetrachloroethane, 1,1,2,2- | | 1,2-Dibromo-3-chloropropane | | 1,2-Dibromoethane | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| **For wells < 150 m from surface water** | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations < 150m from surface water)** | - | - | **0.52** | | **0.067** | | **5.0** | | **40** | | **100** | | **5.0** | | **2.0** | | **20** | | **0.04** | | **0.15** | | **0.12** | | **0.16** | | **0.067** | | **0.04** | | **0.04** | |
| **OWDFMW01** | OWDFMW01-WG-01 | 8/4/2009[a] | <0.150 | U | <0.150 | U | <0.310 | U | <0.310 | U | <0.310 | U | <0.310 | U | <0.310 | U | <0.620 | U | - | | - | | - | | - | | - | | - | | - | |
| | OWDFMW01-WG-02 | 10/13/2009[ab] | <0.15 | U | <0.15 | U | <0.31 | U | <0.31 | U | <0.31 | U | <0.31 | U | <0.31 | U | <0.62 | U | - | | - | | - | | - | | - | | - | | - | |
| | OWDFMW01-WG-03 | 1/26/2010 | <0.300 | U | <0.300 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <1.24 | U | - | | - | | - | | - | | - | | - | | - | |
| | OWDFMW01-WG-04 | 4/26/2010 | <0.300 | U | <0.300 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <1.24 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES007 | 10/21/2010 | <0.26 | U | <0.20 | U | <0.30 | U | <0.34 | U | <0.38 | U | <0.32 | U | <0.46 | U | <0.38 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES008 | 10/21/2010* | <0.26 | U | <0.20 | U | <0.30 | U | <0.34 | U | <0.38 | U | <0.32 | U | <0.46 | U | <0.38 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES017 | 1/21/2011 | <0.26 | U | <0.20 | U | <0.30 | U | <0.34 | U | <0.38 | U | <0.32 | U | <0.46 | U | <0.38 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES018 | 1/21/2011* | <0.26 | U | <0.20 | U | <0.30 | U | <0.34 | U | <0.38 | U | <0.32 | U | <0.46 | U | <0.38 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES029 | 4/21/2011 | <0.26 | U | <0.20 | U | <0.30 | U | **0.21** | **J** | <0.38 | U | <0.32 | U | <0.46 | U | **0.39** | **J** | - | | - | | - | | - | | - | | - | | - | |
| | ES031 | 4/21/2011* | <0.26 | U | <0.20 | U | <0.30 | U | <0.34 | U | <0.38 | U | <0.32 | U | <0.46 | U | <0.38 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES044 | 7/21/2011 | <0.26 | U | <0.20 | U | <0.30 | U | <0.34 | U | <0.38 | U | <0.32 | U | <0.46 | U | <0.38 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES045 | 7/21/2011* | <0.26 | U | <0.20 | U | <0.30 | U | <0.34 | U | <0.38 | U | <0.32 | U | <0.46 | U | <0.38 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES055 | 10/26/2011 | <0.26 | U | <0.20 | U | <0.48 | U | <0.34 | U | <0.38 | U | <0.32 | U | <0.46 | U | <0.38 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES056 | 10/26/2011* | <0.26 | U | <0.20 | U | <0.48 | U | <0.34 | U | <0.38 | U | <0.32 | U | <0.46 | U | <0.38 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES058 | 1/24/2012 | <0.26 | U | <0.20 | U | <0.48 | U | <0.34 | U | <0.38 | U | <0.32 | U | <0.46 | U | <0.38 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES059 | 1/24/2012* | <0.26 | U | <0.20 | U | <0.48 | U | <0.34 | U | <0.38 | U | <0.32 | U | <0.46 | U | <0.38 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES077 | 4/26/2012 | <0.26 | U | <0.20 | U | <0.48 | U | <0.34 | U | <0.38 | U | <0.32 | U | <0.46 | U | <0.38 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES084 | 7/19/2012 | <0.26 | U | <0.20 | U | <0.30 | U | <0.34 | U | <0.38 | U | <0.32 | U | <0.46 | U | <0.38 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES008 | 11/7/2012 | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES007 | 11/7/2012* | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES016 | 1/30/2013 | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES017 | 1/30/2013* | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES025 | 4/24/2013 | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES026 | 4/24/2013* | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES034 | 7/24/2013 | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES035 | 7/24/2013* | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES043 | 10/23/2013 | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES044 | 10/23/2013* | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES053 | 1/27/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES054 | 1/27/2014* | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES086 | 4/23/2014 | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U,ICH | <0.50 | U | <0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES087*** | 4/23/2014* | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U,ICH | <0.50 | U | <0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES109 | 7/24/2014 | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES110 | 7/24/2014* | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES121 | 10/22/2014 | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES122 | 10/22/2014* | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES121X | 1/26/2015 | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES122X | 1/26/2015* | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES137 | 4/22/2015 | <0.20 | U | - | | <0.20 | U | <0.10 | U | <0.20 | U | <0.10 | U | <0.10 | U | <0.20 | U | <0.010 | U | **0.010** | **J** | <0.010 | U | <0.010 | U | <0.015 | U | <0.0040 | UJ | <0.0040 | UJ |
| | ES138 | 4/22/2015* | <0.20 | U | - | | <0.20 | U | <0.10 | U | <0.20 | U | <0.10 | U | <0.10 | U | <0.20 | U | <0.010 | U | **0.0081** | **J** | <0.010 | U | <0.010 | U | <0.015 | U | <0.0040 | UJ | <0.0040 | UJ |
| | ES152 | 7/22/2015 | <0.20 | U | - | | <0.20 | U | <0.10 | U | <0.20 | U | <0.10 | U | <0.10 | U | <0.20 | U | - | | **0.012** | **J** | <0.010 | U | <0.010 | U | <0.015 | U | <0.0040 | U | <0.0040 | U |
| | ES153 | 7/22/2015* | <0.20 | U | - | | <0.20 | U | **0.060** | **J** | <0.20 | U | <0.10 | U | <0.10 | U | <0.20 | U | - | | **0.012** | **J** | <0.010 | U | <0.010 | U | <0.015 | U | <0.0040 | U | <0.0040 | U |
| | ERH002 | 10/19/2015 | <0.20 | U,** | - | | <0.20 | U,** | **0.40** | **J,**** | <0.20 | U,** | <0.10 | U,** | <0.10 | U,** | <0.20 | U,** | <0.010 | U | **0.0009** | **J** | <0.010 | U | <0.010 | U | <0.015 | U | <0.0040 | U | <0.0040 | U |
| | ERH016 | 1/19/2016 | < 0.20 | U | < 15 | U | < 0.20 | U | **0.18** | **Tb,J** | < 0.20 | U | < 0.10 | U | < 0.10 | U | < 0.20 | U | - | - | **0.0096** | **J** | < 0.010 | U | < 0.010 | U | - | - | - | - | < 0.0040 | U |

| **Well Name** | **Sample ID** | **Date Sampled** | **8270C** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | **6020** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Acenaphthene** | | **Acenaphthylene** | | **Anthracene** | | **Benzo[a]anthracene** | | **Benzo[g,h,i]perylene** | | **Benzo[a]pyrene** | | **Benzo[b]fluoranthene** | | **Benzo[k]fluoranthene** | | **Chrysene** | | **Dibenzo[a,h]anthracene** | | **Fluoranthene** | | **Fluorene** | | **Ideno[1,2,3-cd]pyrene** | | **1-Methylnaphthalene** | | **2-Methylnaphthalene** | | **Naphthalene** | | **Phenanthrene** | | **Pyrene** | | **Dissolved Lead** | |
| | | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | |
| **For wells < 150 m from surface water** | **-** | **-** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations < 150m from surface water)** | **-** | **-** | **20** | | **30** | | **0.73** | | **0.027** | | **0.10** | | **0.014** | | **0.092** | | **0.40** | | **0.35** | | **0.0092** | | **8.0** | | **3.9** | | **0.092** | | **2.1** | | **2.1** | | **17** | | **4.6** | | **2.0** | | **5.6** | |
| **OWDFMW01** | OWDFMW01-WG-01 | 8/4/2009[a] | <0.0164 | U | <0.0164 | U | <0.0164 | U | <0.0164 | U | <0.0164 | U | <0.0164 | U | <0.0164 | U | <0.0164 | U | <0.0164 | U | <0.0164 | U | <0.0164 | U | <0.0164 | U | <0.0164 | U | <0.0164 | U | <0.0164 | U | <0.0339 | U | <0.0164 | U | <0.0164 | U | <0.310 | U |
| | OWDFMW01-WG-02 | 10/13/2009[ab] | <0.0168 | U | <0.0168 | U | <0.0168 | U | <0.0168 | U | <0.0168 | U | <0.0168 | U | <0.0168 | U | <0.0168 | U | <0.0168 | U | <0.0168 | U | <0.0168 | U | <0.0168 | U | <0.0168 | U | <0.0168 | U | <0.0168 | U | <0.0346 | U | <0.0168 | U | <0.0168 | U | <0.31 | U |
| | OWDFMW01-WG-03 | 1/26/2010 | <0.0320 | U | <0.0320 | U | <0.0320 | U | <0.0320 | U | <0.0320 | U | <0.0320 | U | <0.0320 | U | <0.0320 | U | <0.0320 | U | <0.0320 | U | <0.0320 | U | <0.0320 | U | <0.0320 | U | <0.0320 | U | <0.0320 | U | <0.0664 | U | <0.0320 | U | <0.0320 | U | <0.620 | U |
| | OWDFMW01-WG-04 | 4/26/2010 | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0730 | U | <0.0352 | U | <0.0352 | U | <0.620 | U |
| | ES007 | 10/21/2010 | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.14 | U | <0.12 | U | <0.14 | U | <0.10 | U | <0.10 | U | <0.16 | U | <0.12 | U | <0.14 | U | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | **0.60** | |
| | ES008 | 10/21/2010* | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.14 | U | <0.12 | U | <0.14 | U | <0.10 | U | <0.10 | U | <0.16 | U | <0.12 | U | <0.14 | U | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | **0.57** | |
| | ES017 | 1/21/2011 | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.14 | U | <0.12 | U | <0.14 | U | <0.10 | U | <0.10 | U | <0.16 | U | <0.12 | U | <0.14 | U | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.22 | U |
| | ES018 | 1/21/2011* | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.14 | U | <0.12 | U | <0.14 | U | <0.10 | U | <0.10 | U | <0.16 | U | <0.12 | U | <0.14 | U | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.22 | U |
| | ES029 | 4/21/2011 | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.14 | U | <0.12 | U | <0.14 | U | <0.10 | U | <0.10 | U | <0.16 | U | <0.12 | U | <0.14 | U | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.22 | U |
| | ES031 | 4/21/2011* | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.14 | U | <0.12 | U | <0.14 | U | <0.10 | U | <0.10 | U | <0.16 | U | <0.12 | U | <0.14 | U | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.22 | U |
| | ES044 | 7/21/2011 | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.14 | U | <0.12 | U | <0.14 | U | <0.10 | U | <0.10 | U | <0.16 | U | <0.12 | U | <0.14 | U | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | **0.27** | **J** |
| | ES045 | 7/21/2011* | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.14 | U | <0.12 | U | <0.14 | U | <0.10 | U | <0.10 | U | <0.16 | U | <0.12 | U | <0.14 | U | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | **0.43** | **J** |
| | ES055 | 10/26/2011 | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.14 | U | <0.12 | U | <0.14 | U | <0.10 | U | <0.10 | U | <0.16 | U | <0.12 | U | <0.14 | U | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | **0.19** | **J** |
| | ES056 | 10/26/2011* | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.14 | U | <0.12 | U | <0.14 | U | <0.10 | U | <0.10 | U | <0.16 | U | <0.12 | U | <0.14 | U | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.22 | U |
| | ES058 | 1/24/2012 | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.12 | U | <0.12 | U | <0.14 | U | <0.10 | U | <0.10 | U | <0.16 | U | <0.12 | U | <0.14 | U | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | **0.20** | **J** |
| | ES059 | 1/24/2012* | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.12 | U | <0.12 | U | <0.14 | U | <0.10 | U | <0.10 | U | <0.16 | U | <0.12 | U | <0.14 | U | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | **0.11** | **J** |
| | ES077 | 4/26/2012 | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.12 | U | <0.12 | U | <0.14 | U | <0.10 | U | <0.10 | U | <0.16 | U | <0.12 | U | <0.14 | U | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.22 | U |
| | ES084 | 7/19/2012 | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.14 | U | <0.12 | U | <0.14 | U | <0.10 | U | <0.10 | U | <0.16 | U | <0.12 | U | <0.14 | U | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.22 | U |
| | ES008 | 11/7/2012 | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | **0.025** | **J** | <0.050 | U | <0.050 | U | <0.20 | U |
| | ES007 | 11/7/2012* | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | **0.035** | **J** | <0.050 | U | <0.050 | U | <0.20 | U |
| | ES016 | 1/30/2013 | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | **0.032** | **J** | <0.050 | U | <0.050 | U | <0.20 | U |
| | ES017 | 1/30/2013* | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | **0.039** | **J** | <0.050 | U | <0.050 | U | <0.20 | U |
| | ES025 | 4/24/2013 | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | **0.063** | **J** | <0.051 | U | <0.051 | U | <0.200 | U |
| | ES026 | 4/24/2013* | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | **0.068** | **J** | <0.050 | U | <0.050 | U | <0.200 | U |
| | ES034 | 7/24/2013 | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | **0.081** | **J** | <0.050 | U | <0.050 | U | <0.200 | U |
| | ES035 | 7/24/2013* | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | <0.048 | U | **0.12** | **J** | <0.048 | U | <0.048 | U | <0.200 | U |
| | ES043 | 10/23/2013 | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | <0.200 | U |
| | ES044 | 10/23/2013* | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | < 0.049 | U | <0.200 | U |
| | ES053 | 1/27/2014 | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | **0.093** | **J** | <0.050 | U | <0.050 | U | <0.200 | U |
| | ES054 | 1/27/2014* | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | **0.085** | **J** | <0.050 | U | <0.050 | U | **0.114** | **J** |
| | ES086 | 4/23/2014 | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | <0.049 | U | **0.035** | **J** | <0.049 | U | <0.049 | U | **0.156** | **J** |
| | ES087*** | 4/23/2014* | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | **0.035** | **J** | <0.050 | U | <0.050 | U | <0.200 | U |
| | ES109 | 7/24/2014 | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | **0.031** | **J** | <0.051 | U | <0.051 | U | <0.200 | U |
| | ES110 | 7/24/2014* | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | **0.027** | **J** | <0.050 | U | <0.050 | U | <0.200 | U |
| | ES121 | 10/22/2014 | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.10 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.10 | U | <0.052 | U | **0.047** | **J** | <0.052 | U | <0.052 | U | **0.206** | **J** |
| | ES122 | 10/22/2014* | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.10 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.10 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | **0.129** | **J** |
| | ES121X | 1/26/2015 | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.10 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.10 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.200 | U |
| | ES122X | 1/26/2015* | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.10 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.10 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.200 | U |
| | ES137 | 4/22/2015 | <0.0050 | U | <0.0050 | U | <0.0050 | U | **0.0033** | **B,J** | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.020 | U | **0.0039** | **JX** | <0.0050 | U | **0.023** | | **0.017** | **J** | **0.025** | | **0.0075** | **J** | <0.010 | U | **0.036** | |
| | ES138 | 4/22/2015* | <0.0050 | U | <0.0050 | U | <0.0050 | U | **0.0029** | **B,J** | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.020 | U | <0.0050 | U | <0.0050 | U | **0.020** | | **0.015** | **J** | **0.023** | | **0.0064** | **J** | <0.010 | U | **0.038** | |
| | ES152 | 7/22/2015 | <0.0050 | U | <0.0050 | U | <0.0050 | U | **0.0030** | **J** | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.020 | U | <0.0050 | U | <0.0050 | U | **0.0088** | **J** | **0.0086** | **J** | **0.014** | **J** | **0.014** | **J** | <0.010 | U | **0.022** | **B** |
| | ES153 | 7/22/2015* | <0.0055 | U | <0.0055 | U | <0.0055 | U | **0.0046** | **J** | <0.0055 | U | <0.0055 | U | <0.0055 | U | <0.0055 | U | <0.0055 | U | <0.0055 | U | <0.022 | U | <0.0055 | U | <0.0055 | U | **0.0096** | **J** | **0.0097** | **J** | **0.016** | **J** | **0.014** | **J** | **0.0063** | **J** | **0.034** | **B** |
| | ERH002 | 10/19/2015 | **0.0082** | **J** | <0.0055 | U | <0.0050 | U | <0.0050 | U | <0.0050 | B,U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | B,U | <0.020 | U | <0.0050 | U | <0.0050 | B,U | **0.019** | **J** | **0.013** | **B,J** | **0.025** | **B,J** | **0.0073** | **J** | <0.010 | U | **0.033** | |
| | ERH016 | 1/19/2016 | **0.0063** | **J** | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.020 | U | < 0.0050 | U | < 0.0050 | U | **0.030** | | **0.020** | | **0.024** | | **0.0063** | **J** | < 0.010 | U | **0.040** | |

| | | | 8015C | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Well Name | Sample ID | Date Sampled | TPH-d | | TPH-g | | TPH-o | | TPH-g | | 1,1,1-Trichloroethane | | 1,1,2-Trichloroethane | | 1,1-Dichloroethane | | 1,1-Dichloroethylene | | 1,2,3-Trichloropropane | | 1,2,4-Tricholorobenzene | | 1,2-Dibromo-3-chloropropane | | 1,2-Dibromoethane | | 1,2-Dichlorobenzene | | 1,2-Dichloroethane | | 1,2-Dichloropropane | | 1,3-Dichlorobenzene | | 1,3-Dichloropropene (total of cis/trans) | | 1,4-Dichlorobenzene | | Acetone | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| **For wells < 150 m from surface water** | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations < 150m from surface water)** | - | - | **100** | | **100** | | **100** | | **100** | | **62** | | **5.0** | | **2.4** | | **7.0** | | **0.6** | | **25** | | **0.04** | | **0.04** | | **10** | | **0.15** | | **5.0** | | **5.0** | | **0.43** | | **5.0** | | **1500** | |
| **HDMW2253-03** | HDMW2253-03-WG-02 | 10/13/2009[ab] | <185 | U | <30 | U | - | | - | | <0.31 | U | <0.31 | U | <0.31 | U | - | U | <0.31 | U | <0.31 | U | <0.62 | U | <0.31 | U | <0.31 | U | <0.15 | U | <0.31 | U | <0.31 | U | <0.15 | U | <0.15 | U | <3.1 | U |
| | HDMW2253-03-WG-03 | 1/26/2010 | **322** | **J** | <60.0 | U | **-** | | - | | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <1.24 | U | <0.620 | U | <0.620 | U | <0.300 | U | <0.620 | U | <0.620 | U | <0.620 | | <0.300 | U | <6.20 | U |
| | HDMW2253-03-WG-04 | 4/26/2010 | <352 | U | <60.0 | U | - | | - | | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <1.24 | U | <0.620 | U | <0.620 | U | <0.300 | U | <0.620 | U | <0.620 | U | <0.620 | | <0.300 | U | <6.20 | U |
| | HDMW2253-03-WG-05 | 7/8/2010 | <320 | U | <60.0 | U | - | | - | | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <1.24 | U | <0.620 | U | <0.620 | U | <0.300 | U | <0.620 | U | <0.620 | U | <0.620 | | <0.300 | U | <6.20 | U |
| | ES006 | 10/21/2010 | <80.8 | U | - | | - | | <12.12 | U | <0.28 | U | <0.40 | U | <0.38 | U | <0.60 | U | <0.78 | U | <0.42 | U | <1.52 | U | <0.40 | U | <0.34 | U | <0.28 | U | <0.34 | U | <0.22 | U | <0.36 | U | <0.38 | U | <1.90 | U |
| | ES016 | 1/21/2011 | <80.8 | U | - | | - | | <12.12 | U | <0.28 | U | <0.40 | U | <0.38 | U | <0.60 | U | <0.78 | U | <0.42 | U | <1.52 | U | <0.40 | U | <0.34 | U | <0.28 | U | <0.34 | U | <0.22 | U | <0.36 | U | <0.38 | U | <1.90 | U |
| | ES028 | 4/21/2011 | <80.8 | U | - | | - | | <12.12 | U | <0.28 | U | <0.40 | U | <0.38 | U | <0.60 | U | <0.78 | U | <0.42 | U | <1.52 | U | <0.40 | U | <0.34 | U | <0.28 | U | <0.34 | U | <0.22 | U | <0.36 | U | <0.38 | U | <1.90 | U |
| | ES043 | 7/21/2011 | <80.8 | U | - | | < 212.0 | U | <12.12 | U | <0.28 | U | <0.40 | U | <0.38 | U | <0.60 | U | <0.78 | U | <0.42 | U | <1.52 | U | <0.40 | U | <0.34 | U | <0.28 | U | <0.34 | U | <0.22 | U | <0.36 | U | <0.38 | U | <1.90 | U |
| | ES053 | 10/26/2011 | <80.8 | U | - | | - | | <12.12 | U | <0.28 | U | <0.40 | U | <0.38 | U | <0.60 | U | <0.78 | U | <0.42 | U | <1.52 | U | <0.40 | U | <0.34 | U | <0.28 | U | <0.34 | U | <0.22 | U | <0.36 | U | <0.38 | U | <1.90 | U |
| | ES057 | 1/24/2012 | <80.8 | U | - | | < 212.0 | U | <12.12 | U | <0.28 | U | <0.40 | U | <0.38 | U | <0.60 | U | <0.78 | U | <0.42 | U | <1.52 | U | <0.40 | U | <0.34 | U | <0.28 | U | <0.34 | U | <0.22 | U | <0.36 | U | <0.38 | U | <1.90 | U |
| | ES076 | 4/26/2012 | **160** | **++** | - | | - | | <12.12 | U | <0.28 | U | <0.40 | U | <0.38 | U | <0.60 | U | <0.78 | U | <0.42 | U | <1.52 | U | <0.40 | U | <0.34 | U | <0.28 | U | <0.34 | U | <0.22 | U | <0.36 | U | <0.38 | U | <1.90 | U |
| | ES083 | 7/19/2012 | <80.8 | U | - | | - | | <12.12 | U | <0.28 | U | <0.40 | U | <0.38 | U | <0.60 | U | <0.78 | U | <0.42 | U | <1.52 | U | <0.40 | U | <0.34 | U | <0.28 | U | <0.34 | U | <0.22 | U | <0.36 | U | <0.38 | U | <1.90 | U |
| | ES009 | 11/7/2012 | **25** | **HD,J** | - | | **-** | | **15** | **BU,B** | <0.50 | BU,U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <10 | U |
| | ES018 | 1/30/2013 | **600** | | - | | **-** | | <30 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <10 | U |
| | ES027 | 4/24/2013 | **45** | **J** | - | | **-** | | <30 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <1.0 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <10 | U |
| | ES036 | 7/24/2013 | < 21 | U | - | | - | | <30 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <1.0 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <10 | U |
| | ES045 | 10/23/2013 | < 20 | U | - | | - | | **15** | **B,J** | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U | < 0.50 | U | < 10 | U, ICH |
| | ES051 | 1/22/2014 | **18** | **HD,J** | - | | - | | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | ES052 | 1/22/2014* | **18** | **HD,J** | - | | - | | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| | ES055 | 1/27/2014 | **35** | **HD,J** | - | | - | | **27** | **B,J** | < 0.50 | U,IH | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 1.0 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <0.50 | U,IH | < 0.50 | U | <10 | U |
| | ES088*** | 4/23/2014 | **220** | **HD** | - | | **-** | | **27** | **B,J** | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <1.0 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U,ICH | <0.50 | U | <10 | U,IH,ICH |
| | ES111 | 7/23/2014 | <12 | U | - | | **-** | | <30 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <1.0 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <10 | U,IH,ICH |
| | ES120 | 10/22/2014 | **14** | **HD,J** | - | | **-** | | <30 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <1.0 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <10 | U,ICH |
| | ES128 | 1/29/2015 | **16** | **HD,J** | - | | **-** | | <30 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <1.0 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <10 | U,IJ |
| | ES136 | 4/22/2015 | **13** | **J** | <25 | U | **55** | **B,J** | **-** | | <0.20 | U | <0.40 | U | <0.20 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.80 | U | <0.20 | U | <0.20 | U | **-** | | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <10 | U |
| | ES151 | 7/22/2015 | **18** | **J** | <25 | U | **77** | **J** | **-** | | <0.20 | U | <0.40 | U | <0.20 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.80 | U | <0.20 | U | <0.20 | U | **-** | | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <10 | U |
| | ERH001 | 10/19/2015 | **21** | **B,J** | **16** | **J** | <56 | B,U | **-** | | <0.20 | U,** | <0.40 | U,** | <0.20 | U,** | <0.20 | J,* | <0.50 | J,* | <0.30 | J,* | <0.80 | U,** | <0.20 | J,* | <0.20 | J,* | **-** | | <0.20 | J,* | <0.20 | J,* | <0.20 | U,** | <0.20 | U,** | <10 | U,** |
| | ERH015 | 1/19/2016 | **43** | **B,J** | < 25 | U | **63** | **B,J** | - | - | < 0.20 | U | < 0.40 | U | < 0.20 | U | < 0.20 | U | < 0.50 | U | < 0.30 | U | < 0.80 | U | < 0.20 | U | < 0.20 | U | - | - | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 10 | U |

| Well Name | Sample ID | Date Sampled | 8260B | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Benzene | | Bromodichloromethane | | Bromoform | | Bromomethane | | Carbon Tetrachloride | | Chlorobenzene | | Chloroethane | | Chloroform | | Chloromethane | | cis-1,2-Dichloroethylene | | Dibromochloromethane | | Ethylbenzene | | Hexachlorobutadiene | | Methyl ethyl ketone (2-Butanone) | | Methyl isobutyl ketone (4-Methyl-2-Pentanone) | | Methyl tert-butyl Ether | | Methylene chloride | | Napthalene | | Styrene | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| **For wells < 150 m from surface water** | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations < 150m from surface water)** | - | - | **5.0** | | **0.12** | | **80** | | **8.7** | | **5.0** | | **25** | | **16** | | **70** | | **1.8** | | **70** | | **0.16** | | **30** | | **0.86** | | **7,100** | | **170** | | **5.0** | | **4.8** | | **17** | | **10** | |
| **HDMW2253-03** | HDMW2253-03-WG-02 | 10/13/2009[ab] | <0.12 | U | <0.15 | U | <0.31 | U | <0.94 | U | <0.31 | U | <0.15 | U | <0.31 | U | <0.3 | U | <0.31 | U | <0.31 | U | <0.15 | U | <0.31 | U | <0.31 | U | <3.1 | U | <3.1 | U | - | | <1 | U | <0.62 | U | <0.31 | U |
| | HDMW2253-03-WG-03 | 1/26/2010 | <0.240 | U | <0.300 | U | <0.620 | U | <1.88 | U | <0.620 | U | <0.300 | U | <0.620 | U | <0.600 | U | <0.620 | U | <0.620 | U | <0.300 | U | <0.620 | U | <0.620 | U | <6.20 | U | <6.20 | U | <3.00 | U | <2.00 | U | <1.24 | U | <0.620 | U |
| | HDMW2253-03-WG-04 | 4/26/2010 | <0.240 | U | <0.300 | U | <0.620 | U | <1.88 | U | <0.620 | U | <0.300 | U | <0.620 | U | <0.600 | U | <0.620 | U | <0.620 | U | <0.300 | U | <0.620 | U | <0.620 | U | <6.20 | U | <6.20 | U | <3.00 | U | <2.00 | U | <1.24 | U | <0.620 | U |
| | HDMW2253-03-WG-05 | 7/8/2010 | <0.240 | U | <0.300 | U | <0.620 | U | <1.88 | U | <0.620 | U | <0.300 | U | <0.620 | U | <0.600 | U | <0.620 | U | <0.620 | U | <0.300 | U | <0.620 | U | <0.620 | U | <6.20 | U | <6.20 | U | <3.00 | U | <2.00 | U | <1.24 | U | <0.620 | U |
| | ES006 | 10/21/2010 | <0.32 | U | <0.28 | U | <0.28 | U | <0.48 | U | <0.20 | U | <0.42 | U | <0.42 | U | <0.14 | U | <0.62 | U | <0.32 | U | <0.38 | U | <0.46 | U | <0.38 | U | <1.20 | U | <3.80 | U | <0.38 | U | <0.70 | U | - | | <0.50 | U |
| | ES016 | 1/21/2011 | <0.32 | U | <0.28 | U | <0.28 | U | <0.48 | U | <0.20 | U | <0.42 | U | <0.42 | U | <0.14 | U | <0.62 | U | <0.32 | U | <0.38 | U | <0.46 | U | <0.38 | U | <1.20 | U | <3.80 | U | <0.38 | U | <0.70 | U | - | | <0.50 | U |
| | ES028 | 4/21/2011 | **0.42** | **J** | <0.28 | U | <0.28 | U | <0.48 | U | <0.20 | U | <0.42 | U | <0.42 | U | <0.14 | U | <0.62 | U | <0.32 | U | <0.38 | U | <0.46 | U | <0.38 | U | <1.20 | U | <3.80 | U | <0.38 | U | <0.70 | U | - | | <0.50 | U |
| | ES043 | 7/21/2011 | <0.32 | U | <0.28 | U | <0.28 | U | <0.48 | U | <0.20 | U | <0.42 | U | <0.42 | U | <0.14 | U | <0.62 | U | <0.32 | U | <0.38 | U | <0.46 | U | <0.38 | U | <1.20 | U | <3.80 | U | <0.38 | U | <0.70 | U | - | | <0.50 | U |
| | ES053 | 10/26/2011 | **0.92** | **J** | <0.28 | U | <0.28 | U | <0.48 | U | <0.20 | U | <0.42 | U | <0.42 | U | <0.14 | U | <0.84 | U | <0.32 | U | <0.38 | U | <0.46 | U | <0.38 | U | <1.20 | U | <3.80 | U | <0.52 | U | <0.70 | U | - | | <0.50 | U |
| | ES057 | 1/24/2012 | <0.32 | U | <0.28 | U | <0.28 | U | <0.48 | U | <0.20 | U | <0.42 | U | <0.42 | U | <0.14 | U | <0.84 | U | <0.32 | U | <0.38 | U | <0.46 | U | <0.38 | U | <1.20 | U | <3.80 | U | <0.52 | U | <0.70 | U | - | | <0.50 | U |
| | ES076 | 4/26/2012 | **0.20** | **J** | <0.28 | U | <0.28 | U | <0.48 | U | <0.20 | U | <0.42 | U | <0.42 | U | <0.14 | U | <0.84 | U | <0.32 | U | <0.38 | U | <0.46 | U | <0.38 | U | <1.20 | U | <3.80 | U | <0.52 | U | <0.70 | U | - | | <0.50 | U |
| | ES083 | 7/19/2012 | <0.32 | U | <0.28 | U | <0.28 | U | <0.48 | U | <0.20 | U | <0.42 | U | <0.42 | U | <0.14 | U | <0.62 | U | <0.32 | U | <0.38 | U | <0.46 | U | <0.38 | U | <1.20 | U | <3.80 | U | <0.38 | U | <0.70 | U | - | | <0.50 | U |
| | ES009 | 11/7/2012 | <0.50 | U | <0.50 | U | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <5.0 | U | <0.50 | U | <5.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <5.0 | U | <5.0 | U | <0.50 | U | <1.0 | U | - | | <0.50 | U |
| | ES018 | 1/30/2013 | <0.50 | U | <0.50 | U | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <5.0 | U | <0.50 | U | <5.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <5.0 | U | <5.0 | U | <0.50 | U | <1.0 | U | - | | <0.50 | U |
| | ES027 | 4/24/2013 | <0.50 | U | <0.50 | U | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <5.0 | U | <0.50 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <5.0 | U | <5.0 | U | <0.50 | U | <1.0 | U | - | | <0.50 | U |
| | ES036 | 7/24/2013 | <0.50 | U | <0.50 | U | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <5.0 | U | <0.50 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <5.0 | U | <5.0 | U | <0.50 | U | <1.0 | U | - | | <0.50 | U |
| | ES045 | 10/23/2013 | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 5.0 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 0.50 | U | < 2.0 | U,IJ | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U,ICH | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U |
| | ES051 | 1/22/2014 | <0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES052 | 1/22/2014* | <0.50 | U | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | < 0.50 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES055 | 1/27/2014 | < 0.50 | U | < 0.50 | U | < 1.0 | U | < 5.0 | U,IH | <0.50 | U,IH | < 0.50 | U | < 5.0 | U,IH | < 0.50 | U | < 2.0 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 5.0 | U | < 5.0 | U | < 0.50 | U | < 1.0 | U | - | | < 0.50 | U |
| | ES088*** | 4/23/2014 | <0.50 | U | <0.50 | U | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <5.0 | U | <0.50 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <5.0 | U,ICH | <5.0 | U | <0.50 | U | <1.0 | U | - | | <0.50 | U |
| | ES111 | 7/23/2014 | <0.50 | U | <0.50 | U | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <5.0 | U | <0.50 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <5.0 | U | <5.0 | U | <0.50 | U | <1.0 | U | - | | <0.50 | U |
| | ES120 | 10/22/2014 | <0.50 | U | <0.50 | U | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <5.0 | U | <0.50 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <5.0 | U,ICH | <5.0 | U | <0.50 | U | <1.0 | U | - | | <0.50 | U |
| | ES128 | 1/29/2015 | <0.50 | U | <0.50 | U | <1.0 | U | <5.0 | U,IH | <0.50 | U | <0.50 | U | <5.0 | U | <0.50 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <5.0 | U | <5.0 | U | <0.50 | U | <1.0 | U | - | | <0.50 | U |
| | ES136 | 4/22/2015 | <0.10 | U | - | | <0.50 | U | <0.30 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | - | | <0.10 | U | <0.30 | U | <4.0 | U | <10 | U | <0.30 | U | <0.20 | U | - | | <0.20 | U |
| | ES151 | 7/22/2015 | <0.10 | U | - | | <0.50 | U | <0.30 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | - | | <0.10 | U | <0.30 | U | <4.0 | U | <10 | U | <0.30 | U | <0.20 | U | - | | <0.20 | U |
| | ERH001 | 10/19/2015 | <0.10 | U,** | - | | <0.50 | U,* | <0.30 | U,** | <0.20 | U,** | <0.20 | J,* | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | J,* | - | | <0.10 | U,** | <0.30 | J,* | <4.0 | U,** | <10 | J,* | <0.30 | J,* | <0.20 | B,U,** | - | | <0.20 | J,** |
| | ERH015 | 1/19/2016 | < 0.10 | U | - | - | < 0.50 | U | < 0.30 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | **0.090** | **J** | < 0.20 | U | - | - | < 0.10 | U | < 0.30 | U | < 4.0 | U | < 10 | U | < 0.30 | U | < 0.20 | B,U | - | - | < 0.20 | U |

Cumulative Groundwater Measurements and Analytical Results for Outside-Tunnel Wells
Red Hill Bulk Fuel Storage Facility

| Well Name | Sample ID | Date Sampled | | | | | | | | | | | | | | | | | 8260SIM | | | | | | | | | | 8011 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Tetrachloroethane, 1,1,1,2- | | Tetrachloroethane, 1,1,2,2- | | Tetrachloroethylene | | Toluene | | trans-1,2- Dichloroethylene | | Trichloroethylene | | Vinyl chloride | | Xylenes (total) | | 1,2-Dibromoethane | | 1,2-Dichloroethane | | Bromodichloromethane | | Dibromochloromethane | | Tetrachloroethane, 1,1,2,2- | | 1,2-Dibromo-3-chloropropane | | 1,2-Dibromoethane | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| **For wells < 150 m from surface water** | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations < 150m from surface water)** | - | - | **0.52** | | **0.067** | | **5.0** | | **40** | | **100** | | **5.0** | | **2.0** | | **20** | | **0.04** | | **0.15** | | **0.12** | | **0.16** | | **0.067** | | **0.04** | | **0.04** | |
| **HDMW2253-03** | HDMW2253-03-WG-02 | 10/13/2009[ab] | <0.15 | U | <0.15 | U | <0.31 | U | <0.31 | U | <0.31 | U | <0.31 | U | <0.31 | U | <0.62 | U | - | | - | | - | | - | | - | | - | | - | |
| | HDMW2253-03-WG-03 | 1/26/2010 | <0.300 | U | <0.300 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <1.24 | U | - | | - | | - | | - | | - | | - | | - | |
| | HDMW2253-03-WG-04 | 4/26/2010 | <0.300 | U | <0.300 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <1.24 | U | - | | - | | - | | - | | - | | - | | - | |
| | HDMW2253-03-WG-05 | 7/8/2010 | <0.300 | U | <0.300 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <1.24 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES006 | 10/21/2010 | <0.26 | U | <0.20 | U | <0.30 | U | <0.34 | U | <0.38 | U | <0.32 | U | <0.46 | U | <0.38 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES016 | 1/21/2011 | <0.26 | U | <0.20 | U | <0.30 | U | <0.34 | U | <0.38 | U | <0.32 | U | <0.46 | U | <0.38 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES028 | 4/21/2011 | <0.26 | U | <0.20 | U | <0.30 | U | <0.34 | U | <0.38 | U | <0.32 | U | <0.46 | U | <0.38 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES043 | 7/21/2011 | <0.26 | U | <0.20 | U | <0.30 | U | <0.34 | U | <0.38 | U | <0.32 | U | <0.46 | U | <0.38 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES053 | 10/26/2011 | <0.26 | U | <0.20 | U | <0.48 | U | <0.34 | U | <0.38 | U | <0.32 | U | <0.46 | U | <0.38 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES057 | 1/24/2012 | <0.26 | U | <0.20 | U | <0.48 | U | <0.34 | U | <0.38 | U | <0.32 | U | <0.46 | U | <0.38 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES076 | 4/26/2012 | <0.26 | U | <0.20 | U | <0.48 | U | <0.34 | U | <0.38 | U | <0.32 | U | <0.46 | U | <0.38 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES083 | 7/19/2012 | <0.26 | U | <0.20 | U | <0.30 | U | <0.34 | U | <0.38 | U | <0.32 | U | <0.46 | U | <0.38 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES009 | 11/7/2012 | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | BU,U | <0.50 | U | <1 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES018 | 1/30/2013 | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES027 | 4/24/2013 | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES036 | 7/24/2013 | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES045 | 10/23/2013 | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES051 | 1/22/2014 | - | | - | | - | | < 0.50 | U | - | | - | | - | | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES052 | 1/22/2014* | - | | - | | - | | < 0.50 | U | - | | - | | - | | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES055 | 1/27/2014 | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | < 0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES088*** | 4/23/2014 | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U,ICH | <0.50 | U | <0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES111 | 7/23/2014 | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES120 | 10/22/2014 | <0.50 | U | <0.50 | U | <0.50 | U | **3.8** | | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES128 | 1/29/2015 | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES136 | 4/22/2015 | <0.20 | U | - | | <0.20 | U | **0.070** | **J** | <0.20 | U | <0.10 | U | <0.10 | U | <0.20 | U | <0.010 | U | <0.015 | U | <0.010 | U | <0.010 | U | <0.015 | U | <0.0040 | UJ | <0.0040 | UJ |
| | ES151 | 7/22/2015 | <0.20 | U | - | | <0.20 | U | <0.10 | U | <0.20 | U | <0.10 | U | <0.10 | U | <0.20 | U | - | | <0.015 | U | <0.010 | U | <0.010 | U | <0.015 | U | <0.0040 | U | <0.0040 | U |
| | ERH001 | 10/19/2015 | <0.20 | U,** | - | | <0.20 | U,** | **0.37** | **J,**** | <0.20 | U,** | <0.10 | U,** | <0.10 | U,** | <0.20 | U,** | - | | <0.015 | U | <0.010 | U | <0.010 | U | <0.015 | U | <0.0040 | U | <0.0040 | U |
| | ERH015 | 1/19/2016 | < 0.20 | U | < 15 | U | < 0.20 | U | **0.24** | **Tb,J** | < 0.20 | U | < 0.10 | U | < 0.10 | U | < 0.20 | U | - | - | < 0.015 | U | < 0.010 | U | < 0.010 | U | - | - | - | - | < 0.0040 | U |

## Cumulative Groundwater Measurements and Analytical Results for Outside-Tunnel Wells
## Red Hill Bulk Fuel Storage Facility

| Well Name | Sample ID | Date Sampled | 8270C | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 6020 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **Acenaphthene** | | **Acenaphthylene** | | **Anthracene** | | **Benzo[a]anthracene** | | **Benzo[g,h,i]perylene** | | **Benzo[a]pyrene** | | **Benzo[b]fluoranthene** | | **Benzo[k]fluoranthene** | | **Chrysene** | | **Dibenzo[a,h]anthracene** | | **Fluoranthene** | | **Fluorene** | | **Ideno[1,2,3-cd]pyrene** | | **1-Methylnaphthalene** | | **2-Methylnaphthalene** | | **Naphthalene** | | **Phenanthrene** | | **Pyrene** | | **Dissolved Lead** | |
| | | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | | **(µg/l)** | |
| **For wells < 150 m from surface water** | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations < 150m from surface water)** | - | - | **20** | | **30** | | **0.73** | | **0.027** | | **0.10** | | **0.014** | | **0.092** | | **0.40** | | **0.35** | | **0.0092** | | **8.0** | | **3.9** | | **0.092** | | **2.1** | | **2.1** | | **17** | | **4.6** | | **2.0** | | **5.6** | |
| **HDMW2253-03** | HDMW2253-03-WG-02 | 10/13/2009[ab] | <0.0169 | U | <0.0169 | U | <0.0169 | U | <0.0169 | U | <0.0169 | U | <0.0169 | U | <0.0169 | U | <0.0169 | U | <0.0169 | U | <0.0169 | U | <0.0169 | U | <0.0169 | U | <0.0169 | U | <0.0169 | U | <0.0169 | U | <0.035 | U | <0.0169 | U | <0.0169 | U | <0.31 | U |
| | HDMW2253-03-WG-03 | 1/26/2010 | <0.0500 | U | <0.0500 | U | <0.0500 | U | <0.0500 | U | <0.0500 | U | <0.0500 | U | <0.0500 | U | <0.0500 | U | <0.0500 | U | <0.0500 | U | <0.0500 | U | <0.0500 | U | <0.0500 | U | <0.0500 | U | <0.0500 | U | <0.103 | U | <0.0500 | U | <0.0500 | U | <0.620 | U |
| | HDMW2253-03-WG-04 | 4/26/2010 | <0.0348 | U | <0.0348 | U | <0.0348 | U | <0.0348 | U | <0.0348 | U | <0.0348 | U | <0.0348 | U | <0.0348 | U | <0.0348 | U | <0.0348 | U | <0.0348 | U | <0.0348 | U | <0.0348 | U | <0.0348 | U | <0.0348 | U | <0.0720 | U | <0.0348 | U | <0.0348 | U | <0.620 | U |
| | HDMW2253-03-WG-05 | 7/8/2010 | <0.0348 | U | <0.0348 | U | <0.0348 | U | <0.0348 | U | <0.0348 | U | <0.0348 | U | <0.0348 | U | <0.0348 | U | <0.0348 | U | <0.0348 | U | <0.0348 | U | <0.0348 | U | <0.0348 | U | <0.0348 | U | <0.0348 | U | **0.0596** | **J** | <0.0348 | U | <0.0348 | U | <0.620 | U |
| | ES006 | 10/21/2010 | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.14 | U | <0.12 | U | <0.14 | U | <0.10 | U | <0.10 | U | <0.16 | U | <0.12 | U | <0.14 | U | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | **0.56** | |
| | ES016 | 1/21/2011 | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.14 | U | <0.12 | U | <0.14 | U | <0.10 | U | <0.10 | U | <0.16 | U | <0.12 | U | <0.14 | U | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.22 | U |
| | ES028 | 4/21/2011 | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.14 | U | <0.12 | U | <0.14 | U | <0.10 | U | <0.10 | U | <0.16 | U | <0.12 | U | <0.14 | U | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.22 | U |
| | ES043 | 7/21/2011 | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.14 | U | <0.12 | U | <0.14 | U | <0.10 | U | <0.10 | U | <0.16 | U | <0.12 | U | <0.14 | U | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | **0.12** | **J** |
| | ES053 | 10/26/2011 | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.14 | U | <0.12 | U | <0.14 | U | <0.10 | U | <0.10 | U | <0.16 | U | <0.12 | U | <0.14 | U | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | **0.90** | |
| | ES057 | 1/24/2012 | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.12 | U | <0.12 | U | <0.14 | U | <0.10 | U | <0.10 | U | <0.16 | U | <0.12 | U | <0.14 | U | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | **0.19** | **J** |
| | ES076 | 4/26/2012 | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.12 | U | <0.12 | U | <0.14 | U | <0.10 | U | <0.10 | U | <0.16 | U | <0.12 | U | <0.14 | U | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | **0.71** | |
| | ES083 | 7/19/2012 | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.14 | U | <0.12 | U | <0.14 | U | <0.10 | U | <0.10 | U | <0.16 | U | <0.12 | U | <0.14 | U | <0.12 | U | <0.12 | U | <0.10 | U | <0.14 | U | <0.16 | U | <0.22 | U |
| | ES009 | 11/7/2012 | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.20 | U |
| | ES018 | 1/30/2013 | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | **0.037** | **J** | <0.050 | U | <0.050 | U | <0.20 | U |
| | ES027 | 4/24/2013 | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | **0.16** | **J** | <0.052 | U | <0.052 | U | **0.102** | **J** |
| | ES036 | 7/24/2013 | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | <0.047 | U | **0.030** | **J** | <0.047 | U | <0.047 | U | <0.200 | U |
| | ES045 | 10/23/2013 | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | < 0.050 | U | **0.041** | **J** | < 0.050 | U | < 0.050 | U | <0.200 | U |
| | ES051 | 1/22/2014 | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.051 | U | <0.051 | U | <0.051 | U | - | | - | | - | |
| | ES052 | 1/22/2014* | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | - | | <0.051 | U | <0.051 | U | <0.051 | U | - | | - | | - | |
| | ES055 | 1/27/2014 | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | **0.064** | **J** | <0.051 | U | <0.051 | U | <0.200 | U |
| | ES088*** | 4/23/2014 | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.200 | U |
| | ES111 | 7/23/2014 | <0.053 | U | <0.053 | U | <0.053 | U | <0.053 | U | <0.053 | U | <0.053 | U | <0.053 | U | <0.053 | U | <0.053 | U | <0.053 | U | <0.053 | U | <0.053 | U | <0.053 | U | <0.053 | U | <0.053 | U | <0.053 | U | <0.053 | U | <0.053 | U | <0.200 | U |
| | ES120 | 10/22/2014 | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.10 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.10 | U | <0.051 | U | <0.051 | U | <0.051 | U | <0.051 | U | **0.101** | **J** |
| | ES128 | 1/29/2015 | <0.053 | U | <0.053 | U | <0.053 | U | <0.053 | U | <0.11 | U | <0.053 | U | <0.053 | U | <0.053 | U | <0.053 | U | <0.053 | U | <0.053 | U | <0.053 | U | <0.053 | U | <0.11 | U | <0.053 | U | <0.053 | U | <0.053 | U | <0.053 | U | <0.200 | U |
| | ES136 | 4/22/2015 | <0.0052 | U | <0.0052 | U | <0.0052 | U | **0.0032** | **B,J** | <0.0052 | U | <0.0052 | U | <0.0052 | U | <0.0052 | U | <0.0052 | U | <0.0052 | U | <0.021 | U | <0.0052 | U | <0.0052 | U | <0.0052 | U | <0.0052 | U | <0.0052 | U | <0.0052 | U | <0.011 | U | **0.078** | |
| | ES151 | 7/22/2015 | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.020 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.010 | U | **0.025** | **B** |
| | ERH001 | 10/19/2015 | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | B,U | <0.0050 | B,U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | B,U | <0.020 | U | <0.0050 | U | <0.0050 | B,U | <0.0050 | U | <0.0050 | B,U | **0.0042** | **B,J** | <0.0050 | U | <0.010 | U | **0.032** | |
| | ERH015 | 1/19/2016 | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.020 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.010 | U | **0.27** | |

## Cumulative Groundwater Measurements and Analytical Results for Outside-Tunnel Wells
## Red Hill Bulk Fuel Storage Facility

| Well Name | Sample ID | Date Sampled | 8015C | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | TPH-d | | TPH-g | | TPH-o | | TPH-g | | 1,1,1-Trichloroethane | | 1,1,2-Trichloroethane | | 1,1-Dichloroethane | | 1,1-Dichloroethylene | | 1,2,3-Trichloropropane | | 1,2,4-Tricholorobenzene | | 1,2-Dibromo-3-chloropropane | | 1,2-Dibromoethane | | 1,2-Dichlorobenzene | | 1,2-Dichloroethane | | 1,2-Dichloropropane | | 1,3-Dichlorobenzene | | 1,3-Dichloropropene (total of cis/trans) | | 1,4-Dichlorobenzene | | Acetone | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| **For wells < 150 m from surface water** | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations < 150m from surface water)** | - | - | **100** | | **100** | | **100** | | **100** | | **62** | | **5.0** | | **2.4** | | **7.0** | | **0.6** | | **25** | | **0.04** | | **0.04** | | **10** | | **0.5** | | **5.0** | | **5.0** | | **0.43** | | **5.0** | | **1500** | |
| **RHMW04** | RHMW04W01 | 9/19/2005[a,b] | **338** | | <50.0 | U | - | | - | | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.30 | U | <0.50 | U | **92.6** | |
| | RHMW04-GW02 | 7/10/2006[a,b] | <100 | U | <50.0 | U | | | | | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.30 | U | <0.50 | U | <5.0 | U |
| | RHMW04-WG-01 | 8/4/2009[a] | <157 | U | <30.0 | U | - | | - | | <0.310 | U | <0.310 | U | <0.310 | U | <0.310 | U | <0.310 | U | <0.310 | U | <0.620 | U | <0.310 | U | <0.310 | U | <0.150 | U | <0.310 | U | <0.310 | U | - | | <0.150 | U | <3.10 | U |
| | RHMWA01-WG-01 | 8/4/2009*[a] | <161 | U | <30.0 | U | - | | - | | <0.310 | U | <0.310 | U | <0.310 | U | <0.310 | U | <0.310 | U | <0.310 | U | <0.620 | U | <0.310 | U | <0.310 | U | <0.150 | U | <0.310 | U | <0.310 | U | - | | <0.150 | U | <3.10 | U |
| | RHMW04-WG-02 | 10/13/2009[ab] | <169 | U | <30 | U | - | | - | | <0.31 | U | <0.31 | U | <0.31 | U | - | | <0.31 | U | <0.31 | U | <0.62 | U | <0.31 | U | <0.31 | U | <0.15 | U | <0.31 | U | <0.31 | U | - | | <0.15 | U | <3.1 | U |
| | RHMWA01-WG-02 | 10/13/2009*[ab] | <174 | U | <30 | U | - | | - | | <0.31 | U | <0.31 | U | <0.31 | U | - | | <0.31 | U | <0.31 | U | <0.62 | U | <0.31 | U | <0.31 | U | <0.15 | U | <0.31 | U | <0.31 | U | - | | <0.15 | U | <3.1 | U |
| | RHMW04-WG-03 | 1/26/2010 | <334 | U | <60.0 | U | - | | - | | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <1.24 | U | <0.620 | U | <0.620 | U | <0.300 | U | <0.620 | U | <0.620 | U | - | | <0.300 | U | <6.20 | U |
| | RHMWA01-WG-03 | 1/26/2010* | <330 | U | <60.0 | U | - | | - | | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <1.24 | U | <0.620 | U | <0.620 | U | <0.300 | U | <0.620 | U | <0.620 | U | - | | <0.300 | U | <6.20 | U |
| | RHMW04-WG-04 | 4/26/2010 | <348 | U | <60.0 | U | - | | - | | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <1.24 | U | <0.620 | U | <0.620 | U | <0.300 | U | <0.620 | U | <0.620 | U | - | | <0.300 | U | <6.20 | U |
| | RHMWA01-WG-04 | 4/26/2010* | <352 | U | <60.0 | U | - | | - | | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <1.24 | U | <0.620 | U | <0.620 | U | <0.300 | U | <0.620 | U | <0.620 | U | - | | <0.300 | U | <6.20 | U |
| | ES112 | 7/23/2014 | **17** | **HD,J** | - | | - | | <30 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <1.0 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <10 | U,IH,ICH |
| | ES119 | 10/29/2014 | <12 | U | - | | - | | <30 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <1.0 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <10 | U,ICH |
| | ES129 | 1/29/2015 | **10** | **HD,J** | - | | - | | <30 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <1.0 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <10 | U,IJ |
| | ES139 | 4/22/2015 | <21 | U | <25 | U | **25** | **B,J** | - | | <0.20 | U | <0.40 | U | <0.20 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.80 | U | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <10 | U |
| | ES156 | 8/20/2015 | 24 | B,J | <25 | U | **40** | **B,J** | - | | <0.20 | U | <0.40 | U | <0.20 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.80 | U | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | **43** | |
| | ERH006 | 10/19/2015 | <22 | B,U | <25 | U | <53 | B,U | - | | <0.20 | U,** | <0.40 | U,** | <0.20 | U,** | <0.20 | J,* | <0.50 | J,* | <0.30 | J,* | <0.80 | U,** | <0.20 | J,* | <0.20 | J,* | - | | <0.20 | J,* | <0.20 | J,* | <0.20 | U,** | <0.20 | U,** | <10 | U,** |
| | ERH019 | 1/19/2016 | **36** | **B,J** | < 25 | U | **52** | **B,J** | - | - | < 0.20 | U | < 0.40 | U | < 0.20 | U | < 0.20 | U | < 0.50 | U | < 0.30 | U | < 0.80 | U | < 0.20 | U | < 0.20 | U | - | - | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | **4.1** | **J** |
| | ERH020 | 1/19/2016 | **29** | **B,J** | < 25 | U | < 53 | B,U | - | - | < 0.20 | U | < 0.40 | U | < 0.20 | U | < 0.20 | U | < 0.50 | U | < 0.30 | U | < 0.80 | U | < 0.20 | U | < 0.20 | U | - | - | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | **3.7** | **J** |
| **RHMW06** | RHMW06-GW-01 | 10/21/2014 | <86 | U | <20 | U | <86 | U | - | | <0.30 | U | <0.50 | U | <0.30 | U | <0.50 | U | <1.00 | U | <0.50 | U | <1.00 | U | <0.50 | U | <0.30 | U | <0.100 | U | <0.30 | U | <0.30 | U | <0.30 | U | <0.30 | U | <2.00 | U |
| | RHMW06-GW-02 | 1/23/2015[d] | <76 | U | <20 | U | <76 | U | - | | <0.30 | U | <0.50 | U | <0.30 | U | <0.50 | U | <1.00 | U | <0.50 | U | <1.00 | U | <0.50 | U | <0.30 | U | <0.100 | U | <0.30 | U | <0.30 | U | <0.30 | U | <0.30 | U | <2.00 | U |
| | ES140 | 4/23/2015 | **20** | **J** | <25 | U | **47** | **B,J** | - | | <0.20 | U | <0.40 | U | <0.20 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.80 | U | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <10 | U |
| | ES155 | 7/28/2015 | <20 | U | <25 | U | <50 | U | - | | <0.20 | U | <0.40 | U | <0.20 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.80 | U | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <10 | U |
| | ERH004 | 10/19/2015 | **17** | **B,J** | <25 | U | <53 | B,U | - | | <0.20 | U,** | <0.40 | U,** | <0.20 | U,** | <0.20 | J,* | <0.50 | J,* | <0.30 | J,* | <0.80 | U,** | <0.20 | J,* | <0.20 | J,* | - | | <0.20 | J,* | <0.20 | J,* | <0.20 | U,** | <0.20 | U,** | <10 | U,** |
| | ERH005 | 10/19/2015 | <21 | B,U | <25 | U | <53 | B,U | - | | <0.20 | U,** | <0.40 | U,** | <0.20 | U,** | <0.20 | J,* | <0.50 | J,* | <0.30 | J,* | <0.80 | U,** | <0.20 | J,* | <0.20 | J,* | - | | <0.20 | J,* | <0.20 | J,* | <0.20 | U,** | <0.20 | U,** | <10 | U,** |
| | ERH018 | 1/19/2016 | **21** | **B,J** | < 25 | U | < 54 | B,U | - | - | < 0.20 | U | < 0.40 | U | < 0.20 | U | < 0.20 | U | < 0.50 | U | < 0.30 | U | < 0.80 | U | < 0.20 | U | < 0.20 | U | - | - | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 10 | U |
| **RHMW07** | RHMW07-GW-01 | 10/20/2014 | **57** | **J** | <20 | U | <78 | U | - | | <0.30 | U | <0.50 | U | <0.30 | U | <0.50 | U | <1.00 | U | <0.50 | U | <1.00 | U | <0.50 | U | <0.30 | U | <0.100 | U | <0.30 | U | <0.30 | U | <0.30 | U | <0.30 | U | **1.9** | **J** |
| | RHMW07-GW-01FD | 10/20/2014 | **66** | **J** | <20 | U | <77 | U | - | | <0.30 | U | <0.50 | U | <0.30 | U | <0.50 | U | <1.00 | U | <0.50 | U | <1.00 | U | <0.50 | U | <0.30 | U | <0.100 | U | <0.30 | U | <0.30 | U | <0.30 | U | <0.30 | U | **1.7** | **J** |
| | RHMW07-GW-02 | 1/22/2015[d] | <75 | U | <20 | U | <75 | U | - | | <0.30 | U | <0.50 | U | <0.30 | U | <0.50 | U | <1.00 | U | <0.50 | U | <1.00 | U | <0.50 | U | <0.30 | U | <0.100 | U | <0.30 | U | <0.30 | U | <0.30 | U | <0.30 | U | <2.00 | U |
| | RHMW07-GW-02FD | 1/22/2015[d*] | <81 | U | <20 | U | <81 | U | - | | <0.30 | U | <0.50 | U | <0.30 | U | <0.50 | U | <1.00 | U | <0.50 | U | <1.00 | U | <0.50 | U | <0.30 | U | <0.100 | U | <0.30 | U | <0.30 | U | <0.30 | U | <0.30 | U | <2.00 | U |
| | ES141 | 4/23/2015 | **26** | **J** | <25 | U | **47** | **B,J** | - | | <0.20 | U | <0.40 | U | <0.20 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.80 | U | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <10 | U |
| | ES154 | 7/27/2015 | **22** | **J** | <25 | U | **48** | **J** | - | | <0.20 | U | <0.40 | U | <0.20 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.80 | U | <0.20 | U | <0.20 | U | - | | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <10 | U |
| | ERH003 | 10/19/2015 | **26** | **B,J** | <25 | U | <59 | B,U | - | | <0.20 | U,** | <0.40 | U,** | <0.20 | U,** | <0.20 | J,* | <0.50 | J,* | <0.30 | J,* | <0.80 | U,** | <0.20 | J,* | <0.20 | J,* | - | | <0.20 | J,* | <0.20 | J,* | <0.20 | U,** | <0.20 | U,** | <10 | U,** |
| | ERH017 | 1/19/2016 | **28** | **B,J** | < 25 | U | **44** | **B,J** | - | - | < 0.20 | U | < 0.40 | U | < 0.20 | U | < 0.20 | U | < 0.50 | U | < 0.30 | U | < 0.80 | U | < 0.20 | U | < 0.20 | U | - | - | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | **4.8** | **J** |

| Well Name | Sample ID | Date Sampled | 8260B | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Benzene | | Bromodichloromethane | | Bromoform | | Bromomethane | | Carbon Tetrachloride | | Chlorobenzene | | Chloroethane | | Chloroform | | Chloromethane | | cis-1,2-Dichloroethylene | | Dibromochloromethane | | Ethylbenzene | | Hexachlorobutadiene | | Methyl ethyl ketone (2-Butanone) | | Methyl isobutyl ketone (4-Methyl-2-Pentanone) | | Methyl tert-butyl Ether | | Methylene chloride | | Napthalene | | Styrene | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| **For wells < 150 m from surface water** | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations < 150m from surface water)** | - | - | **5.0** | | **0.12** | | **80** | | **8.7** | | **5.0** | | **25** | | **16** | | **70** | | **1.8** | | **70** | | **0.16** | | **30** | | **0.86** | | **7,100** | | **170** | | **5.0** | | **4.8** | | **17** | | **10** | |
| **RHMW04** | RHMW04W01 | 9/19/2005[a,b] | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.50 | U | <1.0 | U | <0.50 | U | - | | <0.50 | U | <0.40 | U | <0.50 | U | <0.50 | U | <2.5 | U | <2.5 | U | <0.50 | U | <1.0 | U | <1.0 | U | <0.50 | U |
| | RHMW04-GW02 | 7/10/2006[a,b] | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | <0.50 | U | <0.50 | U | <1.0 | U | <0.50 | U | - | | <0.50 | U | <0.40 | U | <0.50 | U | <0.50 | U | <2.5 | U | <2.5 | U | <0.50 | U | <1.0 | U | <1.0 | U | <0.50 | U |
| | RHMW04-WG-01 | 8/4/2009[a] | <0.120 | U | <0.150 | U | <0.310 | U | <0.940 | U | <0.310 | U | <0.150 | U | <0.310 | U | <0.300 | U | <0.310 | U | <0.310 | U | <0.150 | U | <0.310 | U | <0.310 | U | <3.10 | U | <3.10 | U | - | | <1.00 | U | <0.620 | U | <0.310 | U |
| | RHMWA01-WG-01 | 8/4/2009*[a] | **0.250** | **J** | <0.150 | U | <0.310 | U | <0.940 | U | <0.310 | U | <0.150 | U | <0.310 | U | <0.300 | U | <0.310 | U | <0.310 | U | <0.150 | U | <0.310 | U | <0.310 | U | <3.10 | U | <3.10 | U | - | | <1.00 | U | <0.620 | U | <0.310 | U |
| | RHMW04-WG-02 | 10/13/2009[ab] | <0.12 | U | <0.15 | U | <0.31 | U | <0.94 | U | <0.31 | U | <0.15 | U | <0.31 | U | <0.3 | U | <0.31 | U | <0.31 | U | <0.15 | U | <0.31 | U | <0.31 | U | <3.1 | U | <3.1 | U | - | | <1 | U | <0.62 | U | <0.31 | U |
| | RHMWA01-WG-02 | 10/13/2009*[ab] | <0.12 | U | <0.15 | U | <0.31 | U | <0.94 | U | <0.31 | U | <0.15 | U | <0.31 | U | <0.3 | U | <0.31 | U | <0.31 | U | <0.15 | U | <0.31 | U | <0.31 | U | <3.1 | U | <3.1 | U | - | | <1 | U | <0.62 | U | <0.31 | U |
| | RHMW04-WG-03 | 1/26/2010 | <0.240 | U | <0.300 | U | <0.620 | U | <1.88 | U | <0.620 | U | <0.300 | U | <0.620 | U | <0.600 | U | <0.620 | U | <0.620 | U | <0.300 | U | <0.620 | U | <0.620 | U | <6.20 | U | <6.20 | U | - | | <2.00 | U | <1.24 | U | <0.620 | U |
| | RHMWA01-WG-03 | 1/26/2010* | <0.240 | U | <0.300 | U | <0.620 | U | <1.88 | U | <0.620 | U | <0.300 | U | <0.620 | U | <0.600 | U | <0.620 | U | <0.620 | U | <0.300 | U | <0.620 | U | <0.620 | U | <6.20 | U | <6.20 | U | - | | <2.00 | U | <1.24 | U | <0.620 | U |
| | RHMW04-WG-04 | 4/26/2010 | <0.240 | U | <0.300 | U | <0.620 | U | <1.88 | U | <0.620 | U | <0.300 | U | <0.620 | U | <0.600 | U | <0.620 | U | <0.620 | U | <0.300 | U | <0.620 | U | <0.620 | U | <6.20 | U | <6.20 | U | - | | <2.00 | U | <1.24 | U | <0.620 | U |
| | RHMWA01-WG-04 | 4/26/2010* | <0.240 | U | <0.300 | U | <0.620 | U | <1.88 | U | <0.620 | U | <0.300 | U | <0.620 | U | <0.600 | U | <0.620 | U | <0.620 | U | <0.300 | U | <0.620 | U | <0.620 | U | <6.20 | U | <6.20 | U | - | | <2.00 | U | <1.24 | U | <0.620 | U |
| | ES112 | 7/23/2014 | <0.50 | U | <0.50 | U | <1.0 | U | <5.0 | U | <0.50 | U | <0.50 | U | <5.0 | U | <0.50 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <5.0 | U | <5.0 | U | <0.50 | U | <1.0 | U | - | | <0.50 | U |
| | ES119 | 10/29/2014 | <0.50 | U | <0.50 | U | <1.0 | U | <5.0 | U,IJ | <0.50 | U | <0.50 | U | <5.0 | U | <0.50 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <5.0 | U | <5.0 | U | <0.50 | U | <1.0 | U | - | | <0.50 | U |
| | ES129 | 1/29/2015 | <0.50 | U | <0.50 | U | <1.0 | U | <5.0 | U,IH | <0.50 | U | <0.50 | U | <5.0 | U | <0.50 | U | <2.0 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <5.0 | U | <5.0 | U | <0.50 | U | <1.0 | U | - | | <0.50 | U |
| | ES139 | 4/22/2015 | <0.10 | U | - | | <0.50 | U | <0.30 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | - | | <0.10 | U | <0.30 | U | <4.0 | U | <10 | U | <0.30 | U | <0.20 | U | - | | <0.20 | U |
| | ES156 | 8/20/2015 | <0.10 | U | - | | <0.50 | U | <0.30 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | - | | <0.10 | U | <0.30 | U | <4.0 | U | <10 | U | <0.30 | U | <0.20 | U | - | | <0.20 | U |
| | ERH006 | 10/19/2015 | **0.08** | J,** | - | | <0.50 | U,* | <0.30 | U,** | <0.20 | U,** | <0.20 | U,* | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,* | - | | <0.10 | U,** | <0.30 | U,* | <4.0 | U,** | <10 | U,* | <0.30 | U,* | <0.20 | B,U,** | - | | <0.20 | U,** |
| | ERH019 | 1/19/2016 | < 0.10 | U | - | - | < 0.50 | U | < 0.30 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | - | - | < 0.10 | U | < 0.30 | U | < 4.0 | U | < 10 | U | < 0.30 | U | < 0.20 | B,U | - | - | < 0.20 | U |
| | ERH020 | 1/19/2016 | < 0.10 | U | - | - | < 0.50 | U | < 0.30 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | - | - | < 0.10 | U | < 0.30 | U | < 4.0 | U | < 10 | U | < 0.30 | U | < 0.20 | B,U | - | - | < 0.20 | U |
| **RHMW06** | RHMW06-GW-01 | 10/21/2014 | <0.200 | U | <0.30 | U | <0.30 | U | <0.50 | U | <0.100 | U | <0.50 | U | <0.50 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.30 | U | <0.50 | U | <0.30 | U | <2.00 | U | <5.00 | U | <0.52 | U | <1.00 | U | - | | <0.50 | U |
| | RHMW06-GW-02 | 1/23/2015[d] | <0.200 | U | <0.30 | U | <0.30 | U | <0.50 | U | <0.100 | U | <0.50 | U | <0.50 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.30 | U | <0.50 | U | <0.30 | U | <2.00 | U | <5.00 | U | <0.52 | U | <1.00 | U | - | | <0.50 | U |
| | ES140 | 4/23/2015 | <0.10 | U | - | | <0.50 | U | <0.30 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | - | | <0.10 | U | <0.30 | U | <4.0 | U | <10 | U | <0.30 | U | <0.20 | U | - | | <0.20 | U |
| | ES155 | 7/28/2015 | <0.10 | U | - | | <0.50 | U | <0.30 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | - | | <0.10 | U | <0.30 | U | <4.0 | U | <10 | U | <0.30 | U | <0.20 | U | - | | <0.20 | U |
| | ERH004 | 10/19/2015 | <0.10 | U,** | - | | <0.50 | U,* | <0.30 | U,** | <0.20 | U,** | <0.20 | U,* | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,* | - | | <0.10 | U,** | <0.30 | U,* | <4.0 | U,** | <10 | U,* | <0.30 | U,* | <0.20 | B,U,** | - | | <0.20 | U,** |
| | ERH005 | 10/19/2015 | <0.10 | U,** | - | | <0.50 | U,* | <0.30 | U,** | <0.20 | U,** | <0.20 | U,* | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,* | - | | <0.10 | U,** | <0.30 | U,* | <4.0 | U,** | <10 | U,* | <0.30 | U,* | <0.20 | B,U** | - | | <0.20 | U,** |
| | ERH018 | 1/19/2016 | < 0.10 | U | - | - | < 0.50 | U | < 0.30 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | - | - | < 0.10 | U | < 0.30 | U | < 4.0 | U | < 10 | U | < 0.30 | U | < 0.20 | B,U | - | - | < 0.20 | U |
| **RHMW07** | RHMW07-GW-01 | 10/20/2014 | <0.200 | U | <0.30 | U | <0.30 | U | <0.50 | U | <0.100 | U | <0.50 | U | <0.50 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.30 | U | <0.50 | U | <0.30 | U | <2.00 | U | <5.00 | U | <0.52 | U | <1.00 | U | - | | <0.50 | U |
| | RHMW07-GW-01FD | 10/20/2014 | <0.200 | U | <0.30 | U | <0.30 | U | <0.50 | U | <0.100 | U | <0.50 | U | <0.50 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.30 | U | <0.50 | U | <0.30 | U | <2.00 | U | <5.00 | U | <0.52 | U | <1.00 | U | - | | <0.50 | U |
| | RHMW07-GW-02 | 1/22/2015[d] | <0.200 | U | <0.30 | U | <0.30 | U | <0.50 | U | <0.100 | U | <0.50 | U | <0.50 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.30 | U | <0.50 | U | <0.30 | U | <2.00 | U | <5.00 | U | <0.52 | U | <1.00 | U | - | | <0.50 | U |
| | RHMW07-GW-02FD | 1/22/2015[d*] | <0.200 | U | <0.30 | U | <0.30 | U | <0.50 | U | <0.100 | U | <0.50 | U | <0.50 | U | <0.20 | U | <0.50 | U | <0.30 | U | <0.30 | U | <0.50 | U | <0.30 | U | <2.00 | U | <5.00 | U | <0.52 | U | <1.00 | U | - | | <0.50 | U |
| | ES141 | 4/23/2015 | <0.10 | U | - | | <0.50 | U | <0.30 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | - | | <0.10 | U | <0.30 | U | <4.0 | U | <10 | U | <0.30 | U | <0.20 | U | - | | <0.20 | U |
| | ES154 | 7/27/2015 | <0.10 | U | - | | <0.50 | U | <0.30 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | <0.20 | U | - | | <0.10 | U | <0.30 | U | <4.0 | U | <10 | U | <0.30 | U | <0.20 | U | - | | <0.20 | U |
| | ERH003 | 10/19/2015 | <0.10 | U,** | - | | <0.50 | U,* | <0.30 | U,** | <0.20 | U,** | <0.20 | U,* | <0.20 | U,** | <0.20 | U,** | <0.20 | U,** | <0.20 | U,* | - | | <0.10 | U,** | <0.30 | U,* | <4.0 | U,** | <10 | U,* | <0.30 | U,* | <0.20 | B,U,** | - | | <0.20 | U,** |
| | ERH017 | 1/19/2016 | < 0.10 | U | - | - | < 0.50 | U | < 0.30 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | < 0.20 | U | - | - | < 0.10 | U | < 0.30 | U | < 4.0 | U | < 10 | U | < 0.30 | U | < 0.20 | B,U | - | - | < 0.20 | U |

| Well Name | Sample ID | Date Sampled | | | | | | | | | | | | | | | | | 8260SIM | | | | | | | | | | 8011 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Tetrachloroethane, 1,1,1,2- | | Tetrachloroethane, 1,1,2,2- | | Tetrachloroethylene | | Toluene | | trans-1,2- Dichloroethylene | | Trichloroethylene | | Vinyl chloride | | Xylenes (total) | | 1,2-Dibromoethane | | 1,2-Dichloroethane | | Bromodichloromethane | | Dibromochloromethane | | Tetrachloroethane, 1,1,2,2- | | 1,2-Dibromo-3-chloropropane | | 1,2-Dibromoethane | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| For wells < 150 m from surface water | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| DOH Tier 1 EALs (for locations < 150m from surface water) | - | - | 0.52 | | 0.067 | | 5.0 | | 40 | | 100 | | 5.0 | | 2.0 | | 20 | | 0.04 | | 0.15 | | 0.12 | | 0.16 | | 0.067 | | 0.04 | | 0.04 | |
| RHMW04 | RHMW04W01 | 9/19/2005[a,b] | <0.50 | U | <0.40 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | - | | - | | - | | - | | - | | - | | - | |
| | RHMW04-GW02 | 7/10/2006[a,b] | <0.50 | U | <0.40 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | - | | - | | - | | - | | - | | - | | - | |
| | RHMW04-WG-01 | 8/4/2009[a] | <0.150 | U | <0.150 | U | <0.310 | U | <0.310 | U | <0.310 | U | <0.310 | U | <0.310 | U | <0.620 | U | - | | - | | - | | - | | - | | - | | - | |
| | RHMWA01-WG-01 | 8/4/2009*[a] | <0.150 | U | <0.150 | U | <0.310 | U | <0.310 | U | <0.310 | U | <0.310 | U | <0.310 | U | <0.620 | U | - | | - | | - | | - | | - | | - | | - | |
| | RHMW04-WG-02 | 10/13/2009[ab] | <0.15 | U | <0.15 | U | <0.31 | U | <0.31 | U | <0.31 | U | <0.31 | U | <0.31 | U | <0.62 | U | - | | - | | - | | - | | - | | - | | - | |
| | RHMWA01-WG-02 | 10/13/2009*[ab] | <0.15 | U | <0.15 | U | <0.31 | U | <0.31 | U | <0.31 | U | <0.31 | U | <0.31 | U | <0.62 | U | - | | - | | - | | - | | - | | - | | - | |
| | RHMW04-WG-03 | 1/26/2010 | <0.300 | U | <0.300 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <1.24 | U | - | | - | | - | | - | | - | | - | | - | |
| | RHMWA01-WG-03 | 1/26/2010* | <0.300 | U | <0.300 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <1.24 | U | - | | - | | - | | - | | - | | - | | - | |
| | RHMW04-WG-04 | 4/26/2010 | <0.300 | U | <0.300 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <1.24 | U | - | | - | | - | | - | | - | | - | | - | |
| | RHMWA01-WG-04 | 4/26/2010* | <0.300 | U | <0.300 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <0.620 | U | <1.24 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES112 | 7/23/2014 | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES119 | 10/29/2014 | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES129 | 1/29/2015 | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <0.50 | U | <1.0 | U | - | | - | | - | | - | | - | | - | | - | |
| | ES139 | 4/22/2015 | <0.20 | U | - | | <0.20 | U | <0.10 | U | <0.20 | U | <0.10 | U | <0.10 | U | <0.20 | U | <0.010 | U | <0.015 | U | <0.010 | U | <0.010 | U | <0.015 | U | <0.0040 | UJ | <0.0040 | UJ |
| | ES156 | 8/20/2015 | <0.20 | U | - | | <0.20 | U | <0.10 | U | <0.20 | U | <0.10 | U | <0.10 | U | <0.20 | U | - | - | <0.015 | U | <0.010 | U | <0.010 | U | <0.015 | U | <0.0040 | U | <0.0040 | U |
| | ERH006 | 10/19/2015 | <0.20 | U,** | - | | <0.20 | U,** | 0.420 | J,** | <0.20 | U,** | <0.10 | U,** | <0.10 | U,** | <0.20 | U,** | - | - | <0.015 | U | <0.010 | U | <0.010 | U | <0.015 | U | <0.0040 | U | <0.0040 | U |
| | ERH019 | 1/19/2016 | < 0.20 | U | < 15 | U | < 0.20 | U | < 0.10 | U | < 0.20 | U | < 0.10 | U | < 0.10 | U | < 0.20 | U | - | - | < 0.015 | U | < 0.010 | U | < 0.010 | U | - | - | - | - | < 0.0040 | U |
| | ERH020 | 1/19/2016 | < 0.20 | U | < 15 | U | < 0.20 | U | **0.11** | **Tb,J** | < 0.20 | U | < 0.10 | U | < 0.10 | U | < 0.20 | U | - | - | < 0.015 | U | < 0.010 | U | < 0.010 | U | - | - | - | - | < 0.0040 | U |
| RHMW06 | RHMW06-GW-01 | 10/21/2014 | <0.30 | U | <0.30 | U | <0.30 | U | <0.30 | U | <0.30 | U | <0.30 | U | <0.10 | U | <0.30 | U | - | | - | | - | | - | | - | | <0.019 | U | <0.020 | U |
| | RHMW06-GW-02 | 1/23/2015[d] | <0.30 | U | <0.30 | U | <0.30 | U | <0.30 | U | <0.30 | U | <0.30 | U | <0.10 | U | <0.30 | U | - | | - | | - | | - | | - | | <0.019 | U | <0.020 | U |
| | ES140 | 4/23/2015 | <0.20 | U | - | | <0.20 | U | <0.10 | U | <0.20 | U | <0.10 | U | <0.10 | U | <0.20 | U | <0.010 | U | <0.015 | U | **0.0039** | **B,J** | <0.010 | U | <0.015 | U | <0.0040 | UJ | <0.0040 | UJ |
| | ES155 | 7/28/2015 | <0.20 | U | - | | <0.20 | U | <0.10 | U | <0.20 | U | <0.10 | U | <0.10 | U | <0.20 | U | - | | <0.015 | U | <0.010 | U | <0.010 | U | <0.015 | U | <0.0040 | U | <0.0040 | U |
| | ERH004 | 10/19/2015 | <0.20 | U,** | - | | <0.20 | U,** | **1.1** | ** | <0.20 | U,** | <0.10 | U,** | <0.10 | U,** | <0.20 | U,** | - | | <0.015 | U | <0.010 | B,J | <0.010 | U | <0.015 | U | <0.0040 | U | <0.0040 | U |
| | ERH005 | 10/19/2015 | <0.20 | U,** | - | | <0.20 | U,** | **0.50** | ** | <0.20 | U,** | <0.10 | U,** | <0.10 | U,** | <0.20 | U,** | - | | <0.015 | U | <0.010 | U | <0.010 | U | <0.015 | U | <0.0040 | U | <0.0040 | U |
| | ERH018 | 1/19/2016 | < 0.20 | U | < 15 | U | < 0.20 | U | **0.10** | **Tb,J** | < 0.20 | U | < 0.10 | U | < 0.10 | U | < 0.20 | U | - | - | < 0.015 | U | **6.2** | **J** | < 0.010 | U | - | - | - | - | < 0.0040 | U |
| RHMW07 | RHMW07-GW-01 | 10/20/2014 | <0.30 | U | <0.30 | U | <0.30 | U | <0.30 | U | <0.30 | U | <0.30 | U | <0.10 | U | <0.30 | U | - | | - | | - | | - | | - | | <0.019 | U | <0.020 | U |
| | RHMW07-GW-01FD | 10/20/2014 | <0.30 | U | <0.30 | U | <0.30 | U | <0.30 | U | <0.30 | U | <0.30 | U | <0.10 | U | <0.30 | U | - | | - | | - | | - | | - | | <0.019 | U | <0.020 | U |
| | RHMW07-GW-02 | 1/22/2015[d] | <0.30 | U | <0.30 | U | <0.30 | U | <0.30 | U | <0.30 | U | <0.30 | U | <0.10 | U | <0.30 | U | - | | - | | - | | - | | - | | <0.019 | U | <0.020 | U |
| | RHMW07-GW-02FD | 1/22/2015[d*] | <0.30 | U | <0.30 | U | <0.30 | U | <0.30 | U | <0.30 | U | <0.30 | U | <0.10 | U | <0.30 | U | - | | - | | - | | - | | - | | <0.019 | U | <0.020 | U |
| | ES141 | 4/23/2015 | <0.20 | U | - | | <0.20 | U | <0.10 | U | <0.20 | U | <0.10 | U | <0.10 | U | <0.20 | U | <0.010 | U | <0.015 | U | <0.010 | U | <0.010 | U | <0.015 | U | <0.0040 | UJ | <0.0040 | UJ |
| | ES154 | 7/27/2015 | <0.20 | U | - | | <0.20 | U | <0.10 | U | <0.20 | U | <0.10 | U | <0.10 | U | <0.20 | U | - | | <0.015 | U | <0.010 | U | <0.010 | U | <0.015 | U | <0.0040 | U | <0.0040 | U |
| | ERH003 | 10/19/2015 | <0.20 | U,** | - | | <0.20 | U,** | **0.640** | ** | <0.20 | U,** | <0.10 | U,** | <0.10 | U,** | <0.20 | U,** | - | | <0.015 | U | <0.010 | U | <0.010 | U | <0.015 | U | <0.0040 | U | <0.0040 | U |
| | ERH017 | 1/19/2016 | < 0.20 | U | < 15 | U | < 0.20 | U | < 0.10 | U | < 0.20 | U | < 0.10 | U | < 0.10 | U | < 0.20 | U | - | - | < 0.015 | U | < 0.010 | U | < 0.010 | U | - | - | - | - | < 0.0040 | U |

| Well Name | Sample ID | Date Sampled | 8270C | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | 6020 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Acenaphthene | | Acenaphthylene | | Anthracene | | Benzo[a]anthracene | | Benzo[g,h,i]perylene | | Benzo[a]pyrene | | Benzo[b]fluoranthene | | Benzo[k]fluoranthene | | Chrysene | | Dibenzo[a,h]anthracene | | Fluoranthene | | Fluorene | | Ideno[1,2,3-cd]pyrene | | 1-Methylnaphthalene | | 2-Methylnaphthalene | | Naphthalene | | Phenanthrene | | Pyrene | | Dissolved Lead | |
| | | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | | (µg/l) | |
| **For wells < 150 m from surface water** | - | - | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **DOH Tier 1 EALs (for locations < 150m from surface water)** | - | - | **20** | | **30** | | **0.73** | | **0.027** | | **0.10** | | **0.014** | | **0.092** | | **0.40** | | **0.35** | | **0.0092** | | **8.0** | | **3.9** | | **0.092** | | **2.1** | | **2.1** | | **17** | | **4.6** | | **2.0** | | **5.6** | |
| **RHMW04** | RHMW04W01 | 9/19/2005[a,b] | <0.57 | U | <0.57 | U | <0.57 | U | <0.057 | U | <0.11 | U | <0.11 | U | <0.057 | U | <0.11 | U | <0.11 | U | <0.057 | U | <0.28 | U | <0.28 | U | <0.057 | U | <0.28 | U | <0.28 | U | <0.28 | U | <0.57 | U | <0.28 | U | - | |
| | RHMW04-GW02 | 7/10/2006[a,b] | <0.51 | U | <0.51 | U | <0.51 | U | <0.051 | U | <0.10 | U | <0.10 | U | <0.051 | U | <0.10 | U | <0.10 | U | <0.051 | U | <0.26 | U | <0.26 | U | <0.051 | U | <0.26 | U | <0.26 | U | <0.26 | U | <0.51 | U | <0.26 | U | <10 | U |
| | RHMW04-WG-01 | 8/4/2009[a] | <0.0162 | U | <0.0162 | U | <0.0162 | U | <0.0162 | U | <0.0162 | U | <0.0162 | U | <0.0162 | U | <0.0162 | U | <0.0162 | U | <0.0162 | U | <0.0162 | U | <0.0162 | U | <0.0162 | U | <0.0162 | U | <0.0162 | U | <0.0335 | U | <0.0162 | U | <0.0162 | U | <0.310 | U |
| | RHMWA01-WG-01 | 8/4/2009*[a] | <0.0167 | U | <0.0167 | U | <0.0167 | U | <0.0167 | U | <0.0167 | U | <0.0167 | U | <0.0167 | U | <0.0167 | U | <0.0167 | U | <0.0167 | U | <0.0167 | U | <0.0167 | U | <0.0167 | U | <0.0167 | U | <0.0167 | U | <0.0344 | U | <0.0167 | U | <0.0167 | U | <0.310 | U |
| | RHMW04-WG-02 | 10/13/2009[ab] | <0.0172 | U | <0.0172 | U | <0.0172 | U | <0.0172 | U | <0.0172 | U | <0.0172 | U | <0.0172 | U | <0.0172 | U | <0.0172 | U | <0.0172 | U | <0.0172 | U | <0.0172 | U | <0.0172 | U | <0.0172 | U | <0.0172 | U | <0.0356 | U | <0.0172 | U | <0.0172 | U | <0.31 | U |
| | RHMWA01-WG-02 | 10/13/2009*[ab] | <0.0169 | U | <0.0169 | U | <0.0169 | U | <0.0169 | U | <0.0169 | U | <0.0169 | U | <0.0169 | U | <0.0169 | U | <0.0169 | U | <0.0169 | U | <0.0169 | U | <0.0169 | U | <0.0169 | U | <0.0169 | U | <0.0169 | | <0.0348 | U | <0.0169 | U | <0.0169 | U | <0.31 | U |
| | RHMW04-WG-03 | 1/26/2010 | <0.0326 | U | <0.0326 | U | <0.0326 | U | <0.0326 | U | <0.0326 | U | <0.0326 | U | <0.0326 | U | <0.0326 | U | <0.0326 | U | <0.0326 | U | <0.0326 | U | <0.0326 | U | <0.0326 | U | <0.0326 | U | <0.0326 | U | <0.0674 | U | <0.0326 | U | <0.0326 | U | <0.620 | U |
| | RHMWA01-WG-03 | 1/26/2010* | <0.0338 | U | <0.0338 | U | <0.0338 | U | <0.0338 | U | <0.0338 | U | <0.0338 | U | <0.0338 | U | <0.0338 | U | <0.0338 | U | <0.0338 | U | <0.0338 | U | <0.0338 | U | <0.0338 | U | <0.0338 | U | <0.0338 | U | <0.0696 | U | <0.0338 | U | <0.0338 | U | <0.620 | U |
| | RHMW04-WG-04 | 4/26/2010 | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0730 | U | <0.0352 | U | <0.0352 | U | <0.620 | U |
| | RHMWA01-WG-04 | 4/26/2010* | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0352 | U | <0.0730 | U | <0.0352 | U | <0.0352 | U | <0.620 | U |
| | ES112 | 7/23/2014 | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.200 | U |
| | ES119 | 10/29/2014 | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.099 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.099 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.050 | U | <0.200 | U |
| | ES129 | 1/29/2015 | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.10 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.10 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.052 | U | <0.200 | U |
| | ES139 | 4/22/2015 | <0.0050 | U | **0.0037** | **J** | **0.0051** | **J** | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.020 | U | **0.0060** | **J** | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | **0.0069** | **J** | <0.010 | U | **0.006** | **J** |
| | ES156 | 8/20/2015 | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.020 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | **0.0059** | **J** | **0.0075** | **J** | <0.0050 | U | <0.010 | U | **0.026** | |
| | ERH006 | 10/19/2015 | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | B,U | **0.0076** | B,J | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | **0.011** | **B,J** | <0.020 | U | <0.0050 | U | **0.0087** | **B,J** | **0.0043** | **J** | **0.0047** | **B,J** | **0.0051** | **B,J** | <0.0050 | U | <0.010 | U | **0.044** | |
| | ERH019 | 1/19/2016 | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | **0.0029** | **J** | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.020 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.010 | U | **0.037** | |
| | ERH020 | 1/19/2016 | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | **0.0030** | **J** | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.020 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.010 | U | **0.072** | |
| **RHMW06** | RHMW06-GW-01 | 10/21/2014 | <0.011 | U | <0.011 | U | <0.011 | U | <0.011 | U | <0.011 | U | <0.011 | U | <0.011 | U | <0.011 | U | <0.011 | U | <0.011 | U | <0.011 | U | <0.011 | U | <0.011 | U | <0.011 | U | **0.0064** | **J** | <0.053 | U | <0.011 | U | <0.011 | U | <0.80 | U |
| | RHMW06-GW-02 | 1/23/2015[d] | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.052 | U | <0.010 | U | <0.010 | U | <0.40 | U |
| | ES140 | 4/23/2015 | <0.0052 | U | <0.0052 | U | <0.0052 | U | **0.0028** | **B,J** | <0.0052 | U | <0.0052 | U | <0.0052 | U | <0.0052 | U | <0.0052 | U | <0.0052 | U | <0.021 | U | <0.0052 | U | <0.0052 | U | <0.0052 | U | <0.0052 | U | <0.0052 | U | <0.0052 | U | <0.011 | U | **0.006** | **J** |
| | ES155 | 7/28/2015 | <0.0050 | U | <0.0050 | U | <0.0050 | U | **<0.0050** | **U** | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.020 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.010 | U | **0.006** | **J** |
| | ERH004 | 10/19/2015 | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | B,U | <0.0050 | B,U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | B,U | <0.020 | U | <0.0050 | U | <0.0050 | B,U | <0.0050 | U | <0.0050 | B,U | <0.0050 | B,U | <0.0050 | U | <0.010 | U | **0.012** | **J** |
| | ERH005 | 10/19/2015 | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | B,U | <0.0050 | B,U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | B,U | <0.020 | U | <0.0050 | U | <0.0050 | B,U | <0.0050 | U | <0.0050 | B,U | <0.0050 | B,U | <0.0050 | U | <0.010 | U | **0.016** | **J** |
| | ERH018 | 1/19/2016 | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.020 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.010 | U | **0.010** | **J** |
| **RHMW07** | RHMW07-GW-01 | 10/20/2014 | <0.0096 | U | <0.0096 | U | <0.0096 | U | <0.0096 | U | <0.0096 | U | <0.0096 | U | <0.0096 | U | <0.0096 | U | <0.0096 | U | <0.0096 | U | <0.0096 | U | <0.0096 | U | <0.0096 | U | <0.0096 | U | **0.0084** | **J** | <0.048 | U | <0.0096 | U | <0.0096 | U | <0.80 | U |
| | RHMW07-GW-01FD | 10/20/2014 | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | **0.0060** | **J** | <0.050 | U | <0.010 | U | <0.010 | U | <0.80 | U |
| | RHMW07-GW-02 | 1/22/2015[d] | <0.011 | U | <0.011 | U | <0.011 | U | <0.011 | U | <0.011 | U | <0.011 | U | <0.011 | U | <0.011 | U | <0.011 | U | <0.011 | U | <0.011 | U | <0.011 | U | <0.011 | U | <0.011 | U | <0.011 | U | <0.055 | U | <0.011 | U | <0.011 | U | <0.40 | U |
| | RHMW07-GW-02FD | 1/22/2015[d*] | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.010 | U | <0.050 | U | <0.010 | U | <0.010 | U | <0.40 | U |
| | ES141 | 4/23/2015 | <0.0052 | U | <0.0052 | U | <0.0052 | U | **0.0027** | **B,J** | <0.0052 | U | <0.0052 | U | <0.0052 | U | <0.0052 | U | <0.0052 | U | <0.0052 | U | <0.021 | U | **0.0042** | **J** | <0.0052 | U | <0.0052 | U | <0.0052 | U | <0.0052 | U | **0.0072** | **J** | <0.011 | U | **0.006** | **J** |
| | ES154 | 7/27/2015 | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.020 | U | **0.0042** | **J** | <0.0050 | U | **0.0051** | **J** | **0.0095** | **J** | **0.0060** | **J** | **0.0084** | **J** | <0.010 | U | **0.006** | **J** |
| | ERH003 | 10/19/2015 | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | B,U | <0.0050 | B,U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | U | <0.0050 | B,U | <0.020 | U | <0.0050 | U | <0.0050 | B,U | **0.0067** | **J** | **0.010** | **B,J** | **0.010** | **B,J** | <0.0050 | U | <0.010 | U | **0.013** | **J** |
| | ERH017 | 1/19/2016 | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | **0.0030** | **J** | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.0050 | U | < 0.020 | U | < 0.0050 | U | < 0.0050 | U | **0.0046** | **J** | **0.0077** | **J** | **0.0038** | **J** | < 0.0050 | U | < 0.010 | U | **0.015** | |

**Notes:**

*   duplicate samples

** Samples run passed the EPA recommended holding time.

*** - Samples ES087 and ES088 possibly switched prior to analysis.

HDOH, Tier 1 Environmental Action Levels, Table D-1a. Groundwater Action Levels (Groundwater IS a current or potential drinking water resource, surface water body IS located within 150 meters of release site)

Background historical data are from February 2005 to July 2012.

Results for October 2015 sampling have been adjusted to reflect corrections from hits in the laboratory blank.

Non-detects (from October 2012 and on) are the LOD values.

a - MDL values were used for non-detects

b - MRL values were used for non-detects

d - no analytical lab reports available, used summary table from DOH Quarterly GW Reports

µg/l - micrograms per liter

Grey highlight - exceeds EALs

Bold - detected values

B - analyte was present in the associated method blank

BU - sample analyzed after holding time expired

ICH - initial calibration verification recovery above method CL for this analyte

IH - Calibration verification recovery below method CL for this analyte

IJ - Calibration verification recovery above method CL for this analyte

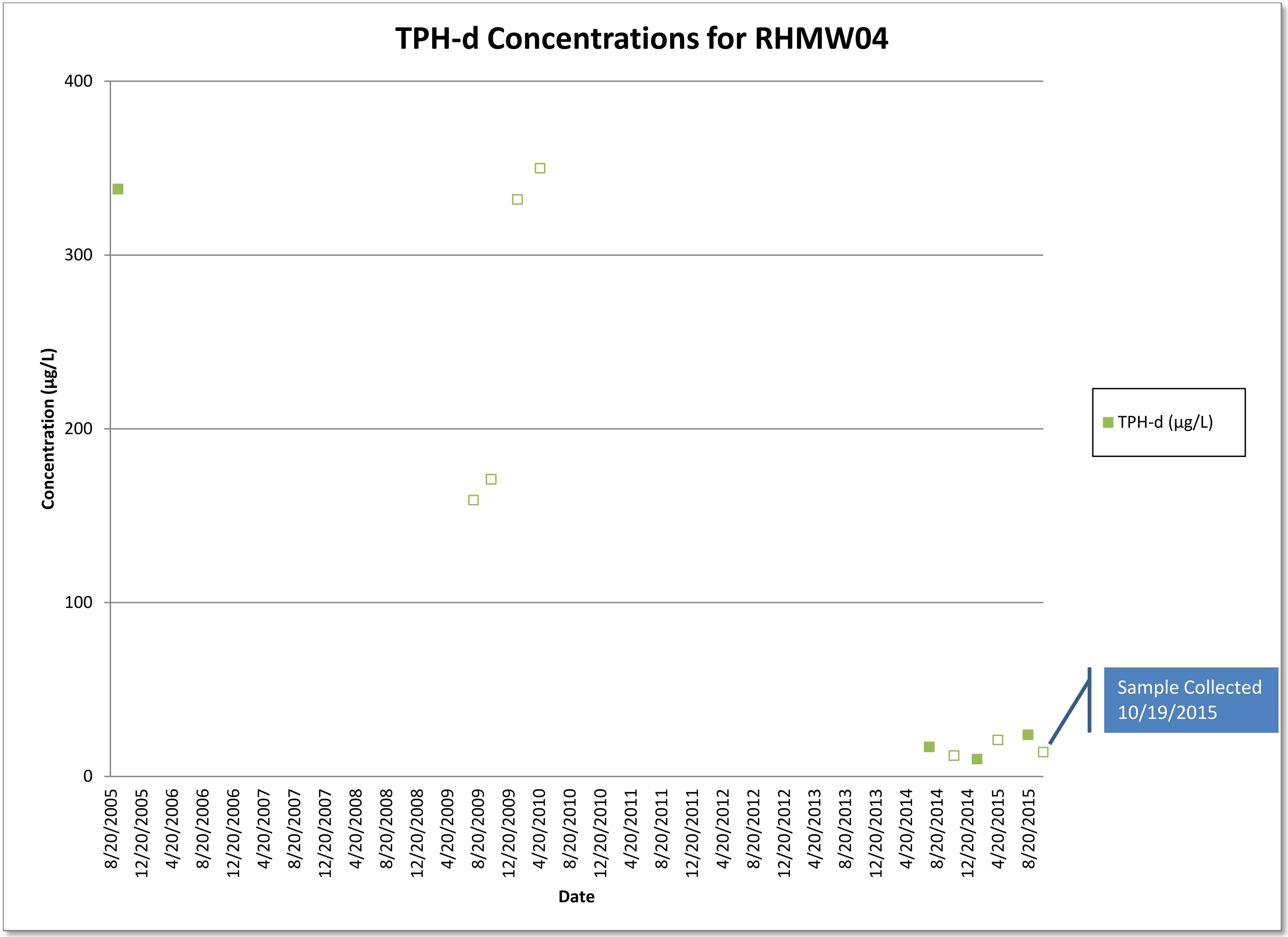
J - indicates an estimated value

U - indicates that the compound was analyzed for but not detected at or above the stated limit. The stated limit is the LOD unless otherwise specified.

HD, Z, ++ - the chromatographic pattern was inconsistent with the profile of the reference fuel standard

X - possible high bias due to matrix interference

Tb - The analyte was also detected in the associated trip blank at a similar concentration


TPH-d Concentrations for RHMW04
Concentration (µg/L)
400
300
200
100
0
8/20/2005
12/20/2005
4/20/2006
8/20/2006
12/20/2006
4/20/2007
8/20/2007
12/20/2007
4/20/2008
8/20/2008
12/20/2008
4/20/2009
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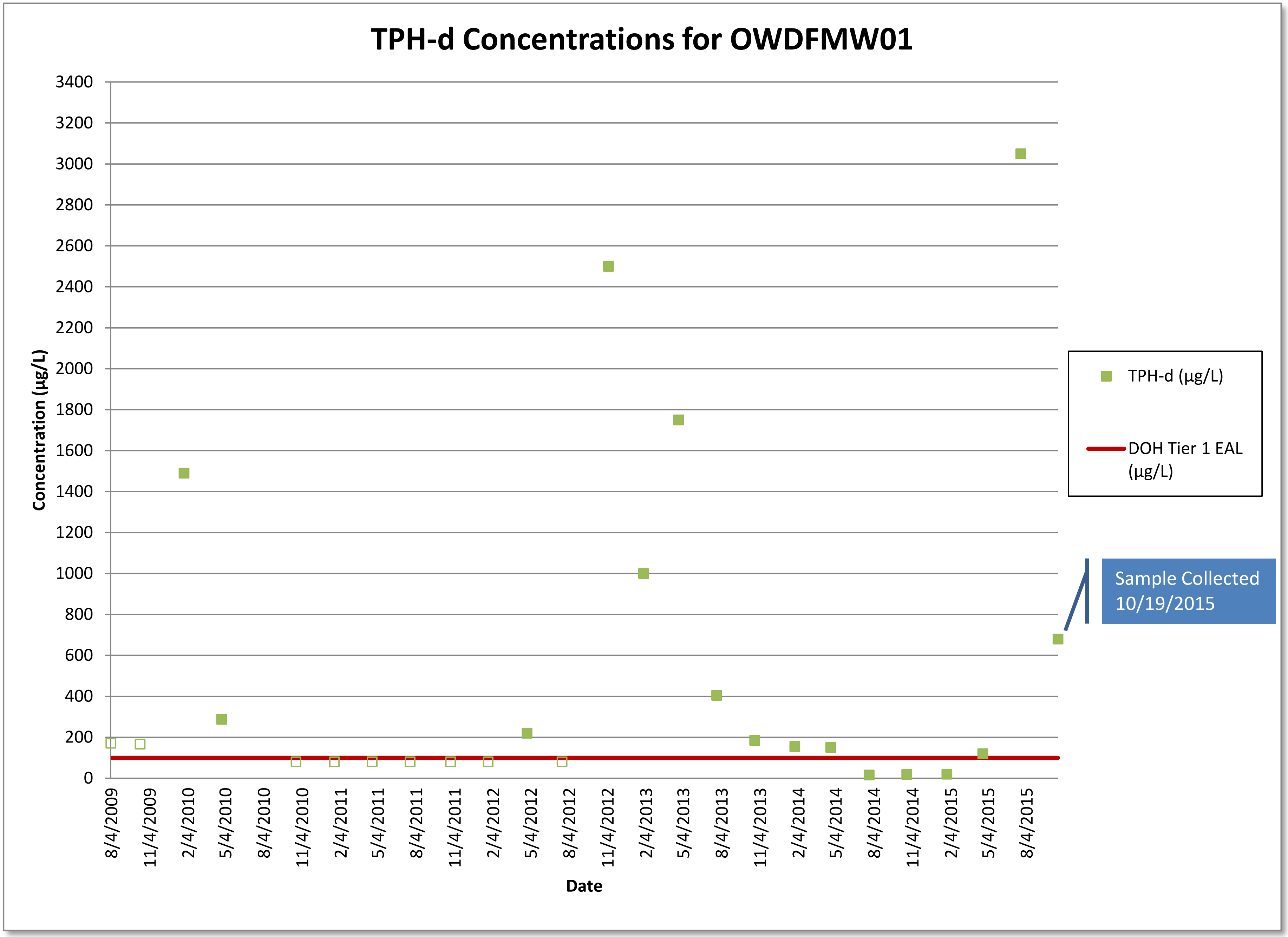
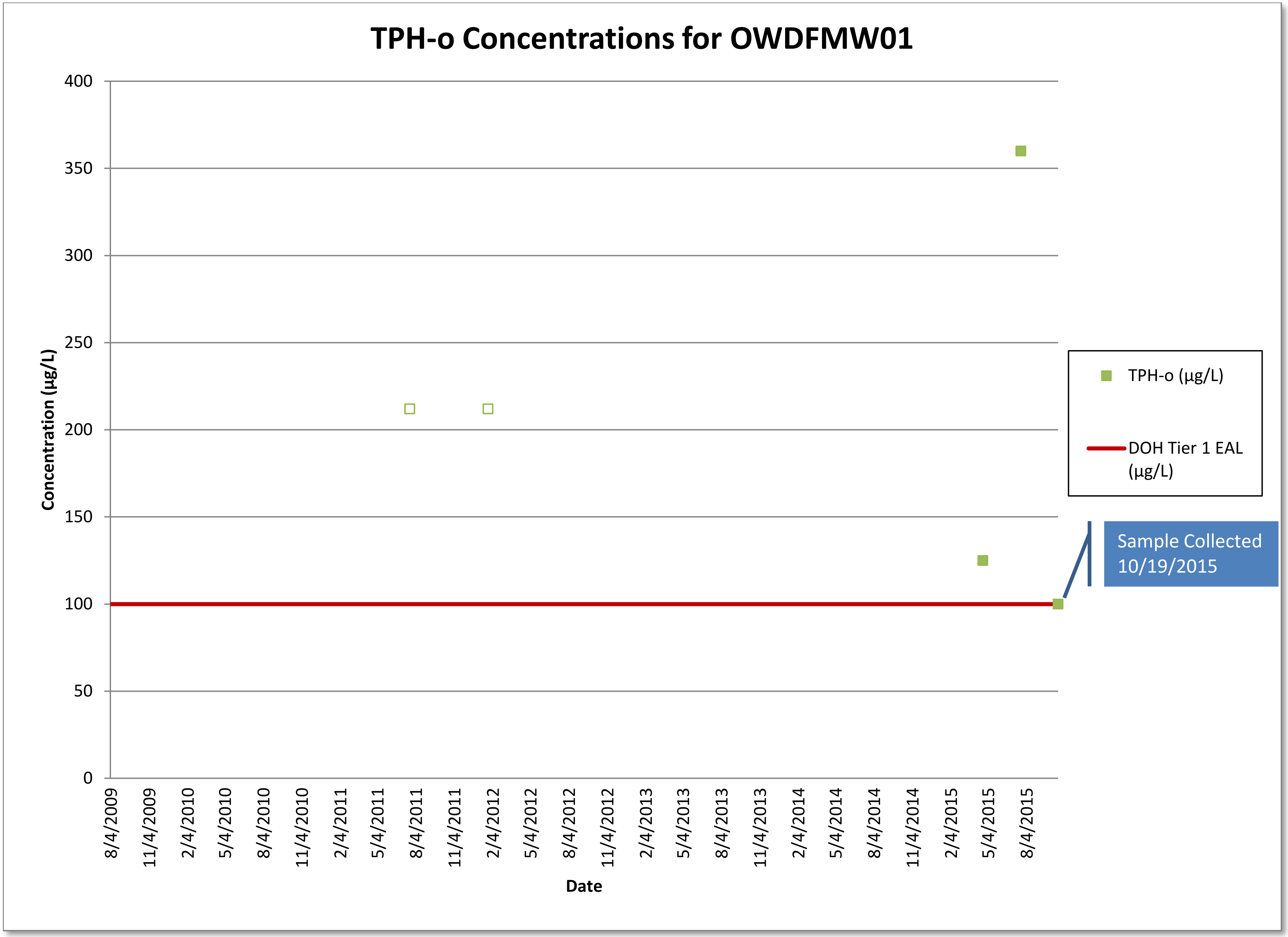
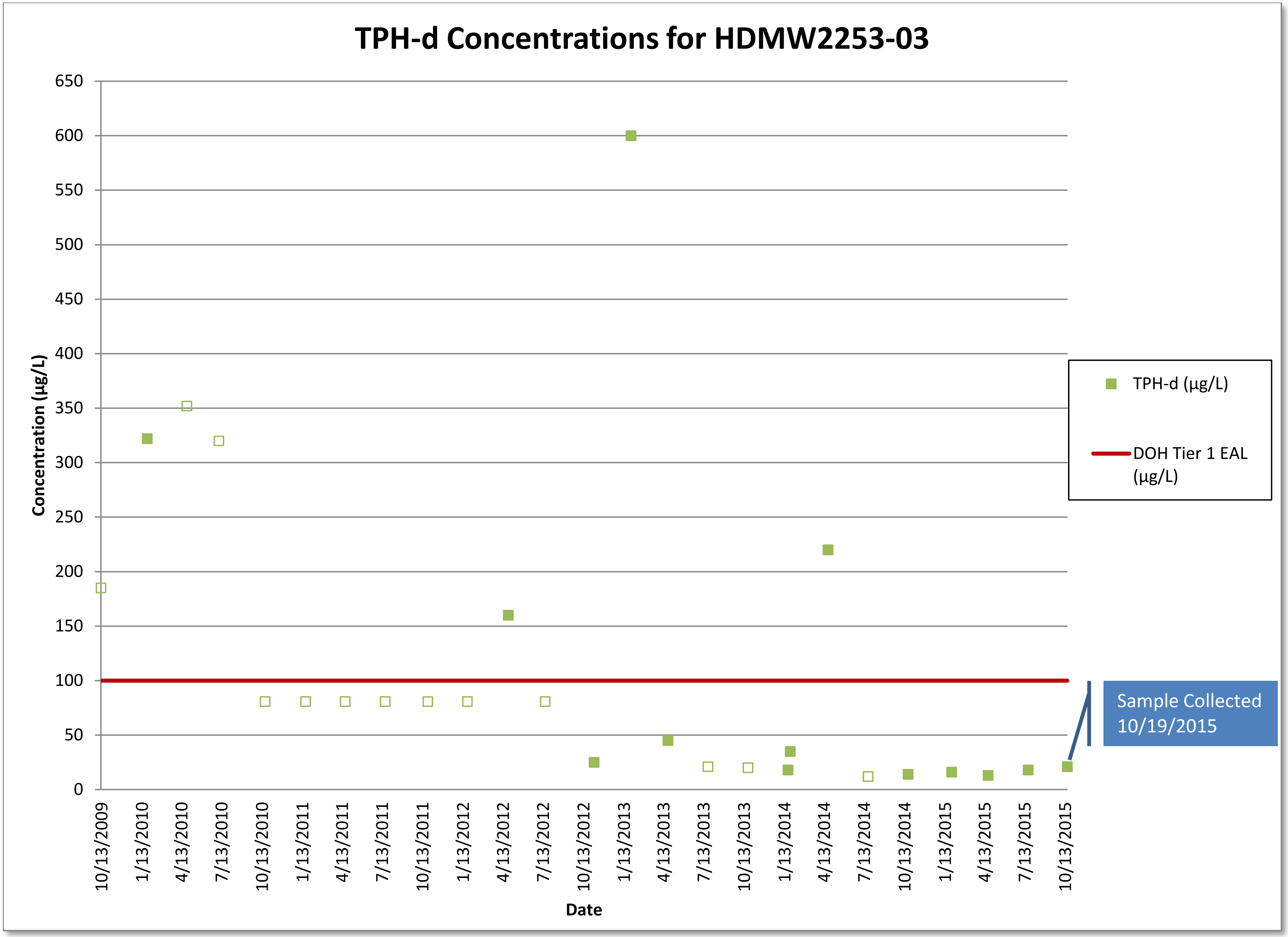
8/20/2011
12/20/2011
4/20/2012
8/20/2012
12/20/2012
4/20/2013
8/20/2013
12/20/2013
4/20/2014
8/20/2014
12/20/2014
4/20/2015
8/20/2015
Date
TPH-d (µg/L)
Sample Collected 10/19/2015


TPH-d Concentrations for OWDFMW01
Concentration (µg/L)
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
8/4/2009
11/4/2009
2/4/2010
5/4/2010
8/4/2010
11/4/2010
2/4/2011
5/4/2011
8/4/2011
11/4/2011
2/4/2012
5/4/2012
8/4/2012
11/4/2012
2/4/2013
5/4/2013
8/4/2013
11/4/2013
2/4/2014
5/4/2014
8/4/2014
11/4/2014
2/4/2015
5/4/2015
8/4/2015
Date
TPH-d (µg/L)
DOH Tier 1 EAL (µg/L)
Sample Collected 10/19/2015


TPH-o Concentrations for OWDFMW01
Concentration (µg/L)
400
350
300
250
200
150
100
50
0
8/4/2009
11/4/2009
2/4/2010
5/4/2010
8/4/2010
11/4/2010
2/4/2011
5/4/2011
8/4/2011
11/4/2011
2/4/2012
5/4/2012
8/4/2012
11/4/2012
2/4/2013
5/4/2013
8/4/2013
11/4/2013
2/4/2014
5/4/2014
8/4/2014
11/4/2014
2/4/2015
5/4/2015
8/4/2015
Date
TPH-o (µg/L)
DOH Tier 1 EAL (µg/L)
Sample Collected 10/19/2015


TPH-d Concentrations for HDMW2253-03
Concentration (µg/L)
650
600
550
500
450
400
350
300
250
200
150
100
50
0
10/13/2009
1/13/2010
4/13/2010
7/13/2010
10/13/2010
1/13/2011
4/13/2011
7/13/2011
10/13/2011
1/13/2012
4/13/2012
7/13/2012
10/13/2012
1/13/2013
4/13/2013
7/13/2013
10/13/2013
1/13/2014
4/13/2014
7/13/2014
10/13/2014
1/13/2015
4/13/2015
7/13/2015
10/13/2015
Date
TPH-d (µg/L)
DOH Tier 1 EAL (µg/L)
Sample Collected 10/19/2015

| Table D.6a Summary Detect Statistics | | | | All Inside Wells, All Data | | | | | All Outside Wells, All Data | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Method | Analyte | Units | Screening Criteria | No. of Detects | Percent Detected | Did Detects Exceed EALs? | Location of Max Concentration | Date Sampled of Max Concentration | No. of Detects | Percent Detected | Did Detects Exceed EALs? | Location of Max Concentration | Date Sampled of Max Concentration |
| 8015 | TPH-d | µg/L | 100 | 194 | 70% | **Yes** | RHMW02 | 20-Jan-16 | 59 | 56% | **Yes** | OWDFMW01 | 22-Jul-15 |
| 8015 | TPH-g | µg/L | 100 | 44 | 33% | **Yes** | RHMW02 | 27-Mar-07 | 1 | 2% | No | HDMW2253-03 | 19-Oct-15 |
| 8015 | TPH-o | µg/L | 100 | 28 | 58% | **Yes** | RHMW01 | 17-Feb-05 | 16 | 44% | **Yes** | OWDFMW01 | 22-Jul-15 |
| 8260B | TPH-g | µg/L | 100 | 40 | 37% | **Yes** | RHMW02 | 28-Jan-13 | 10 | 18% | No | OWDFMW01 | 23-Apr-14 |
| 8260B | 1,1,1-Trichloroethane | µg/L | 200 | 0 | 0% | - | - | - | 0 | 0% | - | - | - |
| 8260B | 1,1,2-Trichloroethane | µg/L | 5 | 0 | 0% | - | - | - | 0 | 0% | - | - | - |
| 8260B | 1,1-Dichloroethane | µg/L | 2.4 | 0 | 0% | - | - | - | 0 | 0% | - | - | - |
| 8260B | 1,1-Dichloroethylene | µg/L | 7 | 1 | 0.4% | No | RHMW03 | 20-Sep-05 | 0 | 0% | - | - | - |
| 8260B | 1,2,3-Trichloropropane | µg/L | 0.6 | 1 | 0.4% | No | RHMW02 | 20-Jul-15 | 0 | 0% | - | - | - |
| 8260B | 1,2,4-Tricholorobenzene | µg/L | 70 | 1 | 0.4% | No | RHMW2254-01 | 10-Sep-07 | 0 | 0% | - | - | - |
| 8260B | 1,2-Dibromo-3- chloropropane | µg/L | 0.04 | 0 | 0% | - | - | - | 0 | 0% | - | - | - |
| 8260B | 1,2-Dibromoethane | µg/L | 0.04 | 0 | 0% | - | - | - | 0 | 0% | - | - | - |
| 8260B | 1,2-Dichlorobenzene | µg/L | 10 | 0 | 0% | - | - | - | 0 | 0% | - | - | - |
| 8260B | 1,2-Dichloroethane | µg/L | 5 | 0 | 0% | - | - | - | 0 | 0% | - | - | - |
| 8260B | 1,2-Dichloropropane | µg/L | 5 | 0 | 0% | - | - | - | 0 | 0% | - | - | - |
| 8260B | 1,3-Dichlorobenzene | µg/L | 5 | 0 | 0% | - | - | - | 0 | 0% | - | - | - |
| 8260B | 1,3-Dichloropropene (total of cis/trans) | µg/L | 0.43 | 0 | 0% | - | - | - | 5 | 5% | **Yes** | OWDFMW01 | 26-Jan-10 |
| 8260B | 1,4-Dichlorobenzene | µg/L | 5 | 0 | 0% | - | - | - | 0 | 0% | - | - | - |
| 8260B | Acetone | µg/L | 1500 | 10 | 5% | No | RHMW05 | 15-Jul-09 | 33 | 32% | No | OWDFMW01 | 22-Jul-15 |
| 8260B | Benzene | µg/L | 5 | 16 | 6% | No | RHMW02 | 4-Feb-09 | 25 | 24% | No | OWDFMW01 | 19-Jul-12 |
| 8260B | Bromodichloromethane | µg/L | 0.12 | 0 | 0% | - | - | - | 1 | 1% | **Yes** | OWDFMW01 | 7-Nov-12 |
| 8260B | Bromoform | µg/L | 80 | 0 | 0% | - | - | - | 0 | 0% | - | - | - |
| 8260B | Bromomethane | µg/L | 8.7 | 1 | 0.4% | No | RHMW2254-01 | 29-Jul-08 | 0 | 0% | - | - | - |
| 8260B | Carbon Tetrachloride | µg/L | 5 | 0 | 0% | - | - | - | 0 | 0% | - | - | - |
| 8260B | Chlorobenzene | µg/L | 50 | 0 | 0% | - | - | - | 0 | 0% | - | - | - |
| 8260B | Chloroethane | µg/L | 16 | 0 | 0% | - | - | - | 0 | 0% | - | - | - |
| 8260B | Chloroform | µg/L | 70 | 1 | 0.4% | No | RHMW01 | 2-Nov-11 | 0 | 0% | - | - | - |
| 8260B | Chloromethane | µg/L | 1.8 | 0 | 0% | - | - | - | 6 | 6% | No | OWDFMW01 | 19-Jan-16 |
| 8260B | cis-1,2-Dichloroethylene | µg/L | 70 | 0 | 0% | - | - | - | 0 | 0% | - | - | - |
| 8260B | Dibromochloromethane | µg/L | 0.16 | 0 | 0% | - | - | - | 0 | 0% | - | - | - |
| 8260B | Ethylbenzene | µg/L | 30 | 50 | 18% | No | RHMW02 | 10-Jul-06 | 0 | 0% | - | - | - |
| 8260B | Hexachlorobutadiene | µg/L | 0.86 | 0 | 0% | - | - | - | 0 | 0% | - | - | - |
| 8260B | Methyl ethyl ketone (2-Butanone) | µg/L | 7,100 | 1 | 0.4% | No | RHMW01 | 14-Oct-09 | 1 | 1% | No | OWDFMW01 | 19-Jul-12 |
| 8260B | Methyl isobutyl ketone (4-Methyl-2-Pentanone) | µg/L | 170 | 0 | 0% | - | - | - | 0 | 0% | - | | |
| 8260B | Methyl tert-butyl Ether | µg/L | 5 | 0 | 0% | - | - | - | 0 | 0% | - | | |
| 8260B | Methylene chloride | µg/L | 4.8 | 3 | 1% | **Yes** | RHMW02 | 10-Jul-06 | 2 | 2% | No | OWDFMW01 | 22-Jul-15 |
| 8260B | Naphthalene | µg/L | 17 | 33 | 35% | **Yes** | RHMW02 | 10-Jul-06 | 0 | 0% | - | - | - |
| 8260B | Styrene | µg/L | 10 | 0 | 0% | - | - | - | 0 | 0% | - | - | - |
| 8260B | Tetrachloroethane, 1,1,1,2- | µg/L | 0.52 | 0 | 0% | - | - | - | 0 | 0% | - | - | - |
| 8260B | Tetrachloroethane, 1,1,2,2- | µg/L | 0.067 | 0 | 0% | - | - | - | 0 | 0% | - | - | - |
| 8260B | Tetrachloroethylene | µg/L | 5 | 0 | 0% | - | - | - | 0 | 0% | - | - | - |
| 8260B | Toluene | µg/L | 40 | 26 | 9% | No | RHMW01 | 15-Jan-14 | 14 | 13% | No | HDMW2253-03 | 22-Oct-14 |
| 8260B | trans-1,2- Dichloroethylene | µg/L | 100 | 0 | 0% | - | - | - | 0 | 0% | - | - | - |
| 8260B | Trichloroethylene | µg/L | 5 | 2 | 1% | **Yes** | RHMW02 | 20-Sep-05 | 0 | 0% | - | - | - |
| 8260B | Vinyl chloride | µg/L | 2 | 0 | 0% | - | - | - | 0 | 0% | - | - | - |
| 8260B | Xylenes, Total (p/m-, o-xylene) | µg/L | 20 | 58 | 21% | No | RHMW02 | 15-Jan-08 | 1 | 1% | No | OWDFMW01 | 21-Apr-11 |
| 504.1 | 1,2-Dibromoethane | µg/L | 0.04 | 0 | 0% | - | - | - | - | - | - | - | - |
| 8260SIM | 1,2-Dibromoethane | µg/L | 0.04 | 0 | 0% | - | - | - | 0 | 0% | - | - | - |
| 8260SIM | 1,2-Dichloroethane | µg/L | 5 | 0 | 0% | - | - | - | 6 | 25% | No | OWDFMW01 | 22-Jul-15 |
| 8260SIM | Bromodichloromethane | µg/L | 0.12 | 0 | 0% | - | - | - | 3 | 13% | **Yes** | RHMW06 | 19-Jan-16 |
| 8260SIM | Dibromochloromethane | µg/L | 0.16 | 0 | 0% | - | - | - | 0 | 0% | - | - | - |
| 8260SIM | Tetrachloroethane, 1,1,2,2- | µg/L | 0.067 | 2 | 11% | No | RHMW02 | 20-Apr-15 | 0 | 0% | - | - | - |
| 8011 | 1,2-Dibromo-3- chloropropane | µg/L | 0.04 | 1 | 8% | No | RHMW01 | 20-Oct-15 | 0 | 0% | - | - | - |
| 8011 | 1,2-Dibromoethane | µg/L | 0.04 | 0 | 0% | - | - | - | 0 | 0% | - | - | - |
| 8270C | Acenaphthene | µg/L | 20 | 90 | 37% | No | RHMW02 | 12-Jun-07 | 2 | 2% | No | OWDFMW01 | 19-Oct-15 |
| 8270C | Acenaphthylene | µg/L | 240 | 14 | 6% | No | RHMW02 | 20-Apr-15 | 1 | 1% | No | RHMW04 | 22-Apr-15 |

| Table D.6a Summary Detect Statistics | | | | All Inside Wells, All Data | | | | | All Outside Wells, All Data | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Method | Analyte | Units | Screening Criteria | No. of Detects | Percent Detected | Did Detects Exceed EALs? | Location of Max Concentration | Date Sampled of Max Concentration | No. of Detects | Percent Detected | Did Detects Exceed EALs? | Location of Max Concentration | Date Sampled of Max Concentration |
| 8270C | Anthracene | µg/L | 22 | 1 | 0.4% | No | RHMW01 | 6-Dec-05 | 1 | 1% | No | RHMW04 | 22-Apr-15 |
| 8270C | Benz[a]anthracene | µg/L | 0.092 | 21 | 9% | No | RHMW02 | 20-Sep-05 | 10 | 10% | No | OWDFMW01 | 22-Jul-15 |
| 8270C | Benzo[g,h,i]perylene | µg/L | 0.13 | 5 | 2% | No | RHMW01 | 28-Jun-05 | 1 | 1% | No | RHMW04 | 19-Oct-15 |
| 8270C | Benzo[a]pyrene | µg/L | 0.2 | 6 | 2% | No | RHMW01 | 28-Jun-05 | 0 | 0% | - | - | - |
| 8270C | Benzo[b]fluoranthene | µg/L | 0.092 | 8 | 3% | No | RHMW02 | 20-Sep-05 | 0 | 0% | - | - | - |
| 8270C | Benzo[k]fluoranthene | µg/L | 0.4 | 4 | 2% | No | RHMW01 | 28-Jun-05 | 0 | 0% | - | - | - |
| 8270C | Chrysene | µg/L | 1 | 13 | 5% | No | RHMW01 | 28-Jun-05 | 0 | 0% | - | - | - |
| 8270C | Dibenzo[a,h]anthracene | µg/L | 0.0092 | 0 | 0% | No | - | - | 1 | 1% | **Yes** | RHMW04 | 19-Oct-15 |
| 8270C | Fluoranthene | µg/L | 130 | 16 | 7% | No | RHMW01 | 28-Jun-05 | 0 | 0% | - | - | - |
| 8270C | Fluorene | µg/L | 240 | 91 | 38% | No | RHMW02 | 10-Sep-07 | 4 | 4% | No | RHMW04 | 22-Apr-15 |
| 8270C | Indeno[1,2,3-cd]pyrene | µg/L | 0.092 | 6 | 2% | No | RHMW01 | 28-Jun-05 | 1 | 1% | No | RHMW04 | 19-Oct-15 |
| 8270C | 1-Methylnaphthalene | µg/L | 4.7 | 113 | 44% | **Yes** | RHMW02 | 10-Jul-06 | 10 | 10% | No | OWDFMW01 | 19-Jan-16 |
| 8270C | 2-Methylnaphthalene | µg/L | 10 | 125 | 45% | **Yes** | RHMW02 | 20-Sep-05 | 15 | 14% | No | OWDFMW01 | 19-Jan-16 |
| 8270C | Naphthalene | µg/L | 17 | 159 | 58% | **Yes** | RHMW02 | 10-Jul-06 | 33 | 31% | No | HDMW2253-03 | 24-Apr-13 |
| 8270C | Phenanthrene | µg/L | 240 | 26 | 11% | No | RHMW01 | 28-Jun-05 | 9 | 9% | No | OWDFMW01 | 22-Jul-15 |
| 8270C | Pyrene | µg/L | 68 | 18 | 7% | No | RHMW01 | 28-Jun-05 | 1 | 1% | No | OWDFMW01 | 22-Jul-15 |
| 6020 | Dissolved Lead (filtered) | µg/L | 15 | 83 | 33% | No | RHMW01 | 17-Feb-05 | 42 | 41% | No | HDMW2253-03 | 26-Oct-11 |
| 6010B/6020/200.8 | Total Lead (unfiltered) | µg/L | - | 19 | 63% | No | RHMW01 | 20-Sep-05 | - | - | - | - | - |

**Analyte detected above screening criterion.**

| Table D.6b Summary Non-Detect Statistics | | | | All Inside Wells, All Data | | | All Outside Wells, All Data | | |
|---|---|---|---|---|---|---|---|---|---|
| Method | Analyte | Units | Screening Criteria | No. of Non-Detects | Percent Non-Detected | Did Non-Detects Exceed EALs? | No. of Non-Detects | Percent Non-Detected | Did Non-Detects Exceed EALs? |
| 8015 | TPH-d | µg/L | 100 | 84 | 30% | **Yes** | 46 | 44% | **Yes** |
| 8015 | TPH-g | µg/L | 100 | 89 | 67% | No | 47 | 98% | No |
| 8015 | TPH-o | µg/L | 100 | 20 | 42% | **Yes** | 20 | 56% | **Yes** |
| 8260B | TPH-g | µg/L | 100 | 69 | 63% | No | 45 | 82% | No |
| 8260B | 1,1,1-Trichloroethane | µg/L | 200 | 231 | 100% | No | 103 | 100% | No |
| 8260B | 1,1,2-Trichloroethane | µg/L | 5 | 231 | 100% | No | 103 | 100% | No |
| 8260B | 1,1-Dichloroethane | µg/L | 2.4 | 231 | 100% | **Yes** | 103 | 100% | No |
| 8260B | 1,1-Dichloroethylene | µg/L | 7 | 228 | 100% | No | 99 | 100% | No |
| 8260B | 1,2,3-Trichloropropane | µg/L | 0.6 | 230 | 100% | **Yes** | 103 | 100% | **Yes** |
| 8260B | 1,2,4-Tricholorobenzene | µg/L | 70 | 230 | 100% | No | 103 | 100% | No |
| 8260B | 1,2-Dibromo-3- chloropropane | µg/L | 0.04 | 231 | 100% | **Yes** | 103 | 100% | **Yes** |
| 8260B | 1,2-Dibromoethane | µg/L | 0.04 | 251 | 100% | **Yes** | 103 | 100% | **Yes** |
| 8260B | 1,2-Dichlorobenzene | µg/L | 10 | 231 | 100% | No | 103 | 100% | No |
| 8260B | 1,2-Dichloroethane | µg/L | 5 | 228 | 100% | **No** | 79 | 100% | No |
| 8260B | 1,2-Dichloropropane | µg/L | 5 | 231 | 100% | No | 103 | 100% | No |
| 8260B | 1,3-Dichlorobenzene | µg/L | 5 | 231 | 100% | No | 103 | 100% | No |
| 8260B | 1,3-Dichloropropene (total of cis/trans) | µg/L | 0.43 | 231 | 100% | **Yes** | 90 | 95% | **Yes** |
| 8260B | 1,4-Dichlorobenzene | µg/L | 5 | 231 | 100% | No | 103 | 100% | No |
| 8260B | Acetone | µg/L | 1500 | 210 | 95% | No | 70 | 68% | No |
| 8260B | Benzene | µg/L | 5 | 261 | 94% | No | 80 | 76% | No |
| 8260B | Bromodichloromethane | µg/L | 0.12 | 207 | 100% | **Yes** | 78 | 99% | **Yes** |
| 8260B | Bromoform | µg/L | 80 | 231 | 100% | No | 103 | 100% | No |
| 8260B | Bromomethane | µg/L | 8.7 | 230 | 100% | No | 103 | 100% | No |
| 8260B | Carbon Tetrachloride | µg/L | 5 | 231 | 100% | No | 103 | 100% | No |
| 8260B | Chlorobenzene | µg/L | 50 | 231 | 100% | No | 103 | 100% | No |
| 8260B | Chloroethane | µg/L | 16 | 231 | 100% | No | 103 | 100% | No |
| 8260B | Chloroform | µg/L | 70 | 230 | 100% | No | 103 | 100% | No |
| 8260B | Chloromethane | µg/L | 1.8 | 231 | 100% | **Yes** | 95 | 94% | **Yes** |
| 8260B | cis-1,2-Dichloroethylene | µg/L | 70 | 231 | 100% | No | 103 | 100% | No |
| 8260B | Dibromochloromethane | µg/L | 0.16 | 207 | 100% | **Yes** | 79 | 100% | **Yes** |
| 8260B | Ethylbenzene | µg/L | 30 | 227 | 82% | No | 105 | 100% | No |
| 8260B | Hexachlorobutadiene | µg/L | 0.86 | 231 | 100% | **Yes** | 103 | 100% | No |
| 8260B | Methyl ethyl ketone (2-Butanone) | µg/L | 7,100 | 230 | 100% | No | 102 | 99% | No |
| 8260B | Methyl isobutyl ketone (4-Methyl-2-Pentanone) | µg/L | 170 | 231 | 100% | No | 103 | 100% | No |
| 8260B | Methyl tert-butyl Ether | µg/L | 5 | 245 | 100% | No | 93 | 100% | No |
| 8260B | Methylene chloride | µg/L | 4.8 | 228 | 99% | **Yes** | 101 | 98% | No |
| 8260B | Naphthalene | µg/L | 17 | 60 | 65% | No | 18 | 100% | No |
| 8260B | Styrene | µg/L | 10 | 231 | 100% | No | 103 | 100% | No |
| 8260B | Tetrachloroethane, 1,1,1,2- | µg/L | 0.52 | 231 | 100% | **Yes** | 103 | 100% | No |
| 8260B | Tetrachloroethane, 1,1,2,2- | µg/L | 0.067 | 213 | 100% | **Yes** | 85 | 100% | **Yes** |
| 8260B | Tetrachloroethylene | µg/L | 5 | 231 | 100% | No | 103 | 100% | No |
| 8260B | Toluene | µg/L | 40 | 251 | 91% | No | 91 | 87% | No |
| 8260B | trans-1,2- Dichloroethylene | µg/L | 100 | 231 | 100% | No | 103 | 100% | No |
| 8260B | Trichloroethylene | µg/L | 5 | 229 | 99% | No | 103 | 100% | No |
| 8260B | Vinyl chloride | µg/L | 2 | 231 | 100% | **Yes** | 103 | 100% | No |
| 8260B | Xylenes, Total (p/m-, o-xylene) | µg/L | 20 | 219 | 79% | No | 104 | 99% | No |
| 504.1 | 1,2-Dibromoethane | µg/L | 0.04 | 19 | 100% | No | - | - | - |
| 8260SIM | 1,2-Dibromoethane | µg/L | 0.04 | 6 | 100% | No | 7 | 100% | No |
| 8260SIM | 1,2-Dichloroethane | µg/L | 5 | 22 | 100% | No | 18 | 75% | No |
| 8260SIM | Bromodichloromethane | µg/L | 0.12 | 18 | 100% | No | 21 | 88% | No |
| 8260SIM | Dibromochloromethane | µg/L | 0.16 | 24 | 100% | No | 24 | 100% | No |
| 8260SIM | Tetrachloroethane, 1,1,2,2- | µg/L | 0.067 | 16 | 89% | **Yes** | 18 | 100% | No |
| 8011 | 1,2-Dibromo-3- chloropropane | µg/L | 0.04 | 12 | 92% | No | 24 | 100% | No |
| 8011 | 1,2-Dibromoethane | µg/L | 0.04 | 24 | 100% | No | 30 | 100% | No |
| 8270C | Acenaphthene | µg/L | 20 | 152 | 63% | No | 101 | 98% | No |
| 8270C | Acenaphthylene | µg/L | 240 | 228 | 94% | No | 102 | 99% | No |
| 8270C | Anthracene | µg/L | 22 | 241 | 100% | No | 102 | 99% | No |

| Table D.6b Summary Non-Detect Statistics | | | | All Inside Wells, All Data | | | All Outside Wells, All Data | | |
|---|---|---|---|---|---|---|---|---|---|
| Method | Analyte | Units | Screening Criteria | No. of Non-Detects | Percent Non-Detected | Did Non-Detects Exceed EALs? | No. of Non-Detects | Percent Non-Detected | Did Non-Detects Exceed EALs? |
| 8270C | Benz[a]anthracene | µg/L | 0.092 | 221 | 91% | **Yes** | 93 | 90% | **Yes** |
| 8270C | Benzo[g,h,i]perylene | µg/L | 0.13 | 237 | 98% | **Yes** | 102 | 99% | **Yes** |
| 8270C | Benzo[a]pyrene | µg/L | 0.2 | 236 | 98% | No | 103 | 100% | No |
| 8270C | Benzo[b]fluoranthene | µg/L | 0.092 | 234 | 97% | **Yes** | 103 | 100% | **Yes** |
| 8270C | Benzo[k]fluoranthene | µg/L | 0.4 | 238 | 98% | No | 103 | 100% | No |
| 8270C | Chrysene | µg/L | 1 | 229 | 95% | No | 103 | 100% | No |
| 8270C | Dibenzo[a,h]anthracene | µg/L | 0.0092 | 242 | 100% | **Yes** | 102 | 99% | **Yes** |
| 8270C | Fluoranthene | µg/L | 130 | 226 | 93% | No | 103 | 100% | No |
| 8270C | Fluorene | µg/L | 240 | 151 | 62% | No | 99 | 96% | No |
| 8270C | Indeno[1,2,3-cd]pyrene | µg/L | 0.092 | 236 | 98% | **Yes** | 102 | 99% | **Yes** |
| 8270C | 1-Methylnaphthalene | µg/L | 4.7 | 143 | 56% | No | 95 | 90% | No |
| 8270C | 2-Methylnaphthalene | µg/L | 10 | 151 | 55% | No | 90 | 86% | No |
| 8270C | Naphthalene | µg/L | 17 | 117 | 42% | No | 72 | 69% | No |
| 8270C | Phenanthrene | µg/L | 240 | 216 | 89% | No | 94 | 91% | No |
| 8270C | Pyrene | µg/L | 68 | 224 | 93% | No | 102 | 99% | No |
| 6020 | Dissolved Lead (filtered) | µg/L | 15 | 166 | 67% | No | 60 | 59% | No |
| 6010B/6020/200.8 | Total Lead (unfiltered) | µg/L | - | 11 | 37% | No | - | - | - |

**Non-detect results above screening criterion.**

Table D.6c All Inside Wells Summary Detect Statistics

| Method | Analyte | Units | Screening Criteria | No. of Samples | No. of Detects | Percent Detected | No. of Non-detects | Detects |  |  |  | Location of Max Concentration | Date Sampled of Max Concentration | Did Detects Exceed EALs? | No. of Detect Exceedances | Percent Detect Exceedance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |  | Min |  | Max |  |  |  |  |  |  |
| 8015 | TPH-d | µg/L | 100 | 278 | 194 | 70% | 84 | 14 | B,J | 6500 | B,Y | RHMW02 | 20-Jan-2016 | **Yes** | 145 | 75% |
| 8015 | TPH-g | µg/L | 100 | 133 | 44 | 33% | 89 | 13.2 | J | 148 | O | RHMW02 | 27-Mar-2007 | **Yes** | 6 | 14% |
| 8015 | TPH-o | µg/L | 100 | 48 | 28 | 58% | 20 | 21 | J | 890 |  | RHMW01 | 17-Feb-2005 | **Yes** | 16 | 57% |
| 8260B | TPH-g | µg/L | 100 | 109 | 40 | 37% | 69 | 13 | J | 660 |  | RHMW02 | 28-Jan-2013 | **Yes** | 6 | 15% |
| 8260B | 1,1,1-Trichloroethane | µg/L | 200 | 231 | 0 | 0% | 231 | - |  | - |  | - | - | - | - | - |
| 8260B | 1,1,2-Trichloroethane | µg/L | 5 | 231 | 0 | 0% | 231 | - |  | - |  | - | - | - | - | - |
| 8260B | 1,1-Dichloroethane | µg/L | 2.4 | 231 | 0 | 0% | 231 | - |  | - |  | - | - | - | - | - |
| 8260B | 1,1-Dichloroethylene | µg/L | 7 | 229 | 1 | 0.4% | 228 | 0.5 |  | 0.5 | U | RHMW03 | 20-Sep-2005 | No | 0 | 0% |
| 8260B | 1,2,3-Trichloropropane | µg/L | 0.6 | 231 | 1 | 0.4% | 230 | 0.27 | J | 0.27 | J | RHMW02 | 20-Jul-2015 | No | 0 | 0% |
| 8260B | 1,2,4-Tricholorobenzene | µg/L | 70 | 231 | 1 | 0.4% | 230 | 0.24 |  | 0.24 | J | RHMW2254-01 | 10-Sep-2007 | No | 0 | 0% |
| 8260B | 1,2-Dibromo-3- chloropropane | µg/L | 0.04 | 231 | 0 | 0% | 231 | - |  | - |  | - | - | - | - | - |
| 8260B | 1,2-Dibromoethane | µg/L | 0.04 | 251 | 0 | 0% | 251 | - |  | - |  | - | - | - | - | - |
| 8260B | 1,2-Dichlorobenzene | µg/L | 10 | 231 | 0 | 0% | 231 | - |  | - |  | - | - | - | - | - |
| 8260B | 1,2-Dichloroethane | µg/L | 5 | 228 | 0 | 0% | 228 | - |  | - |  | - | - | - | - | - |
| 8260B | 1,2-Dichloropropane | µg/L | 5 | 231 | 0 | 0% | 231 | - |  | - |  | - | - | - | - | - |
| 8260B | 1,3-Dichlorobenzene | µg/L | 5 | 231 | 0 | 0% | 231 | - |  | - |  | - | - | - | - | - |
| 8260B | 1,3-Dichloropropene (total of cis/trans) | µg/L | 0.43 | 231 | 0 | 0% | 231 | - |  | - |  | - | - | - | - | - |
| 8260B | 1,4-Dichlorobenzene | µg/L | 5 | 231 | 0 | 0% | 231 | - |  | - |  | - | - | - | - | - |
| 8260B | Acetone | µg/L | 1500 | 220 | 10 | 5% | 210 | 2.4 | J | 65 |  | RHMW05 | 15-Jul-2009 | No | 0 | 0% |
| 8260B | Benzene | µg/L | 5 | 277 | 16 | 6% | 261 | 0.08 | J | 0.26 | J | RHMW02 | 4-Feb-2009 | No | 0 | 0% |
| 8260B | Bromodichloromethane | µg/L | 0.12 | 207 | 0 | 0% | 207 | - |  | - |  | - | - | - | - | - |
| 8260B | Bromoform | µg/L | 80 | 231 | 0 | 0% | 231 | - |  | - |  | - | - | - | - | - |
| 8260B | Bromomethane | µg/L | 8.7 | 231 | 1 | 0.4% | 230 | 1.26 | J | 1.26 | J | RHMW2254-01 | 29-Jul-2008 | No | 0 | 0% |
| 8260B | Carbon Tetrachloride | µg/L | 5 | 231 | 0 | 0% | 231 | - |  | - |  | - | - | - | - | - |
| 8260B | Chlorobenzene | µg/L | 50 | 231 | 0 | 0% | 231 | - |  | - |  | - | - | - | - | - |
| 8260B | Chloroethane | µg/L | 16 | 231 | 0 | 0% | 231 | - |  | - |  | - | - | - | - | - |
| 8260B | Chloroform | µg/L | 70 | 231 | 1 | 0.4% | 230 | 0.13 | J | 0.13 | J | RHMW01 | 2-Nov-2011 | No | 0 | 0% |
| 8260B | Chloromethane | µg/L | 1.8 | 231 | 0 | 0% | 231 | - |  | - |  | - | - | - | - | - |
| 8260B | cis-1,2-Dichloroethylene | µg/L | 70 | 231 | 0 | 0% | 231 | - |  | - |  | - | - | - | - | - |
| 8260B | Dibromochloromethane | µg/L | 0.16 | 207 | 0 | 0% | 207 | - |  | - |  | - | - | - | - | - |
| 8260B | Ethylbenzene | µg/L | 30 | 277 | 50 | 18% | 227 | 0.014 | J | 1.3 |  | RHMW02 | 10-Jul-2006 | No | 0 | 0% |
| 8260B | Hexachlorobutadiene | µg/L | 0.86 | 231 | 0 | 0% | 231 | - |  | - |  | - | - | - | - | - |
| 8260B | Methyl ethyl ketone (2-Butanone) | µg/L | 7,100 | 231 | 1 | 0.4% | 230 | 4.27 | F | 4.27 | F | RHMW01 | 14-Oct-2009 | No | 0 | 0% |
| 8260B | Methyl isobutyl ketone (4-Methyl-2-Pentanone) | µg/L | 170 | 231 | 0 | 0% | 231 | - |  | - |  | - | - | - | - | - |
| 8260B | Methyl tert-butyl Ether | µg/L | 5 | 245 | 0 | 0% | 245 | - |  | - |  | - | - | - | - | - |
| 8260B | Methylene chloride | µg/L | 4.8 | 231 | 3 | 1% | 228 | 0.1 | J | 24.9 | J,B | RHMW02 | 10-Jul-2006 | **Yes** | 1 | 33% |
| 8260B | Naphthalene | µg/L | 17 | 93 | 33 | 35% | 60 | 5.98 |  | 343 |  | RHMW02 | 10-Jul-2006 | **Yes** | 29 | 88% |
| 8260B | Styrene | µg/L | 10 | 231 | 0 | 0% | 231 | - |  | - |  | - | - | - | - | - |
| 8260B | Tetrachloroethane, 1,1,1,2- | µg/L | 0.52 | 231 | 0 | 0% | 231 | - |  | - |  | - | - | - | - | - |
| 8260B | Tetrachloroethane, 1,1,2,2- | µg/L | 0.067 | 213 | 0 | 0% | 213 | - |  | - |  | - | - | - | - | - |
| 8260B | Tetrachloroethylene | µg/L | 5 | 231 | 0 | 0% | 231 | - |  | - |  | - | - | - | - | - |
| 8260B | Toluene | µg/L | 40 | 277 | 26 | 9% | 251 | 0.06 | J | 2.5 |  | RHMW01 | 15-Jan-2014 | No | 0 | 0% |
| 8260B | trans-1,2- Dichloroethylene | µg/L | 100 | 231 | 0 | 0% | 231 | - |  | - |  | - | - | - | - | - |
| 8260B | Trichloroethylene | µg/L | 5 | 231 | 2 | 1% | 229 | 0.17 |  | 8.2 |  | RHMW02 | 20-Sep-2005 | **Yes** | 1 | 50% |
| 8260B | Vinyl chloride | µg/L | 2 | 231 | 0 | 0% | 231 | - |  | - |  | - | - | - | - | - |
| 8260B | Xylenes, Total (p/m-, o-xylene) | µg/L | 20 | 277 | 58 | 21% | 219 | 0.21 | J | 1.1 |  | RHMW02 | 15-Jan-2008 | No | 2 | 3% |
| 504.1 | 1,2-Dibromoethane | µg/L | 0.04 | 19 | 0 | 0% | 19 | - |  | - |  | - | - | - | - | - |
| 8260SIM | 1,2-Dibromoethane | µg/L | 0.04 | 6 | 0 | 0% | 6 | - |  | - |  | - | - | - | - | - |
| 8260SIM | 1,2-Dichloroethane | µg/L | 5 | 22 | 0 | 0% | 22 | - |  | - |  | - | - | - | - | - |
| 8260SIM | Bromodichloromethane | µg/L | 0.12 | 18 | 0 | 0% | 18 | - |  | - |  | - | - | - | - | - |
| 8260SIM | Dibromochloromethane | µg/L | 0.16 | 24 | 0 | 0% | 24 | - |  | - |  | - | - | - | - | - |
| 8260SIM | Tetrachloroethane, 1,1,2,2- | µg/L | 0.067 | 18 | 2 | 11% | 16 | 0.059 |  | 0.065 |  | RHMW02 | 20-Apr-2015 | No | 0 | 0% |
| 8011 | 1,2-Dibromo-3- chloropropane | µg/L | 0.04 | 13 | 1 | 8% | 12 | 0.004 | J | 0.004 | J | RHMW01 | 20-Oct-2015 | No | 0 | 0% |
| 8011 | 1,2-Dibromoethane | µg/L | 0.04 | 24 | 0 | 0% | 24 | - |  | - |  | - | - | - | - | - |
| 8270C | Acenaphthene | µg/L | 20 | 242 | 90 | 37% | 152 | 0.0053 | J | 0.86 | J | RHMW02 | 12-Jun-2007 | No | 0 | 0% |
| 8270C | Acenaphthylene | µg/L | 240 | 242 | 14 | 6% | 228 | 0.0023 | J | 0.26 | X | RHMW02 | 20-Apr-2015 | No | 0 | 0% |
| 8270C | Anthracene | µg/L | 22 | 242 | 1 | 0.4% | 241 | 0.012 | J | 0.012 | J | RHMW01 | 6-Dec-2005 | No | 0 | 0% |
| 8270C | Benz[a]anthracene | µg/L | 0.092 | 242 | 21 | 9% | 221 | 0.0022 | J | 0.071 | J | RHMW02 | 20-Sep-2005 | No | 0 | 0% |

Table D.6c All Inside Wells Summary Detect Statistics

| Method | Analyte | Units | Screening Criteria | No. of Samples | No. of Detects | Percent Detected | No. of Non-detects | Detects | | | | Location of Max Concentration | Date Sampled of Max Concentration | Did Detects Exceed EALs? | No. of Detect Exceedances | Percent Detect Exceedance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Min | | Max | | | | | | |
| 8270C | Benzo[g,h,i]perylene | µg/L | 0.13 | 242 | 5 | 2% | 237 | 0.0034 | J | 0.034 | | RHMW01 | 28-Jun-2005 | No | 0 | 0% |
| 8270C | Benzo[a]pyrene | µg/L | 0.2 | 242 | 6 | 2% | 236 | 0.0061 | J | 0.045 | | RHMW01 | 28-Jun-2005 | No | 0 | 0% |
| 8270C | Benzo[b]fluoranthene | µg/L | 0.092 | 242 | 8 | 3% | 234 | 0.0042 | J | 0.069 | J | RHMW02 | 20-Sep-2005 | No | 0 | 0% |
| 8270C | Benzo[k]fluoranthene | µg/L | 0.4 | 242 | 4 | 2% | 238 | 0.0068 | J | 0.051 | | RHMW01 | 28-Jun-2005 | No | 0 | 0% |
| 8270C | Chrysene | µg/L | 1 | 242 | 13 | 5% | 229 | 0.0038 | J | 0.062 | | RHMW01 | 28-Jun-2005 | No | 0 | 0% |
| 8270C | Dibenzo[a,h]anthracene | µg/L | 0.0092 | 242 | 0 | 0% | 242 | - | | - | | - | - | - | - | - |
| 8270C | Fluoranthene | µg/L | 130 | 242 | 16 | 7% | 226 | 0.0084 | J | 0.093 | | RHMW01 | 28-Jun-2005 | No | 0 | 0% |
| 8270C | Fluorene | µg/L | 240 | 242 | 91 | 38% | 151 | 0.0096 | J | 0.39 | J | RHMW02 | 10-Sep-2007 | No | 0 | 0% |
| 8270C | Indeno[1,2,3-cd]pyrene | µg/L | 0.092 | 242 | 6 | 2% | 236 | 0.0026 | J | 0.037 | | RHMW01 | 28-Jun-2005 | No | 0 | 0% |
| 8270C | 1-Methylnaphthalene | µg/L | 4.7 | 256 | 113 | 44% | 143 | 0.0039 | J | 142 | | RHMW02 | 10-Jul-2006 | **Yes** | 78 | 69% |
| 8270C | 2-Methylnaphthalene | µg/L | 10 | 276 | 125 | 45% | 151 | 0.0029 | J | 88.5 | | RHMW02 | 20-Sep-2005 | **Yes** | 39 | 31% |
| 8270C | Naphthalene | µg/L | 17 | 276 | 159 | 58% | 117 | 0.0046 | J | 180 | | RHMW02 | 10-Jul-2006 | **Yes** | 64 | 40% |
| 8270C | Phenanthrene | µg/L | 240 | 242 | 26 | 11% | 216 | 0.0052 | J | 0.14 | | RHMW01 | 28-Jun-2005 | No | 0 | 0% |
| 8270C | Pyrene | µg/L | 68 | 242 | 18 | 7% | 224 | 0.0058 | J,X | 0.11 | | RHMW01 | 28-Jun-2005 | No | 0 | 0% |
| 6020 | Dissolved Lead (filtered) | µg/L | 15 | 249 | 83 | 33% | 166 | 0.011 | J | 11.9 | | RHMW01 | 17-Feb-2005 | No | 0 | 0% |
| 6010B/6020/200.8 | Total Lead (unfiltered) | µg/L | - | 30 | 19 | 63% | 11 | 0.036 | | 19.6 | | RHMW01 | 20-Sep-2005 | No | 0 | 0% |

Notes:

Inside tunnel wells include sampling locations RHMW01, RHMW02, RHMW03, RHMW05, and RHMW2254-01.

Screening criteria based on the regulatory agencies' February 4, 2016 scoping completion letter and the DOH Tier 1 Environmental Action Levels, Table D-1b. Groundwater Action Levels (Groundwater IS a current or potential drinking water resource, surface water body IS NOT located within 150 meters of release site).

**Blue text** indicates analyte reported at concentrations above screening criterion.

Qualifiers:

B = analyte was present in the associated method blank
F = indicates that the compound was identified ut the concentration was aove the MDL and below the RL
J = indicates an estimated value
O, Y = the chromatographic pattern was inconsistent with the profile of the reference fuel standard
X = possile high bias due to matrix interference

Table D.6d All Inside Wells Summary Non-Detect Statistics

| Method | Analyte | Units | Screening Criteria | No. of Samples | No. of Non-Detects | Percent Non-Detected | Non-Detects | | | | Did Non-Detects Exceed EALs? | No. of Non-Detect Exceedances | Percent Non-Detect Exceedance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Min | | Max | | | | |
| 8015 | TPH-d | µg/L | 100 | 278 | 84 | 30% | 10 | U | 330 | U | **Yes** | 16 | 19% |
| 8015 | TPH-g | µg/L | 100 | 133 | 89 | 67% | 0.5 | U | 60 | U | No | 0 | 0% |
| 8015 | TPH-o | µg/L | 100 | 48 | 20 | 42% | 28 | U | 212 | U | **Yes** | 12 | 60% |
| 8260B | TPH-g | µg/L | 100 | 109 | 69 | 63% | 12.12 | U | 30 | U | No | 0 | 0% |
| 8260B | 1,1,1-Trichloroethane | µg/L | 200 | 231 | 231 | 100% | 0.2 | U | 2.5 | U | No | 0 | 0% |
| 8260B | 1,1,2-Trichloroethane | µg/L | 5 | 231 | 231 | 100% | 0.3 | U | 2.5 | U | No | 0 | 0% |
| 8260B | 1,1-Dichloroethane | µg/L | 2.4 | 231 | 231 | 100% | 0.2 | U | 2.5 | U | **Yes** | 3 | 1% |
| 8260B | 1,1-Dichloroethylene | µg/L | 7 | 229 | 228 | 100% | 0.2 | U | 2.5 | U | No | 0 | 0% |
| 8260B | 1,2,3-Trichloropropane | µg/L | 0.6 | 231 | 230 | 100% | 0.31 | U | 5 | U | **Yes** | 155 | 67% |
| 8260B | 1,2,4-Tricholorobenzene | µg/L | 70 | 231 | 230 | 100% | 0.22 | U | 2.5 | U | No | 0 | 0% |
| 8260B | 1,2-Dibromo-3- chloropropane | µg/L | 0.04 | 231 | 231 | 100% | 0.41 | U | 5 | U | **Yes** | 231 | 100% |
| 8260B | 1,2-Dibromoethane | µg/L | 0.04 | 251 | 251 | 100% | 0.00095 | U | 2.5 | U | **Yes** | 230 | 92% |
| 8260B | 1,2-Dichlorobenzene | µg/L | 10 | 231 | 231 | 100% | 0.2 | U | 2.5 | U | No | 0 | 0% |
| 8260B | 1,2-Dichloroethane | µg/L | 5 | 228 | 228 | 100% | 0.02 | U | 2.5 | U | No | 172 | 75% |
| 8260B | 1,2-Dichloropropane | µg/L | 5 | 231 | 231 | 100% | 0.2 | U | 2.5 | U | No | 0 | 0% |
| 8260B | 1,3-Dichlorobenzene | µg/L | 5 | 231 | 231 | 100% | 0.2 | U | 2.5 | U | No | 0 | 0% |
| 8260B | 1,3-Dichloropropene (total of cis/trans) | µg/L | 0.43 | 231 | 231 | 100% | 0.15 | U | 1.5 | U | **Yes** | 96 | 42% |
| 8260B | 1,4-Dichlorobenzene | µg/L | 5 | 231 | 231 | 100% | 0.15 | U | 2.5 | U | No | 0 | 0% |
| 8260B | Acetone | µg/L | 1500 | 220 | 210 | 95% | 1.9 | U | 25 | U | No | 0 | 0% |
| 8260B | Benzene | µg/L | 5 | 277 | 261 | 94% | 0.1 | U | 2.5 | U | No | 0 | 0% |
| 8260B | Bromodichloromethane | µg/L | 0.12 | 207 | 207 | 100% | 0.15 | U | 2.5 | U | **Yes** | 207 | 100% |
| 8260B | Bromoform | µg/L | 80 | 231 | 231 | 100% | 0.28 | U | 2.5 | U | No | 0 | 0% |
| 8260B | Bromomethane | µg/L | 8.7 | 231 | 230 | 100% | 0.3 | U | 5 | U | No | 0 | 0% |
| 8260B | Carbon Tetrachloride | µg/L | 5 | 231 | 231 | 100% | 0.2 | U | 2.5 | U | No | 0 | 0% |
| 8260B | Chlorobenzene | µg/L | 50 | 231 | 231 | 100% | 0.15 | U | 2.5 | U | No | 0 | 0% |
| 8260B | Chloroethane | µg/L | 16 | 231 | 231 | 100% | 0.2 | U | 5 | U | No | 0 | 0% |
| 8260B | Chloroform | µg/L | 70 | 231 | 230 | 100% | 0.14 | U | 2.5 | U | No | 0 | 0% |
| 8260B | Chloromethane | µg/L | 1.8 | 231 | 231 | 100% | 0.2 | U | 5 | U | **Yes** | 70 | 30% |
| 8260B | cis-1,2-Dichloroethylene | µg/L | 70 | 231 | 231 | 100% | 0.2 | U | 2.5 | U | No | 0 | 0% |
| 8260B | Dibromochloromethane | µg/L | 0.16 | 207 | 207 | 100% | 0.15 | U | 2 | U | **Yes** | 162 | 78% |
| 8260B | Ethylbenzene | µg/L | 30 | 277 | 227 | 82% | 0.1 | U | 2.5 | U | No | 0 | 0% |
| 8260B | Hexachlorobutadiene | µg/L | 0.86 | 231 | 231 | 100% | 0.18 | U | 2.5 | U | **Yes** | 3 | 1% |
| 8260B | Methyl ethyl ketone (2-Butanone) | µg/L | 7,100 | 231 | 230 | 100% | 0.5 | U | 13 | U | No | 0 | 0% |
| 8260B | Methyl isobutyl ketone (4-Methyl-2-Pentanone) | µg/L | 170 | 231 | 231 | 100% | 0.5 | U | 13 | U | No | 0 | 0% |
| 8260B | Methyl tert-butyl Ether | µg/L | 5 | 245 | 245 | 100% | 0.2 | U | 5 | U | No | 0 | 0% |
| 8260B | Methylene chloride | µg/L | 4.8 | 231 | 228 | 99% | 0.2 | U | 5 | U | **Yes** | 2 | 1% |
| 8260B | Naphthalene | µg/L | 17 | 93 | 60 | 65% | 0.44 | U | 1.24 | U | No | 0 | 0% |
| 8260B | Styrene | µg/L | 10 | 231 | 231 | 100% | 0.2 | U | 2.5 | U | No | 0 | 0% |
| 8260B | Tetrachloroethane, 1,1,1,2- | µg/L | 0.52 | 231 | 231 | 100% | 0.15 | U | 2.5 | U | **Yes** | 3 | 1% |
| 8260B | Tetrachloroethane, 1,1,2,2- | µg/L | 0.067 | 213 | 213 | 100% | 0.15 | U | 15 | U | **Yes** | 213 | 100% |
| 8260B | Tetrachloroethylene | µg/L | 5 | 231 | 231 | 100% | 0.2 | U | 2.5 | U | No | 0 | 0% |
| 8260B | Toluene | µg/L | 40 | 277 | 251 | 91% | 0.1 | U | 11 | U | No | 0 | 0% |
| 8260B | trans-1,2- Dichloroethylene | µg/L | 100 | 231 | 231 | 100% | 0.2 | U | 2.5 | U | No | 0 | 0% |
| 8260B | Trichloroethylene | µg/L | 5 | 231 | 229 | 99% | 0.1 | U | 2.5 | U | No | 0 | 0% |
| 8260B | Vinyl chloride | µg/L | 2 | 231 | 231 | 100% | 0.1 | U | 2.5 | U | **Yes** | 3 | 1% |
| 8260B | Xylenes, Total (p/m-, o-xylene) | µg/L | 20 | 277 | 219 | 79% | 0.2 | U | 2.5 | U | No | 0 | 0% |
| 504.1 | 1,2-Dibromoethane | µg/L | 0.04 | 19 | 19 | 100% | 0.0081 | U | 0.0097 | U | No | 0 | 0% |
| 8260SIM | 1,2-Dibromoethane | µg/L | 0.04 | 6 | 6 | 100% | 0.01 | U | 0.01 | U | No | 0 | 0% |
| 8260SIM | 1,2-Dichloroethane | µg/L | 5 | 22 | 22 | 100% | 0.015 | U | 0.015 | U | No | 0 | 0% |
| 8260SIM | Bromodichloromethane | µg/L | 0.12 | 18 | 18 | 100% | 0.01 | U | 0.01 | U | No | 0 | 0% |
| 8260SIM | Dibromochloromethane | µg/L | 0.16 | 24 | 24 | 100% | 0.01 | U | 0.01 | U | No | 0 | 0% |
| 8260SIM | Tetrachloroethane, 1,1,2,2- | µg/L | 0.067 | 18 | 16 | 89% | 0.015 | U | 0.13 | U | **Yes** | 2 | 13% |
| 8011 | 1,2-Dibromo-3- chloropropane | µg/L | 0.04 | 13 | 12 | 92% | 0.004 | U | 0.004 | U | No | 5 | 42% |
| 8011 | 1,2-Dibromoethane | µg/L | 0.04 | 24 | 24 | 100% | 0.004 | U | 0.004 | U | No | 0 | 0% |
| 8270C | Acenaphthene | µg/L | 20 | 242 | 152 | 63% | 0.002 | U | 0.52 | U | No | 0 | 0% |
| 8270C | Acenaphthylene | µg/L | 240 | 242 | 228 | 94% | 0.0018 | U | 0.54 | U | No | 0 | 0% |
| 8270C | Anthracene | µg/L | 22 | 242 | 241 | 100% | 0.0011 | U | 0.54 | U | No | 0 | 0% |
| 8270C | Benz[a]anthracene | µg/L | 0.092 | 242 | 221 | 91% | 0.0021 | U | 0.52 | U | **Yes** | 52 | 24% |

Table D.6d All Inside Wells Summary Non-Detect Statistics

| Method | Analyte | Units | Screening Criteria | No. of Samples | No. of Non-Detects | Percent Non-Detected | Non-Detects | | | | Did Non-Detects Exceed EALs? | No. of Non-Detect Exceedances | Percent Non-Detect Exceedance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Min | | Max | | | | |
| 8270C | Benzo[g,h,i]perylene | µg/L | 0.13 | 242 | 237 | 98% | 0.0037 | U | 0.161 | U | **Yes** | 50 | 21% |
| 8270C | Benzo[a]pyrene | µg/L | 0.2 | 242 | 236 | 98% | 0.0016 | U | 0.161 | U | No | 0 | 0% |
| 8270C | Benzo[b]fluoranthene | µg/L | 0.092 | 242 | 234 | 97% | 0.002 | U | 0.161 | U | **Yes** | 50 | 21% |
| 8270C | Benzo[k]fluoranthene | µg/L | 0.4 | 242 | 238 | 98% | 0.0014 | U | 0.161 | U | No | 0 | 0% |
| 8270C | Chrysene | µg/L | 1 | 242 | 229 | 95% | 0.0013 | U | 0.161 | U | No | 0 | 0% |
| 8270C | Dibenzo[a,h]anthracene | µg/L | 0.0092 | 242 | 242 | 100% | 0.0017 | U | 0.161 | U | **Yes** | 213 | 88% |
| 8270C | Fluoranthene | µg/L | 130 | 242 | 226 | 93% | 0.0024 | U | 0.27 | U | No | 0 | 0% |
| 8270C | Fluorene | µg/L | 240 | 242 | 151 | 62% | 0.0026 | U | 0.26 | U | No | 0 | 0% |
| 8270C | Indeno[1,2,3-cd]pyrene | µg/L | 0.092 | 242 | 236 | 98% | 0.0021 | U | 0.161 | U | **Yes** | 50 | 21% |
| 8270C | 1-Methylnaphthalene | µg/L | 4.7 | 256 | 143 | 56% | 0.005 | U | 0.26 | U | No | 0 | 0% |
| 8270C | 2-Methylnaphthalene | µg/L | 10 | 276 | 151 | 55% | 0.005 | U | 0.26 | U | No | 0 | 0% |
| 8270C | Naphthalene | µg/L | 17 | 276 | 117 | 42% | 0.005 | U | 0.26 | U | No | 0 | 0% |
| 8270C | Phenanthrene | µg/L | 240 | 242 | 216 | 89% | 0.0032 | U | 0.54 | U | No | 0 | 0% |
| 8270C | Pyrene | µg/L | 68 | 242 | 224 | 93% | 0.0023 | U | 0.27 | U | No | 0 | 0% |
| 6020 | Dissolved Lead (filtered) | µg/L | 15 | 249 | 166 | 67% | 0.2 | U | 5 | U | No | 0 | 0% |
| 6010B/6020/200.8 | Total Lead (unfiltered) | µg/L | - | 30 | 11 | 37% | 0.0898 | U | 10 | U | No | 0 | 0% |

Notes:

Inside tunnel wells include sampling locations RHMW01, RHMW02, RHMW03, RHMW05, and RHMW2254-01.

Screening criteria based on the regulatory agencies' February 4, 2016 scoping completion letter and the DOH Tier 1 Environmental Action Levels, Table D-1b. Groundwater Action Levels (Groundwater IS a current or potential drinking water resource, surface water body IS NOT located within 150 meters of release site).

**Blue text** indicates non-detect above screening criterion.

Qualifiers:

U = non-detect

Table D.6e All Outside Wells Summary Detect Statistics

| Method | Analyte | Units | Screening Criteria | No. of Samples | No. of Detects | Percent Detected | No. of Non-detects | Detects | | | | Location of Max Concentration | Date Sampled of Max Concentration | Did Detects Exceed EALs? | No. of Detect Exceedances | Percent Detect Exceedance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Min | | Max | | | | | | |
| 8015C | TPH-d | µg/L | 100 | 105 | 59 | 56% | 46 | 10 | HD,J | 3100 | Z | OWDFMW01 | 22-Jul-2015 | **Yes** | 27 | 46% |
| 8015C | TPH-g | µg/L | 100 | 48 | 1 | 2% | 47 | 16 | J | 16 | J | HDMW2253-03 | 19-Oct-2015 | No | 0 | 0% |
| 8015C | TPH-o | µg/L | 100 | 36 | 16 | 44% | 20 | 25 | B,J | 390 | Z | OWDFMW01 | 22-Jul-2015 | **Yes** | 4 | 25% |
| 8260B | TPH-g | µg/L | 100 | 55 | 10 | 18% | 45 | 14 | B,J | 31 | B,J | OWDFMW01 | 23-Apr-2014 | No | 0 | 0% |
| 8260B | 1,1,1-Trichloroethane | µg/L | 200 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8260B | 1,1,2-Trichloroethane | µg/L | 5 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8260B | 1,1-Dichloroethane | µg/L | 2.4 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8260B | 1,1-Dichloroethylene | µg/L | 7 | 99 | 0 | 0% | 99 | - | | - | | - | - | - | - | - |
| 8260B | 1,2,3-Trichloropropane | µg/L | 0.6 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8260B | 1,2,4-Tricholorobenzene | µg/L | 70 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8260B | 1,2-Dibromo-3- chloropropane | µg/L | 0.04 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8260B | 1,2-Dibromoethane | µg/L | 0.04 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8260B | 1,2-Dichlorobenzene | µg/L | 10 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8260B | 1,2-Dichloroethane | µg/L | 5 | 79 | 0 | 0% | 79 | - | | - | | - | - | - | - | - |
| 8260B | 1,2-Dichloropropane | µg/L | 5 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8260B | 1,3-Dichlorobenzene | µg/L | 5 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8260B | 1,3-Dichloropropene (total of cis/trans) | µg/L | 0.43 | 95 | 5 | 5% | 90 | 0.62 | | 0.62 | | OWDFMW01 | 26-Jan-2010 | **Yes** | 5 | 100% |
| 8260B | 1,4-Dichlorobenzene | µg/L | 5 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8260B | Acetone | µg/L | 1500 | 103 | 33 | 32% | 70 | 1.4 | J | 150 | | OWDFMW01 | 22-Jul-2015 | No | 0 | 0% |
| 8260B | Benzene | µg/L | 5 | 105 | 25 | 24% | 80 | 0.07 | J | 1.3 | | OWDFMW01 | 19-Jul-2012 | No | 0 | 0% |
| 8260B | Bromodichloromethane | µg/L | 0.12 | 79 | 1 | 1% | 78 | 0.5 | BU,J | 0.5 | BU,J | OWDFMW01 | 7-Nov-2012 | **Yes** | 1 | 100% |
| 8260B | Bromoform | µg/L | 80 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8260B | Bromomethane | µg/L | 8.7 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8260B | Carbon Tetrachloride | µg/L | 5 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8260B | Chlorobenzene | µg/L | 50 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8260B | Chloroethane | µg/L | 16 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8260B | Chloroform | µg/L | 70 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8260B | Chloromethane | µg/L | 1.8 | 101 | 6 | 6% | 95 | 0.07 | J | 0.17 | J | OWDFMW01 | 19-Jan-2016 | No | 0 | 0% |
| 8260B | cis-1,2-Dichloroethylene | µg/L | 70 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8260B | Dibromochloromethane | µg/L | 0.16 | 79 | 0 | 0% | 79 | - | | - | | - | - | - | - | - |
| 8260B | Ethylbenzene | µg/L | 30 | 105 | 0 | 0% | 105 | - | | - | | - | - | - | - | - |
| 8260B | Hexachlorobutadiene | µg/L | 0.86 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8260B | Methyl ethyl ketone (2-Butanone) | µg/L | 7,100 | 103 | 1 | 1% | 102 | 1 | J | 1 | J | OWDFMW01 | 19-Jul-2012 | No | 0 | 0% |
| 8260B | Methyl isobutyl ketone (4-Methyl-2-Pentanone) | µg/L | 170 | 103 | 0 | 0% | 103 | - | | - | | | | - | - | - |
| 8260B | Methyl tert-butyl Ether | µg/L | 5 | 93 | 0 | 0% | 93 | - | | - | | | | - | - | - |
| 8260B | Methylene chloride | µg/L | 4.8 | 103 | 2 | 2% | 101 | 0.2 | U | 0.2 | U | OWDFMW01 | 22-Jul-2015 | No | 0 | 0% |
| 8260B | Napthalene | µg/L | 17 | 18 | 0 | 0% | 18 | - | | - | | - | - | - | - | - |
| 8260B | Styrene | µg/L | 10 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8260B | Tetrachloroethane, 1,1,1,2- | µg/L | 0.52 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8260B | Tetrachloroethane, 1,1,2,2- | µg/L | 0.067 | 85 | 0 | 0% | 85 | - | | - | | - | - | - | - | - |
| 8260B | Tetrachloroethylene | µg/L | 5 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8260B | Toluene | µg/L | 40 | 105 | 14 | 13% | 91 | 0.06 | J | 3.8 | | HDMW2253-03 | 22-Oct-2014 | No | 0 | 0% |
| 8260B | trans-1,2- Dichloroethylene | µg/L | 100 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8260B | Trichloroethylene | µg/L | 5 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8260B | Vinyl chloride | µg/L | 2 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8260B | Xylenes (total) | µg/L | 20 | 105 | 1 | 1% | 104 | 0.39 | J | 0.39 | J | OWDFMW01 | 21-Apr-2011 | No | 0 | 0% |
| 8260SIM | 1,2-Dibromoethane | µg/L | 0.04 | 7 | 0 | 0% | 7 | - | | - | | - | - | - | - | - |
| 8260SIM | 1,2-Dichloroethane | µg/L | 5 | 24 | 6 | 25% | 18 | 0.0009 | J | 0.012 | J | OWDFMW01 | 22-Jul-2015 | No | 0 | 0% |
| 8260SIM | Bromodichloromethane | µg/L | 0.12 | 24 | 3 | 13% | 21 | 0.0039 | B,J | 6.2 | J | RHMW06 | 19-Jan-2016 | **Yes** | 1 | 33% |
| 8260SIM | Dibromochloromethane | µg/L | 0.16 | 24 | 0 | 0% | 24 | - | | - | | - | - | - | - | - |
| 8260SIM | Tetrachloroethane, 1,1,2,2- | µg/L | 0.067 | 18 | 0 | 0% | 18 | - | | - | | - | - | - | - | - |
| 8011 | 1,2-Dibromo-3- chloropropane | µg/L | 0.04 | 24 | 0 | 0% | 24 | - | | - | | - | - | - | - | - |
| 8011 | 1,2-Dibromoethane | µg/L | 0.04 | 30 | 0 | 0% | 30 | - | | - | | - | - | - | - | - |
| 8270C | Acenaphthene | µg/L | 20 | 103 | 2 | 2% | 101 | 0.0063 | J | 0.0082 | J | OWDFMW01 | 19-Oct-2015 | No | 0 | 0% |
| 8270C | Acenaphthylene | µg/L | 240 | 103 | 1 | 1% | 102 | 0.0037 | J | 0.0037 | J | RHMW04 | 22-Apr-2015 | No | 0 | 0% |
| 8270C | Anthracene | µg/L | 22 | 103 | 1 | 1% | 102 | 0.0051 | J | 0.0051 | J | RHMW04 | 22-Apr-2015 | No | 0 | 0% |
| 8270C | Benz[a]anthracene | µg/L | 0.092 | 103 | 10 | 10% | 93 | 0.0027 | B,J | 0.0046 | J | OWDFMW01 | 22-Jul-2015 | No | 0 | 0% |
| 8270C | Benzo[g,h,i]perylene | µg/L | 0.13 | 103 | 1 | 1% | 102 | 0.0076 | B,J | 0.0076 | B,J | RHMW04 | 19-Oct-2015 | No | 0 | 0% |

Table D.6e All Outside Wells Summary Detect Statistics

| | | | Screening | No. of | | Percent | No. of Non- | Detects | | | | Location of Max | Date Sampled of | Did Detects | No. of Detect | Percent Detect |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Method | Analyte | Units | Criteria | Samples | No. of Detects | Detected | detects | Min | | Max | | Concentration | Max Concentration | Exceed EALs? | Exceedances | Exceedance |
| 8270C | Benzo[a]pyrene | µg/L | 0.2 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8270C | Benzo[b]fluoranthene | µg/L | 0.092 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8270C | Benzo[k]fluoranthene | µg/L | 0.4 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8270C | Chrysene | µg/L | 1 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8270C | Dibenzo[a,h]anthracene | µg/L | 0.0092 | 103 | 1 | 1% | 102 | 0.011 | B,J | 0.011 | B,J | RHMW04 | 19-Oct-2015 | **Yes** | 1 | 100% |
| 8270C | Fluoranthene | µg/L | 130 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8270C | Fluorene | µg/L | 240 | 103 | 4 | 4% | 99 | 0.0039 | J,X | 0.006 | J | RHMW04 | 22-Apr-2015 | No | 0 | 0% |
| 8270C | Ideno[1,2,3-cd]pyrene | µg/L | 0.092 | 103 | 1 | 1% | 102 | 0.0087 | B,J | 0.0087 | B,J | RHMW04 | 19-Oct-2015 | No | 0 | 0% |
| 8270C | 1-Methylnaphthalene | µg/L | 4.7 | 105 | 10 | 10% | 95 | 0.0043 | J | 0.03 | | OWDFMW01 | 19-Jan-2016 | No | 0 | 0% |
| 8270C | 2-Methylnaphthalene | µg/L | 10 | 105 | 15 | 14% | 90 | 0.0047 | B,J | 0.02 | | OWDFMW01 | 19-Jan-2016 | No | 0 | 0% |
| 8270C | Naphthalene | µg/L | 17 | 105 | 33 | 31% | 72 | 0.0038 | J | 0.16 | J | HDMW2253-03 | 24-Apr-2013 | No | 0 | 0% |
| 8270C | Phenanthrene | µg/L | 240 | 103 | 9 | 9% | 94 | 0.0063 | J | 0.014 | J | OWDFMW01 | 22-Jul-2015 | No | 0 | 0% |
| 8270C | Pyrene | µg/L | 68 | 103 | 1 | 1% | 102 | 0.0063 | J | 0.0063 | J | OWDFMW01 | 22-Jul-2015 | No | 0 | 0% |
| 6020 | Dissolved Lead | µg/L | 15 | 102 | 42 | 41% | 60 | 0.006 | J | 0.9 | | HDMW2253-03 | 26-Oct-2011 | No | 0 | 0% |

Notes:

Outside tunnel wells include sampling locations RHMW04, RHMW06, RHMW07, OWDFMW01, and HDMW2253-03.

Screening criteria based on the regulatory agencies' February 4, 2016 scoping completion letter and the DOH Tier 1 Environmental Action Levels, Table D-1b. Groundwater Action Levels (Groundwater IS a current or potential drinking water resource, surface water body IS NOT located within 150 meters of release site).

**Blue text** indicates analyte reported non-detect above screening criterion.

Qualifiers:
B = analyte was present in the associated method blank
BU = sample analyzed after holding time expired
J = indicates an estimated value
HD, Z, ++ = the chromatographic pattern was inconsistent with the profile of the reference fuel standard
X = possible high bias due to matrix interference

Table D.6f All Outside Wells Summary Non-Detect Statistics

| Method | Analyte | Units | Screening Criteria | No. of Samples | No. of Non-Detects | Percent Non-Detected | Non-Detects | | | | Did Non-Detects Exceed EALs? | No. of Non-Detect Exceedances | Percent Non-Detect Exceedance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Min | | Max | | | | |
| 8015C | TPH-d | µg/L | 100 | 105 | 46 | 44% | 12 | U | 352 | U | **Yes** | 13 | 28% |
| 8015C | TPH-g | µg/L | 100 | 48 | 47 | 98% | 20 | U | 60 | U | No | 0 | 0% |
| 8015C | TPH-o | µg/L | 100 | 36 | 20 | 56% | 50 | U | 212 | U | **Yes** | 6 | 30% |
| 8260B | TPH-g | µg/L | 100 | 55 | 45 | 82% | 12.12 | U | 30 | U | No | 0 | 0% |
| 8260B | 1,1,1-Trichloroethane | µg/L | 200 | 103 | 103 | 100% | 0.2 | U | 0.62 | U | No | 0 | 0% |
| 8260B | 1,1,2-Trichloroethane | µg/L | 5 | 103 | 103 | 100% | 0.31 | U | 0.62 | U | No | 0 | 0% |
| 8260B | 1,1-Dichloroethane | µg/L | 2.4 | 103 | 103 | 100% | 0.2 | U | 0.62 | U | No | 0 | 0% |
| 8260B | 1,1-Dichloroethylene | µg/L | 7 | 99 | 99 | 100% | 0.2 | U | 0.62 | U | No | 2 | 2% |
| 8260B | 1,2,3-Trichloropropane | µg/L | 0.6 | 103 | 103 | 100% | 0.31 | U | 1 | U | **Yes** | 72 | 70% |
| 8260B | 1,2,4-Tricholorobenzene | µg/L | 70 | 103 | 103 | 100% | 0.3 | U | 1 | U | No | 0 | 0% |
| 8260B | 1,2-Dibromo-3- chloropropane | µg/L | 0.04 | 103 | 103 | 100% | 0.62 | U | 5 | U | **Yes** | 103 | 100% |
| 8260B | 1,2-Dibromoethane | µg/L | 0.04 | 103 | 103 | 100% | 0.2 | U | 0.62 | U | **Yes** | 103 | 100% |
| 8260B | 1,2-Dichlorobenzene | µg/L | 10 | 103 | 103 | 100% | 0.2 | U | 0.62 | U | No | 0 | 0% |
| 8260B | 1,2-Dichloroethane | µg/L | 5 | 79 | 79 | 100% | 0.1 | U | 0.5 | U | No | 0 | 0% |
| 8260B | 1,2-Dichloropropane | µg/L | 5 | 103 | 103 | 100% | 0.2 | U | 0.62 | U | No | 0 | 0% |
| 8260B | 1,3-Dichlorobenzene | µg/L | 5 | 103 | 103 | 100% | 0.2 | U | 0.62 | U | No | 0 | 0% |
| 8260B | 1,3-Dichloropropene (total of cis/trans) | µg/L | 0.43 | 95 | 90 | 95% | 0.15 | U | 0.5 | U | **Yes** | 33 | 37% |
| 8260B | 1,4-Dichlorobenzene | µg/L | 5 | 103 | 103 | 100% | 0.15 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Acetone | µg/L | 1500 | 103 | 70 | 68% | 1.9 | U | 10 | U | No | 0 | 0% |
| 8260B | Benzene | µg/L | 5 | 105 | 80 | 76% | 0.1 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Bromodichloromethane | µg/L | 0.12 | 79 | 78 | 99% | 0.15 | U | 0.5 | U | **Yes** | 78 | 100% |
| 8260B | Bromoform | µg/L | 80 | 103 | 103 | 100% | 0.28 | U | 1 | U | No | 0 | 0% |
| 8260B | Bromomethane | µg/L | 8.7 | 103 | 103 | 100% | 0.3 | U | 5 | U | No | 0 | 0% |
| 8260B | Carbon Tetrachloride | µg/L | 5 | 103 | 103 | 100% | 0.1 | U | 0.62 | U | No | 0 | 0% |
| 8260B | Chlorobenzene | µg/L | 50 | 103 | 103 | 100% | 0.15 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Chloroethane | µg/L | 16 | 103 | 103 | 100% | 0.2 | U | 5 | U | No | 0 | 0% |
| 8260B | Chloroform | µg/L | 70 | 103 | 103 | 100% | 0.14 | U | 0.6 | U | No | 0 | 0% |
| 8260B | Chloromethane | µg/L | 1.8 | 101 | 95 | 94% | 0.2 | U | 5 | U | **Yes** | 33 | 35% |
| 8260B | cis-1,2-Dichloroethylene | µg/L | 70 | 103 | 103 | 100% | 0.2 | U | 0.62 | U | No | 0 | 0% |
| 8260B | Dibromochloromethane | µg/L | 0.16 | 79 | 79 | 100% | 0.15 | U | 0.5 | U | **Yes** | 72 | 91% |
| 8260B | Ethylbenzene | µg/L | 30 | 105 | 105 | 100% | 0.1 | U | 0.62 | U | No | 0 | 0% |
| 8260B | Hexachlorobutadiene | µg/L | 0.86 | 103 | 103 | 100% | 0.3 | U | 0.62 | U | No | 0 | 0% |
| 8260B | Methyl ethyl ketone (2-Butanone) | µg/L | 7,100 | 103 | 102 | 99% | 1.2 | U | 6.2 | U | No | 0 | 0% |
| 8260B | Methyl isobutyl ketone (4-Methyl-2-Pentanone) | µg/L | 170 | 103 | 103 | 100% | 2.5 | U | 10 | U | No | 0 | 0% |
| 8260B | Methyl tert-butyl Ether | µg/L | 5 | 93 | 93 | 100% | 0.3 | U | 3 | U | No | 0 | 0% |
| 8260B | Methylene chloride | µg/L | 4.8 | 103 | 101 | 98% | 0.2 | U | 2 | U | No | 0 | 0% |
| 8260B | Napthalene | µg/L | 17 | 18 | 18 | 100% | 0.62 | U | 1.24 | U | No | 0 | 0% |
| 8260B | Styrene | µg/L | 10 | 103 | 103 | 100% | 0.2 | U | 0.62 | U | No | 0 | 0% |
| 8260B | Tetrachloroethane, 1,1,1,2- | µg/L | 0.52 | 103 | 103 | 100% | 0.15 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Tetrachloroethane, 1,1,2,2- | µg/L | 0.067 | 85 | 85 | 100% | 0.15 | U | 15 | U | **Yes** | 85 | 100% |
| 8260B | Tetrachloroethylene | µg/L | 5 | 103 | 103 | 100% | 0.2 | U | 0.62 | U | No | 0 | 0% |
| 8260B | Toluene | µg/L | 40 | 105 | 91 | 87% | 0.1 | U | 0.62 | U | No | 0 | 0% |
| 8260B | trans-1,2- Dichloroethylene | µg/L | 100 | 103 | 103 | 100% | 0.2 | U | 0.62 | U | No | 0 | 0% |
| 8260B | Trichloroethylene | µg/L | 5 | 103 | 103 | 100% | 0.1 | U | 0.62 | U | No | 0 | 0% |
| 8260B | Vinyl chloride | µg/L | 2 | 103 | 103 | 100% | 0.1 | U | 0.62 | U | No | 0 | 0% |
| 8260B | Xylenes (total) | µg/L | 20 | 105 | 104 | 99% | 0.2 | U | 1.24 | U | No | 0 | 0% |
| 8260SIM | 1,2-Dibromoethane | µg/L | 0.04 | 7 | 7 | 100% | 0.01 | U | 0.01 | U | No | 0 | 0% |
| 8260SIM | 1,2-Dichloroethane | µg/L | 5 | 24 | 18 | 75% | 0.015 | U | 0.015 | U | No | 0 | 0% |
| 8260SIM | Bromodichloromethane | µg/L | 0.12 | 24 | 21 | 88% | 0.01 | U | 0.01 | U | No | 0 | 0% |
| 8260SIM | Dibromochloromethane | µg/L | 0.16 | 24 | 24 | 100% | 0.01 | U | 0.01 | U | No | 0 | 0% |
| 8260SIM | Tetrachloroethane, 1,1,2,2- | µg/L | 0.067 | 18 | 18 | 100% | 0.015 | U | 0.015 | U | No | 0 | 0% |
| 8011 | 1,2-Dibromo-3- chloropropane | µg/L | 0.04 | 24 | 24 | 100% | 0.004 | U | 0.019 | U | No | 0 | 0% |
| 8011 | 1,2-Dibromoethane | µg/L | 0.04 | 30 | 30 | 100% | 0.004 | U | 0.02 | U | No | 0 | 0% |
| 8270C | Acenaphthene | µg/L | 20 | 103 | 101 | 98% | 0.005 | U | 0.57 | U | No | 0 | 0% |
| 8270C | Acenaphthylene | µg/L | 240 | 103 | 102 | 99% | 0.005 | U | 0.57 | U | No | 0 | 0% |
| 8270C | Anthracene | µg/L | 22 | 103 | 102 | 99% | 0.005 | U | 0.57 | U | No | 0 | 0% |
| 8270C | Benz[a]anthracene | µg/L | 0.092 | 103 | 93 | 90% | 0.005 | U | 0.14 | U | **Yes** | 22 | 24% |
| 8270C | Benzo[g,h,i]perylene | µg/L | 0.13 | 103 | 102 | 99% | 0.005 | U | 0.16 | U | **Yes** | 22 | 22% |

Table D.6f All Outside Wells Summary Non-Detect Statistics

|  |  |  | Screening | No. of | No. of | Percent | Non-Detects |  |  |  | Did Non-Detects | No. of Non-Detect | Percent Non-Detect |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Method | Analyte | Units | Criteria | Samples | Non-Detects | Non-Detected | Min |  | Max |  | Exceed EALs? | Exceedances | Exceedance |
| 8270C | Benzo[a]pyrene | µg/L | 0.2 | 103 | 103 | 100% | 0.005 | U | 0.14 | U | No | 0 | 0% |
| 8270C | Benzo[b]fluoranthene | µg/L | 0.092 | 103 | 103 | 100% | 0.005 | U | 0.12 | U | **Yes** | 22 | 21% |
| 8270C | Benzo[k]fluoranthene | µg/L | 0.4 | 103 | 103 | 100% | 0.005 | U | 0.14 | U | No | 0 | 0% |
| 8270C | Chrysene | µg/L | 1 | 103 | 103 | 100% | 0.005 | U | 0.11 | U | No | 0 | 0% |
| 8270C | Dibenzo[a,h]anthracene | µg/L | 0.0092 | 103 | 102 | 99% | 0.005 | U | 0.1 | U | **Yes** | 79 | 77% |
| 8270C | Fluoranthene | µg/L | 130 | 103 | 103 | 100% | 0.0096 | U | 0.28 | U | No | 0 | 0% |
| 8270C | Fluorene | µg/L | 240 | 103 | 99 | 96% | 0.005 | U | 0.28 | U | No | 0 | 0% |
| 8270C | Ideno[1,2,3-cd]pyrene | µg/L | 0.092 | 103 | 102 | 99% | 0.005 | U | 0.14 | U | **Yes** | 22 | 22% |
| 8270C | 1-Methylnaphthalene | µg/L | 4.7 | 105 | 95 | 90% | 0.005 | U | 0.28 | U | No | 0 | 0% |
| 8270C | 2-Methylnaphthalene | µg/L | 10 | 105 | 90 | 86% | 0.005 | U | 0.28 | U | No | 0 | 0% |
| 8270C | Naphthalene | µg/L | 17 | 105 | 72 | 69% | 0.005 | U | 0.28 | U | No | 0 | 0% |
| 8270C | Phenanthrene | µg/L | 240 | 103 | 94 | 91% | 0.005 | U | 0.57 | U | No | 0 | 0% |
| 8270C | Pyrene | µg/L | 68 | 103 | 102 | 99% | 0.0096 | U | 0.28 | U | No | 0 | 0% |
| 6020 | Dissolved Lead | µg/L | 15 | 102 | 60 | 59% | 0.2 | U | 10 | U | No | 0 | 0% |

Notes:

Outside tunnel wells include sampling locations RHMW04, RHMW06, RHMW07, OWDFMW01, and HDMW2253-03.

Screening criteria based on the regulatory agencies' February 4, 2016 scoping completion letter and the DOH Tier 1 Environmental Action Levels, Table D-1b. Groundwater Action Levels (Groundwater IS a current or potential drinking water resource, surface water body IS NOT located within 150 meters of release site).

**Blue text** indicates non-detect above screening criterion.

Qualifiers:

U = non-detect

Table D.7a Inside Wells Summary Detect Statistics, Q2-2011 through Q1-2016

| Method | Analyte | Units | Screening Criteria | No. of Samples | No. of Detects | Percent Detected | No. of Non-detects | Detects | | | | Location of Max Concentration | Date Sampled of Max Concentration | Did Detects Exceed EALs? | No. of Detect Exceedances | Percent Detect Exceedance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Min | | Max | | | | | | |
| 8015 | TPH-d | µg/L | 100 | 155 | 112 | 72% | 43 | 14 | B,J | 6500 | B,Y | RHMW02 | 20-Jan-2016 | **Yes** | 70 | 63% |
| 8015 | TPH-g | µg/L | 100 | 24 | 7 | 29% | 17 | 36 | J | 47 | J | RHMW02 | 20-Apr-2015 | No | 0 | 0% |
| 8015 | TPH-o | µg/L | 100 | 38 | 23 | 61% | 15 | 21 | J | 360 | L | RHMW02 | 20-Apr-2015 | **Yes** | 12 | 52% |
| 8260B | TPH-g | µg/L | 100 | 97 | 36 | 37% | 61 | 13 | J | 660 | | RHMW02 | 28-Jan-2013 | **Yes** | 4 | 11% |
| 8260B | 1,1,1-Trichloroethane | µg/L | 200 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | 1,1,2-Trichloroethane | µg/L | 5 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | 1,1-Dichloroethane | µg/L | 2.4 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | 1,1-Dichloroethylene | µg/L | 7 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | 1,2,3-Trichloropropane | µg/L | 0.6 | 126 | 1 | 1% | 125 | 0.27 | J | 0.27 | J | RHMW02 | 20-Jul-2015 | No | 0 | 0% |
| 8260B | 1,2,4-Tricholorobenzene | µg/L | 70 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | 1,2-Dibromo-3- chloropropane | µg/L | 0.04 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | 1,2-Dibromoethane | µg/L | 0.04 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | 1,2-Dichlorobenzene | µg/L | 10 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | 1,2-Dichloroethane | µg/L | 5 | 103 | 0 | 0% | 103 | - | | - | | - | - | - | - | - |
| 8260B | 1,2-Dichloropropane | µg/L | 5 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | 1,3-Dichlorobenzene | µg/L | 5 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | 1,3-Dichloropropene (total of cis/trans) | µg/L | 0.43 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | 1,4-Dichlorobenzene | µg/L | 5 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | Acetone | µg/L | 1500 | 126 | 4 | 3% | 122 | 3.4 | J | 15 | J,ICH | RHMW01 | 15-Jan-2014 | No | 0 | 0% |
| 8260B | Benzene | µg/L | 5 | 152 | 8 | 5% | 144 | 0.08 | J | 0.15 | J | RHMW02 | 28-Jan-2014 | No | 0 | 0% |
| 8260B | Bromodichloromethane | µg/L | 0.12 | 102 | 0 | 0% | 102 | - | | - | | - | - | - | - | - |
| 8260B | Bromoform | µg/L | 80 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | Bromomethane | µg/L | 8.7 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | Carbon Tetrachloride | µg/L | 5 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | Chlorobenzene | µg/L | 50 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | Chloroethane | µg/L | 16 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | Chloroform | µg/L | 70 | 126 | 1 | 1% | 125 | 0.13 | J | 0.13 | J | RHMW01 | 2-Nov-2011 | No | 0 | 0% |
| 8260B | Chloromethane | µg/L | 1.8 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | cis-1,2-Dichloroethylene | µg/L | 70 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | Dibromochloromethane | µg/L | 0.16 | 102 | 0 | 0% | 102 | - | | - | | - | - | - | - | - |
| 8260B | Ethylbenzene | µg/L | 30 | 152 | 36 | 24% | 116 | 0.014 | J | 0.3 | J | RHMW02 | 26-Jan-2012 | No | 0 | 0% |
| 8260B | Hexachlorobutadiene | µg/L | 0.86 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | Methyl ethyl ketone (2-Butanone) | µg/L | 7,100 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | Methyl isobutyl ketone (4-Methyl-2-Pentanone) | µg/L | 170 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | Methyl tert-butyl Ether | µg/L | 5 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | Methylene chloride | µg/L | 4.8 | 126 | 2 | 2% | 124 | 0.1 | J | 0.59 | B,J | RHMW01 | 14-Feb-2012 | No | 0 | 0% |
| 8260B | Naphthalene | µg/L | 17 | 0 | 0 | - | 0 | - | | - | | - | - | - | - | - |
| 8260B | Styrene | µg/L | 10 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | Tetrachloroethane, 1,1,1,2- | µg/L | 0.52 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | Tetrachloroethane, 1,1,2,2- | µg/L | 0.067 | 108 | 0 | 0% | 108 | - | | - | | - | - | - | - | - |
| 8260B | Tetrachloroethylene | µg/L | 5 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | Toluene | µg/L | 40 | 152 | 20 | 13% | 132 | 0.06 | J | 2.5 | | RHMW01 | 15-Jan-2014 | No | 0 | 0% |
| 8260B | trans-1,2- Dichloroethylene | µg/L | 100 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | Trichloroethylene | µg/L | 5 | 126 | 1 | 1% | 125 | 0.17 | J | 0.17 | J | RHMW2254-01 | 17-Apr-2012 | No | 0 | 0% |
| 8260B | Vinyl chloride | µg/L | 2 | 126 | 0 | 0% | 126 | - | | - | | - | - | - | - | - |
| 8260B | Xylenes, Total (p/m-, o-xylene) | µg/L | 20 | 152 | 43 | 28% | 109 | 0.21 | J | 0.69 | J | RHMW02 | 28-Jan-2013 | No | 2 | 5% |
| 504.1 | 1,2-Dibromoethane | µg/L | 0.04 | 0 | 0 | - | 0 | - | | - | | - | - | - | - | - |
| 8260SIM | 1,2-Dibromoethane | µg/L | 0.04 | 6 | 0 | 0% | 6 | - | | - | | - | - | - | - | - |
| 8260SIM | 1,2-Dichloroethane | µg/L | 5 | 22 | 0 | 0% | 22 | - | | - | | - | - | - | - | - |
| 8260SIM | Bromodichloromethane | µg/L | 0.12 | 18 | 0 | 0% | 18 | - | | - | | - | - | - | - | - |
| 8260SIM | Dibromochloromethane | µg/L | 0.16 | 24 | 0 | 0% | 24 | - | | - | | - | - | - | - | - |
| 8260SIM | Tetrachloroethane, 1,1,2,2- | µg/L | 0.067 | 18 | 2 | 11% | 16 | 0.059 | | 0.065 | | RHMW02 | 20-Apr-2015 | No | 0 | 0% |
| 8011 | 1,2-Dibromo-3- chloropropane | µg/L | 0.04 | 13 | 1 | 8% | 12 | 0.004 | | 0.004 | | RHMW01 | 20-Oct-2015 | No | 0 | 0% |
| 8011 | 1,2-Dibromoethane | µg/L | 0.04 | 24 | 0 | 0% | 24 | - | | - | | - | - | - | - | - |
| 8270C | Acenaphthene | µg/L | 20 | 121 | 43 | 36% | 78 | 0.0053 | J | 0.65 | | RHMW02 | 22-Apr-2013 | No | 0 | 0% |
| 8270C | Acenaphthylene | µg/L | 240 | 121 | 8 | 7% | 113 | 0.0041 | J | 0.26 | X | RHMW02 | 20-Apr-2015 | No | 0 | 0% |
| 8270C | Anthracene | µg/L | 22 | 121 | 0 | 0% | 121 | - | | - | | - | - | - | - | - |
| 8270C | Benz[a]anthracene | µg/L | 0.092 | 121 | 13 | 11% | 108 | 0.0026 | B,J | 0.0082 | J | RHMW01 | 20-Jan-2016 | No | 0 | 0% |

**Appendix D.7: Well Summary Stats 5-year (2011–2016) (cont'd)**

**WP/SOW, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, RHSF, JBPHH, O‘ahu, HI**

Table D.7a Inside Wells Summary Detect Statistics, Q2-2011 through Q1-2016

| Method | Analyte | Units | Screening Criteria | No. of Samples | No. of Detects | Percent Detected | No. of Non-detects | Detects | | | | Location of Max Concentration | Date Sampled of Max Concentration | Did Detects Exceed EALs? | No. of Detect Exceedances | Percent Detect Exceedance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Min | | Max | | | | | | |
| 8270C | Benzo[g,h,i]perylene | µg/L | 0.13 | 121 | 1 | 1% | 120 | 0.0034 | J | 0.0034 | J | RHMW01 | 20-Jan-2016 | No | 0 | 0% |
| 8270C | Benzo[a]pyrene | µg/L | 0.2 | 121 | 1 | 1% | 120 | 0.0061 | J | 0.0061 | J | RHMW01 | 20-Jan-2016 | No | 0 | 0% |
| 8270C | Benzo[b]fluoranthene | µg/L | 0.092 | 121 | 2 | 2% | 119 | 0.0042 | J | 0.0063 | J | RHMW01 | 20-Jan-2016 | No | 0 | 0% |
| 8270C | Benzo[k]fluoranthene | µg/L | 0.4 | 121 | 0 | 0% | 121 | - | | - | | - | - | - | - | - |
| 8270C | Chrysene | µg/L | 1 | 121 | 2 | 2% | 119 | 0.0065 | J | 0.0089 | J | RHMW01 | 20-Jan-2016 | No | 0 | 0% |
| 8270C | Dibenzo[a,h]anthracene | µg/L | 0.0092 | 121 | 0 | 0% | 121 | - | | - | | - | - | - | - | - |
| 8270C | Fluoranthene | µg/L | 130 | 121 | 1 | 1% | 120 | 0.018 | J | 0.018 | J | RHMW01 | 20-Jan-2016 | No | 0 | 0% |
| 8270C | Fluorene | µg/L | 240 | 121 | 40 | 33% | 81 | 0.0096 | J | 0.32 | | RHMW02 | 20-Jul-2015 | No | 0 | 0% |
| 8270C | Indeno[1,2,3-cd]pyrene | µg/L | 0.092 | 121 | 2 | 2% | 119 | 0.0026 | J | 0.0042 | J | RHMW01 | 20-Jan-2016 | No | 0 | 0% |
| 8270C | 1-Methylnaphthalene | µg/L | 4.7 | 155 | 65 | 42% | 90 | 0.0039 | J | 71 | J,D | RHMW02 | 25-Jun-2015 | **Yes** | 41 | 63% |
| 8270C | 2-Methylnaphthalene | µg/L | 10 | 155 | 67 | 43% | 88 | 0.0029 | J | 48 | J,D | RHMW02 | 25-Jun-2015 | **Yes** | 17 | 25% |
| 8270C | Naphthalene | µg/L | 17 | 155 | 91 | 59% | 64 | 0.0046 | J | 160 | D | RHMW02 | 20-Jul-2015 | **Yes** | 37 | 41% |
| 8270C | Phenanthrene | µg/L | 240 | 121 | 9 | 7% | 112 | 0.0052 | J | 0.02 | | RHMW01 | 20-Jan-2016 | No | 0 | 0% |
| 8270C | Pyrene | µg/L | 68 | 121 | 4 | 3% | 117 | 0.0058 | J,X | 0.027 | J | RHMW01 | 21-Oct-2013 | No | 0 | 0% |
| 6020 | Dissolved Lead (filtered) | µg/L | 15 | 134 | 58 | 43% | 76 | 0.011 | J | 2.2 | | RHMW2254-01 | 17-Jul-2012 | No | 0 | 0% |
| 6010B/6020/200.8 | Total Lead (unfiltered) | µg/L | - | 18 | 11 | 61% | 7 | 0.036 | | 0.828 | J | RHMW2254-01 | 23-Apr-2013 | No | 0 | 0% |

Notes:

Inside tunnel wells include sampling locations RHMW01, RHMW02, RHMW03, RHMW05, and RHMW2254-01.

Screening criteria based on the regulatory agencies' February 4, 2016 scoping completion letter and the DOH Tier 1 Environmental Action Levels, Table D-1b. Groundwater Action Levels (Groundwater IS a current or potential drinking water resource, surface water body IS NOT located within 150 meters of release site).

**Blue text** indicates analyte reported at concentrations above screening criterion.

Qualifiers:

B = analyte was present in the associated method blank

D = the reported result is from a dilution

ICH = Initial calibration verification recovery above method calibration level for this analyte

L, Y = the chromatographic pattern was inconsistent with the profile of the reference fuel standard

J = indicates an estimated value

X = possible high bias due to matrix interference

## Appendix D.7: Well Summary Stats 5-year (2011–2016)
## WP/SOW, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, RHSF, JBPHH, O‘ahu, HI

Table D.7b Inside Wells Summary Non-Detect Statistics, Q2-2011 through Q1-2016

| Method | Analyte | Units | Screening Criteria | No. of Samples | No. of Non-Detects | Percent Non-Detect | Non-Detects | | | | Did Non-Detects Exceed EALs? | No. of Non-Detect Exceedances | Percent Non-Detect Exceedance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Min | | Max | | | | |
| 8015 | TPH-d | µg/L | 100 | 155 | 43 | 28% | 10 | U | 80.8 | U | No | 0 | 0% |
| 8015 | TPH-g | µg/L | 100 | 24 | 17 | 71% | 25 | U | 25 | U | No | 0 | 0% |
| 8015 | TPH-o | µg/L | 100 | 38 | 15 | 39% | 53 | U | 212 | U | **Yes** | 11 | 73% |
| 8260B | TPH-g | µg/L | 100 | 97 | 61 | 63% | 12.12 | U | 30 | U | No | 0 | 0% |
| 8260B | 1,1,1-Trichloroethane | µg/L | 200 | 126 | 126 | 100% | 0.2 | U | 0.5 | U | No | 0 | 0% |
| 8260B | 1,1,2-Trichloroethane | µg/L | 5 | 126 | 126 | 100% | 0.4 | U | 0.5 | U | No | 0 | 0% |
| 8260B | 1,1-Dichloroethane | µg/L | 2.4 | 126 | 126 | 100% | 0.2 | U | 0.5 | U | No | 0 | 0% |
| 8260B | 1,1-Dichloroethylene | µg/L | 7 | 126 | 126 | 100% | 0.2 | U | 0.6 | U | No | 0 | 0% |
| 8260B | 1,2,3-Trichloropropane | µg/L | 0.6 | 126 | 125 | 99% | 0.5 | U | 2 | U | **Yes** | 102 | 82% |
| 8260B | 1,2,4-Tricholorobenzene | µg/L | 70 | 126 | 126 | 100% | 0.3 | U | 1 | U | No | 0 | 0% |
| 8260B | 1,2-Dibromo-3- chloropropane | µg/L | 0.04 | 126 | 126 | 100% | 0.5 | U | 5 | U | **Yes** | 126 | 100% |
| 8260B | 1,2-Dibromoethane | µg/L | 0.04 | 126 | 126 | 100% | 0.004 | U | 0.5 | U | **Yes** | 125 | 99% |
| 8260B | 1,2-Dichlorobenzene | µg/L | 10 | 126 | 126 | 100% | 0.2 | U | 0.5 | U | No | 0 | 0% |
| 8260B | 1,2-Dichloroethane | µg/L | 5 | 103 | 103 | 100% | 0.02 | U | 0.5 | U | No | 0 | 0% |
| 8260B | 1,2-Dichloropropane | µg/L | 5 | 126 | 126 | 100% | 0.2 | U | 0.5 | U | No | 0 | 0% |
| 8260B | 1,3-Dichlorobenzene | µg/L | 5 | 126 | 126 | 100% | 0.2 | U | 0.5 | U | No | 0 | 0% |
| 8260B | 1,3-Dichloropropene (total of cis/trans) | µg/L | 0.43 | 126 | 126 | 100% | 0.2 | U | 0.5 | U | **Yes** | 73 | 58% |
| 8260B | 1,4-Dichlorobenzene | µg/L | 5 | 126 | 126 | 100% | 0.2 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Acetone | µg/L | 1500 | 126 | 122 | 97% | 1.9 | U | 10 | U | No | 0 | 0% |
| 8260B | Benzene | µg/L | 5 | 152 | 144 | 95% | 0.1 | U | 0.501 | U | No | 0 | 0% |
| 8260B | Bromodichloromethane | µg/L | 0.12 | 102 | 102 | 100% | 0.28 | U | 0.5 | U | **Yes** | 102 | 100% |
| 8260B | Bromoform | µg/L | 80 | 126 | 126 | 100% | 0.28 | U | 2 | U | No | 0 | 0% |
| 8260B | Bromomethane | µg/L | 8.7 | 126 | 126 | 100% | 0.3 | U | 5 | U | No | 0 | 0% |
| 8260B | Carbon Tetrachloride | µg/L | 5 | 126 | 126 | 100% | 0.2 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Chlorobenzene | µg/L | 50 | 126 | 126 | 100% | 0.2 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Chloroethane | µg/L | 16 | 126 | 126 | 100% | 0.2 | U | 5 | U | No | 0 | 0% |
| 8260B | Chloroform | µg/L | 70 | 126 | 125 | 99% | 0.14 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Chloromethane | µg/L | 1.8 | 126 | 126 | 100% | 0.2 | U | 5 | U | **Yes** | 67 | 53% |
| 8260B | cis-1,2-Dichloroethylene | µg/L | 70 | 126 | 126 | 100% | 0.2 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Dibromochloromethane | µg/L | 0.16 | 102 | 102 | 100% | 0.38 | U | 0.5 | U | **Yes** | 102 | 100% |
| 8260B | Ethylbenzene | µg/L | 30 | 152 | 116 | 76% | 0.1 | U | 0.501 | U | No | 0 | 0% |
| 8260B | Hexachlorobutadiene | µg/L | 0.86 | 126 | 126 | 100% | 0.3 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Methyl ethyl ketone (2-Butanone) | µg/L | 7,100 | 126 | 126 | 100% | 0.5 | U | 5 | U | No | 0 | 0% |
| 8260B | Methyl isobutyl ketone (4-Methyl-2-Pentanone) | µg/L | 170 | 126 | 126 | 100% | 0.5 | U | 10 | U | No | 0 | 0% |
| 8260B | Methyl tert-butyl Ether | µg/L | 5 | 126 | 126 | 100% | 0.3 | U | 5 | U | No | 0 | 0% |
| 8260B | Methylene chloride | µg/L | 4.8 | 126 | 124 | 98% | 0.2 | U | 2 | U | No | 0 | 0% |
| 8260B | Naphthalene | µg/L | 17 | 0 | 0 | - | - | | - | | - | - | - |
| 8260B | Styrene | µg/L | 10 | 126 | 126 | 100% | 0.2 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Tetrachloroethane, 1,1,1,2- | µg/L | 0.52 | 126 | 126 | 100% | 0.2 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Tetrachloroethane, 1,1,2,2- | µg/L | 0.067 | 108 | 108 | 100% | 0.2 | U | 15 | U | **Yes** | 108 | 100% |
| 8260B | Tetrachloroethylene | µg/L | 5 | 126 | 126 | 100% | 0.2 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Toluene | µg/L | 40 | 152 | 132 | 87% | 0.1 | U | 0.501 | U | No | 0 | 0% |
| 8260B | trans-1,2- Dichloroethylene | µg/L | 100 | 126 | 126 | 100% | 0.2 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Trichloroethylene | µg/L | 5 | 126 | 125 | 99% | 0.1 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Vinyl chloride | µg/L | 2 | 126 | 126 | 100% | 0.1 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Xylenes, Total (p/m-, o-xylene) | µg/L | 20 | 152 | 109 | 72% | 0.2 | U | 1.01 | U | No | 0 | 0% |
| 504.1 | 1,2-Dibromoethane | µg/L | 0.04 | 0 | 0 | - | - | | - | | - | - | - |
| 8260SIM | 1,2-Dibromoethane | µg/L | 0.04 | 6 | 6 | 100% | 0.01 | U | 0.01 | U | No | 0 | 0% |
| 8260SIM | 1,2-Dichloroethane | µg/L | 5 | 22 | 22 | 100% | 0.015 | U | 0.015 | U | No | 2 | 9% |
| 8260SIM | Bromodichloromethane | µg/L | 0.12 | 18 | 18 | 100% | 0.01 | U | 0.01 | U | No | 5 | 28% |
| 8260SIM | Dibromochloromethane | µg/L | 0.16 | 24 | 24 | 100% | 0.01 | | 0.01 | | No | 0 | 0% |
| 8260SIM | Tetrachloroethane, 1,1,2,2- | µg/L | 0.067 | 18 | 16 | 89% | 0.015 | | 0.13 | | **Yes** | 2 | 13% |
| 8011 | 1,2-Dibromo-3- chloropropane | µg/L | 0.04 | 13 | 12 | 92% | 0.004 | | 0.004 | | No | 5 | 42% |
| 8011 | 1,2-Dibromoethane | µg/L | 0.04 | 24 | 24 | 100% | 0.004 | | 0.004 | | No | 0 | 0% |
| 8270C | Acenaphthene | µg/L | 20 | 121 | 78 | 64% | 0.005 | U | 0.12 | U | No | 0 | 0% |
| 8270C | Acenaphthylene | µg/L | 240 | 121 | 113 | 93% | 0.005 | U | 0.25 | U | No | 0 | 0% |
| 8270C | Anthracene | µg/L | 22 | 121 | 121 | 100% | 0.005 | U | 0.1 | U | No | 0 | 0% |
| 8270C | Benz[a]anthracene | µg/L | 0.092 | 121 | 108 | 89% | 0.005 | U | 0.14 | U | **Yes** | 35 | 32% |

Table D.7b Inside Wells Summary Non-Detect Statistics, Q2-2011 through Q1-2016

| Method | Analyte | Units | Screening Criteria | No. of Samples | No. of Non-Detects | Percent Non-Detect | Non-Detects Min | | Non-Detects Max | | Did Non-Detects Exceed EALs? | No. of Non-Detect Exceedances | Percent Non-Detect Exceedance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8270C | Benzo[g,h,i]perylene | µg/L | 0.13 | 121 | 120 | 99% | 0.005 | U | 0.16 | U | **Yes** | 35 | 29% |
| 8270C | Benzo[a]pyrene | µg/L | 0.2 | 121 | 120 | 99% | 0.005 | U | 0.14 | U | No | 0 | 0% |
| 8270C | Benzo[b]fluoranthene | µg/L | 0.092 | 121 | 119 | 98% | 0.005 | U | 0.12 | U | **Yes** | 35 | 29% |
| 8270C | Benzo[k]fluoranthene | µg/L | 0.4 | 121 | 121 | 100% | 0.005 | U | 0.14 | U | No | 0 | 0% |
| 8270C | Chrysene | µg/L | 1 | 121 | 119 | 98% | 0.005 | U | 0.1 | U | No | 0 | 0% |
| 8270C | Dibenzo[a,h]anthracene | µg/L | 0.0092 | 121 | 121 | 100% | 0.005 | U | 0.1 | U | **Yes** | 97 | 80% |
| 8270C | Fluoranthene | µg/L | 130 | 121 | 120 | 99% | 0.02 | U | 0.16 | U | No | 0 | 0% |
| 8270C | Fluorene | µg/L | 240 | 121 | 81 | 67% | 0.005 | U | 0.12 | U | No | 0 | 0% |
| 8270C | Indeno[1,2,3-cd]pyrene | µg/L | 0.092 | 121 | 119 | 98% | 0.005 | U | 0.14 | U | **Yes** | 35 | 29% |
| 8270C | 1-Methylnaphthalene | µg/L | 4.7 | 155 | 90 | 58% | 0.005 | U | 0.12 | U | No | 0 | 0% |
| 8270C | 2-Methylnaphthalene | µg/L | 10 | 155 | 88 | 57% | 0.005 | U | 0.12 | U | No | 0 | 0% |
| 8270C | Naphthalene | µg/L | 17 | 155 | 64 | 41% | 0.005 | U | 0.1 | U | No | 0 | 0% |
| 8270C | Phenanthrene | µg/L | 240 | 121 | 112 | 93% | 0.005 | U | 0.14 | U | No | 0 | 0% |
| 8270C | Pyrene | µg/L | 68 | 121 | 117 | 97% | 0.01 | U | 0.16 | U | No | 0 | 0% |
| 6020 | Dissolved Lead (filtered) | µg/L | 15 | 134 | 76 | 57% | 0.2 | U | 0.22 | U | No | 0 | 0% |
| 6010B/6020/200.8 | Total Lead (unfiltered) | µg/L | - | 18 | 7 | 39% | 0.0898 | U | 0.0898 | U | No | 0 | 0% |

Notes:

Inside tunnel wells include sampling locations RHMW01, RHMW02, RHMW03, RHMW05, and RHMW2254-01.

Screening criteria based on the regulatory agencies' February 4, 2016 scoping completion letter and the DOH Tier 1 Environmental Action Levels, Table D-1b. Groundwater Action Levels (Groundwater IS a current or potential drinking water resource, surface water body IS NOT located within 150 meters of release site).

**Blue text** indicates non-detect above screening criterion.

Qualifiers:

U = non-detect

Table D.7c Outside Wells Summary Detect Statistics, Q2-2011 through Q1-2016

| Method | Analyte | Units | Screening Criteria | No. of Samples | No. of Detects | Percent Detected | No. of Non-detects | Detects |  |  |  | Location of Max Concentration | Date Sampled of Max Concentration | Did Detects Exceed EALs? | No. of Detect Exceedances | Percent Detect Exceedance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |  | Min |  | Max |  |  |  |  |  |  |
| 8015 | TPH-d | µg/L | 100 | 81 | 55 | 68% | 26 | 10 | HD,J | 3100 | Z | OWDFMW01 | 22-Jul-2015 | Yes | 23 | 42% |
| 8015 | TPH-g | µg/L | 100 | 30 | 1 | 3% | 29 | 16 | J | 16 | J | HDMW2253-03 | 19-Oct-2015 | No | 0 | 0% |
| 8015 | TPH-o | µg/L | 100 | 36 | 16 | 44% | 20 | 25 | B,J | 390 | Z | OWDFMW01 | 22-Jul-2015 | Yes | 4 | 25% |
| 8260B | TPH-g | µg/L | 100 | 49 | 10 | 20% | 39 | 14 | B,J | 31 | B,J | OWDFMW01 | 4/23/2014* | No | 0 | 0% |
| 8260B | 1,1,1-Trichloroethane | µg/L | 200 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | 1,1,2-Trichloroethane | µg/L | 5 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | 1,1-Dichloroethane | µg/L | 2.4 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | 1,1-Dichloroethylene | µg/L | 7 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | 1,2,3-Trichloropropane | µg/L | 0.6 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | 1,2,4-Tricholorobenzene | µg/L | 70 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | 1,2-Dibromo-3- chloropropane | µg/L | 0.04 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | 1,2-Dibromoethane | µg/L | 0.04 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | 1,2-Dichlorobenzene | µg/L | 10 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | 1,2-Dichloroethane | µg/L | 5 | 55 | 0 | 0% | 55 | - |  | - |  | - | - | - | - | - |
| 8260B | 1,2-Dichloropropane | µg/L | 5 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | 1,3-Dichlorobenzene | µg/L | 5 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | 1,3-Dichloropropene (total of cis/trans) | µg/L | 0.43 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | 1,4-Dichlorobenzene | µg/L | 5 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | Acetone | µg/L | 1500 | 79 | 31 | 39% | 48 | 1.7 | J | 150 |  | OWDFMW01 | 22-Jul-2015 | No | 0 | 0% |
| 8260B | Benzene | µg/L | 5 | 81 | 21 | 26% | 60 | 0.07 | J | 1.3 |  | OWDFMW01 | 19-Jul-2012 | No | 0 | 0% |
| 8260B | Bromodichloromethane | µg/L | 0.12 | 55 | 1 | 2% | 54 | 0.5 | BU,J | 0.5 | BU,J | OWDFMW01 | 11/7/2012* | Yes | 1 | 100% |
| 8260B | Bromoform | µg/L | 80 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | Bromomethane | µg/L | 8.7 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | Carbon Tetrachloride | µg/L | 5 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | Chlorobenzene | µg/L | 50 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | Chloroethane | µg/L | 16 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | Chloroform | µg/L | 70 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | Chloromethane | µg/L | 1.8 | 79 | 6 | 8% | 73 | 0.07 | J | 0.17 | J | OWDFMW01 | 1/19/2016 | No | 0 | 0% |
| 8260B | cis-1,2-Dichloroethylene | µg/L | 70 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | Dibromochloromethane | µg/L | 0.16 | 55 | 0 | 0% | 55 | - |  | - |  | - | - | - | - | - |
| 8260B | Ethylbenzene | µg/L | 30 | 81 | 0 | 0% | 81 | - |  | - |  | - | - | - | - | - |
| 8260B | Hexachlorobutadiene | µg/L | 0.86 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | Methyl ethyl ketone (2-Butanone) | µg/L | 7,100 | 79 | 1 | 1% | 78 | 1 | J | 1 | J | OWDFMW01 | 7/19/2012 | No | 0 | 0% |
| 8260B | Methyl isobutyl ketone (4-Methyl-2-Pentanone) | µg/L | 170 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | Methyl tert-butyl Ether | µg/L | 5 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | Methylene chloride | µg/L | 4.8 | 79 | 2 | 3% | 77 | 0.2 | J | 0.2 | J | OWDFMW01 | 22-Jul-2015 | No | 0 | 0% |
| 8260B | Naphthalene | µg/L | 17 | 0 | 0 | - | - | - |  | - |  | - | - | - | - | - |
| 8260B | Styrene | µg/L | 10 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | Tetrachloroethane, 1,1,1,2- | µg/L | 0.52 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | Tetrachloroethane, 1,1,2,2- | µg/L | 0.067 | 61 | 0 | 0% | 61 | - |  | - |  | - | - | - | - | - |
| 8260B | Tetrachloroethylene | µg/L | 5 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | Toluene | µg/L | 40 | 81 | 14 | 17% | 67 | 0.06 | J | 3.8 |  | HDMW2253-03 | 22-Oct-2014 | No | 0 | 0% |
| 8260B | trans-1,2- Dichloroethylene | µg/L | 100 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | Trichloroethylene | µg/L | 5 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | Vinyl chloride | µg/L | 2 | 79 | 0 | 0% | 79 | - |  | - |  | - | - | - | - | - |
| 8260B | Xylenes, Total (p/m-, o-xylene) | µg/L | 20 | 81 | 1 | 1% | 80 | 0.39 | J | 0.39 | J | OWDFMW01 | 21-Apr-2011 | No | 0 | 0% |
| 504.1 | 1,2-Dibromoethane | µg/L | 0.04 | 0 | 0 | - | - | - |  | - |  | - | - | - | - | - |
| 8260SIM | 1,2-Dibromoethane | µg/L | 0.04 | 7 | 0 | 0% | 7 | - |  | - |  | - | - | - | - | - |
| 8260SIM | 1,2-Dichloroethane | µg/L | 5 | 24 | 6 | 25% | 18 | 0.0009 | J | 0.012 | J | OWDFMW01 | 7/22/2015 | No | 0 | 0% |
| 8260SIM | Bromodichloromethane | µg/L | 0.12 | 24 | 3 | 13% | 21 | 0.0039 | B,J | 6.2 | J | RHMW06 | 1/19/2016 | Yes | 1 | 33% |
| 8260SIM | Dibromochloromethane | µg/L | 0.16 | 24 | 0 | 0% | 24 | - |  | - |  | - | - | - | - | - |
| 8260SIM | Tetrachloroethane, 1,1,2,2- | µg/L | 0.067 | 18 | 0 | 0% | 18 | - |  | - |  | - | - | - | - | - |
| 8011 | 1,2-Dibromo-3- chloropropane | µg/L | 0.04 | 24 | 0 | 0% | 24 | - |  | - |  | - | - | - | - | - |
| 8011 | 1,2-Dibromoethane | µg/L | 0.04 | 30 | 0 | 0% | 30 | - |  | - |  | - | - | - | - | - |
| 8270C | Acenaphthene | µg/L | 20 | 79 | 2 | 3% | 77 | 0.0063 | J | 0.0082 | J | OWDFMW01 | 19-Oct-2015 | No | 0 | 0% |
| 8270C | Acenaphthylene | µg/L | 240 | 79 | 1 | 1% | 78 | 0.0037 | J | 0.0037 | J | RHMW04 | 22-Apr-2015 | No | 0 | 0% |
| 8270C | Anthracene | µg/L | 22 | 79 | 1 | 1% | 78 | 0.0051 | J | 0.0051 | J | RHMW04 | 4/22/2015 | No | 0 | 0% |
| 8270C | Benz[a]anthracene | µg/L | 0.092 | 79 | 10 | 13% | 69 | 0.0027 | B,J | 0.0046 | J | OWDFMW01 | 7/22/2015* | No | 0 | 0% |

| Table D.7c | Outside Wells Summary Detect Statistics, Q2-2011 through Q1-2016 | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Screening | No. of | | Percent | No. of Non- | Detects | | | | Location of Max | Date Sampled of | Did Detects | No. of Detect | Percent Detect |
| Method | Analyte | Units | Criteria | Samples | No. of Detects | Detected | detects | Min | | Max | | Concentration | Max Concentration | Exceed EALs? | Exceedances | Exceedance |
| 8270C | Benzo[g,h,i]perylene | µg/L | 0.13 | 79 | 1 | 1% | 78 | 0.0076 | B,J | 0.0076 | B,J | RHMW04 | 19-Oct-2015 | No | 0 | 0% |
| 8270C | Benzo[a]pyrene | µg/L | 0.2 | 79 | 0 | 0% | 79 | - | | - | | - | - | - | - | - |
| 8270C | Benzo[b]fluoranthene | µg/L | 0.092 | 79 | 0 | 0% | 79 | - | | - | | - | - | - | - | - |
| 8270C | Benzo[k]fluoranthene | µg/L | 0.4 | 79 | 0 | 0% | 79 | - | | - | | - | - | - | - | - |
| 8270C | Chrysene | µg/L | 1 | 79 | 0 | 0% | 79 | - | | - | | - | - | - | - | - |
| 8270C | Dibenzo[a,h]anthracene | µg/L | 0.0092 | 79 | 1 | 1% | 78 | 0.011 | B,J | 0.011 | B,J | RHMW04 | 10/19/2015 | **Yes** | 1 | 100% |
| 8270C | Fluoranthene | µg/L | 130 | 79 | 0 | 0% | 79 | - | | - | | - | - | - | - | - |
| 8270C | Fluorene | µg/L | 240 | 79 | 4 | 5% | 75 | 0.0039 | J,X | 0.006 | J | RHMW04 | 22-Apr-2015 | No | 0 | 0% |
| 8270C | Indeno[1,2,3-cd]pyrene | µg/L | 0.092 | 79 | 1 | 1% | 78 | 0.0087 | B,J | 0.0087 | B,J | RHMW04 | 19-Oct-2015 | No | 0 | 0% |
| 8270C | 1-Methylnaphthalene | µg/L | 4.7 | 81 | 10 | 12% | 71 | 0.0043 | J | 0.03 | | OWDFMW01 | 19-Jan-2016 | No | 0 | 0% |
| 8270C | 2-Methylnaphthalene | µg/L | 10 | 81 | 14 | 17% | 67 | 0.0047 | B,J | 0.02 | | OWDFMW01 | 19-Jan-2016 | No | 0 | 0% |
| 8270C | Naphthalene | µg/L | 17 | 81 | 32 | 40% | 49 | 0.0038 | J | 0.16 | J | HDMW2253-03 | 24-Apr-2013 | No | 0 | 0% |
| 8270C | Phenanthrene | µg/L | 240 | 79 | 9 | 11% | 70 | 0.0063 | J | 0.014 | J | OWDFMW01 | 22-Jul-2015 | No | 0 | 0% |
| 8270C | Pyrene | µg/L | 68 | 79 | 1 | 1% | 78 | 0.0063 | J | 0.0063 | J | OWDFMW01 | 7/22/2015* | No | 0 | 0% |
| 6020 | Dissolved Lead (filtered) | µg/L | 15 | 79 | 39 | 49% | 40 | 0.006 | J | 0.9 | | HDMW2253-03 | 26-Oct-2011 | No | 0 | 0% |
| 6010B/6020/200.8 | Total Lead (unfiltered) | µg/L | - | 0 | 0 | - | - | | | | | | | - | | - |

Notes:

Outside tunnel wells include sampling locations RHMW04, RHMW06, RHMW07, OWDFMW01, and HDMW2253-03.

Screening criteria based on the regulatory agencies' February 4, 2016 scoping completion letter and the DOH Tier 1 Environmental Action Levels, Table D-1b. Groundwater Action Levels (Groundwater IS a current or potential drinking water resource, surface water body IS NOT located within 150 meters of release site).

**Blue text** indicates analyte reported at concentrations above screening criterion.

Qualifiers:

B = analyte was present in the associated method blank
BU - sample analyzed after holding time expired
D = the reported result is from a dilution
ICH = Initial calibration verification recovery above method calibration level for this analyte
HD, Z = the chromatographic pattern was inconsistent with the profile of the reference fuel standard
J = indicates an estimated value
X = possible high bias due to matrix interference

# Appendix D.7: Well Summary Stats 5-year (2011–2016)
## WP/SOW, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, RHSF, JBPHH, O‘ahu, HI

Table D.7b Outside Wells Summary Non-Detect Statistics, Q2-2011 through Q1-2016

| Method | Analyte | Units | Screening Criteria | No. of Samples | No. of Non-Detects | Percent Non-Detect | Non-Detects | | | | Did Non-Detects Exceed EALs? | No. of Non-Detect Exceedances | Percent Non-Detect Exceedance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Min | | Max | | | | |
| 8015 | TPH-d | µg/L | 100 | 81 | 26 | 32% | 12 | U | 86 | U | No | 0 | 0% |
| 8015 | TPH-g | µg/L | 100 | 30 | 29 | 97% | 20 | U | 25 | U | No | 0 | 0% |
| 8015 | TPH-o | µg/L | 100 | 36 | 20 | 56% | 50 | U | 212 | U | **Yes** | 6 | 30% |
| 8260B | TPH-g | µg/L | 100 | 49 | 39 | 80% | 12.12 | U | 30 | U | No | 0 | 0% |
| 8260B | 1,1,1-Trichloroethane | µg/L | 200 | 79 | 79 | 100% | 0.2 | U | 0.5 | U | No | 0 | 0% |
| 8260B | 1,1,2-Trichloroethane | µg/L | 5 | 79 | 79 | 100% | 0.4 | U | 0.5 | U | No | 0 | 0% |
| 8260B | 1,1-Dichloroethane | µg/L | 2.4 | 79 | 79 | 100% | 0.2 | U | 0.5 | U | No | 0 | 0% |
| 8260B | 1,1-Dichloroethylene | µg/L | 7 | 79 | 79 | 100% | 0.2 | U | 0.6 | U | No | 0 | 0% |
| 8260B | 1,2,3-Trichloropropane | µg/L | 0.6 | 79 | 79 | 100% | 0.5 | U | 1 | U | **Yes** | 55 | 70% |
| 8260B | 1,2,4-Tricholorobenzene | µg/L | 70 | 79 | 79 | 100% | 0.3 | U | 1 | U | No | 0 | 0% |
| 8260B | 1,2-Dibromo-3- chloropropane | µg/L | 0.04 | 79 | 79 | 100% | 0.8 | U | 5 | U | **Yes** | 79 | 100% |
| 8260B | 1,2-Dibromoethane | µg/L | 0.04 | 79 | 79 | 100% | 0.2 | U | 0.5 | U | **Yes** | 79 | 100% |
| 8260B | 1,2-Dichlorobenzene | µg/L | 10 | 79 | 79 | 100% | 0.2 | U | 0.5 | U | No | 0 | 0% |
| 8260B | 1,2-Dichloroethane | µg/L | 5 | 55 | 55 | 100% | 0.1 | U | 0.5 | U | No | 0 | 0% |
| 8260B | 1,2-Dichloropropane | µg/L | 5 | 79 | 79 | 100% | 0.2 | U | 0.5 | U | No | 0 | 0% |
| 8260B | 1,3-Dichlorobenzene | µg/L | 5 | 79 | 79 | 100% | 0.2 | U | 0.5 | U | No | 0 | 0% |
| 8260B | 1,3-Dichloropropene (total of cis/trans) | µg/L | 0.43 | 79 | 79 | 100% | 0.2 | U | 0.5 | U | **Yes** | 33 | 42% |
| 8260B | 1,4-Dichlorobenzene | µg/L | 5 | 79 | 79 | 100% | 0.2 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Acetone | µg/L | 1500 | 79 | 48 | 61% | 1.9 | U | 10 | U | No | 0 | 0% |
| 8260B | Benzene | µg/L | 5 | 81 | 60 | 74% | 0.1 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Bromodichloromethane | µg/L | 0.12 | 55 | 54 | 98% | 0.28 | U | 0.5 | U | **Yes** | 54 | 100% |
| 8260B | Bromoform | µg/L | 80 | 79 | 79 | 100% | 0.28 | U | 1 | U | No | 0 | 0% |
| 8260B | Bromomethane | µg/L | 8.7 | 79 | 79 | 100% | 0.3 | U | 5 | U | No | 0 | 0% |
| 8260B | Carbon Tetrachloride | µg/L | 5 | 79 | 79 | 100% | 0.1 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Chlorobenzene | µg/L | 50 | 79 | 79 | 100% | 0.2 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Chloroethane | µg/L | 16 | 79 | 79 | 100% | 0.2 | U | 5 | U | No | 0 | 0% |
| 8260B | Chloroform | µg/L | 70 | 79 | 79 | 100% | 0.14 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Chloromethane | µg/L | 1.8 | 79 | 73 | 92% | 0.2 | U | 5 | U | **Yes** | 33 | 45% |
| 8260B | cis-1,2-Dichloroethylene | µg/L | 70 | 79 | 79 | 100% | 0.2 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Dibromochloromethane | µg/L | 0.16 | 55 | 55 | 100% | 0.3 | U | 0.5 | U | **Yes** | 55 | 100% |
| 8260B | Ethylbenzene | µg/L | 30 | 81 | 81 | 100% | 0.1 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Hexachlorobutadiene | µg/L | 0.86 | 79 | 79 | 100% | 0.3 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Methyl ethyl ketone (2-Butanone) | µg/L | 7,100 | 79 | 78 | 99% | 1.2 | U | 5 | U | No | 0 | 0% |
| 8260B | Methyl isobutyl ketone (4-Methyl-2-Pentanone) | µg/L | 170 | 79 | 79 | 100% | 3.8 | U | 10 | U | No | 0 | 0% |
| 8260B | Methyl tert-butyl Ether | µg/L | 5 | 79 | 79 | 100% | 0.3 | U | 0.52 | U | No | 0 | 0% |
| 8260B | Methylene chloride | µg/L | 4.8 | 79 | 77 | 97% | 0.2 | U | 1 | U | No | 0 | 0% |
| 8260B | Naphthalene | µg/L | 17 | 0 | 0 | - | - | | - | | - | | - |
| 8260B | Styrene | µg/L | 10 | 79 | 79 | 100% | 0.2 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Tetrachloroethane, 1,1,1,2- | µg/L | 0.52 | 79 | 79 | 100% | 0.2 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Tetrachloroethane, 1,1,2,2- | µg/L | 0.067 | 61 | 61 | 100% | 0.2 | U | 15 | U | **Yes** | 61 | 100% |
| 8260B | Tetrachloroethylene | µg/L | 5 | 79 | 79 | 100% | 0.2 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Toluene | µg/L | 40 | 81 | 67 | 83% | 0.1 | U | 0.5 | U | No | 0 | 0% |
| 8260B | trans-1,2- Dichloroethylene | µg/L | 100 | 79 | 79 | 100% | 0.2 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Trichloroethylene | µg/L | 5 | 79 | 79 | 100% | 0.1 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Vinyl chloride | µg/L | 2 | 79 | 79 | 100% | 0.1 | U | 0.5 | U | No | 0 | 0% |
| 8260B | Xylenes, Total (p/m-, o-xylene) | µg/L | 20 | 81 | 80 | 99% | 0.2 | U | 1 | U | No | 0 | 0% |
| 504.1 | 1,2-Dibromoethane | µg/L | 0.04 | 0 | 0 | - | - | | - | | - | - | - |
| 8260SIM | 1,2-Dibromoethane | µg/L | 0.04 | 7 | 7 | 100% | 0.01 | U | 0.01 | U | No | 0 | 0% |
| 8260SIM | 1,2-Dichloroethane | µg/L | 5 | 24 | 18 | 75% | 0.015 | U | 0.015 | U | No | 0 | 0% |
| 8260SIM | Bromodichloromethane | µg/L | 0.12 | 24 | 21 | 88% | 0.01 | U | 0.01 | U | No | 0 | 0% |
| 8260SIM | Dibromochloromethane | µg/L | 0.16 | 24 | 24 | 100% | 0.01 | U | 0.01 | U | No | 0 | 0% |
| 8260SIM | Tetrachloroethane, 1,1,2,2- | µg/L | 0.067 | 18 | 18 | 100% | 0.015 | U | 0.015 | U | No | 0 | 0% |
| 8011 | 1,2-Dibromo-3- chloropropane | µg/L | 0.04 | 24 | 24 | 100% | 0.004 | U | 0.019 | U | No | 0 | 0% |
| 8011 | 1,2-Dibromoethane | µg/L | 0.04 | 30 | 30 | 100% | 0.004 | U | 0.02 | U | No | 0 | 0% |
| 8270C | Acenaphthene | µg/L | 20 | 79 | 77 | 97% | 0.005 | U | 0.12 | U | No | 0 | 0% |
| 8270C | Acenaphthylene | µg/L | 240 | 79 | 78 | 99% | 0.005 | U | 0.12 | U | No | 0 | 0% |
| 8270C | Anthracene | µg/L | 22 | 79 | 78 | 99% | 0.005 | U | 0.1 | U | No | 0 | 0% |
| 8270C | Benz[a]anthracene | µg/L | 0.092 | 79 | 69 | 87% | 0.005 | U | 0.14 | U | **Yes** | 16 | 23% |

Table D.7b Outside Wells Summary Non-Detect Statistics, Q2-2011 through Q1-2016

| Method | Analyte | Units | Screening Criteria | No. of Samples | No. of Non-Detects | Percent Non-Detect | Non-Detects |  |  |  | Did Non-Detects Exceed EALs? | No. of Non-Detect Exceedances | Percent Non-Detect Exceedance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  | Min |  | Max |  |  |  |  |
| 8270C | Benzo[g,h,i]perylene | µg/L | 0.13 | 79 | 78 | 99% | 0.005 | U | 0.16 | U | **Yes** | 16 | 21% |
| 8270C | Benzo[a]pyrene | µg/L | 0.2 | 79 | 79 | 100% | 0.005 | U | 0.14 | U | No | 0 | 0% |
| 8270C | Benzo[b]fluoranthene | µg/L | 0.092 | 79 | 79 | 100% | 0.005 | U | 0.12 | U | **Yes** | 16 | 20% |
| 8270C | Benzo[k]fluoranthene | µg/L | 0.4 | 79 | 79 | 100% | 0.005 | U | 0.14 | U | No | 0 | 0% |
| 8270C | Chrysene | µg/L | 1 | 79 | 79 | 100% | 0.005 | U | 0.1 | U | No | 0 | 0% |
| 8270C | Dibenzo[a,h]anthracene | µg/L | 0.0092 | 79 | 78 | 99% | 0.005 | U | 0.1 | U | **Yes** | 55 | 71% |
| 8270C | Fluoranthene | µg/L | 130 | 79 | 79 | 100% | 0.0096 | U | 0.16 | U | No | 0 | 0% |
| 8270C | Fluorene | µg/L | 240 | 79 | 75 | 95% | 0.005 | U | 0.12 | U | No | 0 | 0% |
| 8270C | Indeno[1,2,3-cd]pyrene | µg/L | 0.092 | 79 | 78 | 99% | 0.005 | U | 0.14 | U | **Yes** | 16 | 21% |
| 8270C | 1-Methylnaphthalene | µg/L | 4.7 | 81 | 71 | 88% | 0.005 | U | 0.12 | U | No | 0 | 0% |
| 8270C | 2-Methylnaphthalene | µg/L | 10 | 81 | 67 | 83% | 0.005 | U | 0.12 | U | No | 0 | 0% |
| 8270C | Naphthalene | µg/L | 17 | 81 | 49 | 60% | 0.005 | U | 0.1 | U | No | 0 | 0% |
| 8270C | Phenanthrene | µg/L | 240 | 79 | 70 | 89% | 0.005 | U | 0.14 | U | No | 0 | 0% |
| 8270C | Pyrene | µg/L | 68 | 79 | 78 | 99% | 0.0096 | U | 0.16 | U | No | 0 | 0% |
| 6020 | Dissolved Lead (filtered) | µg/L | 15 | 79 | 40 | 51% | 0.2 | U | 0.8 | U | No | 0 | 0% |
| 6010B/6020/200.8 | Total Lead (unfiltered) | µg/L | - | 0 | 0 | - | - |  | - |  | - | - | - |

Notes:

Outside tunnel wells include sampling locations RHMW04, RHMW06, RHMW07, OWDFMW01, and HDMW2253-03.

Screening criteria based on the regulatory agencies' February 4, 2016 scoping completion letter and the DOH Tier 1 Environmental Action Levels, Table D-1b. Groundwater Action Levels (Groundwater IS a current or potential drinking water resource, surface water body IS NOT located within 150 meters of release site).

**Blue text** indicates non-detect above screening criterion.

Qualifiers:

U = non-detect

Table D.8a All Inside Wells, Lead and Lead Scavengers

| Method | Analyte | Units | Screening Criteria | No. of Samples | No. of Detects | Percent Detected | No. of Non-detects | Detects | | | | Location of Max Concentration | Date Sampled of Max Concentration | Did Detects Exceed EALs? | No. of Detect Exceedances | Percent Detect Exceedance | Non-Detects | | | | Did Non-Detects Exceed EALs? | No. of Non-Detect Exceedances | Percent Non-Detect Exceedance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Min | | Max | | | | | | | Min | | Max | | | | |
| 504.1 | 1,2-Dibromoethane | µg/L | 0.04 | 19 | 0 | 0% | 19 | - | | - | | - | - | - | - | - | 0.0081 | U | 0.0097 | U | No | 0 | 0% |
| 8260SIM | 1,2-Dibromoethane | µg/L | 0.04 | 6 | 0 | 0% | 6 | - | | - | | - | - | - | - | - | 0.01 | U | 0.01 | U | No | 0 | 0% |
| 8260SIM | 1,2-Dichloroethane | µg/L | 5 | 22 | 0 | 0% | 22 | - | | - | | - | - | - | - | - | 0.015 | U | 0.015 | U | No | 0 | 0% |
| 8011 | 1,2-Dibromoethane | µg/L | 0.04 | 24 | 0 | 0% | 24 | - | | - | | - | - | - | - | - | 0.004 | U | 0.004 | U | No | 0 | 0% |
| 6020 | Dissolved Lead (filtered) | µg/L | 15 | 249 | 83 | 33% | 166 | 0.011 | J | 11.9 | | RHMW01 | 17-Feb-2005 | No | 0 | 0% | 0.2 | U | 5 | U | No | 0 | 0% |
| 6010B/6020/200.8 | Total Lead (unfiltered) | µg/L | - | 30 | 19 | 63% | 11 | 0.036 | | 19.6 | | RHMW01 | 20-Sep-2005 | No | 0 | 0% | 0.0898 | U | 10 | U | No | 0 | 0% |

Notes:

Lead scavengers were analyzed:

- for RHMW01, during all 2005 sampling events, and during the Q2-2015 through Q1-2016 events.
- for RHMW02, during the Q2-2015 through Q1-2016 events.
- for RHMW03, during the Q2-2015 through Q1-2016 events.
- for RHMW05, during the Q2-2015 through Q1-2016 events.
- for RHMW2254, during all 2005 sampling events, and during the Q2-2015 through Q1-2016 events.

Lead results are presented for comparison purposes with the lead scavenger analytes (i.e., 1,2-dibromoethane [EDB] and 1,2-dichloroethane).

Screening criteria based on the regulatory agencies' February 4, 2016 scoping completion letter and the DOH Tier 1 Environmental Action Levels, Table D-1b. Groundwater Action Levels (Groundwater IS a current or potential drinking water resource, surface water body IS NOT located within 150 meters of release site).

Qualifiers:

J = estimated value

U = non-detect

# Appendix D.8: Lead Scavenger Statistics
# WP/SOW, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, RHSF, JBPHH, O‘ahu, HI

Table D.8b All Outside Wells, Lead and Lead Scavengers

| Method | Analyte | Units | Screening Criteria | No. of Samples | No. of Detects | Percent Detected | No. of Non-Detects | Detects Min | | Detects Max | | Location of Max Concentration | Date Sampled of Max Concentration | Did Detects Exceed EALs? | No. of Detect Exceedances | Percent Detect Exceedance | Non-Detects Min | | Non-Detects Max | | Did Non-Detects Exceed EALs? | No. of Non-Detect Exceedances | Percent Non-Detect Exceedance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8260SIM | 1,2-Dibromoethane | µg/L | 0.04 | 7 | 0 | 0% | 7 | - | | - | | - | - | - | - | - | 0.01 | U | 0.01 | U | No | 0 | 0% |
| 8260SIM | 1,2-Dichloroethane | µg/L | 5 | 24 | 6 | 25% | 18 | 0.0009 | J | 0.012 | J | OWDFMW01 | 22-Jul-2015 | No | 0 | 0% | 0.015 | U | 0.015 | U | No | 0 | 0% |
| 8011 | 1,2-Dibromoethane | µg/L | 0.04 | 30 | 0 | 0% | 30 | - | | - | | - | - | - | - | - | 0.0040 | U | 0.02 | U | No | 0 | 0% |
| 6020 | Dissolved Lead | µg/L | 15 | 102 | 42 | 41% | 60 | 0.006 | J | 0.9 | | HDMW2253-03 | 26-Oct-2011 | No | 0 | 0% | 0.2 | U | 10 | U | No | 0 | 0% |

Notes:

Lead scavengers were analyzed for all outside wells during the Q2-2015 through Q1-2016 sampling events.

Lead results are presented for comparison purposes with the lead scavenger analytes (i.e., 1,2-dibromoethane [EDB] and 1,2-dichloroethane).

Screening criteria based on the regulatory agencies' February 4, 2016 scoping completion letter and the DOH Tier 1 Environmental Action Levels, Table D-1b. Groundwater Action Levels (Groundwater IS a current or potential drinking water resource, surface water body IS NOT located within 150 meters of release site).

Qualifiers:

J = estimated value

U = non-detect

Table D.9-1 Soil Vapor Results for SV02 (ppbv)
Historical Soil Vapor Results - March 2008 Through Present Event

| Date | SV02S | SV02M | SV02D |
|---|---|---|---|
| 3/24/2008 | NC | NC | NC |
| 5/6/2008 | 129 | 252 | 157 |
| 5/29/2008 | 1785 | 1217 | 657 |
| 7/3/2008 | 1090 | 984 | 525 |
| 7/31/2008 | 728 | 677 | 437 |
| 9/2/2008 | 754 | 693 | 434 |
| 9/29/2008 | 520 | 553 | 456 |
| 10/23/2008 | 493 | 555 | 413 |
| 11/25/2008 | 3396 | 1762 | 2792 |
| 1/14/2009 | 89 | 329 | 312 |
| 2/5/2009 | 188 | 264 | 202 |
| 2/26/2009 | 1912 | 348 | 184 |
| 4/1/2009 | 169 | 195 | 102 |
| 4/20/2009 | 704 | 557 | 504 |
| 5/27/2009 | 1473 | 835 | 799 |
| 6/29/2009 | 2141 | 659 | 511 |
| 7/20/2009 | 1360 | 628 | 544 |
| 8/28/2009 | 564 | 318 | 258 |
| 9/24/2009 | 488 | 294 | 241 |
| 10/29/2009 | 999 | 425 | 533 |
| 11/19/2009 | 305 | 283 | 241 |
| 12/16/2009 | 356 | 284 | 238 |
| 1/28/2010 | 684 | 283 | 299 |
| 2/22/2010 | 364 | 159 | 135 |
| 3/25/2010 | 394 | 340 | 277 |
| 4/28/2010 | 385 | 282 | 209 |
| 5/26/2010 | 374 | 252 | 294 |
| 6/28/2010 | 400 | 253 | 223 |
| 7/28/2010 | 332 | 232 | 205 |
| 9/29/2010 | 224 | 217 | 207 |
| 10/18/2010 | 525 | 577 | 565 |
| 11/16/2010 | 303 | 424 | 338 |
| 12/14/2010 | 313 | 416 | 330 |
| 1/14/2011 | 494 | 357 | 651 |
| 2/15/2011 | 280 | 298 | 283 |
| 3/15/2011 | 221 | 208 | 217 |
| 4/18/2011 | 327 | 270 | 305 |
| 5/18/2011 | 980 | 562 | 755 |
| 6/22/2011 | 184 | 205 | 162 |
| 7/27/2011 | 101 | 83 | 86 |
| 9/22/2011 | 318 | 268 | 313 |
| 10/27/2011 | 270 | 241 | 211 |
| 11/22/2011 | 235 | 226 | 183 |
| 12/16/2011 | 408 | 333 | 397 |
| 1/20/2012 | 103 | 111 | 239 |
| 2/23/2012 | 132 | 167 | 161 |
| 3/13/2012 | 222 | 155 | 58 |
| 4/16/2012 | 115 | 92 | 149 |
| 5/15/2012 | 146 | 145 | 131 |
| 6/19/2012 | 292 | 276 | 230 |
| 7/10/2012 | 206 | 184 | 194 |
| 8/14/2012 | 389 | 362 | 348 |
| 10/24/2012 | 166 | 139 | 144 |
| 11/26/2012 | 101 | 72 | 110 |
| 12/18/2012 | 106 | 83 | 97 |
| 1/31/2013 | 546 | 914 | 966 |
| 2/28/2013 | 47 | 26 | 18 |
| 3/28/2013 | 12 | 12 | 5 |
| 4/25/2013 | 13 | 15 | 18 |
| 5/30/2013 | 204 | 153 | 176 |
| 6/27/2013 | 13 | 15 | 15 |
| 7/25/2013 | 258 | 252 | 316 |
| 8/29/2013 | 165 | 28 | 11 |
| 9/26/2013 | 304 | 263 | 306 |
| 10/24/2013 | 281 | 271 | 285 |
| 11/21/2013 | 186 | 172 | 140 |
| 12/23/2013 | 21 | 33 | 61 |
| 1/30/2014 | 11 | 11 | 8 |
| 2/24/2014 | 135 | 51 | 82 |
| 3/5/2014 | 1 | 0 | 0 |
| 3/10/2014 | 1 | 11 | 1 |
| 3/25/2014 | 146 | 19 | 47 |
| 4/7/2014 | 575 | 342 | 308 |
| 4/22/2014 | 739 | 610 | 662 |
| 5/8/2014 | 481 | 308 | 333 |
| 5/21/2014 | 344 | 280 | 278 |
| 5/27/2014 | 481 | 697 | 413 |
| 6/11/2014 | 527 | 475 | 468 |
| 6/23/2014 | 170 | 183 | 169 |
| 7/21/2014 | 527 | 392 | 426 |
| 8/27/2014 | 180 | 105 | 199 |
| 9/25/2014 | 1028 | 827 | 830 |
| 10/29/2014 | 409 | 227 | 164 |
| 11/20/2014 | 194 | 167 | 309 |
| 12/23/2014 | 810 | 811 | 715 |
| 1/28/2015 | 3808 | 2150 | 2530 |
| 2/27/2015 | 129 | 160 | 133 |
| 3/26/2015 | 360 | 115 | 176 |
| 4/20/2015 | 157 | 123 | 164 |
| 5/28/2015 | 1285 | 1146 | 1011 |
| 6/25/2015 | 159 | 172 | 248 |
| 7/20/2015 | 238 | 187 | 243 |
| 8/27/2015 | 196 | 199 | 270 |
| 9/23/2015 | 341 | 305 | 311 |
| 10/20/2015 | 276 | 314 | 323 |
| 11/18/2015 | NC1 | NC1 | NC1 |
| 12/17/2015 | 320 | 904 | 226 |
| 1/20/2016 | 739 | 616 | 731 |
| 2/17/2016 | 671 | 664 | 662 |
| 3/15/2016 | 550 | 565 | 512 |

ppbv = parts per billion by volume
NC = Not collected
NC1 = Not collected due to maintenance work being performed on the tank

Table D.9-2 Soil Vapor Results for SV03 (ppbv)

Historical Soil Vapor Results - March 2008 Through Present Event

| Date | SV03S | SV03M | SV03D |
|---|---|---|---|
| 3/24/2008 | 458 | 248 | 579 |
| 5/6/2008 | 668 | 521 | 328 |
| 5/29/2008 | 652 | 685 | 458 |
| 7/3/2008 | 1504 | 1044 | 1024 |
| 7/31/2008 | 1313 | 1245 | 951 |
| 9/2/2008 | 1645 | 1458 | 1237 |
| 9/29/2008 | 4425 | 3982 | 1804 |
| 10/23/2008 | 1423 | 1261 | 1058 |
| 11/25/2008 | 1060 | 1417 | 742 |
| 1/14/2009 | 4658 | 1593 | 1635 |
| 2/5/2009 | 710 | 1756 | 1470 |
| 2/26/2009 | 2616 | 1486 | 822 |
| 4/1/2009 | 407 | 611 | 571 |
| 4/20/2009 | 419 | 573 | 546 |
| 5/27/2009 | 568 | 528 | 481 |
| 6/29/2009 | 592 | 665 | 662 |
| 7/20/2009 | 1000 | 971 | 1272 |
| 8/28/2009 | 615 | 703 | 587 |
| 9/24/2009 | 658 | 838 | 860 |
| 10/29/2009 | 782 | 816 | 902 |
| 11/19/2009 | 697 | 707 | 740 |
| 12/16/2009 | 553 | 800 | 632 |
| 1/28/2010 | 531 | 569 | 575 |
| 2/22/2010 | 469 | 641 | 457 |
| 3/25/2010 | 410 | 919 | 750 |
| 4/28/2010 | 478 | 733 | 642 |
| 5/26/2010 | 467 | 470 | 621 |
| 6/28/2010 | 540 | 645 | 582 |
| 7/28/2010 | 504 | 528 | 520 |
| 9/29/2010 | 242 | 257 | 259 |
| 10/18/2010 | 876 | 691 | 863 |
| 11/16/2010 | 492 | 367 | 581 |
| 12/14/2010 | 178 | 463 | 732 |
| 1/14/2011 | 436 | 555 | 627 |
| 2/15/2011 | 438 | 474 | 542 |
| 3/15/2011 | 272 | 300 | 350 |
| 4/18/2011 | 354 | 316 | 401 |
| 5/18/2011 | 565 | 672 | 840 |
| 6/22/2011 | 386 | 268 | 328 |
| 7/27/2011 | 126 | 115 | 127 |
| 8/26/2011 | 108 | 94 | 146 |
| 9/22/2011 | 318 | 309 | 346 |
| 10/27/2011 | 246 | 294 | 269 |
| 11/22/2011 | 265 | 265 | 338 |
| 12/16/2011 | 274 | 218 | 161 |
| 1/20/2012 | 223 | 101 | 151 |
| 2/23/2012 | 150 | 174 | 190 |
| 3/13/2012 | 173 | 341 | 104 |
| 4/16/2012 | 230 | 100 | 131 |
| 5/15/2012 | 166 | 162 | 196 |
| 6/19/2012 | 329 | 422 | 402 |
| 7/10/2012 | 245 | 246 | 265 |
| 8/14/2012 | 356 | 365 | 410 |
| 10/24/2012 | 246 | 178 | 168 |
| 11/26/2012 | 108 | 136 | 139 |
| 12/18/2012 | 109 | 79 | 78 |
| 1/31/2013 | 17 | 12 | 54 |
| 2/28/2013 | 215 | 104 | 127 |
| 3/28/2013 | 52 | 15 | 42 |
| 4/25/2013 | 27 | 34 | 39 |
| 5/30/2013 | 145 | 160 | 141 |
| 6/27/2013 | 25 | 35 | 35 |
| 7/25/2013 | 179 | 146 | 145 |
| 8/29/2013 | 8 | 2 | 13 |
| 9/26/2013 | 49 | 27 | 35 |
| 10/24/2013 | 277 | 277 | 277 |
| 11/21/2013 | 128 | 150 | 129 |
| 12/23/2013 | 8 | 6 | 17 |
| 1/30/2014 | 41 | 46 | 9444 |
| 2/24/2014 | 70 | 162 | 5290 |
| 3/5/2014 | 20 | 17 | 26800 |
| 3/10/2014 | 8 | 27 | 5922 |
| 3/25/2014 | 87 | 385 | 274000 |
| 4/7/2014 | 676 | 1054 | 12300 |
| 4/22/2014 | 1056 | 1266 | 2442 |
| 5/8/2014 | 877 | 1096 | 1525 |
| 5/21/2014 | 1085 | 1378 | 1864 |
| 5/27/2014 | 915 | 1278 | 1536 |
| 6/11/2014 | 1148 | 1138 | 1424 |
| 6/23/2014 | 1970 | 2931 | 3530 |
| 7/21/2014 | 1021 | 1133 | 1215 |
| 8/27/2014 | 749 | 885 | 1050 |
| 9/25/2014 | 1298 | 1214 | 1187 |
| 10/29/2014 | 199 | 222 | 254 |
| 11/20/2014 | 731 | 919 | 856 |
| 12/23/2014 | 1403 | 1860 | 2004 |
| 1/28/2015 | 8037 | 10300 | 8075 |
| 2/27/2015 | 422 | 2231 | 435 |
| 3/26/2015 | 210 | 236 | 554 |
| 4/20/2015 | 363 | 422 | 436 |
| 5/28/2015 | 5289 | 6657 | 6075 |
| 6/25/2015 | 287 | 435 | 386 |
| 7/20/2015 | 849 | 880 | 880 |
| 8/27/2015 | 381 | 496 | 576 |
| 9/23/2015 | 2316 | 1334 | 1223 |
| 10/20/2015 | 488 | 552 | 619 |
| 11/18/2015 | 469 | 451 | 435 |
| 12/17/2015 | 418 | 434 | 506 |
| 1/20/2016 | 844 | 908 | 963 |
| 2/17/2016 | 761 | 801 | 888 |
| 3/15/2016 | 747 | 832 | 841 |

ppbv = parts per billion by volume

Action Level (ppbv) = 280,000

Table D.9-3 Soil Vapor Results for SV04 (ppbv)
Historical Soil Vapor Results - March 2008 Through Present Event

| Date | SV04S | SV04M | SV04D |
|---|---|---|---|
| 3/24/2008 | 468 | 641 | 827 |
| 5/6/2008 | 1076 | 1235 | 1228 |
| 5/29/2008 | 613 | 634 | 681 |
| 7/3/2008 | 696 | 898 | 806 |
| 7/31/2008 | 836 | 1009 | 1144 |
| 9/2/2008 | 972 | 1270 | 1233 |
| 9/29/2008 | 941 | 1454 | 1436 |
| 10/23/2008 | 802 | 1192 | 1321 |
| 11/25/2008 | 460 | 799 | 893 |
| 1/14/2009 | 72 | 1081 | 1138 |
| 2/5/2009 | 136 | 561 | 746 |
| 2/26/2009 | 1920 | 1147 | 847 |
| 4/1/2009 | 365 | 586 | 608 |
| 4/20/2009 | 465 | 662 | 695 |
| 5/27/2009 | 489 | 627 | 740 |
| 6/29/2009 | 526 | 714 | 796 |
| 7/20/2009 | 603 | 1354 | 1010 |
| 8/28/2009 | 511 | 647 | 751 |
| 9/24/2009 | 609 | 734 | 846 |
| 10/29/2009 | 682 | 931 | 881 |
| 11/19/2009 | 569 | 739 | 788 |
| 12/16/2009 | 464 | 655 | 726 |
| 1/28/2010 | 448 | 592 | 616 |
| 2/22/2010 | 381 | 555 | 713 |
| 3/25/2010 | 539 | 761 | 656 |
| 4/28/2010 | 505 | 627 | 683 |
| 5/26/2010 | 463 | 618 | 600 |
| 6/28/2010 | 460 | 582 | 626 |
| 7/28/2010 | 449 | 566 | 588 |
| 9/29/2010 | 297 | 306 | 318 |
| 10/18/2010 | 715 | 843 | 788 |
| 11/16/2010 | 422 | 644 | 440 |
| 12/14/2010 | 335 | 306 | 270 |
| 1/14/2011 | 568 | 555 | 633 |
| 2/15/2011 | 501 | 609 | 609 |
| 3/15/2011 | 292 | 375 | 471 |
| 4/18/2011 | 394 | 475 | 394 |
| 5/18/2011 | 652 | 983 | 978 |
| 6/22/2011 | 356 | 339 | 317 |
| 7/27/2011 | 102 | 187 | 162 |
| 8/26/2011 | 137 | 205 | 162 |
| 9/22/2011 | 359 | 373 | 363 |
| 10/27/2011 | 236 | 281 | 238 |
| 11/22/2011 | 337 | 356 | 345 |
| 12/16/2011 | 709 | 799 | 652 |
| 1/20/2012 | 104 | 121 | 141 |
| 2/23/2012 | 175 | 209 | 436 |
| 3/13/2012 | 146 | 139 | 114 |
| 4/16/2012 | 241 | 141 | 116 |
| 5/15/2012 | 224 | 228 | 253 |
| 6/19/2012 | 360 | 464 | 404 |
| 7/10/2012 | 276 | 287 | 289 |
| 8/14/2012 | 340 | 351 | 358 |
| 10/24/2012 | 221 | 162 | 155 |
| 11/26/2012 | 138 | 187 | 159 |
| 12/18/2012 | 85 | 99 | 66 |
| 1/31/2013 | 38 | 54 | 423 |
| 2/28/2013 | 87 | 79 | 51 |
| 3/28/2013 | 12 | 24 | 24 |
| 4/25/2013 | 28 | 39 | 36 |
| 5/30/2013 | 117 | 131 | 135 |
| 6/27/2013 | 16 | 23 | 26 |
| 7/25/2013 | 115 | 130 | 123 |
| 8/29/2013 | 121 | 192 | 190 |
| 9/26/2013 | 5 | 18 | 11 |
| 10/24/2013 | 295 | 285 | 254 |
| 11/21/2013 | 98 | 129 | 159 |
| 12/23/2013 | 4 | 14 | 11 |
| 1/30/2014 | 132 | 165 | 135 |
| 2/24/2014 | 163 | 149 | 138 |
| 3/5/2014 | 536 | 493 | 520 |
| 3/10/2014 | 116 | 51 | 72 |
| 3/25/2014 | 9682 | 11800 | 9134 |
| 4/7/2014 | 1382 | 1217 | 1035 |
| 4/22/2014 | 769 | 948 | 870 |
| 5/8/2014 | 658 | 721 | 748 |
| 5/21/2014 | 666 | 861 | 944 |
| 5/27/2014 | 540 | 670 | 817 |
| 6/11/2014 | 657 | 762 | 754 |
| 6/23/2014 | 98 | 1075 | 1233 |
| 7/21/2014 | 557 | 625 | 735 |
| 8/27/2014 | 245 | 296 | 210 |
| 9/25/2014 | 614 | 612 | 512 |
| 10/29/2014 | 194 | 136 | 139 |
| 11/202014 | 409 | 315 | 373 |
| 12/232014 | 1265 | 1311 | 1483 |
| 1/28/2015 | 14800 | 13400 | 14800 |
| 2/27/2015 | 370 | 343 | 217 |
| 3/26/2015 | 682 | 488 | 814 |
| 4/20/2015 | 339 | 336 | 268 |
| 5/28/2015 | 8401 | 8427 | 10500 |
| 6/25/2015 | 233 | 276 | 295 |
| 7/20/2015 | 179 | 241 | 385 |
| 8/27/2015 | 209 | 357 | 406 |
| 9/23/2015 | 460 | 376 | 304 |
| 10/20/2015 | 489 | 541 | 627 |
| 11/18/2015 | 425 | 395 | 405 |
| 12/17/2015 | 323 | 310 | 320 |
| 1/20/2016 | 543 | 557 | 602 |
| 2/17/2016 | 617 | 594 | 585 |
| 3/15/2016 | 520 | 515 | 501 |

ppbv = parts per billion by volume

Table D.9-4 Soil Vapor Results for SV05 (ppbv)

Historical Soil Vapor Results - March 2008 Through Present Event

| Date | SV05S | SV05M | SV05D |
|---|---|---|---|
| 3/24/2008 | 1295 | 716 | 697 |
| 5/6/2008 | 5441 | 4214 | 4012 |
| 5/29/2008 | 6523 | 4636 | 3984 |
| 7/3/2008 | 5195 | 4218 | 3957 |
| 7/31/2008 | 5190 | 3785 | 2894 |
| 9/2/2008 | 6905 | 5581 | 3681 |
| 9/29/2008 | 7149 | 6405 | 3960 |
| 10/23/2008 | 3497 | 3690 | 2518 |
| 11/25/2008 | 3750 | 5221 | 3741 |
| 1/14/2009 | 9519 | 20567 | 12473 |
| 2/5/2009 | 1744 | 1824 | 1638 |
| 2/26/2009 | 7015 | 2820 | 1616 |
| 4/1/2009 | 1178 | 996 | 1179 |
| 4/20/2009 | 1209 | 1146 | 1326 |
| 5/27/2009 | 1120 | 1054 | 1123 |
| 6/29/2009 | 1055 | 1061 | 1131 |
| 7/20/2009 | 1237 | 1296 | 1582 |
| 8/28/2009 | 1776 | 1314 | 1457 |
| 9/24/2009 | 1901 | 1722 | 1906 |
| 10/29/2009 | 1430 | 1507 | 1724 |
| 11/19/2009 | 780 | 2100 | 2715 |
| 12/16/2009 | 210 | 2068 | 3418 |
| 1/28/2010 | 818 | 976 | 1227 |
| 2/22/2010 | 487 | 1453 | 2234 |
| 3/25/2010 | 1028 | 1473 | 1484 |
| 4/28/2010 | 398 | 1417 | 1532 |
| 5/26/2010 | 1002 | 980 | 1147 |
| 6/28/2010 | 64900 | 42100 | 25600 |
| 7/28/2010 | 38167 | 46633 | 59433 |
| 9/29/2010 | NC1 | NC1 | NC1 |
| 10/18/2010 | NC1 | NC1 | NC1 |
| 11/16/2010 | NC1 | NC1 | NC1 |
| 12/14/2010 | NC1 | NC1 | NC1 |
| 1/13/2011 | NC1 | NC1 | NC1 |
| 2/15/2011 | NC1 | NC1 | NC1 |
| 3/15/2011 | NC1 | NC1 | NC1 |
| 4/18/2011 | NC1 | NC1 | NC1 |
| 5/18/2011 | NC1 | NC1 | NC1 |
| 6/22/2011 | NC1 | NC1 | NC1 |
| 7/27/2011 | NC1 | NC1 | NC1 |
| 8/26/2011 | NC1 | NC1 | NC1 |
| 9/22/2011 | NC1 | NC1 | NC1 |
| 10/27/2011 | NC1 | NC1 | NC1 |
| 11/22/2011 | NC1 | NC1 | NC1 |
| 12/16/2011 | NC1 | NC1 | NC1 |
| 1/20/2012 | NC1 | NC1 | NC1 |
| 2/23/2012 | NC1 | NC1 | NC1 |
| 3/13/2012 | NC1 | NC1 | NC1 |
| 4/16/2012 | NC1 | NC1 | NC1 |
| 5/15/2012 | NC1 | NC1 | NC1 |
| 6/19/2012 | NC1 | NC1 | NC1 |
| 7/10/2012 | NC1 | NC1 | NC1 |
| 8/14/2012 | NC1 | NC1 | NC1 |
| 10/24/2012 | NC1 | NC1 | NC1 |
| 11/26/2012 | NC1 | NC1 | NC1 |
| 12/18/2012 | NC1 | NC1 | NC1 |
| 1/31/2013 | NC1 | NC1 | NC1 |
| 2/28/2013 | NC1 | NC1 | NC1 |
| 3/28/2013 | NC1 | NC1 | NC1 |
| 4/25/2013 | NC1 | NC1 | NC1 |
| 5/30/2013 | 215 | 221 | 184 |
| 6/27/2013 | 115 | 233 | 232 |
| 7/25/2013 | 208 | 218 | 322 |
| 8/29/2013 | 63 | 68 | 161 |
| 9/26/2013 | 14 | 29 | 114 |
| 10/24/2013 | 229 | 250 | 201 |
| 11/21/2013 | 94 | 120 | 109 |
| 12/23/2013 | 50 | 622 | 794 |
| 1/15/2014 | 96 | 225000 | 204000 |
| 1/30/2014 | 818 | 150000 | 176000 |
| 2/24/2014 | 597 | 68200 | 100000 |
| 3/5/2014 | 492 | 96600 | 217000 |
| 3/10/2014 | 308 | 111000 | 204000 |
| 3/21/2014 | 593 | 99600 | 182000 |
| 3/25/2014 | 3144 | 271000 | 209000 |
| 4/3/2014 | 43700 | 384000 | 426000 |
| 4/7/2014 | 76100 | 413000 | 401000 |
| 4/16/2014 | 106000 | 437000 | 398000 |
| 4/22/2014 | 105000 | 383000 | 381000 |
| 5/1/2014 | 159000 | 450000 | 426000 |
| 5/8/2014 | 130000 | 377000 | 327000 |
| 5/15/2014 | 165000 | 401000 | 337000 |
| 5/21/2014 | 131000 | 415000 | 380000 |
| 5/27/2014 | 125000 | 369000 | 349000 |
| 6/3/2014 | 134000 | 341000 | 359000 |
| 6/11/2014 | 105000 | 288000 | 279000 |
| 6/19/2014 | 173000 | 284000 | 309000 |
| 6/23/2014 | 34500 | 45600 | 78700 |
| 7/9/2014 | 39700 | 277000 | 267000 |
| 7/21/2014 | 111000 | 234000 | 237000 |
| 8/27/2014 | 148000 | 205000 | 222000 |
| 9/25/2014 | 94500 | 208000 | 195000 |
| 10/29/2014 | 57400 | 180000 | 177000 |
| 11/20/2014 | 82200 | 198000 | 229000 |
| 12/232014 | 70100 | 102000 | 97000 |
| 1/28/2015 | 97900 | 172000 | 208000 |
| 2/27/2015 | 66300 | 136000 | 189000 |
| 3/26/2015 | 75200 | 88900 | 73800 |
| 4/20/2015 | 245000 | 158000 | 150000 |
| 5/28/2015 | 287000 | 143000 | 171000 |
| 6/25/2015 | 83800 | 93000 | 153000 |
| 7/21/2015 | 73400 | 79800 | 175000 |
| 8/27/2015 | 84000 | 81000 | 135000 |
| 9/23/2015 | 148667 | 103123 | 126433 |
| 10/20/2015 | 170300 | 113700 | 176267 |
| 11/18/2015 | 153333 | 92350 | 153867 |
| 12/17/2015 | 267467 | 155000 | 317400 |
| 1/20/2016 | 303367 | 66763 | 165267 |
| 2/17/2016 | 295600 | 146400 | 211900 |
| 3/15/2016 | 319000 | 161667 | 226233 |

ppbv = parts per billion by volume

NC1 = Not collected due to maintenance work being performed on the tank

Action Level (ppbv) = 280,000

Table D.9-5 Soil Vapor Results for SV06 (ppbv)

Historical Soil Vapor Results - March 2008 Through Present Event

| Date | SV06S | SV06M |
|---|---|---|
| 3/24/2008 | 18567 | 8861 |
| 5/6/2008 | 13733 | 9828 |
| 5/29/2008 | 13333 | 6932 |
| 7/3/2008 | 10560 | 5075 |
| 7/31/2008 | 10502 | 3373 |
| 9/2/2008 | 11416 | 3030 |
| 9/29/2008 | 10456 | 2772 |
| 10/23/2008 | 8337 | 2255 |
| 11/25/2008 | 10683 | 2143 |
| 1/14/2009 | 32867 | 13533 |
| 2/5/2009 | 7624 | 1128 |
| 2/26/2009 | 7936 | 1160 |
| 4/1/2009 | 6857 | 688 |
| 4/20/2009 | 6872 | 692 |
| 5/27/2009 | 6940 | 535 |
| 6/29/2009 | 6161 | 584 |
| 7/20/2009 | 7120 | 860 |
| 8/28/2009 | 5901 | 1075 |
| 9/24/2009 | 6917 | 1417 |
| 10/29/2009 | 5430 | 1027 |
| 11/19/2009 | 6129 | 2937 |
| 12/16/2009 | 5549 | 2673 |
| 1/28/2010 | 5721 | 559 |
| 2/22/2010 | 4841 | 2775 |
| 3/25/2010 | 5709 | 1043 |
| 4/28/2010 | 5905 | 1997 |
| 5/26/2010 | 4483 | 1261 |
| 6/28/2010 | 4800 | 1539 |
| 7/28/2010 | 4347 | 1693 |
| 9/29/2010 | 1090 | 457 |
| 10/18/2010 | 675 | 1084 |
| 11/16/2010 | 1142 | 413 |
| 12/14/2010 | 2043 | 646 |
| 1/14/2011 | 566 | 1282 |
| 2/15/2011 | 2245 | 352 |
| 3/15/2011 | 2542 | 173 |
| 4/18/2011 | 2412 | 484 |
| 5/18/2011 | 2343 | 613 |
| 6/22/2011 | 221 | 1558 |
| 7/27/2011 | 100 | 909 |
| 8/26/2011 | 210 | 924 |
| 9/22/2011 | 380 | 1385 |
| 10/27/2011 | 189 | 1155 |
| 11/22/2011 | 200 | 1098 |
| 12/16/2011 | 621 | 651 |
| 1/20/2012 | 342 | 537 |
| 2/23/2012 | 943 | 348 |
| 3/13/2012 | 330 | 816 |
| 4/16/2012 | 357 | 756 |
| 5/15/2012 | 699 | 462 |
| 6/19/2012 | 384 | 498 |
| 7/10/2012 | 305 | 373 |
| 8/14/2012 | 476 | 417 |
| 10/24/2012 | 225 | 474 |
| 11/26/2012 | NC1 | NC1 |
| 12/18/2012 | NC1 | NC1 |
| 1/31/2013 | NC1 | NC1 |
| 2/28/2013 | NC1 | NC1 |
| 3/28/2013 | NC1 | NC1 |
| 4/25/2013 | NC1 | NC1 |
| 5/30/2013 | NC1 | NC1 |
| 6/27/2013 | 143 | 378 |
| 7/25/2013 | 280 | 742 |
| 8/29/2013 | 131 | 1066 |
| 9/26/2013 | 9 | 566 |
| 10/24/2013 | 1291 | 1485 |
| 11/21/2013 | 160 | 322 |
| 12/23/2013 | 3 | 39 |
| 1/30/2014 | 6424 | 4097 |
| 2/24/2014 | 3046 | 1457 |
| 3/5/2014 | 6165 | 2033 |
| 3/10/2014 | 7204 | 1644 |
| 3/21/2014 | 195 | 605 |
| 3/25/2014 | 2169 | 551 |
| 4/3/2014 | 32000 | 18600 |
| 4/7/2014 | 23100 | 18800 |
| 4/16/2014 | 31000 | 14900 |
| 4/22/2014 | 31100 | 27300 |
| 5/1/2014 | 35500 | 21400 |
| 5/8/2014 | 23900 | 15900 |
| 5/15/2014 | 1948 | 365 |
| 5/21/2014 | 43600 | 24500 |
| 5/27/2014 | 31900 | 17000 |
| 6/3/2014 | 38900 | 23300 |
| 6/11/2014 | 23800 | 12600 |
| 6/19/2014 | 18100 | 10400 |
| 6/23/2014 | 2747 | 314 |
| 7/9/2014 | 29600 | 25400 |
| 7/21/2014 | 21900 | 21600 |
| 8/27/2014 | 31200 | 14000 |
| 9/25/2014 | 28000 | 18700 |
| 10/29/2014 | 12600 | 11000 |
| 11/20/2014 | 17100 | 4886 |
| 12/23/2014 | 10900 | 9042 |
| 1/28/2015 | 2051 | 482 |
| 2/27/2015 | 17700 | 6909 |
| 3/26/2015 | 11500 | 7734 |
| 4/20/2015 | 13300 | 8747 |
| 5/28/2015 | 763 | 33 |
| 6/25/2015 | 4536 | 3873 |
| 7/21/2015 | 11000 | 6679 |
| 8/27/2015 | 718 | 731 |
| 9/23/2015 | 486 | 130 |
| 10/20/2015 | 1881 | 586 |
| 11/18/2015 | NC1 | NC1 |
| 12/17/2015 | 1620 | 739 |
| 1/20/2016 | 1548 | 846 |
| 2/17/2016 | 1763 | 966 |
| 3/15/2016 | 1797 | 1025 |

ppbv = parts per billion by volume

NC1 = Not collected due to maintenance work being performed on the tank

Table D.9-6 Soil Vapor Results for SV07 (ppbv)
Historical Soil Vapor Results - March 2008 Through Present Event

| Date | SV07S | SV07M | SV07D |
|---|---|---|---|
| 3/24/2008 | 981 | 1966 | 21667 |
| 5/6/2008 | 5331 | 9047 | 12433 |
| 5/29/2008 | NC | 8698 | 12867 |
| 7/3/2008 | 6074 | 8759 | 16000 |
| 7/31/2008 | 4572 | 6737 | 20367 |
| 9/2/2008 | 4852 | 7576 | 21067 |
| 9/29/2008 | 4786 | 8620 | 22100 |
| 10/23/2008 | 3224 | 5459 | 21733 |
| 11/25/2008 | 1894 | 4069 | 12867 |
| 1/14/2009 | 2707 | 2567 | 10667 |
| 2/5/2009 | 1208 | 1780 | 7718 |
| 2/26/2009 | 7846 | 3623 | 9532 |
| 4/1/2009 | 1227 | 1268 | 12033 |
| 4/20/2009 | 1334 | 1434 | 12700 |
| 5/27/2009 | 1144 | 1353 | 18233 |
| 6/29/2009 | 1107 | 1184 | 9743 |
| 7/20/2009 | 1660 | 1595 | 11667 |
| 8/28/2009 | 1550 | 1207 | 3078 |
| 9/24/2009 | 1716 | 1481 | 2213 |
| 10/29/2009 | 1042 | 1214 | 6121 |
| 11/19/2009 | 657 | 1210 | 5342 |
| 12/16/2009 | 599 | 875 | 12633 |
| 1/28/2010 | 1032 | 872 | 4079 |
| 2/22/2010 | 444 | 728 | 3519 |
| 3/25/2010 | 762 | 886 | 16200 |
| 4/28/2010 | 288 | 689 | 2365 |
| 5/26/2010 | 782 | 731 | 3244 |
| 6/28/2010 | 629 | 628 | 1786 |
| 7/28/2010 | 703 | 801 | 6775 |
| 9/29/2010 | 344 | 363 | 372 |
| 10/18/2010 | 839 | 685 | 712 |
| 11/16/2010 | 701 | 288 | 356 |
| 12/14/2010 | 369 | 335 | 323 |
| 1/13/2011 | 210 | 283 | 451 |
| 2/15/2011 | 550 | 351 | 364 |
| 3/15/2011 | 267 | 255 | 296 |
| 4/18/2011 | 321 | 326 | 333 |
| 5/18/2011 | 851 | 871 | 900 |
| 6/22/2011 | 279 | 475 | 274 |
| 7/27/2011 | 137 | 342 | 166 |
| 8/26/2011 | 96 | 132 | 135 |
| 9/22/2011 | 298 | 443 | 361 |
| 10/27/2011 | 310 | 537 | 351 |
| 11/22/2011 | 249 | 431 | 311 |
| 12/16/2011 | 424 | 157 | 114 |
| 1/20/2012 | 96 | 356 | 133 |
| 2/23/2012 | 153 | 213 | 148 |
| 3/13/2012 | 68 | 782 | 144 |
| 4/16/2012 | 258 | 708 | 385 |
| 5/15/2012 | 148 | 1877 | 394 |
| 6/19/2012 | 421 | 686 | 483 |
| 7/10/2012 | 288 | 638 | 388 |
| 8/14/2012 | 348 | 680 | 477 |
| 10/24/2012 | 232 | 552 | 278 |
| 11/26/2012 | 88 | 87 | 100 |
| 12/18/2012 | NC1 | NC1 | NC1 |
| 1/31/2013 | NC1 | NC1 | NC1 |
| 2/28/2013 | NC1 | NC1 | NC1 |
| 3/28/2013 | NC1 | NC1 | NC1 |
| 4/25/2013 | NC1 | NC1 | NC1 |
| 5/30/2013 | NC1 | NC1 | NC1 |
| 6/27/2013 | 234 | 676 | 273 |
| 7/25/2013 | 164 | 583 | 232 |
| 8/29/2013 | 173 | 104 | 38 |
| 9/26/2013 | 7 | 253 | 7 |
| 10/24/2013 | 281 | 396 | 228 |
| 11/21/2013 | 122 | 122 | 191 |
| 12/23/2013 | 2 | 8 | 5 |
| 1/30/2014 | 6350 | 6539 | 5180 |
| 2/24/2014 | 1187 | 849 | 690 |
| 3/5/2014 | 4406 | 3890 | 4119 |
| 3/10/2014 | 4287 | 3687 | 3654 |
| 3/21/2014 | 102 | 512 | 170 |
| 3/25/2014 | 17300 | 15000 | 13900 |
| 4/3/2014 | 33700 | 32900 | 31700 |
| 4/7/2014 | 26100 | 29400 | 27700 |
| 4/16/2014 | 32900 | 34400 | 29200 |
| 4/22/2014 | 31700 | 33500 | 31900 |
| 5/1/2014 | 39700 | 34000 | 33800 |
| 5/8/2014 | 38000 | 41800 | 25600 |
| 5/15/2014 | 1209 | 1063 | 1188 |
| 5/21/2014 | 52800 | 53400 | 34500 |
| 5/27/2014 | 32900 | 43000 | 23900 |
| 6/3/2014 | 24100 | 36700 | 29800 |
| 6/11/2014 | 20900 | 24200 | 17100 |
| 6/19/2014 | 20300 | 20500 | 13900 |
| 6/23/2014 | 495 | 193 | 198 |
| 7/9/2014 | 37500 | 34400 | 21900 |
| 7/21/2014 | 34900 | NC2 | 24900 |
| 8/27/2014 | 31400 | 18200 | 17000 |
| 9/25/2014 | 23000 | 22000 | 17600 |
| 10/27/2014 | 310 | 209 | 540 |
| 11/20/2014 | 10500 | 8478 | 12800 |
| 12/23/2014 | 13500 | NC2 | 13100 |
| 1/28/2015 | 208 | 108 | 15000 |
| 2/27/2015 | 13200 | 4855 | 5347 |
| 3/26/2015 | 4567 | 5280 | 3260 |
| 4/20/2015 | 7434 | 7660 | 51300 |
| 5/28/2015 | 8 | 0 | 3740 |
| 6/25/2015 | 7341 | 4485 | 7246 |
| 7/21/2015 | 10200 | 7399 | 5863 |
| 8/27/2015 | 1025 | 957 | 726 |
| 9/23/2015 | 0 | 0 | 113 |
| 10/20/2015 | 474 | NC | 569 |
| 11/18/2015 | 328 | NC | 96503 |
| 12/17/2015 | 596 | NC | 3086 |
| 1/20/2016 | 719 | NC | 714 |
| 2/17/2016 | 699 | NC | 832 |
| 3/15/2016 | 849 | NC | 956 |

ppbv = parts per billion by volume

NC = Not collected

NC1 = Not collected due to maintenance work being performed on the tank

NC2 = Not collected due to an obstruction in vapor line

Table D.9-7 Soil Vapor Results for SV08 (ppbv)

Historical Soil Vapor Results - March 2008 Through Present Event

| Date | SV08S | SV08M | SV08D |
|---|---|---|---|
| 3/24/2008 | 324 | 353 | 428 |
| 5/6/2008 | 4266 | 3274 | 2286 |
| 5/29/2008 | 541 | 607 | 482 |
| 7/3/2008 | 1764 | 1730 | 1397 |
| 7/31/2008 | 602 | 804 | 684 |
| 9/2/2008 | 1463 | 1605 | 1051 |
| 9/29/2008 | 2397 | 1859 | 1152 |
| 10/23/2008 | 1358 | 1119 | 866 |
| 11/25/2008 | 2780 | 2166 | 1393 |
| 1/14/2009 | 7153 | 6517 | 4762 |
| 2/5/2009 | 1211 | 1263 | 797 |
| 2/26/2009 | 1289 | 1019 | 669 |
| 4/1/2009 | 310 | 416 | 367 |
| 4/20/2009 | 400 | 484 | 454 |
| 5/27/2009 | 258 | 367 | 358 |
| 6/29/2009 | 464 | 491 | 474 |
| 7/20/2009 | 612 | 690 | 727 |
| 8/28/2009 | 450 | 546 | 563 |
| 9/24/2009 | 627 | 726 | 752 |
| 10/29/2009 | 617 | 697 | 762 |
| 11/19/2009 | 779 | 860 | 877 |
| 12/16/2009 | 1157 | 1247 | 1382 |
| 1/28/2010 | 508 | 579 | 621 |
| 2/22/2010 | 690 | 727 | 840 |
| 3/25/2010 | 555 | 573 | 612 |
| 4/28/2010 | 688 | 742 | 756 |
| 5/26/2010 | 477 | 560 | 553 |
| 6/28/2010 | 525 | 607 | 609 |
| 7/28/2010 | 515 | 539 | 610 |
| 9/29/2010 | 295 | 345 | 352 |
| 10/18/2010 | 582 | 1221 | 988 |
| 11/16/2010 | 629 | 612 | 740 |
| 12/14/2010 | 488 | 657 | 471 |
| 1/13/2011 | 556 | 796 | 862 |
| 2/15/2011 | 431 | 485 | 541 |
| 3/15/2011 | 169 | 284 | 304 |
| 4/18/2011 | 364 | 456 | 489 |
| 5/18/2011 | 909 | 1222 | 1263 |
| 6/22/2011 | 172 | 412 | 266 |
| 7/27/2011 | 99 | 139 | 320 |
| 8/26/2011 | 84 | 157 | 180 |
| 9/22/2011 | 277 | 301 | 309 |
| 10/27/2011 | 250 | 338 | 309 |
| 11/22/2011 | 177 | 268 | 355 |
| 12/16/2011 | 67 | 211 | 162 |
| 1/20/2012 | 169 | 105 | 340 |
| 2/23/2012 | 222 | 222 | 129 |
| 3/13/2012 | 85 | 134 | 391 |
| 4/16/2012 | 485 | 204 | 377 |
| 5/15/2012 | 106 | 157 | 153 |
| 6/19/2012 | 428 | 466 | 418 |
| 7/10/2012 | 291 | 325 | 290 |
| 8/14/2012 | 296 | 285 | 285 |
| 10/24/2012 | 214 | 216 | 400 |
| 11/26/2012 | 53 | 76 | 51 |
| 12/18/2012 | NC1 | NC1 | NC1 |
| 1/31/2013 | NC1 | NC1 | NC1 |
| 2/28/2013 | NC1 | NC1 | NC1 |
| 3/28/2013 | NC1 | NC1 | NC1 |
| 4/25/2013 | NC1 | NC1 | NC1 |
| 5/30/2013 | NC1 | NC1 | NC1 |
| 6/27/2013 | 224 | 235 | 402 |
| 7/25/2013 | 133 | 176 | 132 |
| 8/29/2013 | 16 | 28 | 19 |
| 9/26/2013 | 15 | 2 | 2 |
| 10/24/2013 | 207 | 2013 | 197 |
| 11/21/2013 | 76 | 73 | 88 |
| 12/23/2013 | 4 | 2 | 6 |
| 1/30/2014 | 2170 | 2698 | 2952 |
| 2/24/2014 | 601 | 423 | 428 |
| 3/5/2014 | 1814 | 2492 | 3097 |
| 3/10/2014 | 1819 | 2348 | 2274 |
| 3/21/2014 | 102 | 469 | 354 |
| 3/25/2014 | 6152 | 7880 | 7474 |
| 4/3/2014 | 12800 | 17100 | 18100 |
| 4/7/2014 | 13500 | 14300 | 17300 |
| 4/16/2014 | 12900 | 15600 | 15800 |
| 4/22/2014 | 16600 | 19300 | 21000 |
| 5/1/2014 | 15600 | 19200 | 20100 |
| 5/8/2014 | 11800 | 14100 | 13300 |
| 5/15/2014 | 419 | 1315 | 1073 |
| 5/21/2014 | 16500 | 20900 | 21200 |
| 5/27/2014 | 11200 | 15100 | 13500 |
| 6/3/2014 | 12600 | 19300 | 22300 |
| 6/11/2014 | 7109 | 10600 | 10800 |
| 6/19/2014 | 8307 | 10700 | 9120 |
| 6/23/2014 | 133 | 22 | 54 |
| 7/9/2014 | 11300 | 14900 | 15300 |
| 7/21/2014 | 13200 | 16500 | 16800 |
| 8/27/2014 | 10500 | 12700 | 12500 |
| 9/25/2014 | 10500 | 11300 | 11600 |
| 10/27/2014 | 248 | 1196 | 129 |
| 11/20/2014 | 4113 | 5894 | 4398 |
| 12/23/2014 | 7996 | 7265 | 6710 |
| 1/28/2015 | 74 | 237 | 50 |
| 2/27/2015 | 3916 | 3201 | 4689 |
| 3/26/2015 | 3867 | 6634 | 4870 |
| 4/20/2015 | 5268 | 5860 | 3343 |
| 5/28/2015 | 0 | 0 | 0 |
| 6/25/2015 | 2124 | 3323 | 3232 |
| 7/21/2015 | 3163 | 3223 | 3430 |
| 8/27/2015 | 401 | 549 | 475 |
| 9/23/2015 | 0 | 0 | 0 |
| 10/20/2015 | 339 | 412 | 373 |
| 11/18/2015 | 87 | 93 | 69 |
| 12/17/2015 | 486 | 538 | 494 |
| 1/20/2016 | 642 | 644 | 635 |
| 2/17/2016 | 611 | 633 | 608 |
| 3/15/2016 | 581 | 596 | 599 |

ppbv = parts per billion by volume

NC1 = Not collected due to maintenance work being performed on the tank

Table D.9-8 Soil Vapor Results for SV09 (ppbv)
Historical Soil Vapor Results - March 2008 Through Present Event

| Date | SV09S | SV09M | SV09D |
|---|---|---|---|
| 3/24/2008 | 309 | 405 | NC |
| 5/6/2008 | 6462 | 7644 | 654 |
| 5/29/2008 | 878 | 825 | 451 |
| 7/3/2008 | 4190 | 4238 | 2301 |
| 7/31/2008 | 1024 | 961 | 646 |
| 9/2/2008 | 1949 | 1616 | 1047 |
| 9/29/2008 | 2714 | 2058 | 1232 |
| 10/23/2008 | 1458 | 1114 | 673 |
| 11/25/2008 | 2142 | 1855 | 1134 |
| 1/14/2009 | 4851 | 3250 | NC |
| 2/5/2009 | 786 | 457 | NC |
| 2/26/2009 | 930 | 503 | NC |
| 4/1/2009 | 241 | 233 | NC |
| 4/20/2009 | 329 | 361 | NC |
| 5/27/2009 | 234 | 326 | 183 |
| 6/29/2009 | 400 | 425 | 342 |
| 7/20/2009 | 566 | 645 | 704 |
| 8/28/2009 | 434 | 515 | 512 |
| 9/24/2009 | 663 | 708 | 630 |
| 10/29/2009 | 689 | 710 | 709 |
| 11/19/2009 | 861 | 898 | 928 |
| 12/16/2009 | 1084 | 1176 | 1410 |
| 1/28/2010 | 421 | 473 | 510 |
| 2/22/2010 | 659 | 716 | 877 |
| 3/25/2010 | 555 | 625 | 670 |
| 4/28/2010 | 575 | 743 | 858 |
| 5/26/2010 | 461 | 519 | 543 |
| 6/28/2010 | 531 | 590 | 627 |
| 7/28/2010 | 455 | 549 | 630 |
| 9/29/2010 | 304 | 357 | 377 |
| 10/18/2010 | 592 | 700 | 923 |
| 11/16/2010 | 488 | 567 | 607 |
| 12/14/2010 | 437 | 495 | 633 |
| 1/13/2011 | 574 | 572 | 668 |
| 2/15/2011 | 407 | 405 | 586 |
| 3/15/2011 | 261 | 312 | NC2 |
| 4/18/2011 | 320 | 365 | NC2 |
| 5/18/2011 | 918 | 1102 | NC2 |
| 6/22/2011 | 223 | 141 | NC2 |
| 7/27/2011 | 181 | 158 | NC2 |
| 8/26/2011 | 122 | 100 | NC2 |
| 9/22/2011 | 302 | 296 | NC2 |
| 10/27/2011 | 270 | 271 | NC2 |
| 11/22/2011 | 180 | 243 | NC2 |
| 12/16/2011 | 170 | 80 | 379 |
| 1/20/2012 | 80 | 148 | NC2 |
| 2/23/2012 | 130 | 135 | 110 |
| 3/13/2012 | 73 | 360 | NC2 |
| 4/16/2012 | 344 | 1212 | NC2 |
| 5/15/2012 | 137 | 122 | NC2 |
| 6/19/2012 | 626 | 518 | NC2 |
| 7/10/2012 | 325 | 298 | NC2 |
| 8/14/2012 | 339 | 350 | NC2 |
| 10/24/2012 | 204 | 335 | 208 |
| 11/26/2012 | 72 | 60 | 78 |
| 12/18/2012 | 63 | 83 | 87 |
| 1/31/2013 | 16 | 13 | 66 |
| 2/28/2013 | 58 | 20 | 133 |
| 3/28/2013 | 47 | 37 | 14 |
| 4/25/2013 | 42 | 42 | 59 |
| 5/30/2013 | 226 | 189 | 184 |
| 6/27/2013 | 38 | 39 | 47 |
| 7/25/2013 | 110 | 119 | 184 |
| 8/29/2013 | 8 | 39 | 23 |
| 9/26/2013 | 0 | 3 | 2 |
| 10/24/2013 | 200 | 170 | 167 |
| 11/21/2013 | 89 | 127 | 133 |
| 12/23/2013 | 13 | 8 | 2 |
| 1/30/2014 | 1488 | 1963 | 2408 |
| 2/24/2014 | 307 | 330 | 319 |
| 3/5/2014 | 915 | 1474 | 1614 |
| 3/10/2014 | 777 | 1569 | 1656 |
| 3/25/2014 | 2629 | 4246 | 5465 |
| 4/7/2014 | 5750 | 9329 | 10400 |
| 4/22/2014 | 7038 | 12600 | 12200 |
| 5/8/2014 | 6407 | 10100 | 10400 |
| 5/21/2014 | 10300 | 14100 | 14500 |
| 5/27/2014 | 4725 | 8296 | 10200 |
| 6/11/2014 | 5415 | 8278 | 10100 |
| 6/23/2014 | 10 | 7 | 22 |
| 7/21/2014 | 6459 | 9981 | 12000 |
| 8/27/2014 | 7069 | 9198 | 10200 |
| 9/25/2014 | 6795 | 8583 | 8125 |
| 10/27/2014 | 95 | 127 | 185 |
| 11/20/2014 | 3016 | 3303 | 4102 |
| 12/23/2014 | 4832 | 4555 | 5213 |
| 1/28/2015 | 41 | 43 | 87 |
| 2/27/2015 | 2106 | 2286 | 2689 |
| 3/26/2015 | 3101 | 2997 | 4885 |
| 4/20/2015 | 1456 | 2342 | 2410 |
| 5/28/2015 | 0 | 0 | 2 |
| 6/25/2015 | 2527 | 2039 | 3074 |
| 7/21/2015 | 1734 | 2331 | 2383 |
| 8/27/2015 | 360 | 859 | 224 |
| 9/23/2015 | 5 | 11 | 44 |
| 10/20/2015 | 388 | 357 | 476 |
| 11/18/2015 | 103 | 89 | 97 |
| 12/17/2015 | 399 | 420 | 390 |
| 1/20/2016 | 647 | 703 | 693 |
| 2/17/2016 | 590 | 591 | 567 |
| 3/15/2016 | 635 | 633 | 662 |

ppbv = parts per billion by volume
NC = Not collected
NC2 = Not collected due to an obstruction in vapor line

Table D.9-9 Soil Vapor Results for SV10 (ppbv)

Historical Soil Vapor Results - March 2008 Through Present Event

| Date | SV10S | SV10D |
|---|---|---|
| 3/24/2008 | 246 | 158 |
| 5/6/2008 | 5368 | 3713 |
| 5/29/2008 | 521 | 316 |
| 7/3/2008 | 3212 | 1677 |
| 7/31/2008 | 855 | 443 |
| 9/2/2008 | 1410 | 848 |
| 9/29/2008 | 2266 | 1205 |
| 10/23/2008 | 1043 | 646 |
| 11/25/2008 | 1825 | 860 |
| 1/14/2009 | 5568 | 2867 |
| 2/5/2009 | 957 | 423 |
| 2/26/2009 | 798 | 270 |
| 4/1/2009 | 194 | 135 |
| 4/20/2009 | 241 | 174 |
| 5/27/2009 | 194 | 110 |
| 6/29/2009 | 312 | 258 |
| 7/20/2009 | 340 | 424 |
| 8/28/2009 | 352 | 302 |
| 9/24/2009 | 539 | 479 |
| 10/29/2009 | 546 | 496 |
| 11/19/2009 | 751 | 604 |
| 12/16/2009 | 1093 | 1141 |
| 1/28/2010 | 356 | 333 |
| 2/22/2010 | 711 | 708 |
| 3/25/2010 | 521 | 815 |
| 4/28/2010 | 662 | 695 |
| 5/26/2010 | 420 | 337 |
| 6/28/2010 | 440 | 402 |
| 7/28/2010 | 417 | 994 |
| 9/29/2010 | 288 | 273 |
| 10/18/2010 | 639 | 686 |
| 11/16/2010 | 454 | 625 |
| 12/14/2010 | 385 | 335 |
| 1/13/2011 | 467 | 501 |
| 2/15/2011 | 310 | 302 |
| 3/15/2011 | 222 | 246 |
| 4/18/2011 | 288 | 297 |
| 5/18/2011 | 979 | 1077 |
| 6/22/2011 | 103 | 216 |
| 7/27/2011 | 82 | 88 |
| 8/26/2011 | 64 | 97 |
| 9/22/2011 | 260 | 301 |
| 10/27/2011 | 245 | 204 |
| 11/22/2011 | 189 | 195 |
| 12/16/2011 | 141 | 92 |
| 1/20/2012 | 224 | 196 |
| 2/23/2012 | 139 | 112 |
| 3/13/2012 | 387 | 283 |
| 4/16/2012 | 323 | 201 |
| 5/15/2012 | 75 | 87 |
| 6/19/2012 | 319 | 306 |
| 7/10/2012 | 288 | 353 |
| 8/14/2012 | 220 | 225 |
| 10/24/2012 | 164 | 130 |
| 11/26/2012 | 51 | 41 |
| 12/18/2012 | 16 | 36 |
| 1/31/2013 | 11 | 2 |
| 2/28/2013 | 91 | 83 |
| 3/28/2013 | 23 | 20 |
| 4/25/2013 | 31 | 40 |
| 5/30/2013 | 91 | 301 |
| 6/27/2013 | 137 | 301 |
| 7/25/2013 | 100 | 61 |
| 8/29/2013 | 529 | 1621 |
| 9/26/2013 | 0 | 3 |
| 10/24/2013 | 191 | 167 |
| 11/21/2013 | 69 | 76 |
| 12/23/2013 | 7 | 12 |
| 1/30/2014 | 483 | 358 |
| 2/24/2014 | 165 | 147 |
| 3/5/2014 | 365 | 45 |
| 3/10/2014 | 280 | 73 |
| 3/25/2014 | 1148 | 493 |
| 4/7/2014 | 3364 | 2393 |
| 4/22/2014 | 3381 | 3335 |
| 5/8/2014 | 2876 | 3278 |
| 5/21/2014 | 3836 | 3776 |
| 5/27/2014 | 2850 | 2424 |
| 6/11/2014 | 2037 | 4089 |
| 6/23/2014 | 10 | 7 |
| 7/21/2014 | 3334 | 3640 |
| 8/27/2014 | 3650 | 3073 |
| 9/25/2014 | 4093 | 3720 |
| 10/27/2014 | 62 | 117 |
| 11/20/2014 | 2124 | 1069 |
| 12/23/2014 | 2225 | 1543 |
| 1/28/2015 | 46 | 74 |
| 2/27/2015 | 1187 | 598 |
| 3/26/2015 | 104 | 97 |
| 4/20/2015 | 741 | 1175 |
| 5/28/2015 | 0 | 0 |
| 6/25/2015 | 959 | 839 |
| 7/21/2015 | 823 | 822 |
| 8/27/2015 | 292 | 363 |
| 9/23/2015 | 71 | 3 |
| 10/20/2015 | 380 | 318 |
| 11/18/2015 | 103 | 77 |
| 12/17/2015 | 403 | 403 |
| 1/20/2016 | 608 | 667 |
| 2/17/2016 | 574 | 541 |
| 3/15/2016 | 608 | 570 |

ppbv = parts per billion by volume

Table D.9-10 Soil Vapor Results for SV11 (ppbv)

Historical Soil Vapor Results - March 2008 Through Present Event

| Date | SV11M | SV11D |
|---|---|---|
| 3/24/2008 | 304 | 419 |
| 5/6/2008 | 2770 | NC2 |
| 5/29/2008 | 1507 | NC2 |
| 7/3/2008 | 2318 | NC2 |
| 7/31/2008 | 1409 | NC2 |
| 9/2/2008 | 3459 | NC2 |
| 9/29/2008 | 3157 | NC2 |
| 10/23/2008 | 1234 | NC2 |
| 11/25/2008 | 1238 | NC2 |
| 1/14/2009 | 2123 | NC2 |
| 2/5/2009 | 425 | NC2 |
| 2/26/2009 | 298 | NC2 |
| 4/1/2009 | 117 | NC2 |
| 4/20/2009 | 333 | NC2 |
| 5/27/2009 | 210 | NC2 |
| 6/29/2009 | 364 | NC2 |
| 7/20/2009 | 462 | NC2 |
| 8/28/2009 | 403 | NC2 |
| 9/24/2009 | 763 | NC2 |
| 10/29/2009 | 734 | NC2 |
| 11/19/2009 | 744 | NC2 |
| 12/16/2009 | 1142 | NC2 |
| 1/28/2010 | 396 | NC2 |
| 2/22/2010 | 619 | NC2 |
| 3/25/2010 | 847 | NC2 |
| 4/28/2010 | 738 | NC2 |
| 5/26/2010 | 880 | NC2 |
| 6/28/2010 | 444 | NC2 |
| 7/28/2010 | 440 | NC2 |
| 9/29/2010 | 321 | NC2 |
| 10/18/2010 | 720 | NC2 |
| 11/16/2010 | 326 | NC2 |
| 12/14/2010 | 198 | NC2 |
| 1/13/2011 | 418 | NC2 |
| 2/15/2011 | 343 | NC2 |
| 3/15/2011 | 224 | NC2 |
| 4/18/2011 | 260 | NC2 |
| 5/18/2011 | 920 | NC2 |
| 6/22/2011 | 183 | NC2 |
| 7/27/2011 | 145 | NC2 |
| 8/26/2011 | 86 | NC2 |
| 9/22/2011 | 333 | NC2 |
| 10/27/2011 | 290 | NC2 |
| 11/22/2011 | 183 | NC2 |
| 12/16/2011 | 75 | NC2 |
| 1/20/2012 | 272 | NC2 |
| 2/23/2012 | 135 | NC2 |
| 3/13/2012 | 144 | NC2 |
| 4/16/2012 | 157 | NC2 |
| 5/15/2012 | 66 | NC2 |
| 6/19/2012 | 347 | NC2 |
| 7/10/2012 | 252 | NC2 |
| 8/14/2012 | 342 | NC2 |
| 10/24/2012 | 163 | 303 |
| 11/26/2012 | 121 | 45 |
| 12/18/2012 | 31 | 35 |
| 1/31/2013 | 0 | 10 |
| 2/28/2013 | 9 | 100 |
| 3/28/2013 | 14 | NC2 |
| 4/25/2013 | 44 | NC2 |
| 5/30/2013 | 122 | 158 |
| 6/27/2013 | 27 | NC2 |
| 7/25/2013 | 138 | NC2 |
| 8/29/2013 | 784 | 448 |
| 9/26/2013 | 52 | NC2 |
| 10/24/2013 | 321 | NC2 |
| 11/21/2013 | 471 | NC2 |
| 12/23/2013 | 14 | NC2 |
| 1/30/2014 | 374 | NC2 |
| 2/24/2014 | 307 | NC2 |
| 3/28/2014 | 53 | NC2 |
| 4/21/2014 | 167 | NC2 |
| 5/28/2014 | 959 | NC2 |
| 6/24/2014 | 17 | NC2 |
| 7/22/2014 | 240 | NC2 |
| 8/27/2014 | 3218 | NC2 |
| 9/25/2014 | 3185 | NC2 |
| 10/27/2014 | 154 | NC2 |
| 11/20/2014 | 1182 | NC2 |
| 12/23/2014 | 1261 | NC2 |
| 1/28/2015 | 99 | NC2 |
| 2/27/2015 | 1056 | NC2 |
| 3/26/2015 | 2294 | NC2 |
| 4/20/2015 | 835 | NC2 |
| 5/28/2015 | 4184 | NC2 |
| 6/25/2015 | 9065 | NC2 |
| 7/21/2015 | 10200 | NC2 |
| 8/27/2015 | 5595 | NC2 |
| 9/23/2015 | 2584 | NC2 |
| 10/20/2015 | 3045 | NC2 |
| 11/18/2015 | 2714 | NC2 |
| 12/17/2015 | 1071 | NC2 |
| 1/20/2016 | 1534 | NC2 |
| 2/17/2016 | 2316 | NC2 |
| 3/15/2016 | 947 | NC2 |

ppbv = parts per billion by volume

NC2 = Not collected due to an obstruction in vapor line

Table D.9-11 Soil Vapor Results for SV12 (ppbv)

Historical Soil Vapor Results - March 2008 Through Present Event

| Date | SV12S | SV12M | SV12D |
|---|---|---|---|
| 3/24/2008 | 231 | 183 | 191 |
| 5/6/2008 | 6055 | 5542 | 3161 |
| 5/29/2008 | 3915 | 2840 | 1461 |
| 7/3/2008 | 5374 | 3809 | 2209 |
| 7/31/2008 | 4420 | 4202 | 989 |
| 9/2/2008 | 5132 | 5948 | 2929 |
| 9/29/2008 | 5794 | 5435 | 2544 |
| 10/23/2008 | 2237 | 2067 | 471 |
| 11/25/2008 | 1376 | 2066 | 532 |
| 1/14/2009 | -1 | -1 | 11 |
| 2/5/2009 | 46 | 210 | 226 |
| 2/26/2009 | 463 | 257 | 266 |
| 4/1/2009 | 122 | 120 | 149 |
| 4/20/2009 | 245 | 229 | 244 |
| 5/27/2009 | 162 | 95 | 113 |
| 6/29/2009 | 274 | 245 | 257 |
| 7/20/2009 | 402 | 354 | 510 |
| 8/28/2009 | 360 | 304 | 326 |
| 9/24/2009 | 680 | 621 | 542 |
| 10/29/2009 | 675 | 651 | 597 |
| 11/19/2009 | 1058 | 273 | 280 |
| 12/16/2009 | 311 | 43 | 50 |
| 1/28/2010 | 279 | 281 | 336 |
| 2/22/2010 | 12 | 14 | 104 |
| 3/25/2010 | 265 | 569 | 467 |
| 4/28/2010 | 175 | 401 | 444 |
| 5/26/2010 | 439 | 403 | 319 |
| 6/28/2010 | 341 | 351 | 383 |
| 7/28/2010 | 397 | 280 | 346 |
| 9/29/2010 | 276 | 247 | 283 |
| 10/18/2010 | 722 | 668 | 560 |
| 11/16/2010 | 12 | 146 | 252 |
| 12/14/2010 | 251 | 242 | 272 |
| 1/13/2011 | 333 | 195 | 221 |
| 2/15/2011 | 357 | 331 | 312 |
| 3/15/2011 | 317 | 339 | 228 |
| 4/18/2011 | 278 | 269 | 285 |
| 5/18/2011 | 943 | 988 | 1005 |
| 6/22/2011 | 274 | 278 | 228 |
| 7/27/2011 | 78 | 84 | 132 |
| 8/26/2011 | 134 | 111 | 80 |
| 9/22/2011 | 279 | 347 | 1631 |
| 10/27/2011 | 237 | 256 | 243 |
| 11/22/2011 | 303 | 280 | 244 |
| 12/16/2011 | 69 | 185 | 154 |
| 1/20/2012 | 103 | 200 | 297 |
| 2/23/2012 | 145 | 148 | 104 |
| 3/13/2012 | 231 | 190 | 423 |
| 4/16/2012 | 116 | 95 | 123 |
| 5/15/2012 | 115 | 98 | 130 |
| 6/19/2012 | 303 | 309 | 315 |
| 7/10/2012 | 337 | 288 | 345 |
| 8/14/2012 | 285 | 258 | 228 |
| 10/24/2012 | 153 | 140 | 135 |
| 11/26/2012 | 21 | 29 | 34 |
| 12/15/2012 | 12 | 23 | 17 |
| 1/31/2013 | 6 | 8 | 7 |
| 2/28/2013 | 98 | 54 | 14 |
| 3/28/2013 | 10 | 16 | 9 |
| 4/25/2013 | 31 | 62 | 35 |
| 5/30/2013 | 73 | 46 | 39 |
| 6/27/2013 | 39 | 32 | 44 |
| 7/25/2013 | 70 | 101 | 66 |
| 8/29/2013 | 75 | 8 | 270 |
| 9/26/2013 | 8 | 8 | 4 |
| 10/24/2013 | 192 | 221 | 198 |
| 11/21/2013 | 140 | 124 | 110 |
| 12/23/2013 | 11 | 4 | 2 |
| 1/30/2014 | 270 | 200 | 264 |
| 2/24/2014 | 135 | 148 | 215 |
| 3/28/2014 | 45 | 42 | 66 |
| 4/21/2014 | 237 | 166 | 290 |
| 5/28/2014 | 743 | 774 | 810 |
| 6/24/2014 | 374 | 244 | 326 |
| 7/22/2014 | 232 | 217 | 290 |
| 8/27/2014 | 2769 | 2607 | 2469 |
| 9/25/2014 | 1979 | 2338 | 1877 |
| 10/27/2014 | 77 | 144 | 81 |
| 11/20/2014 | 1147 | 721 | 512 |
| 12/23/2014 | 1075 | 632 | 834 |
| 1/28/2015 | 15 | 46 | 63 |
| 2/27/2015 | 609 | 396 | 331 |
| 3/26/2015 | 1203 | 964 | 992 |
| 4/20/2015 | 681 | 595 | 728 |
| 5/28/2015 | 0 | 0 | 0 |
| 6/25/2015 | 897 | 673 | 792 |
| 7/21/2015 | 940 | 875 | 490 |
| 8/27/2015 | 1047 | 1016 | 601 |
| 9/23/2015 | 64 | 8 | 1 |
| 10/20/2015 | 584 | 371 | 334 |
| 11/18/2015 | 207 | 101 | 99 |
| 12/17/2015 | 541 | 510 | 514 |
| 1/20/2016 | 618 | 630 | 573 |
| 2/17/2016 | 616 | 530 | 543 |
| 3/15/2016 | 465 | 421 | 381 |

ppbv = parts per billion by volume

Table D.9-12 Soil Vapor Results for SV13 (ppbv)

Historical Soil Vapor Results - March 2008 Through Present Event

| Date | SV13S | SV13M | SV13D |
|---|---|---|---|
| 3/24/2008 | 283 | 385 | 1195 |
| 5/6/2008 | 177 | 258 | 640 |
| 5/29/2008 | 3108 | 2384 | 1792 |
| 7/3/2008 | 3464 | 2566 | 1880 |
| 7/31/2008 | 3469 | 2529 | 1421 |
| 9/2/2008 | 5475 | 4141 | 2931 |
| 9/29/2008 | 4872 | 3471 | 1978 |
| 10/23/2008 | 1504 | 1148 | 838 |
| 11/25/2008 | 2961 | 2176 | 1256 |
| 1/14/2009 | 2832 | 4390 | 8757 |
| 2/5/2009 | 250 | 453 | 815 |
| 2/26/2009 | 713 | 596 | 604 |
| 4/1/2009 | 154 | 230 | 362 |
| 4/20/2009 | 294 | 340 | 492 |
| 5/27/2009 | 202 | 280 | 452 |
| 6/29/2009 | 353 | 387 | 516 |
| 7/20/2009 | 402 | 493 | 667 |
| 8/28/2009 | 360 | 464 | 622 |
| 9/24/2009 | 554 | 648 | 791 |
| 10/29/2009 | 674 | 800 | 1016 |
| 11/19/2009 | 774 | 904 | 1622 |
| 12/16/2009 | 507 | 729 | 2026 |
| 1/28/2010 | 334 | 410 | 542 |
| 2/22/2010 | 254 | 315 | 792 |
| 3/25/2010 | 414 | 483 | 863 |
| 4/28/2010 | 3406 | 4463 | 1736 |
| 5/26/2010 | 438 | 513 | 600 |
| 6/28/2010 | 418 | 503 | 637 |
| 7/28/2010 | 417 | 508 | 661 |
| 9/29/2010 | 258 | 306 | 382 |
| 10/18/2010 | 585 | 632 | 737 |
| 11/16/2010 | 386 | 500 | 626 |
| 12/14/2010 | 422 | 562 | 572 |
| 1/13/2011 | 577 | 825 | 878 |
| 2/15/2011 | 513 | 429 | 565 |
| 3/15/2011 | 255 | 306 | 434 |
| 4/18/2011 | 318 | 364 | 501 |
| 5/18/2011 | 1374 | 1557 | 1915 |
| 6/22/2011 | 290 | 253 | 370 |
| 7/27/2011 | 159 | 132 | 150 |
| 8/26/2011 | 154 | 151 | 207 |
| 9/22/2011 | 283 | 352 | 390 |
| 10/27/2011 | 206 | 217 | 361 |
| 11/22/2011 | 177 | 264 | 394 |
| 12/16/2011 | 860 | 125 | 107 |
| 1/20/2012 | 69 | 229 | 170 |
| 2/23/2012 | 115 | 116 | 201 |
| 3/13/2012 | 82 | 83 | 282 |
| 4/16/2012 | 122 | 85 | 161 |
| 5/15/2012 | 152 | 103 | 233 |
| 6/19/2012 | 266 | 373 | 382 |
| 7/10/2012 | 252 | 256 | 369 |
| 8/14/2012 | 121 | 287 | 334 |
| 10/24/2012 | 152 | 138 | 195 |
| 11/26/2012 | 59 | 43 | 20 |
| 12/18/2012 | 42 | 2 | 9 |
| 1/31/2013 | 3 | 0 | 2 |
| 2/28/2013 | 25 | 44 | 38 |
| 3/28/2013 | 32 | 7 | 4 |
| 4/25/2013 | 18 | 25 | 43 |
| 5/30/2013 | 39 | 40 | 39 |
| 6/27/2013 | 36 | 35 | 44 |
| 7/25/2013 | 77 | 81 | 148 |
| 8/29/2013 | 0 | 205 | 255 |
| 9/26/2013 | 0 | 3 | 0 |
| 10/24/2013 | 206 | 183 | 186 |
| 11/21/2013 | 83 | 66 | 68 |
| 12/23/2013 | 9 | 6 | 11 |
| 1/30/2014 | 440 | 929 | 1109 |
| 2/24/2014 | 116 | 98 | 99 |
| 3/28/2014 | 90 | 151 | 332 |
| 4/21/2014 | 198 | 575 | 560 |
| 5/28/2014 | 89 | 1031 | 1615 |
| 6/24/2014 | 161 | 616 | 727 |
| 7/22/2014 | 495 | 815 | 1191 |
| 8/27/2014 | 2657 | 4638 | 2877 |
| 9/25/2014 | 1414 | 2193 | 2562 |
| 10/27/2014 | 149 | 145 | 205 |
| 11/20/2014 | 1093 | 1208 | 738 |
| 12/23/2014 | 1148 | 1610 | 1621 |
| 1/28/2015 | 85 | 66 | 75 |
| 2/27/2015 | 822 | 973 | 1309 |
| 3/26/2015 | 1889 | 2160 | 2562 |
| 4/20/2015 | 774 | 939 | 1145 |
| 5/28/2015 | 0 | 0 | 0 |
| 6/25/2015 | 640 | 1178 | 1594 |
| 7/21/2015 | 682 | 1079 | 1431 |
| 8/27/2015 | 654 | 659 | 412 |
| 9/23/2015 | 37 | 10 | 59 |
| 10/20/2015 | 270 | 242 | 286 |
| 11/18/2015 | 115 | 98 | 125 |
| 12/17/2015 | 393 | 382 | 350 |
| 1/20/2016 | 502 | 530 | 707 |
| 2/17/2016 | 567 | 542 | 615 |
| 3/15/2016 | 373 | 379 | 407 |

ppbv = parts per billion by volume

Table D.9-13 Soil Vapor Results for SV14 (ppbv)

Historical Soil Vapor Results - March 2008 Through Present Event

| Date | SV14S | SV14M | SV14D |
|---|---|---|---|
| 3/24/2008 | NC | NC | 347 |
| 5/6/2008 | 761 | 2302 | 438 |
| 5/29/2008 | 728 | 2056 | 619 |
| 7/3/2008 | 1898 | 2816 | 620 |
| 7/31/2008 | 698 | 2204 | 871 |
| 9/2/2008 | 868 | 2325 | 960 |
| 9/29/2008 | 480 | 2101 | 1359 |
| 10/23/2008 | 106 | 2477 | 663 |
| 11/25/2008 | 86 | 2666 | 705 |
| 1/14/2009 | 0 | 2977 | 4798 |
| 2/5/2009 | 27 | 3042 | 596 |
| 2/26/2009 | 8 | 3080 | 746 |
| 4/1/2009 | 225 | 3971 | 468 |
| 4/20/2009 | 267 | 3385 | 506 |
| 5/27/2009 | 154 | 3392 | 477 |
| 6/29/2009 | 184 | 2912 | 588 |
| 7/20/2009 | 408 | 3312 | 692 |
| 8/28/2009 | 617 | 3080 | 674 |
| 9/24/2009 | 646 | 3903 | 858 |
| 10/29/2009 | 378 | 3199 | 795 |
| 11/19/2009 | 63 | 3249 | 756 |
| 12/16/2009 | 0 | 3417 | 854 |
| 1/28/2010 | 349 | 3550 | 589 |
| 2/22/2010 | 72 | 2795 | 481 |
| 3/25/2010 | 312 | 4006 | 676 |
| 4/28/2010 | 83 | 3617 | 666 |
| 5/26/2010 | 405 | 4383 | 751 |
| 6/28/2010 | 387 | 5258 | 789 |
| 7/28/2010 | 375 | 5447 | 753 |
| 9/29/2010 | 280 | 334 | 255 |
| 10/18/2010 | 567 | 597 | 498 |
| 11/16/2010 | 152 | 438 | 431 |
| 12/14/2010 | 248 | 176 | 452 |
| 1/13/2011 | 539 | 604 | 473 |
| 2/15/2011 | 359 | 525 | 522 |
| 3/15/2011 | 228 | 217 | 311 |
| 4/18/2011 | 128 | 460 | 550 |
| 5/18/2011 | 1049 | 1481 | 1767 |
| 6/22/2011 | 242 | 266 | 306 |
| 7/27/2011 | 67 | 109 | 158 |
| 8/26/2011 | 89 | 169 | 254 |
| 9/22/2011 | 88 | 58 | 112 |
| 10/27/2011 | 142 | 148 | 236 |
| 11/22/2011 | 162 | 189 | 257 |
| 12/16/2011 | 61 | 156 | 72 |
| 1/20/2012 | 48 | 105 | 71 |
| 2/23/2012 | 127 | 133 | 180 |
| 3/13/2012 | 140 | 514 | 89 |
| 4/16/2012 | 222 | 68 | 77 |
| 5/15/2012 | 72 | 190 | 124 |
| 6/19/2012 | 356 | 352 | 406 |
| 7/10/2012 | 238 | 241 | 292 |
| 8/14/2012 | 179 | 234 | 237 |
| 10/24/2012 | 123 | 157 | 128 |
| 11/26/2012 | 7 | 13 | 11 |
| 12/18/2012 | 2 | 2 | 5 |
| 1/31/2013 | 0 | 4 | 6 |
| 2/28/2013 | 5 | 518 | 84 |
| 3/28/2013 | 12 | 16 | 5 |
| 4/25/2013 | 14 | 29 | 20 |
| 5/30/2013 | 25 | 112 | 47 |
| 6/27/2013 | 29 | 280 | 39 |
| 7/25/2013 | 58 | 124 | 87 |
| 8/29/2013 | 426 | 53 | 862 |
| 9/26/2013 | 8 | 12 | 4 |
| 10/24/2013 | 170 | 170 | 160 |
| 11/21/2013 | 75 | 70 | 69 |
| 12/23/2013 | NC1 | NC1 | NC1 |
| 1/30/2014 | NC1 | NC1 | NC1 |
| 2/24/2014 | NC1 | NC1 | NC1 |
| 3/28/2014 | 82 | 261 | 170 |
| 4/21/2014 | 282 | 253 | 349 |
| 5/28/2014 | 471 | 640 | 697 |
| 6/24/2014 | 175 | 523 | 824 |
| 7/22/2014 | 323 | 474 | 634 |
| 8/27/2014 | 1376 | 1248 | 1327 |
| 9/25/2014 | 1295 | 1023 | 1067 |
| 10/27/2014 | 0 | 123 | 127 |
| 11/20/2014 | 564 | 678 | 422 |
| 12/23/2014 | 582 | 548 | 654 |
| 1/28/2015 | 44 | 24 | 85 |
| 2/27/2015 | 430 | 371 | 648 |
| 3/26/2015 | 996 | 937 | 1088 |
| 4/20/2015 | 191 | 111 | 434 |
| 5/28/2015 | 0 | 0 | 0 |
| 6/25/2015 | 560 | 550 | 986 |
| 7/21/2015 | 469 | 454 | 500 |
| 8/27/2015 | 711 | 892 | 344 |
| 9/23/2015 | 148 | 66 | 62 |
| 10/20/2015 | 295 | 320 | 303 |
| 11/18/2015 | 118 | 123 | 161 |
| 12/17/2015 | 406 | 418 | 415 |
| 1/20/2016 | 546 | 543 | 589 |
| 2/17/2016 | 539 | 520 | 543 |
| 3/15/2016 | 523 | 532 | 501 |

ppbv = parts per billion by volume

NC = Not collected

NC1 = Not collected due to maintenance work being performed on the tank

Table D.9-14 Soil Vapor Results for SV15 (ppbv)

Historical Soil Vapor Results - March 2008 Through Present Event

| Date | SV15S | SV15M | SV15D |
|---|---|---|---|
| 3/24/2008 | 318 | 600 | 415 |
| 5/6/2008 | 831 | 709 | 478 |
| 5/29/2008 | 763 | 2082 | 1135 |
| 7/3/2008 | 1541 | 1073 | 649 |
| 7/31/2008 | 2349 | 2076 | 1540 |
| 9/2/2008 | 2585 | 2087 | 1510 |
| 9/29/2008 | 4746 | 3991 | 2496 |
| 10/23/2008 | 1905 | 1711 | 1116 |
| 11/25/2008 | 2886 | 2483 | 1045 |
| 1/14/2009 | 7650 | 6457 | 4743 |
| 2/5/2009 | 1892 | 1182 | 904 |
| 2/26/2009 | 605 | 448 | 324 |
| 4/1/2009 | 175 | 249 | 247 |
| 4/20/2009 | 288 | 343 | 351 |
| 5/27/2009 | 194 | 251 | 216 |
| 6/29/2009 | 367 | 417 | 882 |
| 7/20/2009 | 383 | 457 | 977 |
| 8/28/2009 | 328 | 388 | 711 |
| 9/24/2009 | 475 | 569 | 759 |
| 10/29/2009 | 472 | 571 | 708 |
| 11/19/2009 | 442 | 483 | 673 |
| 12/16/2009 | 182 | 200 | 541 |
| 1/28/2010 | 346 | 779 | 527 |
| 2/22/2010 | 204 | NC2 | 442 |
| 3/25/2010 | 806 | NC2 | 542 |
| 4/28/2010 | 451 | NC2 | 599 |
| 5/26/2010 | 407 | NC2 | 608 |
| 6/28/2010 | 378 | NC2 | 592 |
| 7/28/2010 | 353 | NC2 | 623 |
| 9/29/2010 | 264 | NC2 | 328 |
| 10/18/2010 | 552 | NC2 | 677 |
| 11/16/2010 | 550 | NC2 | 605 |
| 12/14/2010 | 556 | NC2 | 544 |
| 1/13/2011 | 539 | NC2 | 625 |
| 2/15/2011 | 439 | NC2 | 552 |
| 3/15/2011 | 289 | NC2 | 367 |
| 4/18/2011 | 264 | NC2 | 368 |
| 5/18/2011 | 2031 | NC2 | 2864 |
| 6/22/2011 | 285 | NC2 | 314 |
| 7/27/2011 | 164 | NC2 | 193 |
| 8/26/2011 | 131 | NC2 | 192 |
| 9/22/2011 | 112 | NC2 | 136 |
| 10/27/2011 | 199 | NC2 | 196 |
| 11/22/2011 | 150 | NC2 | 230 |
| 12/16/2011 | 85 | NC2 | 94 |
| 1/20/2012 | 101 | NC2 | 36 |
| 2/23/2012 | 271 | NC2 | 130 |
| 3/13/2012 | 117 | NC2 | 86 |
| 4/16/2012 | 832 | NC2 | 398 |
| 5/15/2012 | 142 | NC2 | 153 |
| 6/19/2012 | 561 | NC2 | 570 |
| 7/10/2012 | 361 | NC2 | 454 |
| 8/14/2012 | 303 | NC2 | 59 |
| 10/24/2012 | 145 | 69 | 146 |
| 11/26/2012 | 15 | 19 | 12 |
| 12/18/2012 | 10 | 7 | 9 |
| 1/31/2013 | 4 | 2 | 2 |
| 2/28/2013 | 38 | NC2 | 85 |
| 3/28/2013 | 11 | NC2 | 13 |
| 4/25/2013 | 18 | NC2 | 25 |
| 5/30/2013 | NC1 | NC1 | NC1 |
| 6/27/2013 | 59 | NC2 | 24 |
| 7/25/2013 | 68 | NC2 | 90 |
| 8/29/2013 | 266 | 573 | 710 |
| 9/26/2013 | 14 | NC2 | 7 |
| 10/24/2013 | 181 | NC2 | 170 |
| 11/21/2013 | 46 | NC2 | 43 |
| 12/23/2013 | 18 | NC2 | 13 |
| 1/30/2014 | 376 | NC2 | 1025 |
| 2/24/2014 | 32 | NC2 | 65 |
| 3/28/2014 | 285 | NC2 | 372 |
| 4/21/2014 | 302 | NC2 | 623 |
| 5/28/2014 | 558 | NC2 | 1071 |
| 6/24/2014 | 240 | NC2 | 260 |
| 7/22/2014 | 663 | NC2 | 1321 |
| 8/27/2014 | 1916 | NC2 | 1026 |
| 9/25/2014 | 1857 | NC2 | 3159 |
| 10/27/2014 | 0 | NC2 | 0 |
| 11/20/2014 | 754 | NC2 | 539 |
| 12/23/2014 | 673 | NC2 | 886 |
| 1/28/2015 | 62 | NC2 | 71 |
| 2/27/2015 | 687 | NC2 | 956 |
| 3/26/2015 | 1270 | NC2 | 1585 |
| 4/20/2015 | 600 | NC2 | 651 |
| 5/28/2015 | 0 | NC2 | 0 |
| 6/25/2015 | 851 | NC2 | 1239 |
| 7/21/2015 | 515 | NC2 | 927 |
| 8/27/2015 | 586 | NC2 | 1126 |
| 9/23/2015 | 193 | NC2 | 185 |
| 10/20/2015 | 277 | NC2 | 230 |
| 11/18/2015 | 253 | NC2 | 194 |
| 12/17/2015 | 338 | NC2 | 311 |
| 1/20/2016 | 560 | NC2 | 633 |
| 2/17/2016 | 527 | NC2 | 530 |
| 3/15/2016 | 551 | NC2 | 502 |

ppbv = parts per billion by volume

NC1 = Not collected due to maintenance work being performed on the tank

NC2 = Not collected due to an obstruction in vapor line

Table D.9-15 Soil Vapor Results for SV16 (ppbv)

Historical Soil Vapor Results - March 2008 Through Present Event

| Date | SV16S | SV16M | SV16D |
|---|---|---|---|
| 3/24/2008 | 73 | 81 | 195 |
| 5/6/2008 | 1521 | 561 | 445 |
| 5/29/2008 | 1576 | 636 | 359 |
| 7/3/2008 | 2395 | 1108 | 1022 |
| 7/31/2008 | 936 | 528 | 448 |
| 9/2/2008 | 1300 | 347 | 383 |
| 9/29/2008 | 1461 | 580 | 808 |
| 10/23/2008 | 788 | 143 | 356 |
| 11/25/2008 | 2594 | 106 | 293 |
| 1/14/2009 | 0 | 91 | 361 |
| 2/5/2009 | 1738 | 655 | 294 |
| 2/26/2009 | 70 | 39 | 176 |
| 4/1/2009 | 24 | 32 | 87 |
| 4/20/2009 | 198 | 182 | 238 |
| 5/27/2009 | 25 | 0 | 86 |
| 6/29/2009 | 181 | 154 | 256 |
| 7/20/2009 | 238 | 140 | 245 |
| 8/28/2009 | 178 | 157 | 269 |
| 9/24/2009 | 346 | 284 | 356 |
| 10/29/2009 | 248 | 215 | 326 |
| 11/19/2009 | 216 | 192 | 327 |
| 12/16/2009 | 238 | 116 | 301 |
| 1/28/2010 | 175 | 167 | 288 |
| 2/22/2010 | 106 | 80 | 209 |
| 3/25/2010 | 581 | 214 | 707 |
| 4/28/2010 | 217 | 184 | 447 |
| 5/26/2010 | 1633 | 211 | 489 |
| 6/28/2010 | 1144 | 210 | 307 |
| 7/28/2010 | 1112 | 199 | 300 |
| 9/29/2010 | 302 | 359 | 297 |
| 10/18/2010 | 576 | 562 | 535 |
| 11/16/2010 | 461 | 435 | 467 |
| 12/14/2010 | 198 | 225 | 327 |
| 1/13/2011 | 923 | 492 | 256 |
| 2/15/2011 | 1348 | 386 | 470 |
| 3/15/2011 | 331 | 235 | 240 |
| 4/18/2011 | 230 | 106 | 190 |
| 5/18/2011 | 2334 | 2654 | 2985 |
| 6/22/2011 | 305 | 330 | 227 |
| 7/27/2011 | 113 | 470 | 98 |
| 8/26/2011 | 765 | 257 | 157 |
| 9/22/2011 | 151 | 219 | 121 |
| 10/27/2011 | 214 | 180 | 155 |
| 11/22/2011 | 183 | 239 | 245 |
| 12/16/2011 | 93 | 121 | 77 |
| 1/20/2012 | 198 | 134 | 95 |
| 2/23/2012 | 195 | 66 | 111 |
| 3/13/2012 | 172 | 154 | 282 |
| 4/16/2012 | 1280 | 226 | 780 |
| 5/15/2012 | 247 | 159 | 116 |
| 6/19/2012 | 89 | 67 | 570 |
| 7/10/2012 | 199 | 152 | 340 |
| 8/14/2012 | 155 | 131 | 344 |
| 10/24/2012 | 166 | 91 | 81 |
| 11/26/2012 | 92 | 79 | 11 |
| 12/18/2012 | 4 | 28 | 3 |
| 1/31/2013 | 13 | 5 | 4 |
| 2/28/2013 | 77 | 12 | 51 |
| 3/28/2013 | 21 | 7 | 10 |
| 4/25/2013 | 27 | 28 | 36 |
| 5/30/2013 | 56 | 27 | 28 |
| 6/27/2013 | 51 | 28 | 24 |
| 7/25/2013 | 76 | 62 | 63 |
| 8/29/2013 | 0 | 0 | 0 |
| 9/26/2013 | 2 | 18 | 20 |
| 10/24/2013 | 173 | 145 | 172 |
| 11/21/2013 | 74 | 163 | 67 |
| 12/23/2013 | 5 | 2 | 6 |
| 1/30/2014 | 139 | 102 | 95 |
| 2/24/2014 | 44 | 24 | 65 |
| 3/28/2014 | 388 | 281 | 220 |
| 4/21/2014 | 298 | 302 | 253 |
| 5/28/2014 | 348 | 334 | 327 |
| 6/24/2014 | 107 | 169 | 158 |
| 7/22/2014 | 552 | 455 | 488 |
| 8/27/2014 | 602 | 590 | 1026 |
| 9/25/2014 | 1226 | 1143 | 719 |
| 10/27/2014 | 0 | 0 | 0 |
| 11/20/2014 | 458 | 216 | 274 |
| 12/23/2014 | 470 | 442 | 363 |
| 1/28/2015 | 63 | 19 | 54 |
| 2/27/2015 | 333 | 162 | 310 |
| 3/26/2015 | 113 | 116 | 884 |
| 4/20/2015 | 297 | 303 | 393 |
| 5/28/2015 | 0 | 0 | 0 |
| 6/25/2015 | 531 | 346 | 432 |
| 7/28/2015 | 44 | 93 | 50 |
| 8/27/2015 | 689 | 777 | 349 |
| 9/23/2015 | 477 | 367 | 220 |
| 10/20/2015 | 240 | 289 | 249 |
| 11/18/2015 | 735 | 573 | 376 |
| 12/17/2015 | 416 | 406 | 432 |
| 1/20/2016 | 526 | 580 | 552 |
| 2/17/2016 | 705 | 603 | 578 |
| 3/15/2016 | 591 | 589 | 607 |

ppbv = parts per billion by volume

Table D.9-16 Soil Vapor Results for SV17 (ppbv)

Historical Soil Vapor Results - March 2008 Through Present Event

| Date | SV17S | SV17M | SV17D |
|---|---|---|---|
| 3/24/2008 | NC | NC | NC |
| 5/6/2008 | NC | NC | NC |
| 5/29/2008 | NC | NC | NC |
| 7/3/2008 | NC | NC | NC |
| 7/31/2008 | NC | NC | NC |
| 9/2/2008 | NC | NC | NC |
| 9/29/2008 | NC | NC | NC |
| 10/23/2008 | NC | NC | NC |
| 11/25/2008 | 967 | 980 | 896 |
| 1/14/2009 | 9419 | 11433 | 13567 |
| 2/5/2009 | 10594 | 12100 | 12933 |
| 2/26/2009 | 8678 | 11367 | 15567 |
| 4/1/2009 | 8397 | 11867 | 15633 |
| 4/20/2009 | 9344 | 10967 | 11000 |
| 5/27/2009 | 7656 | 9032 | 10567 |
| 6/29/2009 | 6046 | 7697 | 8982 |
| 7/20/2009 | 6489 | 7536 | 9093 |
| 8/28/2009 | 5075 | 5971 | 6506 |
| 9/24/2009 | 4882 | 5345 | 5290 |
| 10/29/2009 | 5158 | 5709 | 8051 |
| 11/19/2009 | 4031 | 4441 | 5115 |
| 12/16/2009 | 2550 | 2564 | 2840 |
| 1/28/2010 | 1866 | 2367 | 2497 |
| 2/22/2010 | 2304 | 2793 | 2846 |
| 3/25/2010 | 1488 | 1853 | 1865 |
| 4/28/2010 | 1442 | 1797 | 2072 |
| 5/26/2010 | 1240 | 1445 | 1637 |
| 6/28/2010 | 1405 | 1483 | 1773 |
| 7/28/2010 | 2035 | 2238 | 3745 |
| 9/29/2010 | NC1 | NC1 | NC1 |
| 10/18/2010 | NC1 | NC1 | NC1 |
| 11/16/2010 | NC1 | NC1 | NC1 |
| 12/14/2010 | NC1 | NC1 | NC1 |
| 1/13/2011 | NC1 | NC1 | NC1 |
| 2/15/2011 | NC1 | NC1 | NC1 |
| 3/15/2011 | NC1 | NC1 | NC1 |
| 4/18/2011 | NC1 | NC1 | NC1 |
| 5/18/2011 | NC1 | NC1 | NC1 |
| 6/22/2011 | NC1 | NC1 | NC1 |
| 7/27/2011 | NC1 | NC1 | NC1 |
| 8/26/2011 | NC1 | NC1 | NC1 |
| 9/22/2011 | NC1 | NC1 | NC1 |
| 10/27/2011 | NC1 | NC1 | NC1 |
| 11/22/2011 | NC1 | NC1 | NC1 |
| 12/16/2011 | NC1 | NC1 | NC1 |
| 1/20/2012 | NC1 | NC1 | NC1 |
| 2/23/2012 | NC1 | NC1 | NC1 |
| 3/13/2012 | NC1 | NC1 | NC1 |
| 4/16/2012 | NC1 | NC1 | NC1 |
| 5/15/2012 | NC1 | NC1 | NC1 |
| 6/19/2012 | NC1 | NC1 | NC1 |
| 7/10/2012 | NC1 | NC1 | NC1 |
| 8/14/2012 | NC1 | NC1 | NC1 |
| 10/24/2012 | NC1 | NC1 | NC1 |
| 11/26/2012 | NC1 | NC1 | NC1 |
| 12/18/2012 | NC1 | NC1 | NC1 |
| 1/31/2013 | NC1 | NC1 | NC1 |
| 2/28/2013 | NC1 | NC1 | NC1 |
| 3/28/2013 | NC1 | NC1 | NC1 |
| 4/25/2013 | NC1 | NC1 | NC1 |
| 5/30/2013 | NC1 | NC1 | NC1 |
| 6/27/2013 | 274 | NC3 | NC3 |
| 7/25/2013 | 672 | 837 | 876 |
| 8/29/2013 | 2162 | 2884 | 3069 |
| 9/26/2013 | 1716 | 945 | 1209 |
| 10/24/2013 | 601 | 638 | 648 |
| 11/21/2013 | 3065 | 3349 | 3218 |
| 12/23/2013 | 1243 | 2496 | 3023 |
| 1/30/2014 | 1598 | 2378 | 2980 |
| 2/24/2014 | 4069 | 3944 | 3884 |
| 3/28/2014 | 5033 | 5987 | 6391 |
| 4/21/2014 | 5221 | 4941 | 4541 |
| 5/28/2014 | 2452 | 3239 | 3827 |
| 6/24/2014 | 3138 | 2865 | 2892 |
| 7/22/2014 | 1578 | 2156 | 2804 |
| 8/27/2014 | 1419 | 2492 | 2954 |
| 9/25/2014 | 1468 | 2056 | 1043 |
| 10/28/2014 | 190 | 205 | 257 |
| 11/20/2014 | 618 | 849 | 998 |
| 12/23/2014 | 805 | 1126 | 1319 |
| 1/28/2015 | 170 | 202 | 282 |
| 2/27/2015 | 366 | 530 | 877 |
| 3/26/2015 | 3095 | 2472 | 3938 |
| 4/20/2015 | 510 | 734 | 952 |
| 5/28/2015 | 36 | 268 | 11 |
| 6/25/2015 | 462 | 755 | 955 |
| 7/28/2015 | 117 | 243 | 275 |
| 8/27/2015 | 647 | 779 | 1045 |
| 9/23/2015 | 237 | 334 | 358 |
| 10/20/2015 | 372 | 439 | 424 |
| 11/18/2015 | 1082 | 1010 | 1078 |
| 12/17/2015 | 561 | 612 | 593 |
| 1/20/2016 | 699 | 810 | 759 |
| 2/17/2016 | 765 | 647 | 714 |
| 3/15/2016 | 701 | 736 | 818 |

ppbv = parts per billion by volume

NC = Not collected

NC1 = Not collected due to maintenance work being performed on the tank

NC3 = Not collected due to insufficient tedlar bags

Table D.9-17 Soil Vapor Results for SV18 (ppbv)

Historical Soil Vapor Results - March 2008 Through Present Event

| Date | SV18S | SV18D |
|---|---|---|
| 3/24/2008 | 385 | 662 |
| 5/6/2008 | 1162 | 1033 |
| 5/29/2008 | 1127 | 1224 |
| 7/3/2008 | 1844 | 1287 |
| 7/31/2008 | 1679 | 1380 |
| 9/2/2008 | 1724 | 1792 |
| 9/29/2008 | 2515 | 2509 |
| 10/23/2008 | 1377 | 1481 |
| 11/25/2008 | 1130 | 1262 |
| 1/14/2009 | 364 | 996 |
| 2/5/2009 | 2099 | 1861 |
| 2/26/2009 | 454 | 915 |
| 4/1/2009 | 681 | 820 |
| 4/20/2009 | 772 | 963 |
| 5/27/2009 | 931 | 1146 |
| 6/29/2009 | 900 | 1122 |
| 7/20/2009 | 1180 | 1597 |
| 8/28/2009 | 1447 | 2156 |
| 9/24/2009 | 1362 | 1549 |
| 10/29/2009 | 1341 | 1888 |
| 11/19/2009 | 1817 | 2209 |
| 12/16/2009 | 534 | 776 |
| 1/28/2010 | 693 | 888 |
| 2/22/2010 | 1327 | 1631 |
| 3/25/2010 | 1072 | 1222 |
| 4/28/2010 | 991 | 1575 |
| 5/26/2010 | 845 | 1190 |
| 6/28/2010 | 939 | 1299 |
| 7/28/2010 | 1131 | 1485 |
| 9/29/2010 | 422 | 580 |
| 10/18/2010 | 595 | 839 |
| 11/16/2010 | 577 | 778 |
| 12/14/2010 | 212 | 725 |
| 1/13/2011 | 390 | 512 |
| 2/15/2011 | 400 | 662 |
| 3/15/2011 | 450 | 515 |
| 4/18/2011 | 449 | 518 |
| 5/18/2011 | 460 | 742 |
| 6/22/2011 | 405 | 551 |
| 7/27/2011 | 250 | 380 |
| 8/26/2011 | 216 | 382 |
| 9/22/2011 | 241 | 367 |
| 10/27/2011 | 269 | 358 |
| 11/22/2011 | 286 | 403 |
| 12/16/2011 | 237 | 327 |
| 1/20/2012 | 107 | 233 |
| 2/23/2012 | 283 | 326 |
| 3/13/2012 | 190 | 373 |
| 4/16/2012 | 248 | 402 |
| 5/15/2012 | 399 | 594 |
| 6/19/2012 | 684 | 875 |
| 7/10/2012 | 1425 | 992 |
| 8/14/2012 | 824 | 853 |
| 10/24/2012 | 752 | 584 |
| 11/26/2012 | 215 | 185 |
| 12/18/2012 | 171 | 142 |
| 1/31/2013 | 1423 | 1275 |
| 2/28/2013 | 913 | 654 |
| 3/28/2013 | 460 | 572 |
| 4/25/2013 | 266 | 293 |
| 5/30/2013 | 307 | 239 |
| 6/27/2013 | 244 | 264 |
| 7/25/2013 | 1037 | 1197 |
| 8/29/2013 | 5225 | 5326 |
| 9/26/2013 | 3190 | 3132 |
| 10/24/2013 | 2333 | 2309 |
| 11/21/2013 | 5227 | 3157 |
| 12/23/2013 | 8679 | 8606 |
| 1/30/2014 | 1949 | 2116 |
| 2/24/2014 | 2674 | 3241 |
| 3/28/2014 | 1392 | 2545 |
| 4/21/2014 | 1973 | 2082 |
| 5/28/2014 | 2856 | 2607 |
| 6/24/2014 | 1727 | 2050 |
| 7/22/2014 | 1474 | 2823 |
| 8/27/2014 | 137 | 1478 |
| 9/25/2014 | 3361 | 3679 |
| 10/28/2014 | 2001 | 2008 |
| 11/20/2014 | 3033 | 3404 |
| 12/23/2014 | 3026 | 3421 |
| 1/28/2015 | 1179 | 1762 |
| 2/27/2015 | 1154 | 1398 |
| 3/26/2015 | NC1 | NC1 |
| 4/20/2015 | 20100 | 38400 |
| 5/28/2015 | 47 | 1191 |
| 6/25/2015 | 17200 | 14200 |
| 7/28/2015 | 17600 | 19100 |
| 8/27/2015 | 18000 | 15000 |
| 9/23/2015 | 9188 | 11625 |
| 10/20/2015 | 13670 | 16280 |
| 11/18/2015 | 27097 | 27153 |
| 12/17/2015 | 32387 | 27093 |
| 1/20/2016 | 31047 | 27463 |
| 2/17/2016 | 28737 | 27267 |
| 3/15/2016 | 1533 | 1699 |

ppbv = parts per billion by volume

NC1 = Not collected due to maintenance work being performed on the tank

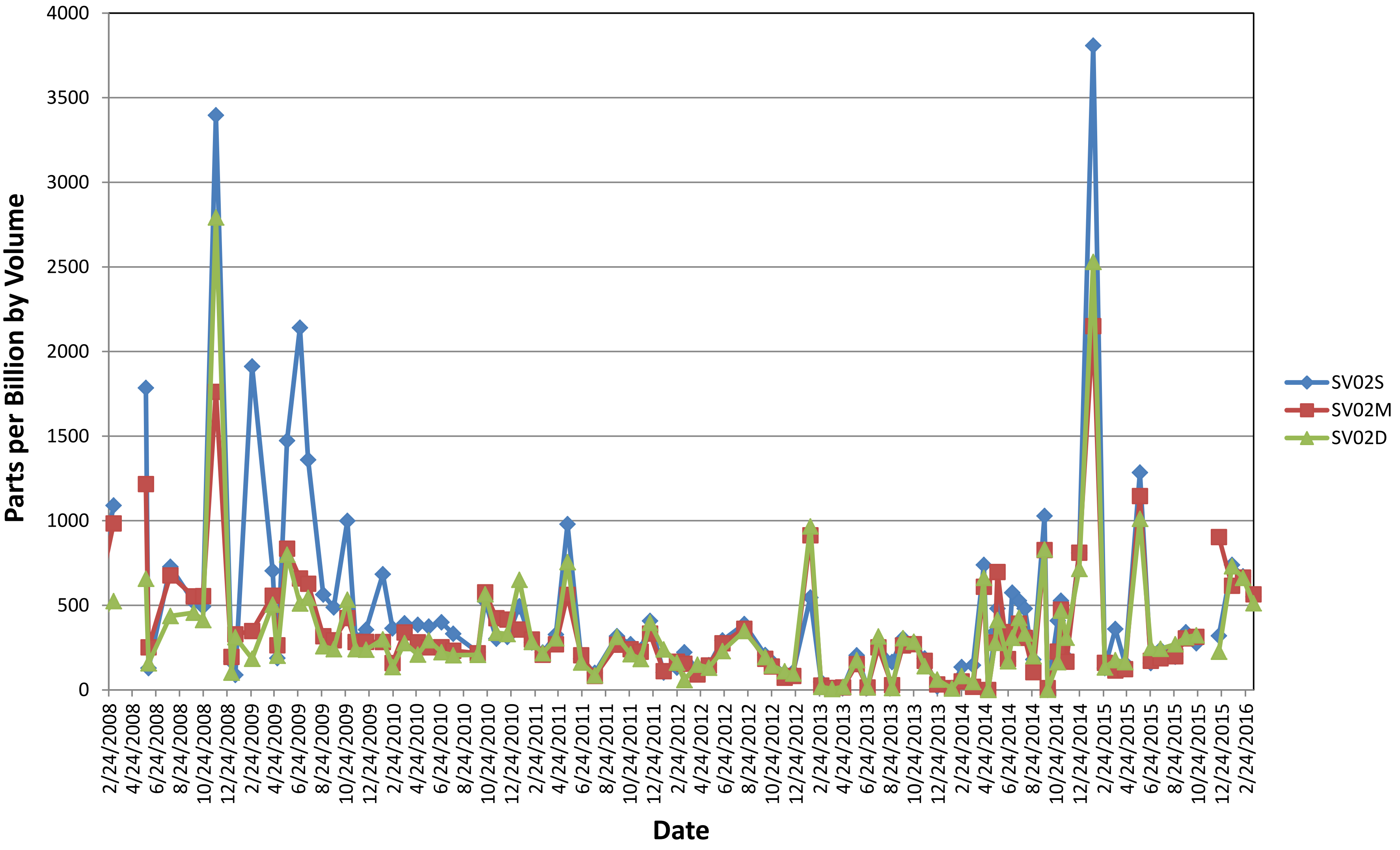
### Table D.9-18 Soil Vapor Results for SV20 (ppbv)

Historical Soil Vapor Results - March 2008 Through Present Event

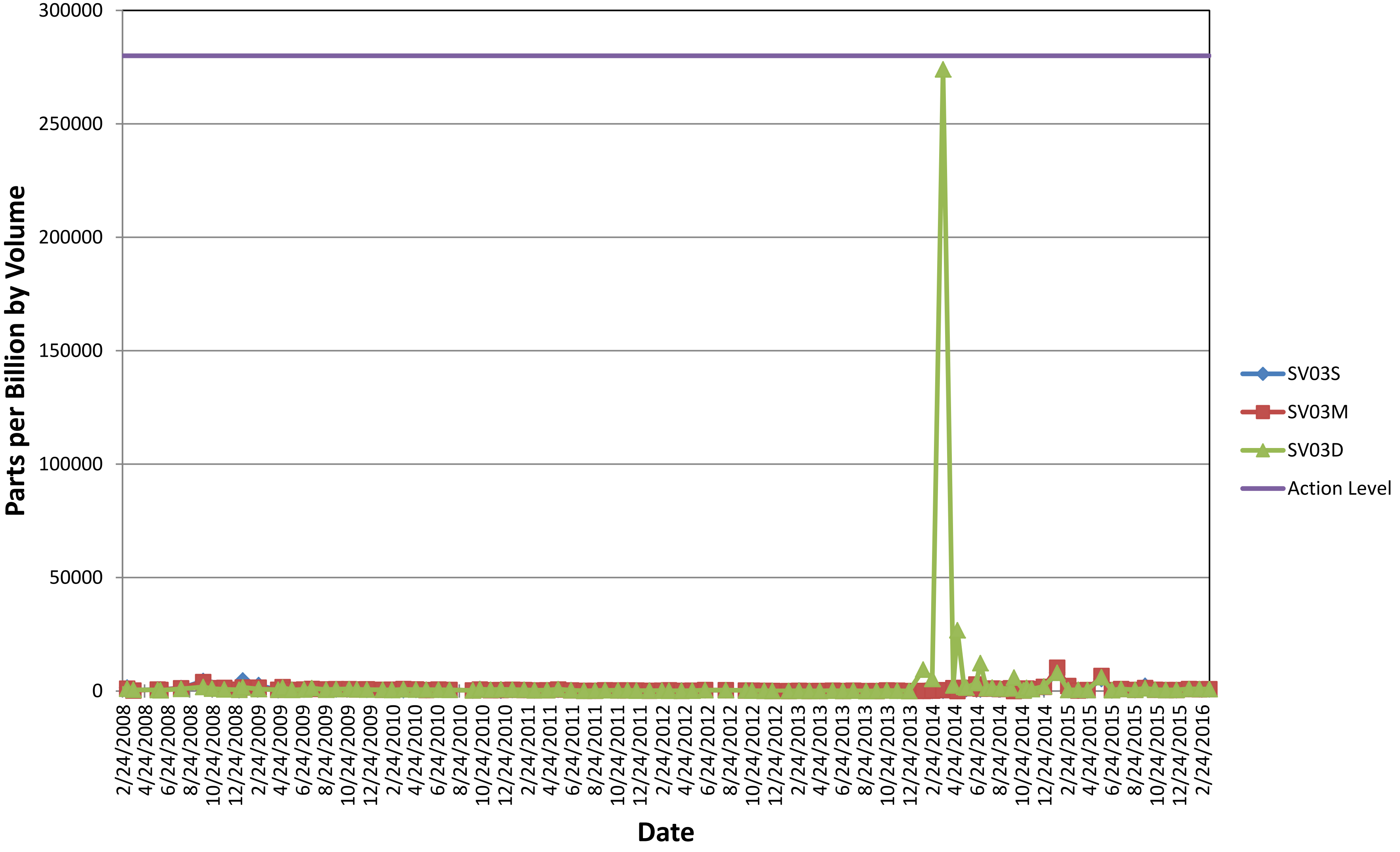
| Date | SV20S | SV20M | SV20D |
|---|---|---|---|
| 3/24/2008 | 963 | 507 | 1133 |
| 5/6/2008 | 2045 | 1700 | 1390 |
| 5/29/2008 | 11633 | 14833 | 22667 |
| 7/3/2008 | 4892 | 3425 | 6976 |
| 7/31/2008 | 2963 | 2758 | 4201 |
| 9/2/2008 | 2709 | 1954 | 2556 |
| 9/29/2008 | 2796 | 1996 | 1874 |
| 10/23/2008 | 1399 | 1401 | 1609 |
| 11/25/2008 | 1091 | 1005 | 1208 |
| 1/14/2009 | 570 | 672 | 714 |
| 2/5/2009 | 2553 | 1920 | 1170 |
| 2/26/2009 | 515 | 622 | 674 |
| 4/1/2009 | 604 | 645 | 595 |
| 4/20/2009 | 798 | 604 | 600 |
| 5/27/2009 | 594 | 627 | 574 |
| 6/29/2009 | 651 | 663 | 631 |
| 7/20/2009 | 691 | 680 | 729 |
| 8/28/2009 | 403 | 431 | 473 |
| 9/24/2009 | 732 | 762 | 662 |
| 10/29/2009 | 1280 | 2259 | 788 |
| 11/19/2009 | 2013 | 2070 | 2789 |
| 12/16/2009 | 2112 | 2863 | 3545 |
| 1/28/2010 | 451 | 485 | 666 |
| 2/22/2010 | 1648 | 1825 | 2599 |
| 3/25/2010 | 1019 | 1004 | 1625 |
| 4/28/2010 | 815 | 1183 | 1597 |
| 5/26/2010 | 668 | 693 | 746 |
| 6/28/2010 | 726 | 866 | 898 |
| 7/28/2010 | 689 | 922 | 1191 |
| 9/29/2010 | 220 | 255 | 284 |
| 10/18/2010 | 567 | 593 | 602 |
| 11/16/2010 | 365 | 322 | 293 |
| 12/14/2010 | 398 | 484 | 390 |
| 1/13/2011 | 113 | 271 | 306 |
| 2/15/2011 | 239 | 361 | 302 |
| 3/15/2011 | 283 | 368 | 352 |
| 4/18/2011 | 540 | 378 | 396 |
| 5/18/2011 | 549 | 722 | 752 |
| 6/22/2011 | 282 | 347 | 339 |
| 7/27/2011 | 256 | 305 | 248 |
| 8/26/2011 | 252 | 220 | 251 |
| 9/22/2011 | 147 | 240 | 164 |
| 10/27/2011 | 223 | 263 | 245 |
| 11/22/2011 | 212 | 334 | 316 |
| 12/16/2011 | 119 | 149 | 361 |
| 1/20/2012 | 59 | 88 | 57 |
| 2/23/2012 | 254 | 393 | 312 |
| 3/13/2012 | 162 | 236 | 203 |
| 4/16/2012 | 424 | 201 | 135 |
| 5/15/2012 | 155 | 160 | 176 |
| 6/19/2012 | 383 | 350 | 354 |
| 7/10/2012 | 509 | 514 | 563 |
| 8/14/2012 | 494 | 443 | 384 |
| 10/24/2012 | 131 | 150 | 264 |
| 11/26/2012 | 95 | 80 | 106 |
| 12/18/2012 | 39 | 22 | 32 |
| 1/31/2013 | 223 | 204 | 159 |
| 2/28/2013 | 274 | 296 | 286 |
| 3/28/2013 | 209 | 263 | 246 |
| 4/25/2013 | 150 | 182 | 163 |
| 5/30/2013 | 80 | 95 | 80 |
| 6/27/2013 | 137 | 65 | 66 |
| 7/25/2013 | 250 | 282 | 332 |
| 8/29/2013 | 581 | 459 | 360 |
| 9/26/2013 | 214 | 64 | 323 |
| 10/24/2013 | 454 | 405 | 311 |
| 11/21/2013 | 350 | 317 | 215 |
| 12/23/2013 | 787 | 704 | 777 |
| 1/30/2014 | 560 | 584 | 697 |
| 2/24/2014 | 571 | 505 | 293 |
| 3/28/2014 | 214 | 242 | 118 |
| 4/21/2014 | 526 | 561 | 545 |
| 5/28//2014 | 1139 | 1451 | 1438 |
| 6/24//2014 | 1160 | 1271 | 1143 |
| 7/22//2014 | 1587 | 1877 | 2213 |
| 8/27/2014 | 630 | 1526 | 1618 |
| 9/25/2014 | 1531 | 1561 | 1472 |
| 10/28/2014 | 283 | 208 | 211 |
| 11/20/2014 | 620 | 566 | 983 |
| 12/23/2014 | 1227 | 1273 | 1516 |
| 1/28/2015 | 101 | 72 | 80 |
| 2/27/2015 | 495 | 575 | 898 |
| 3/26/2015 | 2211 | 1593 | 2041 |
| 4/20/2015 | 3939 | 4586 | 3207 |
| 5/28/2015 | 3 | 29 | 11 |
| 6/25/2015 | 2169 | 2456 | 2209 |
| 7/28/2015 | 1840 | 1994 | 1724 |
| 8/27/2015 | 2117 | 2222 | 2673 |
| 9/23/2015 | 259 | 379 | 455 |
| 10/20/2015 | 697 | 608 | 595 |
| 11/18/2015 | 523 | 556 | 549 |
| 12/17/2015 | 1010 | 820 | 813 |
| 1/20/2016 | 355 | 427 | 385 |
| 2/17/2016 | 692 | 724 | 567 |
| 3/15/2016 | 737 | 840 | 733 |

ppbv = parts per billion by volume

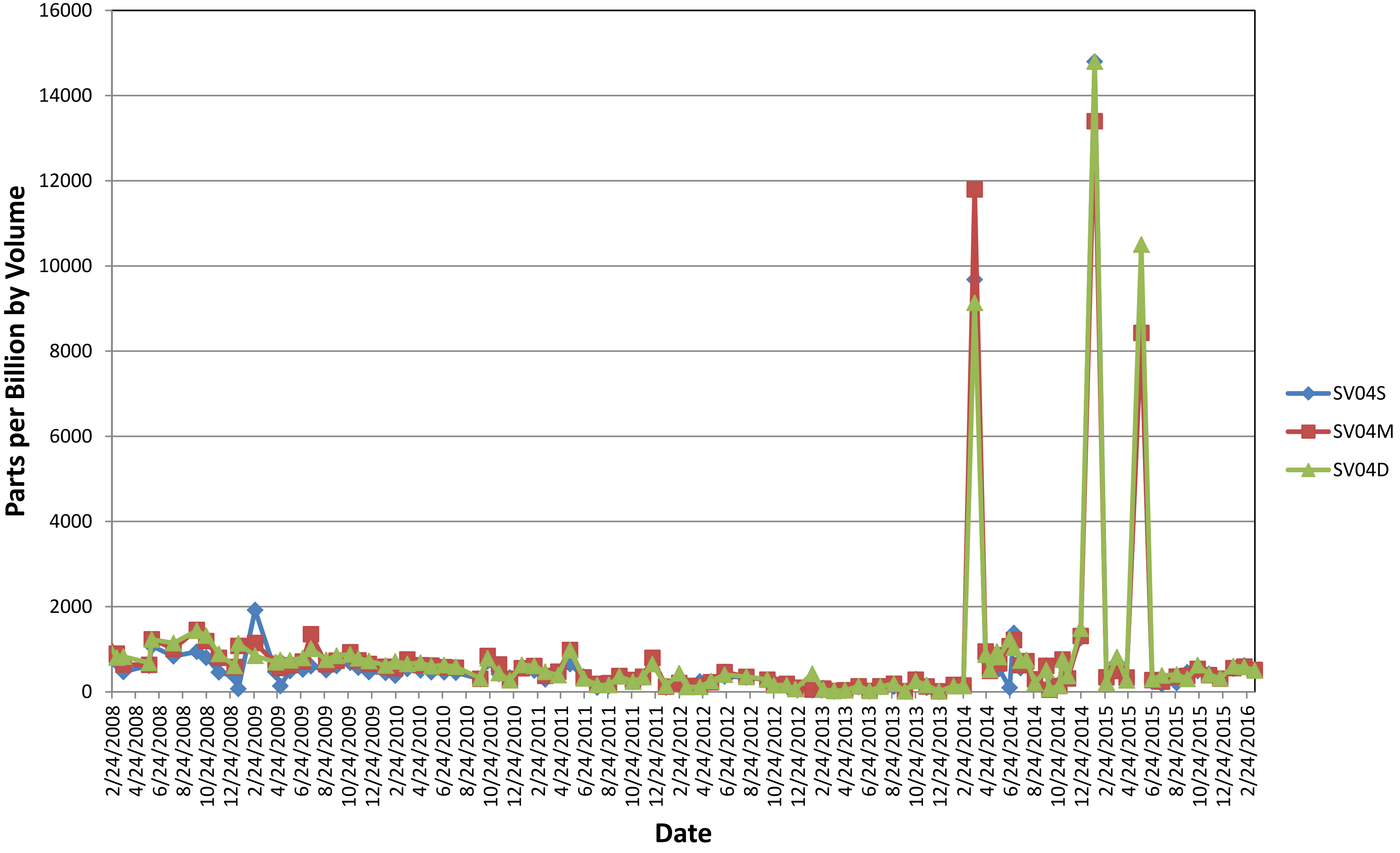
# Figure 1
# Soil Vapor Measurements
# SV02



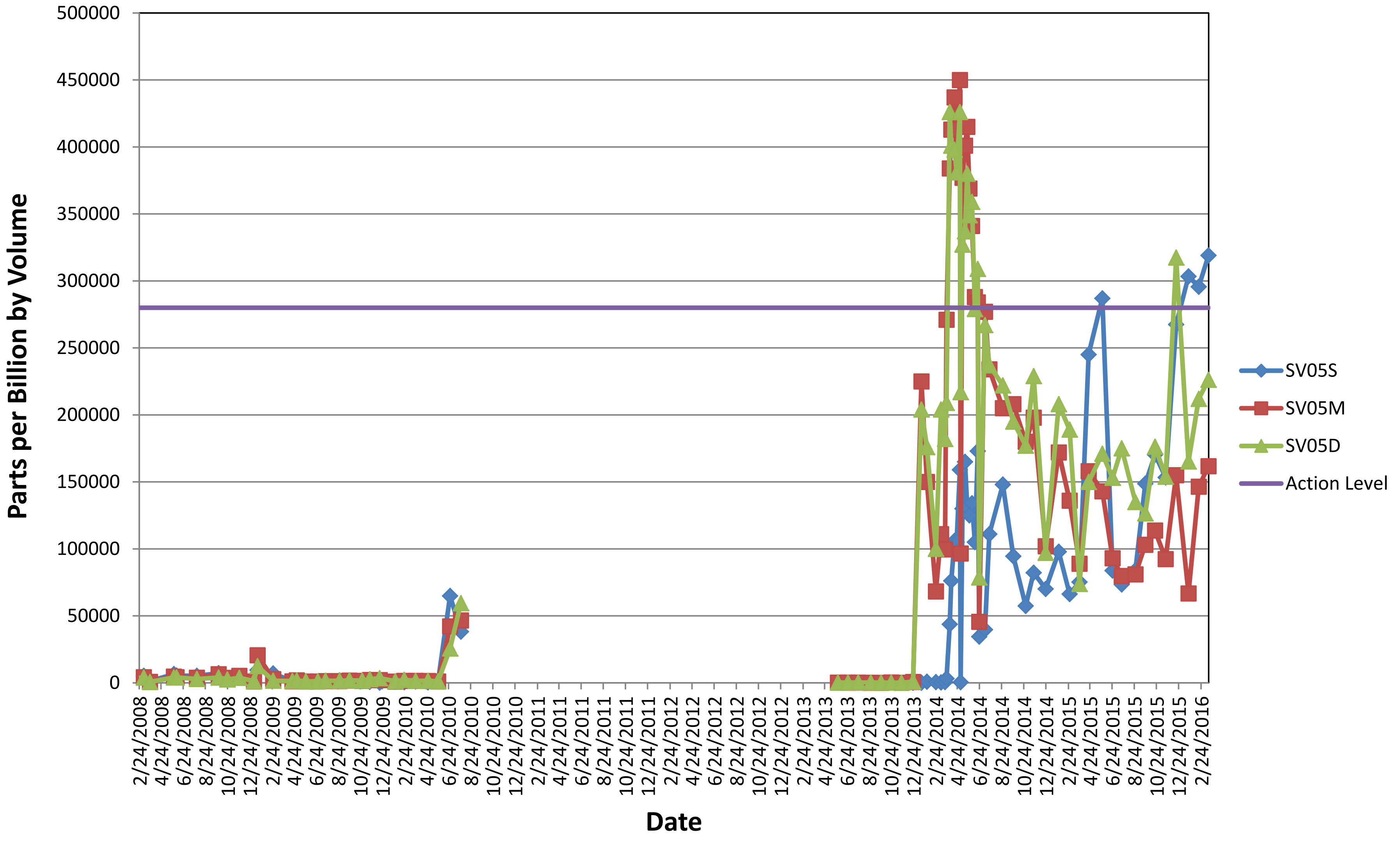
# Figure 2
# Soil Vapor Measurements
# SV03



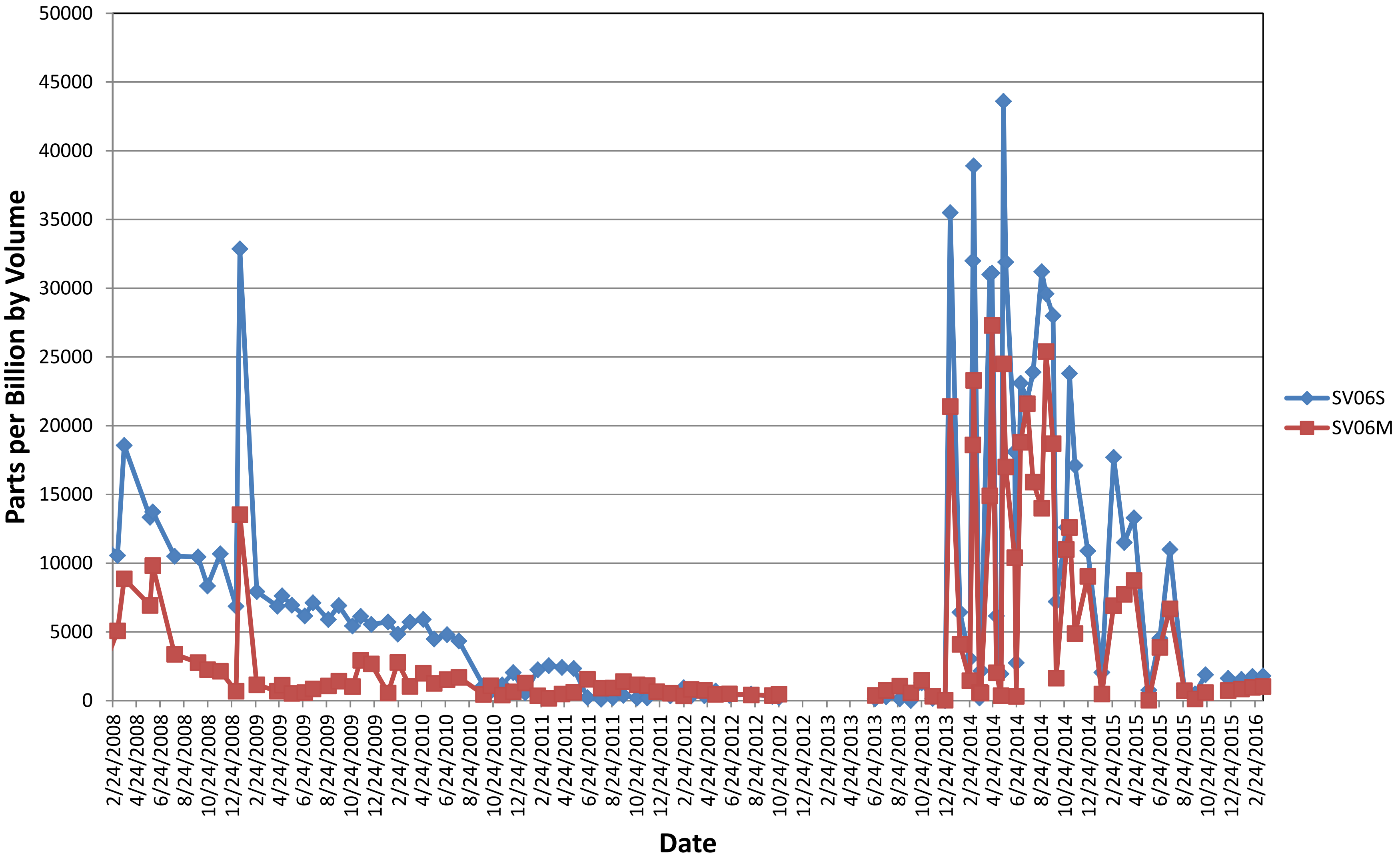
# Figure 3
# Soil Vapor Measurements
# SV04



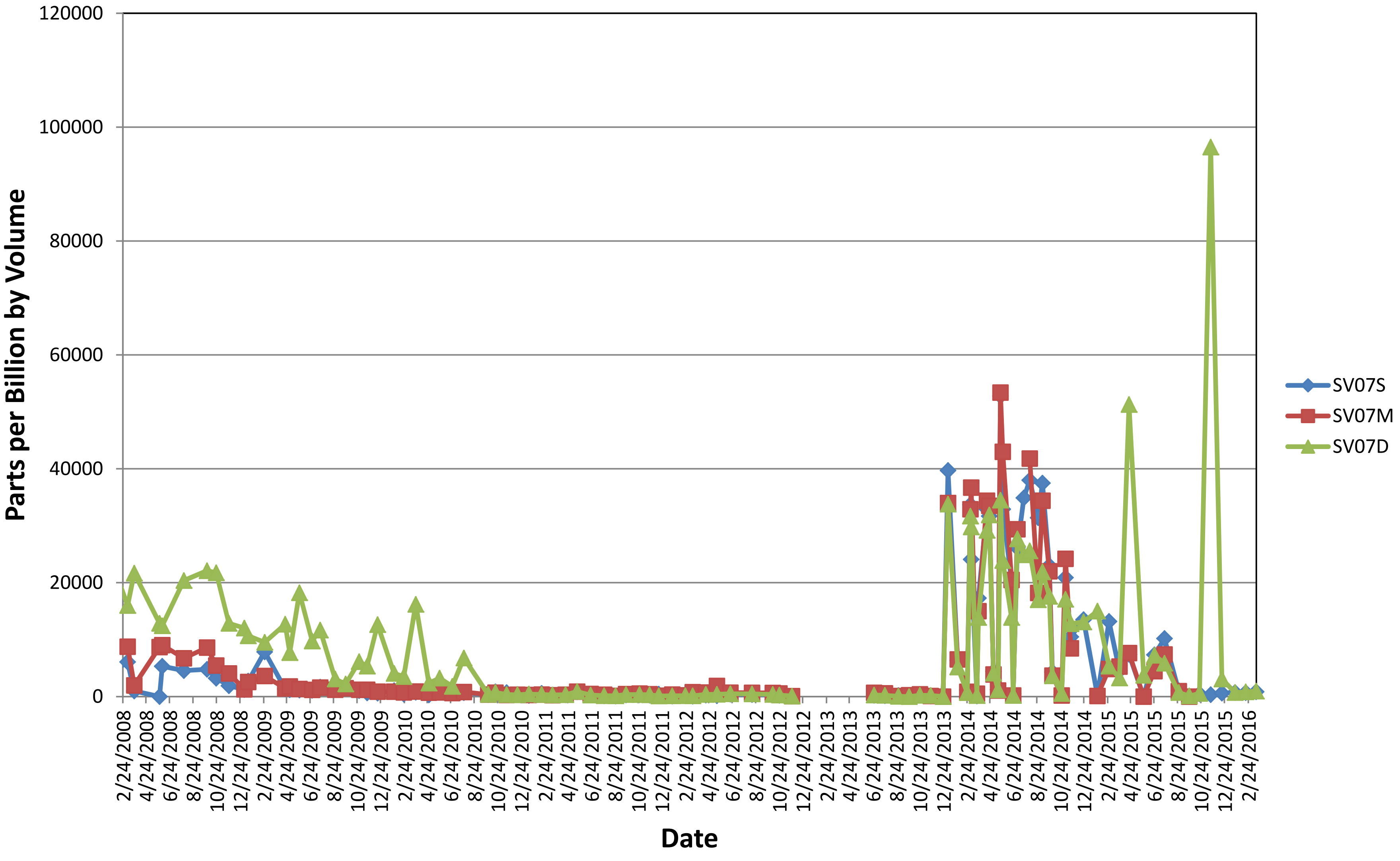
# Figure 4
# Soil Vapor Measurements
# SV05



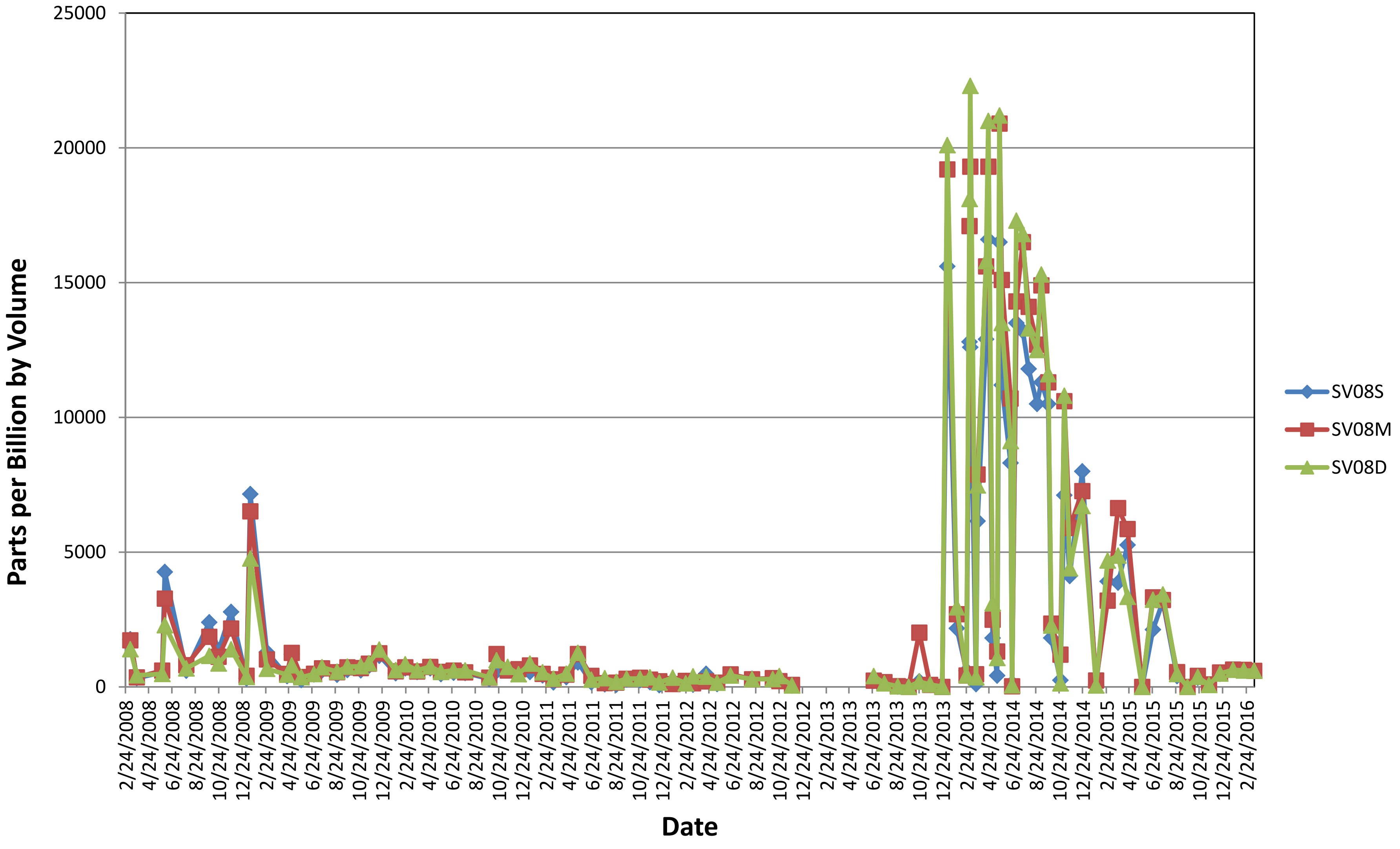
# Figure 5
# Soil Vapor Measurements
# SV06



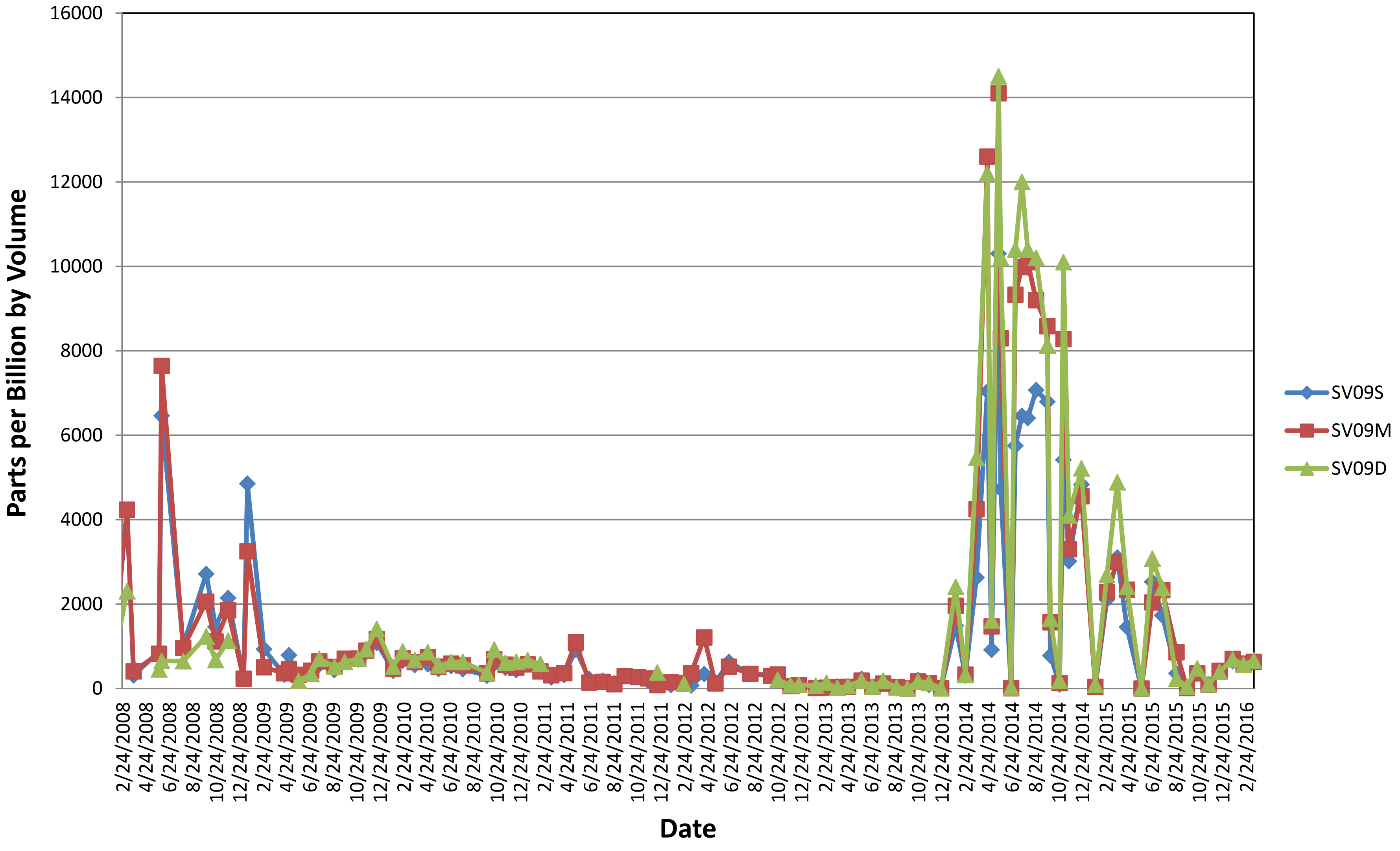
# Figure 6
# Soil Vapor Measurements
# SV07

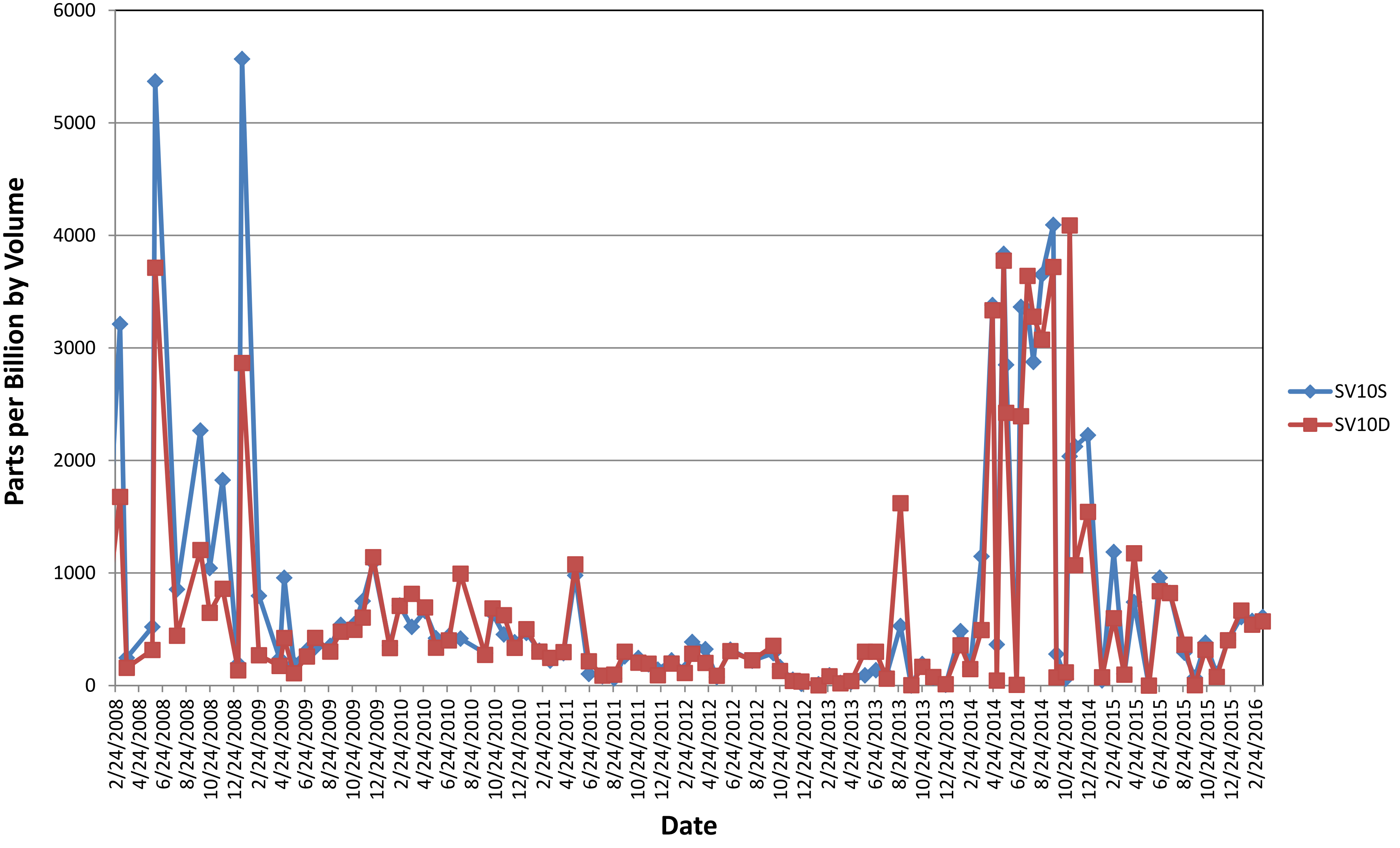


# Figure 7
# Soil Vapor Measurements
# SV08



## Figure 8
## Soil Vapor Measurements
## SV09





## Figure 9
## Soil Vapor Measurements
## SV10

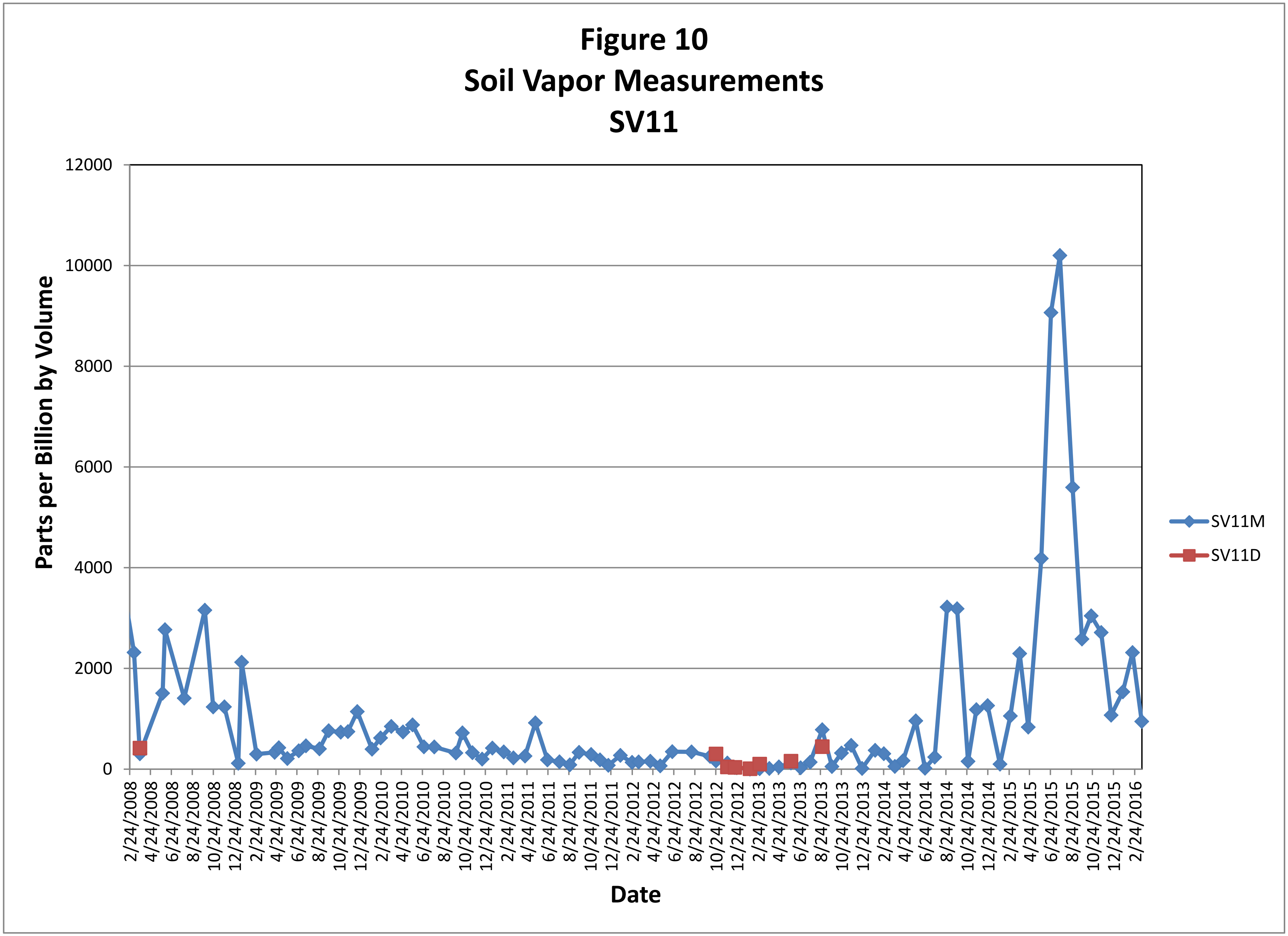
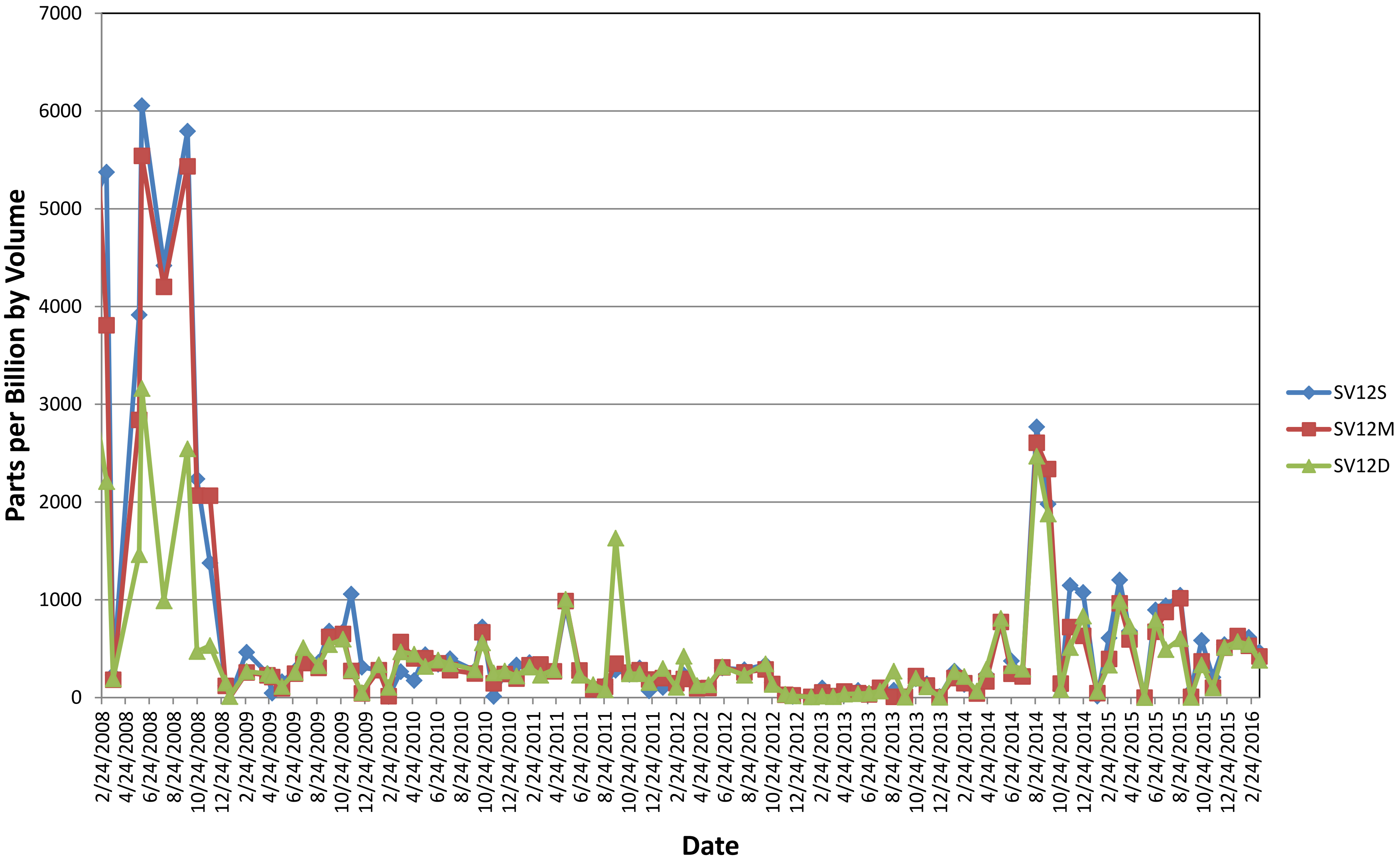
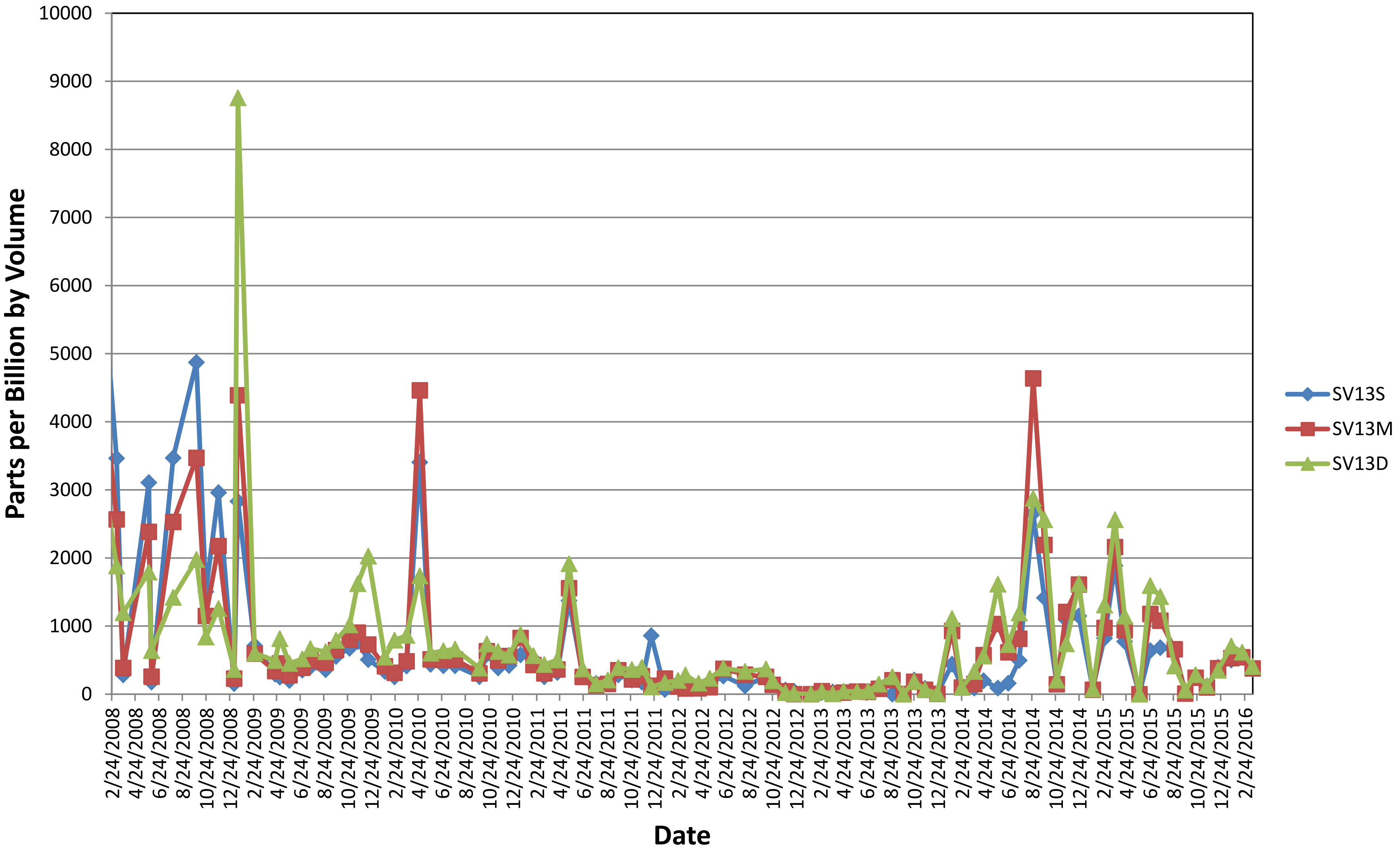


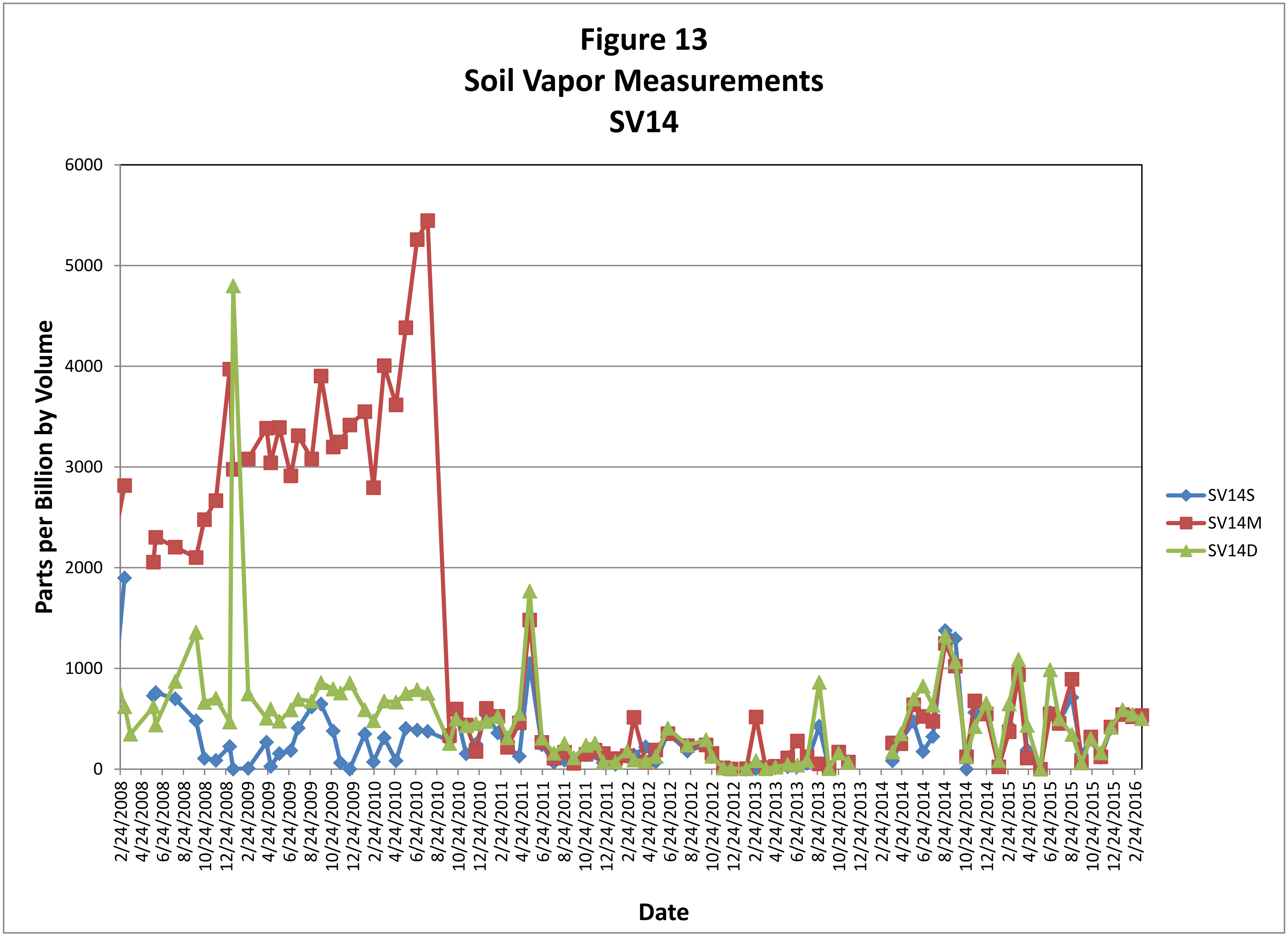
Figure 10
Soil Vapor Measurements
SV11
Parts per Billion by Volume
12000
10000
8000
6000
4000
2000
0
2/24/2008
4/24/2008
6/24/2008
8/24/2008
10/24/2008
12/24/2008
2/24/2009
4/24/2009
6/24/2009
8/24/2009
10/24/2009
12/24/2009
2/24/2010
4/24/2010
6/24/2010
8/24/2010
10/24/2010
12/24/2010
2/24/2011
4/24/2011
6/24/2011
8/24/2011
10/24/2011
12/24/2011
2/24/2012
4/24/2012
6/24/2012
8/24/2012
10/24/2012
12/24/2012
2/24/2013
4/24/2013
6/24/2013
8/24/2013
10/24/2013
12/24/2013
2/24/2014
4/24/2014
6/24/2014
8/24/2014
10/24/2014
12/24/2014
2/24/2015
4/24/2015
6/24/2015
8/24/2015
10/24/2015
12/24/2015
2/24/2016
Date
SV11M
SV11D

## Figure 11
## Soil Vapor Measurements
## SV12



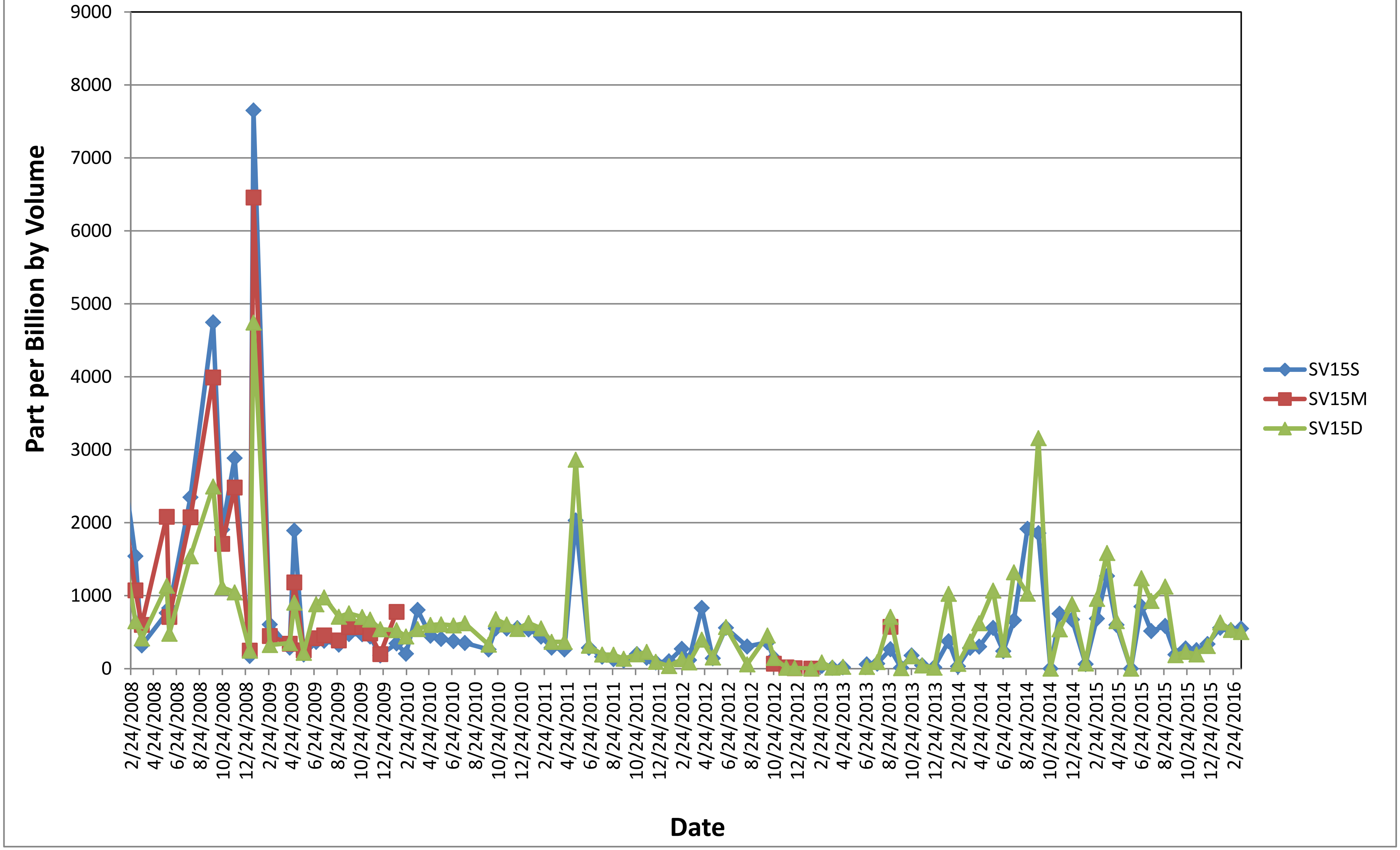
# Figure 12
# Soil Vapor Measurements
# SV13



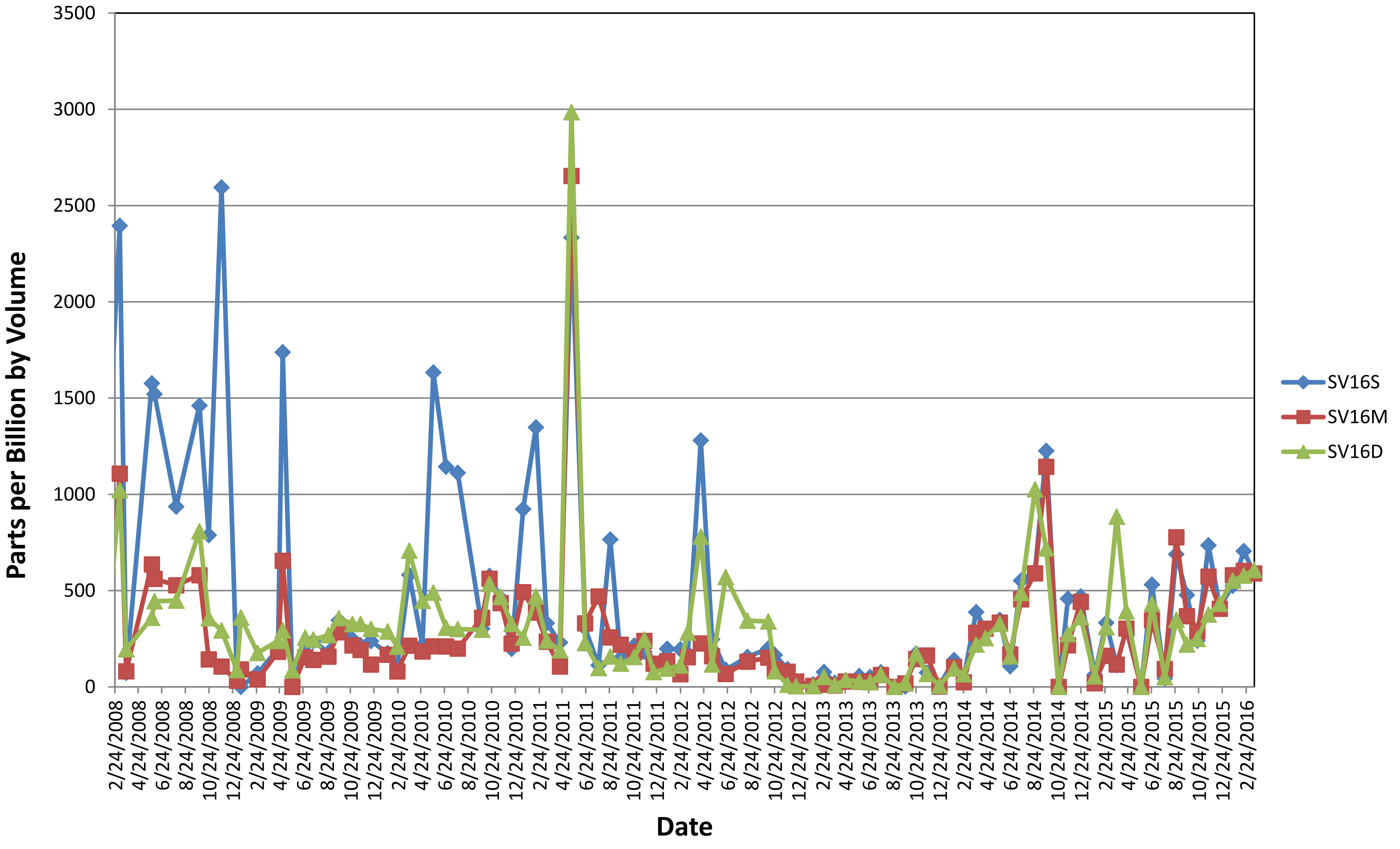


# Figure 13
# Soil Vapor Measurements
# SV14

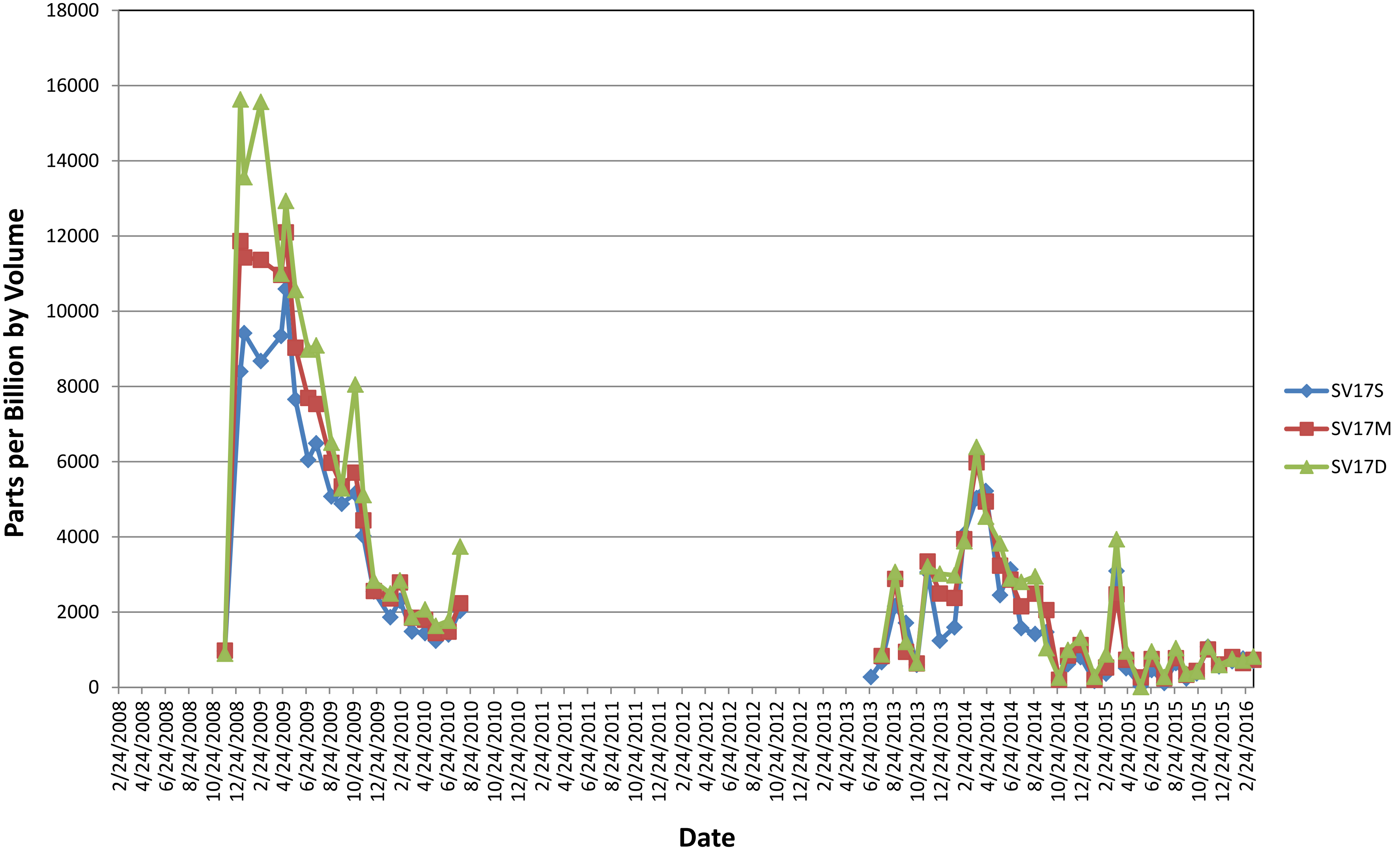
# Figure 14
# Soil Vapor Measurements
# SV15



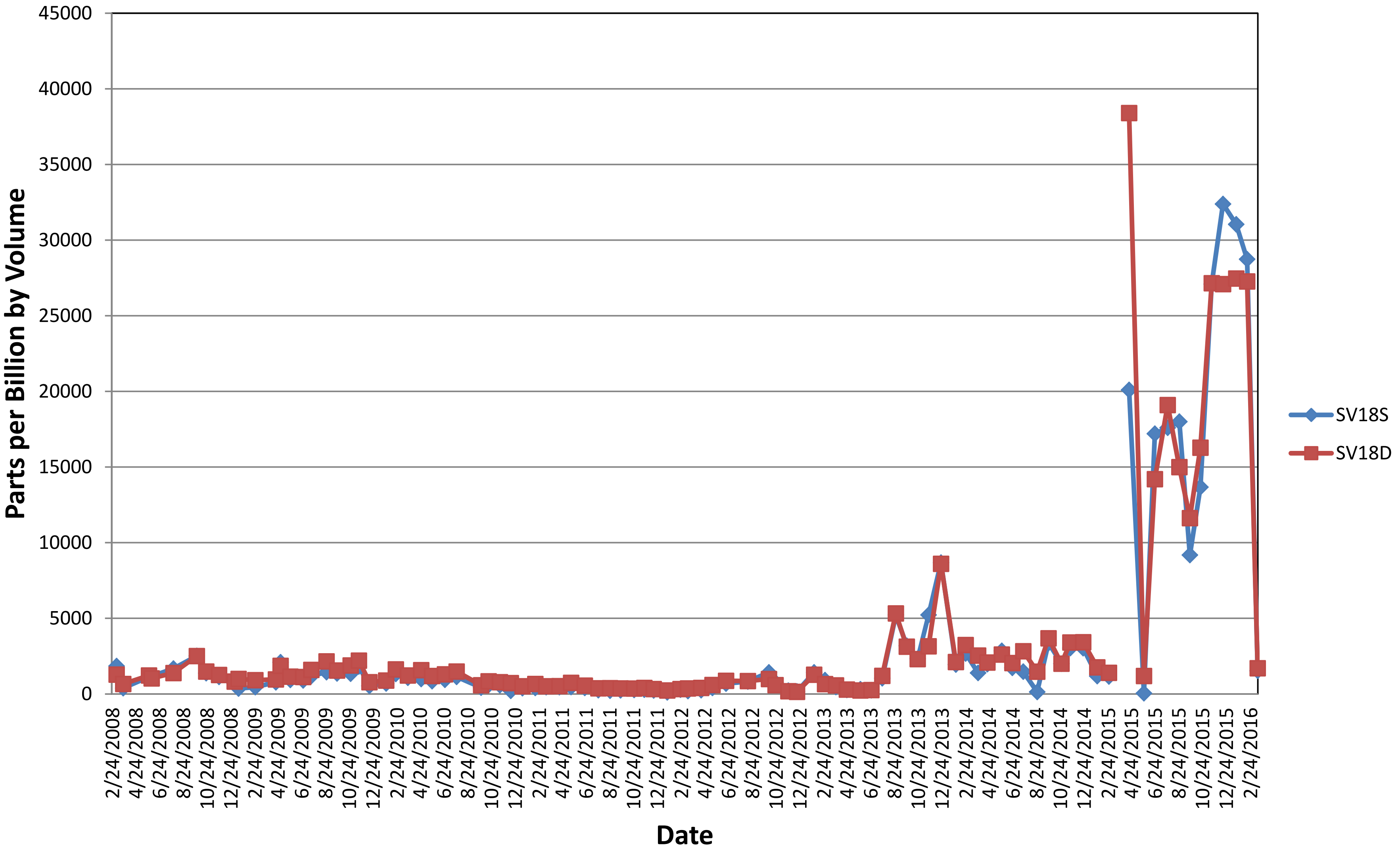
# Figure 15
# Soil Vapor Measurements
# SV16



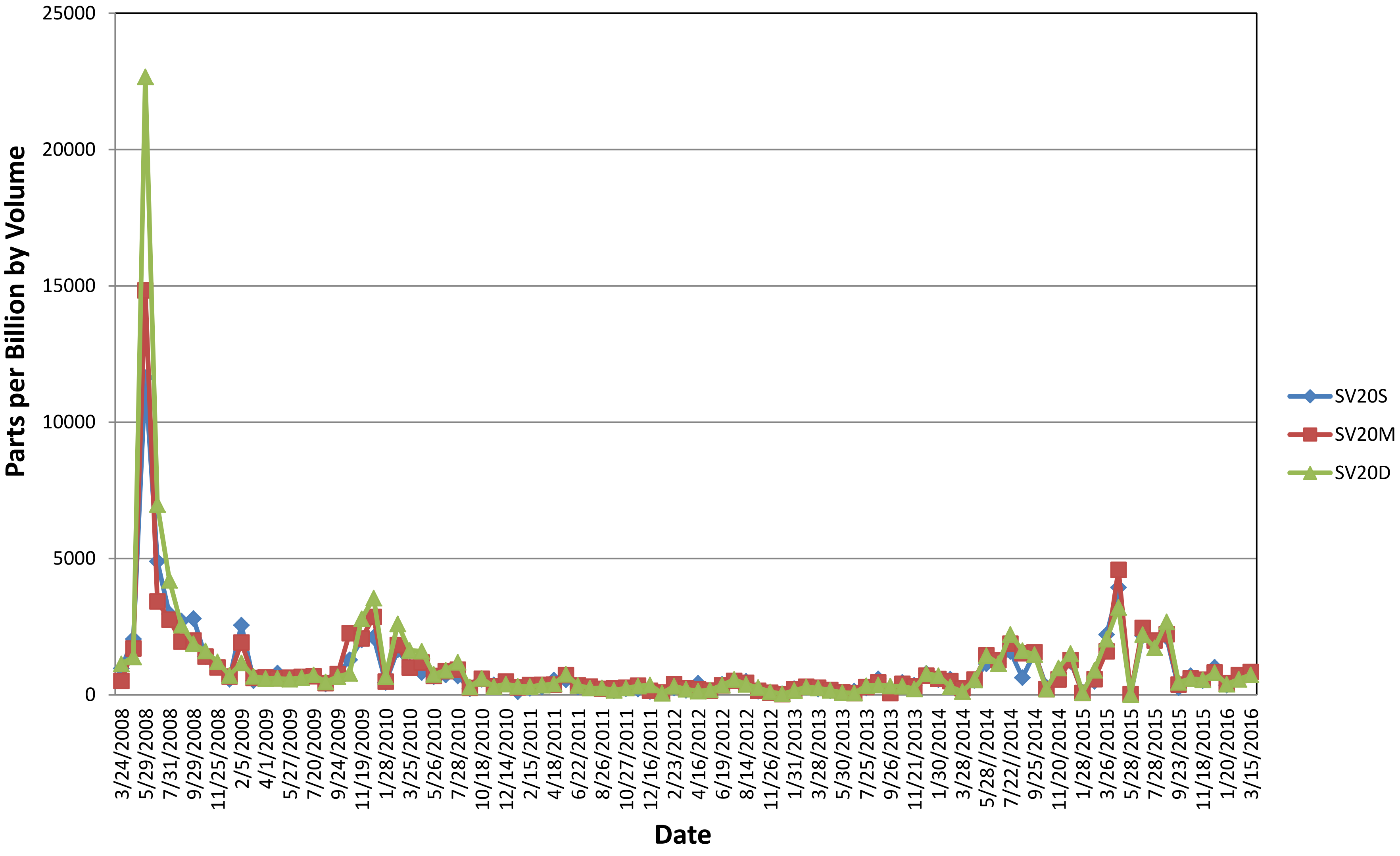
# Figure 16
# Soil Vapor Measurements
# SV17



## Figure 17
## Soil Vapor Measurements
## SV18



## Figure 18
## Soil Vapor Measurements
## SV20



# Appendix E:
# NAPL Investigation Technologies

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# CONTENTS

## TABLES

# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| °C | degree Celsius |
| bgs | below ground surface |
| DPT | direct-push technology |
| EM | electromagnetic |
| ER | electrical resistivity |
| GPR | ground-penetrating radar |
| IP | induced polarization |
| LIF | laser-induced fluorescence |
| MIP | membrane interface probe |
| MRS | magnetic resonance sounding |
| NAPL | non-aqueous-phase liquid |
| PAH | polynuclear aromatic hydrocarbon |
| RHSF | Red Hill Bulk Fuel Storage Facility |
| SOW | scope of work |
| SP | spontaneous potential |
| UST | underground storage tank |
| UVOST | ultraviolet optical screening tool |
| WP | work plan |

# 1. Potential NAPL Investigation Technologies for RHSF

The complex subsurface geology at the Red Hill Bulk Fuel Storage Facility (RHSF), as outlined in Section 3.7 of this Work Plan, presents obstacles and challenges to the potential implementation and likelihood of success of investigation technologies that could be used to investigate the location of non-aqueous-phase liquid (NAPL) in the vadose zone. Section 2 discusses the various methods and technologies that are currently used in the environmental industry to evaluate the nature and extent of NAPL, and evaluates their potential for successful implementation at RHSF. Section 2.7 summarizes the evaluation and presents recommendations for the RHSF Investigation and Remediation of Releases and Groundwater Protection and Evaluation investigation. Of the technologies identified, only one is recommended as a potentially viable tool to screen the subsurface for NAPL and map subsurface geological features at RHSF: the geophysical method electrical resistivity (Section 3). Due to the site stratigraphy, depth of the tanks, and other factors described below, while electrical resistivity is the most suitable of the available methods, it is not clear whether this method would be successful at locating NAPL in the vadose zone.

# 2. Technology Evaluation

The following NAPL investigation technologies have been identified as available, and their suitability for this investigation is evaluated in this section:

- Borings and groundwater monitoring wells
- Laser-induced fluorescence (LIF)
- Membrane interface probe (MIP)
- Dye impregnated liners
- Soil gas survey
- Geophysical methods
  - Electrical Resistivity (ER)
  - Seismic Survey
  - Spontaneous Potential (SP)
  - Gravity and Magnetic
  - Induced Polarization (IP)
  - Ground-Penetrating Radar (GPR)
  - Magnetic Resonance Sounding (MRS)
  - Electromagnetic (EM)

## 2.1 BORINGS AND GROUNDWATER MONITORING WELLS

Advancing boreholes and constructing groundwater monitoring wells is one of the most common methods used to evaluate the presence of subsurface NAPL. These methods can be very effective in shallow sites comprised of alluvium, sand, or other relatively homogeneous or well-defined materials, where the location of NAPL can be accurately predicted. However, these methods have substantial limitations for this site, as discussed below.

*General Technological Capabilities:* An intrusive drilling program can provide several benefits, including the collection of soil and groundwater samples for laboratory and geological analysis and the ability to conduct long-term monitoring for the presence of NAPL on the groundwater surface. The visual confirmation of geological features and subsurface lithology can also be useful for modeling and evaluating remedial alternatives. There is also no depth limitation when using boreholes and monitoring wells to study NAPL.

*Site-Specific Evaluation:* The effective use of boreholes and monitoring wells to confirm the presence and determine the extent of NAPL in the subsurface is, however, limited to whether NAPL is present in the borehole or monitoring well. Assuming a typical borehole diameter of 4–8 inches, this method can be "hit and miss," especially in fractured and heterogeneous rock formations such as those found on site, and can become highly cost-prohibitive if numerous boreholes and monitoring wells are constructed. Furthermore, drilling numerous boreholes into the subsurface increases the potential for creating a preferential pathway for NAPL to migrate vertically to groundwater. First, because the site geology is highly heterogeneous with interbedded low and high permeability layers, advancing boreholes in the vicinity of the underground storage tanks (USTs) would elevate the risk that NAPL could reach the groundwater (where it has not yet been detected in measurable amounts). Second, the very presence of the tank farm itself and associated structural stability concerns limit the feasibility of advancing boreholes in the vicinity of the USTs. It can also be one of the most cost-prohibitive methods when used alone and not supplemented by another technology.

While this method is currently in use to a certain degree, to the extent that existing boring and monitoring wells have already been advanced, and more are proposed in this investigation, extensive advancement of boreholes in the vicinity of the USTs in order to "chase" NAPL at the RHSF site is not recommended.

### 2.2 LASER-INDUCED FLUORESCENCE

LIF technologies can detect the presence of polynuclear aromatic hydrocarbons (PAHs) in borehole sidewalls. An ultraviolet optical screening tool (UVOST) utilizes the principals of fluorescence, in which molecules absorb light at a particular wavelength and then emit light of a longer wavelength after a brief interval. PAHs and other polycyclic aromatic compounds are particularly capable of fluorescence. The UVOST system uses direct-push technology (DPT) to lower a sapphire-window into the subsurface, where it measures this fluorescence.

*General Technological Capabilities:* LIF provides for real-time determination of the presence of NAPL without the need for extensive laboratory analysis. However, like the borehole and monitoring well method described in the previous subsection, LIF methods can be very "hit or miss" in heterogeneous and fractured rock formations, and the technology cannot detect dissolved-phase contamination.

*Site-Specific Evaluation:* Because LIF can detect NAPL only in the borehole itself, the heterogeneous and fractured rock formations at Red Hill may require the drilling of numerous boreholes into the subsurface to adequately delineate subsurface NAPL. Such activity can be cost-prohibitive and can also increase the potential of creating a preferential pathway for NAPL to migrate vertically to groundwater. Therefore, use of LIF for the RHSF investigation is not recommended.

### 2.3 MEMBRANE INTERFACE PROBE

MIP evaluates the presence of residual- and dissolved-phase petroleum constituents in the subsurface using a probe advanced into the subsurface by DPT. The probe is heated to temperatures between 100 and 120 degrees Celsius (°C), which volatilizes residual- and dissolved-phase contaminants out of the media immediately surrounding the probe. The volatilized compounds pass through the probe’s semi-permeable membrane and are transferred through tubing to the ground surface for real-time analysis.

*General Technological Capabilities:* MIP is effective at delineating dissolved-phase petroleum contamination and results can be used to infer the presence or absence of NAPL. Because the effectiveness of MIP is contingent on the volatilization of compounds, it is most effective in detecting organic chemicals with relatively low boiling points (i.e., less than 100°C). The probe can become damaged if driven directly through NAPL.

*Site-Specific Evaluation:* The use of boreholes to delineate NAPL is expected be very “hit or miss” in a fractured and heterogeneous rock formation such as the Red Hill vadose zone, and it is likely that a large number of boreholes would be necessary to locate and delineate a NAPL plume. Construction of numerous boreholes is cost-prohibitive and can create preferential pathways for NAPL to migrate vertically to groundwater. Since many of the chemicals of potential concern proposed for the Tank 5 release investigation have boiling points greater than 100°C, MIP is not the ideal technology for investigating releases at the RHSF site. Therefore, use of MIP for the RHSF investigation is not recommended.

### 2.4 DYE-IMPREGNATED LINER

Dye-impregnated liner membranes installed in an open borehole change color when in contact with NAPL. After the liner is placed within the borehole, the liner is filled with water to force it against the borehole sidewall. Following a manufacturer-specified contact time, the liner is removed from the borehole by pulling a tether anchored at the bottom of the membrane, which turns the membrane inside out as it is removed. The liner can be inspected at the ground surface for color changes due to NAPL, thereby inferring the depth and approximate vertical profile of the plume.

*General Technological Capabilities:* Use of dye-impregnated liners is a reliable method for determining the presence, depth, and vertical profile of subsurface NAPL. The technology has no geologic restrictions, and can be used in bedrock. Dye-impregnated liners rely on adequate contact with the borehole sidewall, and therefore their effectiveness is contingent on the ability to construct a borehole with a compatible diameter; smaller borehole diameters (2.25–3.5 inches) are preferable.

*Site-Specific Evaluation:* Use of dye-impregnated liners is expected to work in the heterogeneous formation at Red Hill. However, a sufficiently small-diameter borehole may not be constructible in the fractured rock formation of Red Hill. The use of boreholes to delineate NAPL is also expected to be very “hit or miss” in the Red Hill vadose zone, and it is likely that a large quantity of boreholes would be necessary to locate and delineate a NAPL plume. Construction of numerous boreholes is cost-prohibitive and can also create preferential pathways for NAPL to migrate vertically to groundwater. Therefore, use of dye-impregnated liners for the RHSF investigation is not recommended.

## 2.5 PASSIVE SOIL GAS SURVEY

A passive soil gas survey detects NAPL in boreholes by deploying samplers containing an adsorbent material in shallow boreholes (i.e., 5–10 feet below ground surface [bgs]), where the sampler can adsorb soil gas emanating from the surrounding formation. The sample is then retrieved and submitted to an offsite laboratory for analysis.

*General Technological Capabilities:* In general, passive soil gas surveys for the detection of NAPL use boreholes excavated within 5–10 feet of the ground surface. The less-invasive aspect of this technology is desirable because it avoids the potential creation of preferential pathways, which would allow NAPL to migrate vertically and impact groundwater. Monitoring soil gas is more effective for detecting near-surface plumes of lighter-range petroleum fuels, such as gasoline.

*Site-Specific Evaluation:* Due to the depth to groundwater at the RHSF site (i.e., over 500 feet bgs, depending on location) and the types of fuels historically stored in Tank 5 (i.e., middle distillates and heavier fuels), soil gas surveys would not be effective at detecting deeper plumes of NAPL at the site. In addition, the site's subsurface geology is highly heterogeneous, and vapors may migrate horizontally as they also migrate upward, meaning that detecting them at the surface may not be indicative of where the source is in the subsurface. Therefore, conducting a passive soil gas survey for the RHSF investigation is not recommended.

## 2.6 GEOPHYSICAL METHODS

Several geophysical methods for NAPL detection and delineation are currently being used in the environmental investigation industry.

### 2.6.1 Electrical Resistivity Tomography

ER tomography can detect the presence of subsurface fluids such as NAPL by measuring the resistivity of subsurface formations. An electric current is induced into the ground, and the resistivity of subsurface materials between electrodes located on the ground surface is measured. Subsurface fluids filling the pore space in the geological formation can be detected and delineated by measuring changes in resistivity.

*General Technological Capabilities:* Electrodes are reported to be sensitive enough to determine minor differences in resistivity between NAPL and unimpacted material. The depth of investigation can be increased by adjusting the spacing of electrodes. Installation of electrodes requires minimal drilling at the ground surface, therefore achieving cost savings and avoiding the potential creation of vertical migration pathways. By collecting data over time, plume migration can be documented.

*Site-Specific Evaluation:* Although ER has been successfully used at other sites, many previous uses have been for plumes located at much shallower depths than the potential plume depth at Red Hill. The resistivity electrodes located at the ground surface require a relatively level and straight path to be effective, and the uneven topography and heavily vegetated terrain at Red Hill, as well as interference from the USTs, could pose significant challenges in deploying ER at the site. A pilot test study is therefore recommended to determine the feasibility of ER for the RHSF investigation (see Section 3).

### 2.6.2 Seismic Survey

A seismic survey constructs an image of the subsurface by inducing seismic energy into the subsurface (e.g., using an air gun or seismic vibrator) and measuring the wave energy that reflects and refracts to the ground surface as the seismic waves encounter interfaces between materials with different acoustic impedances. Differences in the velocities of the seismic waves detected at the surface are used to construct the subsurface image.

*General Technological Capabilities:* Seismic technology is most commonly used for mapping faults and fractures in bedrock formations. It can also detect the groundwater surface, perched groundwater, and voids that could potentially contain NAPL.

*Site-Specific Evaluation:* Seismic technology is not generally used in environmental investigations, and its effectiveness at detecting NAPL is not well documented. Although seismic methods have been successfully used in DNAPL investigations where the stratigraphy is relatively simple (EPA 2004), due to the complex geology of the RHSF site, accurate interpretation of the seismic data would likely be very difficult or impossible. Use of seismic technology for the RHSF investigation is therefore not recommended.

### 2.6.3 Spontaneous Potential

SP is used for formation evaluation and groundwater investigation. SP logging measures small differences in the electric potential (measured in millivolts) between an electrode advanced to various depths in a borehole and a ground electrode at the surface.

*General Technological Capabilities:* SP is used primarily for investigating the integrity of earthen dams/dikes. SP can identify where water is flowing in the subsurface, but is poorly suited for detecting NAPL.

*Site-Specific Evaluation:* Because SP's effectiveness at detecting NAPL is not well documented, it is not recommended for the RHSF investigation. Furthermore, as discussed above, advancing boreholes in the vicinity of the USTs would be expensive and increase the risk that NAPL could reach the groundwater.

*Gravity and Magnetic Survey:* Gravity and magnetic surveys involve measuring changes in either the gravity field or magnetic field (natural or induced) using highly sensitive instruments.

*General Technological Capabilities:* Gravity and magnetic surveys are used primarily in the exploration of large ore bodies and sometimes petroleum exploration, usually to identify smaller areas of interest. Such surveys can be quickly and easily performed over large areas.

*Site-Specific Evaluation:* Gravity and magnetic surveys are not generally used in environmental investigations. Because their effectiveness at detecting NAPL is not well documented, they are not recommended for the RHSF investigation.

### 2.6.4 Induced Polarization

IP is a subsurface imaging technique used to identify subsurface materials. The method is similar to ER tomography (i.e., an electric current is induced into the subsurface through two electrodes, and voltage is monitored through two other electrodes). It measures the voltage decay or chargeability over a specified time interval after the induced voltage is removed. It is a secondary resistivity method that uses the same equipment as ER tomography.

*General Technological Capabilities:* IP has been successfully used at other sites to investigate landfills and petroleum NAPL and to map lithologies. IP can be combined with ER tomography. The use of the same equipment as ER allows for the potential to collect greater amounts of information without an additional mobilization.

*Site-Specific Evaluation:* Because IP uses the same equipment as ER tomography, this method might be effective at the RHSF site. However, ER tomography is a more advanced method for imaging subsurface features; therefore, IP is not recommended for the current RHSF investigation.

#### 2.6.5 Ground-Penetrating Radar

GPR is a high-resolution acoustic imaging technique that pulses electromagnetic radiation in the microwave band of the radio spectrum and detects the reflected signals from subsurface structures.

*General Technological Capabilities:* GPR is most commonly used to characterize stratigraphy and identify fractures or other preferential pathways (e.g., utility corridors or voids) that can affect contaminant transport. GPR can also be used to image shallow structures such as USTs.

*Site-Specific Evaluation:* GPR could potentially be used to map near-surface NAPL, but is typically effective only at depths less than 20 feet bgs (EPA 2004). Therefore, GPR may not be effective at Red Hill, where the groundwater is more than 500 ft bgs at some locations, and is not recommended for the RHSF investigation.

#### 2.6.6 Magnetic Resonance Sounding

MRS measurements can be used to indirectly estimate the water content of saturated and unsaturated zones in the earth's subsurface. A MRS survey is generally conducted in three stages: ambient electromagnetic noise is measured; a pulse of electrical current is transmitted to the subsurface, thereby creating an EM field; and the EM is terminated and the magnetic resonance signal is measured.

*General Technological Capabilities:* MRS is commonly used to estimate depth to groundwater, permeability, and water content, but its use for NAPL investigations is less common. MRS instrumentation can be sensitive to interference from power lines and is poorly suited for sites dominated by volcanic rock formations.

*Site-Specific Evaluation:* Because it is poorly suited for the volcanic rock formations present at Red Hill, MRS is not recommended for the RHSF investigation.

#### 2.6.7 Electromagnetic

EM methods use the principle of induction to measure the electrical conductivity of the subsurface. The depth of penetration can be increased by adjusting the separation distance and orientation of the EM coils.

*General Technological Capabilities:* EM is typically used to characterize subsurface hydrogeology and to map landfills and other conductive soil and groundwater contamination, conductive faults/fracture planes, and geologic structures. Multiple EM methods can be used to investigate subsurface features.

*Site-Specific Evaluation:* Although NAPLs are non-conductive and can alter the bulk electrical properties of the surrounding matrix (e.g., soil, groundwater), EM methods are affected by metal structures such as pipes, fences, and tanks, and have not proven reliable for locating subsurface NAPL (EPA 2004); therefore, EM is not recommended for the current RHSF investigation.

### 2.7 SUMMARY OF NAPL INVESTIGATION TECHNOLOGIES

Table E-1 summarizes the recommendations for each evaluated NAPL technology. While it is not clear whether any of these methods will be successful at locating LNAPL in the complex Red Hill geology, ER is considered the most promising of these technologies. Therefore, ER is recommended for further evaluation at this time; the other technologies are not presently recommended due to the complex nature of the Red Hill subsurface geology, site constraints, and the various technologies' low likelihood of producing actionable data.

**Table E-1: Summary of NAPL Investigation Technology Recommendations**

| Technology | Recommendation | Notes |
|---|---|---|
| Drilling Borings and Groundwater Monitoring Well Installation | Not Recommended | Use of boreholes can be potentially expensive and can create preferential pathways for NAPL to migrate. |
| LIF Tools (e.g., UVOST) | Not Recommended | Use of boreholes can be potentially expensive and can create preferential pathways for NAPL to migrate. |
| MIP | Not Recommended | Use of boreholes can be potentially expensive and can create preferential pathways for NAPL to migrate. |
| Dye-Impregnated Liner | Not Recommended | Use of boreholes can be potentially expensive and can create preferential pathways for NAPL to migrate. |
| Soil Gas Survey (Passive) | Not Recommended | Less effective for the middle distillates and heavier fuels stored in Tank #5. |
| Electrical Resistivity (ER) (e.g., tomography) | Recommended for Further Evaluation | May be useful for RHSF NAPL investigation. See discussion of proposed use in Section 3. |
| Seismic Survey | Not Recommended | Not generally used for environmental investigations. |
| SP | Not Recommended | Not generally used to detect NAPL. The required boreholes can be expensive and may create preferential pathways for NAPL migration. |
| Gravity and Magnetic Survey | Not Recommended | Ability to detect NAPL is not well documented. |
| IP | Not Recommended | IP might be effective for the RHSF NAPL investigation. However, ER tomography is a more advanced method for imaging subsurface features; therefore, IP is not recommended. |
| GPR | Not Recommended | Effective only to shallow depths (i.e., 20 feet bgs). |
| MRS | Not Recommended | Not suited for sites with volcanic rock formations. |
| EM | Not Recommended | EM methods are affected by metal structures such as pipes, fences, and tanks, and have not proven reliable for locating subsurface NAPL; therefore, EM is not recommended. |

## 3. Proposed Electrical Resistivity Survey

An ER tomography survey capable of screening the subsurface for anomalous zones related to contaminant distribution (e.g., light and dense NAPL), potential preferential flow pathways, and geologic mapping is recommended for the RHSF site. The ER survey would augment the existing dataset (i.e., boring, monitoring well, and core data) as necessary to adequately characterize the site geology and might locate subsurface NAPL.

A pilot-scale ER survey is recommended, with nine transects in the lower tunnel and lower adit, and one transect on the ground surface at the top of the Red Hill ridge above the tank farm. Appropriate access requirements would need to be arranged for the survey, including permission to drill 0.5-inch-diameter probes up to 1 foot deep into the concrete floor of the tunnel and adit. The holes will be patched with concrete following completion of the survey. In addition, the ground surface transect would require vegetation clearance if an area that does not require vegetation clearance cannot be identified.

Each transect is anticipated to be spaced according to the electrode spacing and survey line distances listed in Table E-2; however, the actual electrode spacing and survey line distances will be adjusted to field conditions.

**Table E-2: Proposed ER Transect Spacing, Length, and Image Depths**

| Proposed Location/Use | Electrode Spacing (ft) | Survey Line (ft) | Corresponding Image Depth (ft) |
|---|---|---|---|
| Within lower tunnel for sensitivity testing and higher resolution imaging | 5 | 271 | 54 |
| Within tunnel or adit for deep geologic mapping | 13 | 722 | 147 |
| On ground surface | 36 | 1,984 | 400 |

Note: Electrode spacing and survey line distances will be adjusted based on field conditions.
ft foot or feet

Typically, ER surveys are conducted in conjunction with targeted confirmation drilling and sampling to improve the interpretation of data and calibrate electrical imagery to subsurface geology and the presence or absence of NAPL and bioactivity. Due to restrictions associated with drilling within the RHSF tunnels, existing boring logs and core data will instead be used to facilitate interpretation of the ER pilot test results. The principal objective of the pilot testing will be to evaluate the ability of the ER method to accurately locate subsurface NAPL at the RHSF site, which will depend on factors including the local geology and depth of NAPL. Local geologic and hydrogeologic features, such as perched groundwater and subsurface voids (e.g., lava tubes), could yield "false results"; however, the potential for false results will be reduced by evaluating the ER data in conjunction with the existing boring logs and core data.

The ER tomography data acquired during the pilot testing will be evaluated to confirm whether the method is likely to be effective for locating subsurface NAPL. If the method proves to be effective, and if further analysis will advance the objectives of the AOC, the survey may be expanded as necessary to further evaluate the potential presence of NAPL.

## 4. References

Environmental Protection Agency, United States (EPA). 2004. *Site Characterization Technologies for DNAPL Investigations.* EPA 542-R-04-017, Office of Solid Waste and Emergency Response (5102G). September.

# Appendix F:
# Remedial Alternatives Preliminary Analysis

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# CONTENTS

**TABLES**

# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| BWS | Board of Water Supply, City and County of Honolulu |
| COPC | chemical of potential concern |
| ISCO | in-situ chemical oxidation |
| MNA | monitored natural attenuation |
| NAPL | non-aqueous-phase liquid |
| O&M | operations and maintenance |
| RHSF | Red Hill Bulk Fuel Storage Facility |
| SOW | scope of work |
| SVE | soil vapor extraction |
| WP | work plan |

# REMEDIAL TECHNOLOGIES PRELIMINARY ANALYSIS

## 1. Introduction

As discussed in Section 2.3 of this Work Plan and Scope of Work (WP/SOW), previous and ongoing groundwater monitoring at the RHSF site suggests the January 2014 release from Tank 5 has not significantly impacted groundwater underlying the site. Although the absence of evidence of an ongoing release suggests that the non-aqueous-phase liquid (NAPL) plume in the vadose zone may be stable (i.e., not migrating to the groundwater), alternatives for remedial action to ensure that the groundwater resource underlying the site is protected from contamination will be evaluated following completion of the field investigation.

The remedial action objective for the site is to prevent petroleum product and its constituent chemicals from migrating to groundwater in the vicinity of the City and County of Honolulu Board of Water Supply (BWS) and Navy drinking water pump stations at concentrations exceeding State of Hawaiʻi Department of Health Environmental Action Levels for sites where groundwater is a current or potential drinking water resource. Preliminary evaluations of alternatives for in-situ and ex-situ remediation of NAPL in the vadose zone and aqueous-phase chemicals of potential concern (COPCs) in the groundwater are presented in Section 2 and Section 3, respectively. This analysis is preliminary, based on currently available site data, and will be revisited upon completion of the planned investigation activities and analyses; therefore, while some of the remedial technologies evaluated below may be effective if remedial action is required for the site, no conclusions are presented at this time.

## 2. NAPL Remediation Technologies

### 2.1 EXCAVATION AND REMOVAL

Excavation and removal involves the physical removal of contaminated media. Soil and other contaminated materials excavated from the RHSF site would be containerized and disposed of off site.

*General Technological Capabilities:* Excavation and removal can be an effective way to remove grossly contaminated soil to prevent the contact with or the spreading or leaching of contaminants. Excavation is most effective in relatively shallow alluvial soils, and in cases where contamination has not migrated far or is relatively concentrated.

*Site-Specific Evaluation:* Excavation is one of the simplest and most widely used methods for the quick removal of shallow soil contamination; however, mass excavation at the RHSF site is not feasible due to the potentially great depth of contamination, fractured rock formation, and impracticality of excavating large volumes of rock and soil from beneath the tanks.

### 2.2 SOIL VAPOR EXTRACTION

Soil vapor extraction (SVE) involves the application of negative air pressure (vacuum) to the vadose zone via extraction wells to stimulate in-situ volatilization and vapor removal. Negative air pressure is typically created using a blower or vacuum pump located on the ground surface. Several methods are available for the treatment of extracted air and contaminated vapors, including activated carbon, biofiltration, and high heat.

*General Technological Capabilities:* SVE is widely used and has a proven track record for the remediation of residual hydrocarbon contamination in the vadose zone. SVE is effective at remediating NAPL contamination when combined with other technologies, such as bioventing and NAPL recovery. Consideration of the effective porosity and moisture content of the geologic formation is critical during design of the extraction well network because both are highly influential on an extraction well’s radius of influence. Furthermore, proper construction of wells is important to prevent vertical short-circuiting, which can occur if clean air intrudes into the well, especially in complex geological formations like those at RHSF.

*Site-Specific Evaluation:* Due to the size of the release from Tank 5 (i.e., suspected to be 27,000 gallons), a large volume of NAPL is potentially present in the vadose zone underlying the site. Given the likelihood that a NAPL plume exists, SVE alone would require a long period of time to remove the NAPL, and would incur long-term operations and maintenance (O&M) costs.

### 2.3 MULTI-PHASE EXTRACTION

Multi-phase extraction, or bioslurping, involves the application of a high negative pressure (vacuum) to the subsurface via extraction wells to remove both liquid and vapor-phase contaminants. Typically, a vacuum is applied at the capillary fringe to remove NAPL from the surface of the water table.

*General Technological Capabilities:* Similar to SVE, multi-phase extraction has a proven track record for the remediation of residual hydrocarbons and NAPL. Multi-phase extraction systems are capable of minimizing groundwater drawdown, which in turn limits the formation of a smear zone.

*Site-Specific Evaluation:* Proper design of extraction wells is critical for the effective operation of multi-phase extraction systems. Consideration of effective porosity, depth, and pump size are important for ensuring remedial objectives can be achieved. Short-circuiting can diminish effectiveness, especially in complex geological formations like those at RHSF. Extracted liquid media would require proper containerization and disposal, and extracted vapor would likely require treatment prior to atmospheric discharge. Long-term O&M would likely be required for this alternative.

### 2.4 BIO-VENTING

Bio-venting involves the injection of air or oxygen into the subsurface to stimulate the growth of microorganisms capable of biodegrading hydrocarbons. Under aerobic conditions, these microorganisms are able to derive energy through reactions in which carbon substrates (i.e., petroleum constituents) are used as electron donors and oxygen is used as an electron acceptor. As opposed to air sparging, only enough air flow is provided to stimulate microbial activity. Air is generally applied to areas of residual contamination.

*General Technological Capabilities:* Aerobic biodegradation is a proven process for the treatment of petroleum compounds. The rate of biodegradation can be enhanced by the introduction of nutrient amendments, specialized microorganisms, or other technologies (vapor extraction). Similar to other remedial technologies that rely on biological processes, the treatment time is contingent on the aeration and oxygenation of the aquifer, biodegradation rates, and changes in the groundwater chemistry and NAPL saturation and mass in the aquifer.

*Site-Specific Evaluation:* A pilot study would likely be required prior to full-scale operation in order to evaluate the oxygen and nutrient amendments required to optimize biodegradation in the Red Hill subsurface. Short-circuiting can diminish effectiveness, especially in complex geological formations like those at RHSF. Long-term O&M with periodic groundwater sampling would be required to confirm a decrease in concentrations of petroleum compounds and any associated daughter products.

### 2.5 NAPL RECOVERY

This technology involves the direct removal of NAPL from wells or excavations using active (e.g., pumps, skimmers, bailers) or passive methods (e.g., absorbent materials). In order for NAPL recovery to even be considered, the location of NAPL must be known. Once extracted, NAPL would require appropriate handling and processing for disposal.

*General Technological Capabilities:* NAPL recovery is a widely used technology with proven track record for removal of NAPL from known locations. It is typically combined with other technologies (vapor extraction or bioventing) to provide for a more robust cleanup of residual- and dissolved-phase contamination.

*Site-Specific Evaluation:* As discussed in Section 3 of the WP/SOW, the heterogeneous and fractured nature of the Red Hill geology complicates the detection and mapping of NAPL in the vadose zone below the RHSF tanks. If NAPL cannot be located and delineated, then NAPL recovery cannot be considered. Furthermore, NAPL recovery technologies rely on drilling and construction of extraction wells, which could provide new pathways for transport of contamination to previously unimpacted stratigraphic layers and the underlying groundwater.

### 2.6 SURFACTANT FLUSHING WITH PUMP AND TREAT

Surfactant flushing involves the injection of biodegradable surfactants (e.g., soaps and detergents) into the vadose or saturated zones in order to mobilize residual hydrocarbons for removal via extraction wells. Typically, surfactants are injected as an aqueous solution into contaminated zones through vertical wells. The resulting effluent is extracted downgradient of the injection point, where it is pumped to the ground surface for treatment or disposal.

*General Technological Capabilities:* The application of a surfactant to a subsurface NAPL plume enhances conventional pump and treat methods by increasing the solubility and mobility of contaminants at the source, making them more mobile and extractable. The technology can be effective at depth, but the radius of influence depends on matrix, porosity, and moisture. Handling and processing of liquid waste is required.

*Site-Specific Evaluation:* If used at the RHSF site, the toxicity and mobility of the flushing compound would need to be considered to avoid contamination of groundwater. The drilling of both injection and extraction wells could create new pathways for contaminant transport in the subsurface at the RHSF site.

## 3. Groundwater Remediation Technologies

### 3.1 AIR SPARGING WITH VAPOR EXTRACTION

SVE can be combined with air sparging for the remediation of groundwater. Air sparging involves the injection of ambient air below the water table to strip volatile organic compounds from the water, while also providing aerobic microorganisms with oxygen to enhance biodegradation. An air compressor on the ground surface is typically used to inject air into groundwater through injection wells. As air passes through groundwater, contaminants in the water partition into the air.

*General Technological Capabilities:* While air sparging is a proven and widely used technology to remediate hydrocarbon contamination of groundwater, complications can result if the introduced oxygen causes formation of precipitates or bacterial biofilm which can clog the well screen and inhibit the flow of groundwater through the formation.

*Site-Specific Evaluation:* As with other NAPL investigation and remedial technologies that require the advancement of boreholes, drilling activities associated with injection well construction at the RHSF site could create new flow pathways that could transport contamination to previously unimpacted soil and rock formations, as well as the underlying groundwater.

## 3.2 MONITORED NATURAL ATTENUATION

Monitored natural attenuation (MNA) relies on natural processes, including biodegradation, sorption, dilution, evaporation, and other naturally occurring processes, to decrease concentrations of contaminants in soil and groundwater. Periodic groundwater sampling is typically conducted to monitor COPC concentrations and geochemical parameters. Analytes may include petroleum constituents, anions and cations, and dissolved gases. MNA can be enhanced with the addition of nutrients and can be combined with bio-venting and vapor extraction for a more robust treatment of different phases (i.e., vapor and residual). In some instances, MNA can generate methane gas.

*General Technological Capabilities:* MNA is a low-cost remedial alternative with a proven track record; however, because MNA is not an active treatment, degradation rates are generally low relative to those achieved by active treatment technologies, and long-term sampling and analysis of groundwater would be required.

*Site-Specific Evaluation:* In general, natural attenuation processes can be very effective for petroleum-impacted sites where the contaminated groundwater occurs in fractured rock, as at the RHSF site, and it is likely that natural attenuation is already occurring. If MNA is selected as the remedial action or as a component of the remedial action for RHSF (e.g., to address residual contamination remaining after active remediation), data collected during this and previous investigations can be used to augment data collected during future long-term monitoring.

## 3.3 PUMP AND TREAT

Pump and treat remedial technologies involve the ex-situ treatment of groundwater (e.g., activated carbon filtration, air stripping) to remove dissolved-phase hydrocarbons. As part of the technology, vertical extraction wells would be installed into known dissolved-phase plumes or upgradient of drinking water wells. Groundwater would be pumped from the extraction wells directly into an aboveground treatment system or holding tank. Wastes produced as a result of the treatment (e.g., used filters) would require proper disposal.

*General Technological Capabilities:* Although pump and treat methods are most effective when the dissolved-phase plume is accurately delineated, it can also be used to prevent potential dissolved-phase contamination from reaching downgradient drinking water wells.

*Site-Specific Evaluation:* Based on previous and ongoing groundwater monitoring at the RHSF site (Section 2.3 of the WP/SOW), the Tank 5 release does not yet appear to have significantly impacted groundwater underlying the site. However, due to the size of the release and complex heterogeneous and fractured lithology below the tanks, NAPL is likely present within the vadose zone. Because the potential for this NAPL to impact groundwater still exists, a pump and treat system could be placed directly upgradient of the BWS and Navy drinking water wells in the area to prevent dissolved-phase contamination from reaching the pumping stations.

### 3.4 MULTI-PHASE EXTRACTION

As described in Section 2.3, multi-phase extraction can be effective for remediation of both free product and aqueous-phase contamination in groundwater.

### 3.5 CHEMICAL OXIDATION

In-situ chemical oxidation (ISCO) involves the injection of strong oxidant solutions or gas mixtures into the aquifer to oxidize dissolved petroleum constituents. Oxidants are typically injected directly into the NAPL and downgradient plume; the oxidants can include hydrogen peroxide, Fenton’s reagent, potassium permanganate, persulfate, and ozone. In order for ISCO to be effective, the chemical oxidants must directly contact the contaminants. Products of the oxidation reactions are water and carbon dioxide, inert compounds that do not require further treatment.

*General Technological Capabilities:* Although chemical oxidants used in ISCO technologies are generally more expensive compared to amendments used in other remedial technologies, ISCO treatment times are shorter and do not generate large volumes of waste by-products that require further treatment or disposal. In order for ISCO to be effective, however, the location of subsurface NAPL must be known so that the chemical oxidant can be injected directly into the contaminated zone.

*Site-Specific Evaluation:* Due to the complex geology of the Red Hill area, it may be impossible to define the extent of subsurface NAPL with the accuracy required to identify suitable locations for oxidant injection. In addition, ISCO may not be feasible for sites where groundwater represents a current or potential drinking water resource because the chemical oxidants can themselves contaminate groundwater.

## 4. Summary of Remedial Technologies

Table F-1 summarizes the alternatives that may be appropriate for further consideration after completion of the investigation activities. These recommendations are tentative, and subject to change based on the investigation results.

**Table F-1: Summary of Remedial Technology Review and Recommendations**

| Remedial Technology | Recommendation | Notes |
|---|---|---|
| **NAPL Remediation** | | |
| Excavation | Not Recommended | Infeasible due to the depth of contamination |
| Soil Vapor Extraction | Recommended for Further Consideration | Proven technology that can be effective in a variety of geologic environments |
| Multi-Phase Extraction | Recommended for Further Consideration | Proven technology that can be effective in a variety of geologic environments |
| Bio-Venting | Recommended for Further Consideration | Proven technology that can be effective in a variety of geologic environments |
| Surfactant Flushing | Not Recommended | Flushing agents could negatively impact groundwater quality |

| Remedial Technology | Recommendation | Notes |
|---|---|---|
| **Groundwater Remediation** | | |
| Monitored Natural Attenuation | Recommended for Further Consideration | Proven technology that can be effective in a variety of geologic environments; would require long-term monitoring of groundwater |
| Pump and Treat | Recommended for Further Consideration | Proven technology that can be effective in a variety of geologic environments |
| Air Sparging with Vapor Extraction | Recommended for Further Consideration | Proven technology that can be effective in a variety of geologic environments |
| Multi-Phase Extraction | Recommended for Further Consideration | Proven technology that can be effective in a variety of geologic environments |
| Chemical Oxidation | Not Recommended | Chemical oxidants could negatively impact groundwater quality |
| NAPL Recovery | Recommended for Further Consideration | Appropriate only if NAPL is encountered |

# Appendix G:
# Analytical Chemistry

# CONTENTS

**ATTACHMENT**

**TABLES**

# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| % | percent |
| °C | degree Celsius |
| %D | percent difference |
| μg/L | microgram per liter [equivalent to ppb] |
| AECOM | AECOM Technical Services, Inc. |
| AOC | Administrative Order on Consent |
| AVGAS | aviation gasoline |
| BFB | 4-bromofluorobenzene |
| bgs | below ground surface |
| BTEX | benzene, toluene, ethylbenzene, xylenes |
| CA | corrective action |
| CAS | Chemical Abstracts Service |
| CCV | continuing calibration verification |
| COC | chain-of-custody |
| COPC | chemical of potential concern |
| COR | Contracting Officer’s Representative |
| CTO | contract task order |
| D | difference |
| DDT | dichlorodiphenyltrichloroethane |
| DFTPP | decafluorotriphenylphosphine |
| DL | detection limit |
| DoD | Department of Defense, United States |
| DOH | Department of Health, State of Hawai‘i |
| DQA | data quality assessment |
| DQAR | data quality assessment report |
| DQI | data quality indicator |
| DQO | data quality objective |
| EAL | Environmental Action Level |
| EHE | environmental hazard evaluation |
| EICP | extracted ion current profile |
| ELAP | Environmental Laboratory Accreditation Program |
| EPA | Environmental Protection Agency, United States |
| F-76 | Marine Diesel Fuel |
| ft | foot or feet |
| g | gram |
| GC | gas chromatography |
| GC-FID | gas chromatography-flame ionization detector |
| GC-MS | gas chromatography-mass spectrometry |
| $H_2SO_4$ | sulfuric acid |
| HCl | hydrogen chloride |
| HEER | Hazard Evaluation and Emergency Response Office, State of Hawai‘i Department of Health |
| ICAL | initial calibration |
| ICV | initial calibration verification |
| ID | identification |
| IS | internal standard |
| JP | Jet Fuel Propellant |
| L | liter |
| LCS | laboratory control sample |
| LOD | limit of detection |

| | |
|---|---|
| LOQ | limit of quantitation |
| LTM | long-term monitoring |
| m | meter |
| MB | method blank |
| MCL | Maximum Contaminant Level |
| mL | milliliter |
| MOGAS | motor gasoline |
| MPC | measurement performance criteria |
| MS | matrix spike |
| MSD | matrix spike duplicate |
| N/A | not applicable |
| $NaHSO_4$ | sodium bisulfate |
| NAP | natural attenuation parameter |
| NAVFAC | Naval Facilities Engineering Command |
| NIST | National Institute of Standards and Technology |
| no. | number |
| NSFO | Navy Special Fuel Oil |
| oz | ounce |
| PAH | polynuclear aromatic hydrocarbon |
| PAL | project action level |
| PARCC | precision, accuracy, representativeness, comparability, and completeness |
| PCE | tetrachloroethylene |
| PFTBA | perfluorotributylamine |
| PQO | project quality objective |
| PVC | polyvinyl chloride |
| QA | quality assurance |
| QC | quality control |
| QSM | Quality Systems Manual |
| RHSF | Red Hill Bulk Fuel Storage Facility |
| RPD | relative percent difference |
| RRT | relative retention time |
| RSD | relative standard deviation |
| RT | retention time |
| SDG | sample delivery group |
| SIM | selective ion monitoring |
| SOP | standard operating procedure |
| SOW | scope of work |
| SSRBL | site-specific risk-based level |
| TBD | to be determined |
| TCE | trichloroethylene |
| TGM | Technical Guidance Manual |
| TPH | total petroleum hydrocarbons |
| TPH-d | total petroleum hydrocarbons – diesel range organics |
| TPH-g | total petroleum hydrocarbons – gasoline range organics |
| TPH-o | total petroleum hydrocarbons – residual range organics (i.e., TPH-oil) |
| UST | underground storage tank |
| VOA | volatile organic analysis |
| VOC | volatile organic compound |
| WP | work plan |

# 1. Task 3: Identify Chemicals of Potential Concern

Task 3 of the Investigation and Remediation of Releases and Groundwater Protection and Evaluation Work Plan and Scope of Work (WP/SOW) includes identifying the chemicals of potential concern (COPCs) for this investigation. This Appendix evaluates the existing groundwater data and presents recommended COPCs and screening levels for use in this investigation and the ongoing groundwater long-term monitoring (LTM) program at the Red Hill Bulk Fuel Storage Facility (RHSF).

## 1.1 FUEL STORED AT THE FACILITY

Historically, RHSF stored multiple fuel types in the facility. The tanks have contained diesel oil, Navy Special Fuel Oil (NSFO), Navy Distillate, Marine Diesel Fuel (also known as F-76), aviation gasoline (AVGAS), motor gasoline (MOGAS), and Jet Fuel Propellant (JP)-5 (DON 2002). Originally, Tanks 3 through 20 contained NSFO, and Tanks 1 and 2 stored diesel oil. Over time, each tank has been converted to store a variety of different fuel types. Interviews with Fleet Industrial Supply Center (now known as Naval Supply Systems Command Fleet Logistics Center) personnel verified that the storage of NSFO in RHSF was terminated during the mid-1980s, and AVGAS and MOGAS have not been stored in the tanks since the late 1960s (DON 2002). Since the early 2000s, the tanks have been used to store only three fuel types: JP-5, JP-8, and F-76. Table 1-1 lists the fuel currently stored in each tank.

**Table 1-1: Fuels Currently Stored at RHSF**

| Tank ID | Current Fuel Stored | Fuel Stored in Tank Since |
|---|---|---|
| 1 | Empty (permanently removed from service) | — |
| 2 | JP-8 | early 2000s |
| 3 | JP-8 | early 2000s |
| 4 | JP-8 | early 2000s |
| 5 | JP-8 (temporarily removed from service) | early 2000s |
| 6 | JP-8 | early 2000s |
| 7 | JP-5 | circa 1996 |
| 8 | JP-5 | circa 1996 |
| 9 | JP-5 | circa 1996 |
| 10 | JP-5 | circa 1996 |
| 11 | JP-5 | late 1990s |
| 12 | JP-5 | late 1990s |
| 13 | F-76 [a] | circa 2000 |
| 14 | F-76 [a] | circa 2000 |
| 15 | F-76 | 1998 |
| 16 | F-76 | 1998 |
| 17 | JP-5 | 1/15/1969 [b] |
| 18 | JP-5 | 1/10/1969 [b] |
| 19 | Empty (permanently removed from service) | — |
| 20 | JP-5 | 4/4/1972 [b] |

ID identification

[a] Currently being converted from F-76 to JP-5.

[b] Tank fuel dates from the *Red Hill Bulk Fuel Storage Facility Investigation Report* (DON 2002).

## 1.2 GROUNDWATER COPC LIST AND SCREENING CRITERIA

The February 4, 2016 scoping completion letter issued by the State of Hawai‘i Department of Health (DOH) and the United States Environmental Protection Agency (EPA) presents the COPCs and screening criteria for the groundwater investigation (Appendix B.2). The rationales for the selected COPCs are presented below.

### 1.2.1 Rationale for COPCs

The DOH Hazard Evaluation and Emergency Response Office (HEER) *Technical Guidance Manual* (TGM) (the “DOH-HEER TGM”) recommends specific analytes to be tested for sites with residual petroleum contamination (DOH 2009). Table 9-5 of the DOH-HEER TGM lists recommended target analytes for middle distillates such as those stored at RHSF (e.g., diesel, kerosene, jet fuels) for groundwater, including total petroleum hydrocarbons (TPH); benzene, toluene, ethylbenzene, xylenes (BTEX); naphthalene; and methylnaphthalenes (1- and 2-). Recommended target analytes for gasolines are TPH, BTEX, naphthalene, methyl tert-butyl ether, and appropriate additives and breakdown products (e.g., tert-butyl alcohol, lead, ethanol) (DOH 2009). The site currently stores JP-5, JP-8, and F-76 fuels, and has not stored leaded fuels since 1968. The existing LTM program includes the analytes listed in Table 9-5 of the DOH-HEER TGM (DOH 2009) for gasolines and middle distillates, plus additional volatile organic compounds (VOCs) and polynuclear aromatic hydrocarbons (PAHs). These additional VOCs and PAHs are not related to the fuels stored in the tanks, but may have been included in the LTM COPC list because these are part of the analyte list often reported by laboratories for the VOC and PAH analytical methods. Therefore, if these additional VOCs and PAHs are not associated with fuels stored on site, have not been detected at the site, and are not known to be degradation products of those analytes detected at the site, they are not recommended to be retained for analysis in this investigation and future groundwater LTM sampling events.

The groundwater LTM program currently analyzes groundwater samples for the full list of analytes in the following analyte groups: TPH-gasoline range organics (TPH-g), TPH-diesel range organics (TPH-d), and TPH-residual range organics (TPH-o); VOCs; PAHs; and dissolved and total lead. The samples are also analyzed for lead scavengers. Detailed lists of all analytes and summary statistics for each monitoring well are presented in Appendix D. The summary statistics for the historical analytical results show the frequency of detections for each analyte and whether results exceeded the DOH Tier 1 Environmental Action Levels (EALs). Analytes that have never been detected or have been consistently detected below EALs are recommended to be removed from the program. During the course of the program, 40 analytes have been detected in at least one monitoring well. However, only 10 of these 40 analytes were detected at concentrations exceeding the DOH EALs at least once since 2006, and an additional 9 of the 40 analytes were reported at non-detect concentrations above the DOH EALs since 2006. These 19 analytes are highlighted in Table 1-2.

Four of the ten detected EAL exceedances (i.e., total 1,3-dichloropropene, bromodichloromethane, methylene chloride, and trichloroethylene) are either likely from contamination during the analysis, or were present only at the Oily Waste Disposal Facility, which itself was the far more likely (and downgradient) source of contamination, based on its historical site use, and especially considering that none of these analytes have been detected in the wells directly below or downgradient of the tank farm.

The nine analytes reported as non-detect above EALs (specifically VOCs and PAHs) are likely not present at the site. Many of the VOCs are known contaminants from historical agricultural activities, and therefore these VOCs are unlikely to be present at RHSF because there have been no known agricultural activities at the facility. Additionally, several PAHs are unlikely to be present in the groundwater due to the very low solubility properties of heavy-molecular-weight PAHs.

Lead scavengers (i.e., 1,2-dibromoethane and 1,2-dichloroethane) are also recommended to be removed from the analyte list for the existing wells in the LTM program (i.e., RHMW01 to 07, OWDFMW01, HDMW2253-03, and RHMW2254-01). Lead scavengers have been detected only at the Oily Waste Disposal Facility monitoring well (OWDFMW01), and have never been detected above the EAL (Appendix D.8). Well OWDFMW01 was installed to investigate the Oily Waste Disposal Facility, not RHSF. Because these detections were at a different and downgradient facility, and because lead scavengers have never been detected at any of the RHSF-installed wells, RHSF was not the source of these detections. Moreover, fuels stored at RHSF in recent decades did not have lead additives; the only fuel known to have lead additives (AVGAS) was last stored at RHSF prior to 1968. However, lead scavengers will be analyzed for in the newly installed groundwater monitoring wells that are part of the investigation and the LTM program.

Therefore, of the COPCs analyzed in the LTM program, ten are recommended to be maintained in the LTM program. These ten analytes include the six analytes consistently exceeding EALs and four VOCs that have not been detected above EALs but are associated with middle distillate fuels: TPH-g, TPH-d, TPH-o, naphthalene, 1-methylnaphthalene, 2-methylnaphthalene, and BTEX. This is similar to (and a superset of) the DOH-HEER TGM Middle Distillate List: TPH, BTEX, naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene (DOH 2009, Table 9-5 Target Analytes for Releases of Petroleum Products). Additionally, lead scavengers (1,2-dichloroethane and 1,2-dibromoethane) are recommended to be analyzed for in samples collected from the proposed new monitoring wells RHMW08, RHMW09, RHMW10, and RHMW11 during the first two monitoring events. Monitored natural attenuation parameters (NAPs) dissolved oxygen, ferrous iron, methane, sulfate, nitrate, and chloride will also be analyzed for all groundwater samples during the investigation.

Table 1-2 presents the recommendation regarding whether to retain for each analyte previously evaluated during the LTM program, and discusses the rationale for each recommendation. Table 1-3 summarizes the COPCs recommended for this investigation and the ongoing LTM program.

**Table 1-2: Groundwater Analyte Recommendations and Rationales**

| Analytical Group/ Method | Analyte | Keep COPC in Monitoring Program? | Rationale |
|---|---|---|---|
| **TPH/8015** | **TPH-d** | **Yes** | **Detected above EAL. Analyte associated with fuels stored on site.** |
| **TPH/8015** | **TPH-g** | **Yes** | **Detected above EAL. Analyte associated with fuels stored on site.** |
| **TPH/8015** | **TPH-o** | **Yes** | **Detected above EAL. Analyte associated with fuels stored on site.** |
| VOC/8260 | 1,1,1-Trichloroethane | No | Not detected throughout LTM program |
| VOC/8260 | 1,1,2-Trichloroethane | No | Not detected throughout LTM program |
| VOC/8260 | 1,1-Dichloroethane | No | Non-detect above EAL. 1,1-Dichloroethane is used mostly as an intermediate in the manufacture of 1,1,1-trichloroethane. Because 1,1,1-trichloroethane was not detected throughout the LTM program, 1,1-dichloroethane is unlikely to be present as well.[a] |
| VOC/8260 | 1,1-Dichloroethylene | No | Detected only once throughout LTM program (at RHMW03), and detected below EAL. This analyte is not associated with fuels stored on site, and are not known to be degradation products of those analytes detected at the site. |

| Analytical Group/ Method | Analyte | Keep COPC in Monitoring Program? | Rationale |
|---|---|---|---|
| VOC/8260 | 1,2,3-Trichloropropane | No | Detected in samples below EALs, with some non-detect above EAL. This analyte is not associated with fuels stored on site. TCP is an impurity associated with a soil fumigant D-D (a mixture of 1,2-dichloropropane, 1,3-dichloropropene, and 2,3-dichloropropene) used to control nematodes on pineapple farms in Hawai'i. The site area has no history of pineapple cultivation. There is no known documentation of pineapple agriculture in Hālawa Valley or Moanalua Valley.[b] |
| VOC/8260 | 1,2,4-Tricholorobenzene | No | Detected only once throughout LTM program (at RHMW2254), and detected below EAL. This analyte is not associated with fuels stored on site. |
| VOC/8260 | 1,2-Dibromo-3-chloropropane | No | Non-detect above EAL. DBCP has been used agriculturally as a nematocide.[b] This analyte is not associated with fuels stored on site. |
| VOC/8260 | 1,2-Dibromoethane | No | Non-detect above EAL. EDB has been used as a soil fumigant used to kill nematodes in pineapple industry.[b] This analyte is not associated with fuels stored on site. |
| VOC/8260 | 1,2-Dichlorobenzene | No | Not detected throughout LTM program |
| VOC/8260 | 1,2-Dichloroethane | No | Non-detect above EAL. The most common use of 1,2-dichloroethane is in the production of vinyl chloride which is used to make a variety of plastic and vinyl products including PVC pipes, furniture and automobile upholstery, wall coverings, housewares, and automobile parts. It is also used to as a solvent and is added to leaded gasoline to remove lead. Vinyl chloride has never been detected in any of the groundwater samples and PVC is not manufactured in Hawai'i. Also leaded gasoline has never been stored within the tanks. It is unlikely that 1,2-dichloroethane is present at the site.[c] This analyte is not associated with fuels stored on site. |
| VOC/8260 | 1,2-Dichloropropane | No | Not detected throughout LTM program. Soil fumigant used to kill nematodes in pineapple industry.[b] |
| VOC/8260 | 1,3-Dichlorobenzene | No | Not detected throughout LTM program |
| VOC/8260 | 1,3-Dichloropropene (total of cis/trans) | No | Detected only at the Oily Waste Disposal Facility, and reported as non-detect above EAL in other wells. Soil fumigant used to kill nematodes in pineapple industry.[b] This analyte is not associated with fuels stored on site. |
| VOC/8260 | 1,4-Dichlorobenzene | No | Not detected throughout LTM program |
| VOC/8260 | Acetone | No | Detected in samples below EALs. This analyte is not associated with fuels stored on site. |
| **VOC/8260** | **Benzene** | **Yes** | **Detected in samples below EALs. Analyte associated with fuels stored on site.** |
| VOC/8260 | Bromodichloromethane | No | Detected only at the Oily Waste Disposal Facility, and reported as non-detect above EAL in other wells. BDCM is a chlorination disinfection byproduct and, therefore, not associated with petroleum stored at the facility.[d] This analyte is not associated with fuels stored on site. |
| VOC/8260 | Bromoform | No | Not detected throughout LTM program |
| VOC/8260 | Bromomethane | No | Detected in samples below EALs. This analyte is not associated with fuels stored on site. |
| VOC/8260 | Carbon Tetrachloride | No | Not detected throughout LTM program |
| VOC/8260 | Chlorobenzene | No | Not detected throughout LTM program |
| VOC/8260 | Chloroethane | No | Not detected throughout LTM program |
| VOC/8260 | Chloroform | No | Detected in samples below EALs. This analyte is not associated with fuels stored on site. |

| Analytical Group/ Method | Analyte | Keep COPC in Monitoring Program? | Rationale |
|---|---|---|---|
| VOC/8260 | Chloromethane | No | Detected in samples below EALs, with some non-detect above EAL. Most of the chloromethane that is released into the environment is from natural sources, such as chemical reactions that occur in the oceans, thus is not affiliated with activities associated with RHSF.[e] |
| VOC/8260 | cis-1,2-Dichloroethylene | No | Not detected throughout LTM program |
| VOC/8260 | Dibromochloromethane | No | Non-detect above EAL. Most dibromochloromethane that enters the environment is formed as byproducts when chlorine is added to drinking water to kill bacteria. Chlorination activities are not associated with the project site. Also associated with DBCM is Bromoform (a disinfection by-product) and bromoform was not detected throughout the LTM program.[f] |
| **VOC/8260** | **Ethylbenzene** | **Yes** | **Detected in samples below EALs. Analyte associated with fuels stored on site.** |
| VOC/8260 | Hexachlorobutadiene | No | Non-detect above EAL. Hexachlorobutadiene is mainly used to make rubber compounds. It is also used as a solvent, and to make lubricants, in gyroscopes, as a heat transfer liquid, and as a hydraulic fluid. These activities are not associated with our site and unlikely to be present.[g] |
| VOC/8260 | Methyl ethyl ketone (2-Butanone) | No | Detected in samples below EALs. This analyte is not associated with fuels stored on site. |
| VOC/8260 | Methyl isobutyl ketone (4-Methyl-2-Pentanone) | No | Not detected throughout LTM program |
| VOC/8260 | Methyl tert-butyl Ether | No | Not detected throughout LTM program |
| VOC/8260 | Methylene chloride | No | Detected above EAL. Detections are more likely the result of laboratory contaminant. The highest detection reported is associated with method blank contamination and the duplicate of a primary sample with no detections reported for that sample. This analyte is not associated with fuels stored on site. |
| VOC/8260 | Styrene | No | Not detected throughout LTM program |
| VOC/8260 | Tetrachloroethane, 1,1,1,2- | No | Non-detect above EAL. Although 1,1,1,2-tetrachloroethane apparently is not produced or used commercially in large quantities, it may be formed incidentally during the manufacture of other chlorinated ethanes. It is present as an unisolated intermediate in some processes for the manufacture of trichloroethylene and tetrachloroethylene from 1,2-dichloroethane. Because it is associated as an impurity of the manufacturing of TCE and PCE and detections of TCE and PCE were sparse, it is unlikely that it is present at the project site at concentrations of concern.[h] |
| VOC/8260 | Tetrachloroethane, 1,1,2,2- | No | Detected in samples below EALs, with some non-detect above EAL. 1,1,2,2-Tetrachloroethane was used in large amounts to produce other chemicals, as an industrial solvent to clean and degrease metals, and as an ingredient in paints and pesticides but is not commonly found in drinking water, soil, or food.[i] |
| VOC/8260 | Tetrachloroethylene | No | Not detected throughout LTM program |
| **VOC/8260** | **Toluene** | **Yes** | **Detected in samples below EALs. Analyte associated with fuels stored on site.** |
| VOC/8260 | trans-1,2-Dichloroethylene | No | Not detected throughout LTM program |
| VOC/8260 | Trichloroethylene | No | Detected above EAL. TCE was detected in MW02 in the first LTM event. In that first event, the primary sample had a detection of 8.2 µg/L (exceeding the EAL of 5 µg/L) and the associated field duplicate was non-detect at 5 µg/L (reporting limit) and 2.5 µg/L (method detection limit). The subsequent 178 sampling events report no detections of TCE. It is more likely that the detection of TCE was the result of contamination. This analyte is not associated with fuels stored on site. |

| Analytical Group/ Method | Analyte | Keep COPC in Monitoring Program? | Rationale |
|---|---|---|---|
| VOC/8260 | Vinyl chloride | No | Non-detect above EAL. Vinyl chloride is used to make PVC and is also a breakdown product of TCE and PCE. PVC is not manufactured in Hawai‘i. Cis- and trans-1,2-dichloroethylene are intermediate breakdown products of TCE and PCE prior to vinyl chloride; cis- and trans-1,2-dichloroethylene have not been detected in the LTM, and therefore vinyl chloride is not likely to present. |
| **VOC/8260** | **Xylenes, Total (p/m-, o-xylene)** | **Yes** | **Detected in samples below EALs. Analyte associated with fuels stored on site.** |
| PAHs/8270 SIM | Acenaphthene | No | Detected in samples below EALs. This analyte is not associated with fuels stored on site, and are not known to be degradation products of those analytes detected at the site. |
| PAHs/8270 SIM | Acenaphthylene | No | Detected in samples below EALs. This analyte is not associated with fuels stored on site, and are not known to be degradation products of those analytes detected at the site. |
| PAHs/8270 SIM | Anthracene | No | Detected in samples below EALs. This analyte is not associated with fuels stored on site, and are not known to be degradation products of those analytes detected at the site. |
| PAHs/8270 SIM | Benzo[a]anthracene | No | Detected in samples below EALs, with some non-detect above EAL. This is a 4-ring PAH. Physical and chemical characteristics of PAHs vary with molecular weight. Resistance to oxidation, reduction, and vaporization increases with increasing molecular weight but decreases in aqueous solubility. 2-ring PAH, naphthalene has a water solubility of 12,500–34,000 µg/L at 25 °C, whereas 4-ring PAHs such as chrysene and fluoranthene has a water solubility of 1.9 µg/L and 260 µg/L, respectively. Because fluoranthene has been detected at trace levels below the EALs, it is unlikely that PAHs with same number of rings or higher would be present in the groundwater.[j] |
| PAHs/8270 SIM | Benzo[g,h,i]perylene | No | Detected in samples below EALs, with some non-detect above EAL. This is a 6-ring PAH. Because fluoranthene (a 4-ring PAH) has been detected at trace levels below the EALs, it is unlikely that PAHs with same number of rings or higher would be present in the groundwater due to decreasing solubility of the larger PAH compounds. |
| PAHs/8270 SIM | Benzo[a]pyrene | No | Detected in samples below EALs, with some non-detect above EAL. This is a 5-ring PAH. Because fluoranthene (a 4-ring PAH) has been detected at trace levels below the EALs, it is unlikely that PAHs with same number of rings or higher would be present in the groundwater due to decreasing solubility of the larger PAH compounds. |
| PAHs/8270 SIM | Benzo[b]fluoranthene | No | Detected in samples below EALs, with some non-detect above EAL. This is a 5-ring PAH. Because fluoranthene (a 4-ring PAH) has been detected at trace levels below the EALs, it is unlikely that PAHs with same number of rings or higher would be present in the groundwater due to decreasing solubility of the larger PAH compounds. |
| PAHs/8270 SIM | Benzo[k]fluoranthene | No | Detected in samples below EALs. This is a 5-ring PAH. Because fluoranthene (a 4-ring PAH) has been detected at trace levels below the EALs, it is unlikely that PAHs with same number of rings or higher would be present in the groundwater due to decreasing solubility of the larger PAH compounds. |
| PAHs/8270 SIM | Chrysene | No | Detected in samples below EALs. This analyte is not associated with fuels stored on site, and are not known to be degradation products of those analytes detected at the site. |
| PAHs/8270 SIM | Dibenzo[a,h]anthracene | No | Non-detect above EAL. This is a 5-ring PAH. Because fluoranthene (a 4-ring PAH) has been detected at trace levels below the EALs, it is unlikely that PAHs with same number of rings or higher would be present in the groundwater due to decreasing solubility of the larger PAH compounds. |

| Analytical Group/ Method | Analyte | Keep COPC in Monitoring Program? | Rationale |
|---|---|---|---|
| PAHs/8270 SIM | Fluoranthene | No | Detected in samples below EALs. This analyte is not associated with fuels stored on site, and is not known to be a degradation product of those analytes detected at the site. |
| PAHs/8270 SIM | Fluorene | No | Detected in samples below EALs. This analyte is not associated with fuels stored on site, and is not known to be a degradation product of those analytes detected at the site. |
| PAHs/8270 SIM | Indeno[1,2,3-cd]pyrene | No | Detected in samples below EALs, with some non-detect above EAL. This is a 6-ring PAH. Because fluoranthene (a 4-ring PAH) has been detected at trace levels below the EALs, it is unlikely that PAHs with same number of rings or higher would be present in the groundwater due to decreasing solubility of the larger PAH compounds. |
| **PAHs/8270 SIM** | **1-Methylnaphthalene** | **Yes** | **Detected above EAL. Analyte associated with fuels stored on site.** |
| **PAHs/8270 SIM** | **2-Methylnaphthalene** | **Yes** | **Detected above EAL. Analyte associated with fuels stored on site.** |
| **PAHs/8270 SIM** | **Naphthalene** | **Yes** | **Detected above EAL. Analyte associated with fuels stored on site.** |
| PAHs/8270 SIM | Phenanthrene | No | Detected in samples below EALs. This analyte is not associated with fuels stored on site, and is not known to be a degradation product of those analytes detected at the site. |
| PAHs/8270 SIM | Pyrene | No | Detected in samples below EALs. This analyte is not associated with fuels stored on site, and is not known to be a degradation product of those analytes detected at the site. |
| Lead/6010 | Dissolved Lead (filtered) | No | Detected in samples below EAL, with some non-detect above EAL. Dissolved lead has been reported non-detect above the EAL only once (at RHMW04). All positive detections have been below EAL. Additionally, leaded petroleum has not been stored on site since the 1960s. |
| Lead/6010 | Total Lead (unfiltered) | No | Detected in samples below EALs. Analyzed only at sampling point RHMW2254 (infiltration gallery); all other samples are field-filtered. |

Notes:
**Bold text** indicates analytes that are recommended to be retained in the analytical program.
Blue row indicates analytes that were detected above the DOH EALs.
Gray row indicates analytes that were reported only as non-detects above the EAL.

| | |
|---|---|
| µg/L | microgram per liter [equivalent to ppb] |
| °C | degree Celsius |
| PCE | tetrachloroethylene |
| PVC | polyvinyl chloride |
| SIM | selective ion monitoring |
| TCE | trichloroethylene |

[a] Information from Agency for Toxic Substances and Disease Registry (ATSDR): http://www.atsdr.cdc.gov/toxfaqs/TF.asp?id=717&tid=129.
[b] Information from DOH-HEER TGM (2009).
[c] Information from ATSDR: http://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=110**.**
[d] Information from ATSDR: http://www.atsdr.cdc.gov/PHS/PHS.asp?id=706&tid=127.
[e] Information from ATSDR: http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=586&tid=109.
[f] Information from ATSDR: http://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=128.
[g] Information from ATSDR: http://www.atsdr.cdc.gov/toxfaqs/TF.asp?id=864&tid=168.
[h] Information from http://monographs.iarc.fr/ENG/Monographs/vol71/mono71-53.pdf.
[i] Information from ATSDR: http://www.atsdr.cdc.gov/toxguides/toxguide-93.pdf.
[j] Information from http://www.env.gov.bc.ca/wat/wq/BCguidelines/pahs/pahs-01.htm.

**Table 1-3: COPC List**

| COPC | Monitoring Well | Frequency |
|---|---|---|
| TPH-g, TPH-d, TPH-o, BTEX, 1-methylnaphthalene, 2-methylnaphthalene, naphthalene, and natural attenuation parameters (NAPs) (dissolved oxygen, ferrous iron, sulfate, nitrate, chloride) | RHMW01, RHMW02, RHMW03, RHMW04, RHMW05, RHMW06, RHMW07, RHMW08, RHMW09, RHMW10, RHMW11, RHMW2254-01, HDMW2253-03, and OWDFMW01 | Every investigation groundwater sampling event |
| TPH-d and TPH-o with silica gel cleanup | RHMW01, RHMW02, RHMW03, and RHMW05 | One wet-season and one dry-season investigation sampling event |
| Lead scavengers (1,2-dichloroethane and 1,2-dibromoethane) | RHMW08, RHMW09, RHMW10, and RHMW11, | One year of investigation groundwater sampling; may be dropped from COPC list if results are non-detect |

### 1.2.2 Groundwater Screening Criteria

Prior to the February 4, 2016 scoping completion letter presenting the screening criteria to be used for the groundwater results, the LTM program used screening criteria based on the DOH Tier 1 EALs as presented in *Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater* (DOH 2011) (the “DOH-HEER EHE Guidance”). The DOH-HEER EHE Guidance is divided into two volumes: Volume 1 is the user’s guide and provides guidance for the identification and evaluation of environmental hazards, and Volume 2 provides detailed information and data that were used to develop the Tier 1 EALs.

The DOH Tier 1 EALs are the lowest action level, based on a host of conservative assumptions, representing the concentration of the contaminant where the threat of human health or the environment is considered to be insignificant under any site condition (DOH 2011). Exceeding the Tier 1 EAL for a specific analyte does not necessarily indicate that the contamination poses significant environmental concerns, only that additional evaluation is warranted (DOH 2011). In general, groundwater action levels are more stringent for sites that threaten a potential source of drinking water. This is particularly true for chemicals that are highly mobile in the subsurface and easily leached from impacted soil. For chemicals that are especially toxic to aquatic life, however, Tier 1 action levels for sites that threaten drinking water resources may be driven by surface water or aquatic habitat protection concerns rather than by drinking water concerns (DOH 2011). Portions of Figure 1-2 and Figure 2-5 of the DOH-HEER EHE Guidance that are related to groundwater (DOH 2011) are shown in Table 1-4. Table 1-4 briefly discusses the models and approaches used to develop the Tier 1 EALs for groundwater for each type of environmental hazard.

**Table 1-4: Summary of Models and Approaches to Develop DOH Groundwater Tier 1 EALs**

| Environmental Hazard | Description | Model and Approach |
|---|---|---|
| Human Health Risk: Contamination of drinking water supplies | Toxicity concerns related to contamination of groundwater that is a current or potential source of drinking water. | Hawai‘i DOH-promulgated drinking water standards or EPA Regional Screening Levels model for tap water. Refer to DOH-HEER EHE Guidance Appendix 1 (Section 5.2 & Table D-3 series) and Appendix 2 (DOH 2011). |
| Human Health Risk: Vapor Intrusion | Emission of volatile contaminants from groundwater and intrusion into overlying buildings. | EPA vapor intrusion spreadsheets. Refer to DOH-HEER EHE Guidance Appendix 1 (Section 5.4 & Table C-1a) and Appendix 4 (DOH 2011). |
| Impact to Aquatic Habitats | Discharges of contaminated groundwater and toxicity to aquatic organisms. | Hawai‘i DOH-promulgated surface water standards or EPA and other references if not available. Refer to DOH-HEER EHE Guidance Appendix 1 (Section 5.3 and Table D-4 series) (DOH 2011). |

| Environmental Hazard | Description | Model and Approach |
|---|---|---|
| Gross Contamination | Includes taste and odor concerns for contaminated drinking water supplies, free product, potential, sheens and odors on surface water, and general resource degradation. | Massachusetts Department of Environmental Protection approach, modified as indicated. Refer to DOH-HEER EHE Guidance Appendix 1 (Section 5.5 & Table G series) (DOH 2011). |

EPA Environmental Protection Agency, United States

The LTM program used two sets of Tier 1 EALs depending on each monitoring well's distance to the nearest surface water body, as presented in Table A-2 in Appendix A of the DOH-HEER EHE Guidance (DOH 2011). Wells located within 150 meters of the nearest water body (i.e., Hālawa Stream) are compared to EALs in Table D-1a, and wells located greater than 150 meters from Hālawa Stream are compared to EALs in Table D-1b. The difference between these two sets of groundwater Tier 1 EALs is that Table D-1a takes into consideration the chronic or long-term toxicity of each analyte to aquatic habitats in the determination of the EAL—that is, contaminant concentrations in groundwater should meet chronic surface water goals at the point that the groundwater discharges into a sensitive aquatic habitat (DOH 2011). In contrast, Table D-1b uses the acute or immediate toxicity of the analyte to the aquatic habitat. Tier 1 EALs between Table D-1a and D-1b tend to be identical for each environmental hazard type, with the exception of the aquatic habitat impacts, which typically result in a significant decrease in the EALs once the site is within 150 meters of a surface water body.

The nearest surface water body, Hālawa Stream, is a losing stream located at a higher elevation than the tank bottoms, and therefore should not be affected by releases from the tanks. More importantly, both Hālawa and Moanalua streams are losing streams located approximately 100 feet or more above the groundwater table. Therefore, even if a release from RHSF were to migrate to the groundwater table, data indicate that groundwater would not migrate *up* from the groundwater to the streams; therefore, any groundwater impacts would not affect the streams or ecological receptors that use the streams. Accordingly, the DOH-HEER EHE Guidance states that if "*long-term monitoring of groundwater (e.g., 2-plus years) adequately demonstrates that a plume is not likely to discharge into a surface water body above chronic goals even though it is within 150m of the body, then acute surface water goals can be used as final cleanup and closure levels*" (DOH 2011). Similarly, petroleum plumes in groundwater greater than 150 meters from release site "*will never naturally migrate to a surface water body and that this concern does not need to be addressed*" (DOH 2011). Therefore, it is appropriate to compare all of the analytical results in this investigation and the LTM to the Table D-1b EALs, because there are no indications of any completed pathways (and thus no threat) to ecological receptors in nearby water bodies. Table 1-5 summarizes the groundwater screening criteria presented in the February 4, 2016 letter that will be used for this investigation and future LTM events.

**Table 1-5: Groundwater Screening Criteria**

| COPC | Screening Criterion (µg/L) |
|---|---|
| TPH-g | 100 |
| TPH-d | 100 |
| TPH-o | 100 |
| Benzene | 5 |
| Ethylbenzene | 30 |
| Toluene | 40 |
| Xylenes, total | 20 |

| COPC | Screening Criterion (µg/L) |
|---|---|
| 1-Methylnaphthalene | 4.7 |
| 2-Methylnaphthalene | 10 |
| Naphthalene | 17 |
| 1,2-Dibromoethane [a] | 0.04 |
| 1,2-Dichloroethane [a] | 5 [b] |

[a] 1,2-Dibromoethane and 1,2-Dichloroethane (lead scavengers) will be analyzed only in RHMW08, RHMW09, RHMW10, and RHMW11 samples. Lead scavenger analysis can be dropped after 1 year of sampling if results are non-detect.

[b] Screening criterion for 1,2-dichloroethane is based on the EPA Maximum Contaminant Levels (EPA 2015) rather than the DOH Tier 1 Table D-1b EALs (DOH 2011).

## 1.3 TPH WEATHERING

TPH-d and TPH-o results from the groundwater LTM program indicate that total hydrocarbons are present in the groundwater. However, the data do not provide information on whether the hydrocarbons in the groundwater exhibit any weathering, which, if confirmed, would support the hypothesis that natural attenuation of the fuel is occurring in the subsurface. Therefore, in order to investigate the degree of weathering of TPH in groundwater in the vicinity of the underground storage tanks (USTs), split samples will be collected for select TPH-d and TPH-o analyses, which will be prepared using silica gel cleanup prior to TPH analysis. Silica gel cleanup can be performed as an additional preparation step (in accordance with EPA Method 3630) prior to running the sample extract through the analytical instrument (usually using EPA Method 8015 for analysis).

Hydrocarbons from biological sources and processes, such as by-products of fuel weathering, are usually polar, while hydrocarbons from fresh petroleum are usually non-polar. Silica gel cleanup is commonly used to separate polar from nonpolar hydrocarbons. Polar compounds will preferentially adsorb to silica, while non-polar compounds will not. DOH-HEER TGM Section 9.3.1.2, *Total Petroleum Hydrocarbons*, discusses the use of silica gel cleanup to separate out the polar TPH fraction and compare the remaining non-polar TPH fraction to the screening criteria (DOH 2009). "*Comparison of data for groundwater samples tested with and without silica gel cleanup could be useful for assessing the state of natural biodegradation within a plume of petroleum-contaminated groundwater and optimizing remedial and monitoring actions*" (DOH 2009). Silica gel cleanup is recommended to be performed for samples from RHMW01, RHMW02, and RHMW03 because TPH has historically been detected in the groundwater at these wells; additionally, silica gel cleanup is also recommended for groundwater samples from RHMW05 because this groundwater monitoring well lies downgradient of the USTs and upgradient of the Navy Supply Well 2254-01, in the region where natural attenuation is likely to be occurring. Evaluation of the non-polar TPH results from these wells may indicate weathering, which would be expected to be more prominent in the downgradient wells compared to RHMW02 (the well closest to Tank 5). The February 4, 2016 letter also indicated the implementation of silica gel cleanup for samples from the monitoring location OWDFMW01. It is recommended that silica gel cleanup not be performed on samples collected from the monitoring well OWDFMW01 because it is downgradient of Navy Supply Well 2254-01, and is an existing Comprehensive Environmental Response, Compensation, and Liability Act site that potentially contains additional chemical compounds in the subsurface that may interfere with the data analysis. OWDFMW01 exhibits groundwater geochemical and COPC data dissimilar to other sampling locations in the monitoring well network (as seen in the TPH chromatography in the groundwater monitoring reports) and is likely related to the historical oily waste disposal activities performed at the site. Rather, samples from RHMW05, including the analysis of NAPs, may provide far more useful and productive data to characterize natural attenuation occurring near the site, including upgradient of the nearest supply well.

Performing the silica gel cleanup on split samples from RHMW01, RHMW02, RHMW03, and RHMW05 will provide information on the ratio of nonpolar (i.e., unweathered) and polar (i.e., weathered) hydrocarbons. Performing silica gel cleanup during the first two (wet- and dry-season) groundwater sampling events will allow for comparison of polar-to-nonpolar fractions and may provide an additional line of evidence regarding whether natural attenuation is occurring in the subsurface, and may help quantify the rate of attenuation. The combined use of the silica-gel-cleaned TPH data with the non-silica-gel-cleaned TPH data can help further refine the conceptual site model by helping to identify where biodegradation is likely occurring within the monitoring well network. Combined with the natural attenuation data, the silica-gel-cleaned TPH data can provide compelling evidence that biodegradation is occurring. There is a remote potential for the silica-gel-cleaned TPH results to be inconsistent with the NAPs. If such an instance were to occur, the silica-gel-cleaned TPH data would support the assumption that biodegradation is occurring because the silica-gel-cleaned TPH results are direct measurements of non-polar petroleum hydrocarbons (which are assumed to be petroleum degradation by-products) and NAPs are indicators of the current aquifer conditions only.

# 2. Analytical Data Quality Plan

This section discusses the various methods, procedures, and criteria that will be used in acquiring and evaluating the analytical data generated for the investigation.

The sample matrix, number of samples, and number and type of laboratory quality assurance (QA)/quality control (QC) samples are summarized in the subsections below. Details on the analytical group, sample masses and volumes, sample container specifications, preservation requirements, and maximum holding times are also identified.

The laboratory will provide full electronic data deliverable files, portable document format files of the data deliverables for all project data, and a hard copy of data deliverables for all results including results from secondary subcontract laboratories. Designated samples will be used to obtain necessary subsamples for laboratory QC measurements (i.e., analytical sample duplicate and sample matrix spike [MS]/matrix spike duplicate [MSD] pairs). Tasks will be completed using the laboratory standard operating procedures (SOPs).

An independent third party will be procured to provide data validation services and to verify and evaluate the usability of the data.

Analytical data packages will be uploaded into AECOM Technical Services, Inc.’s (AECOM) Microsoft SQL server 2005, which is managed via EQuIS (Environmental Data Management Software). All other data generated in the field and reports generated for the project will be stored as computer readable data files by AECOM in their Honolulu, Hawai‘i office.

## 2.1 FIELD QUALITY CONTROL SAMPLES

Field QC samples are detailed in Table 2-1.

**Table 2-1: Measurement Performance Criteria Table – Field QC Samples**

| QC Sample | Analytical Group [a] | Frequency [b] | DQI | Measurement Performance Criteria |
|---|---|---|---|---|
| Field duplicate | TPH-g, TPH-d, TPH-o, PAHs | 10% of primary samples collected per matrix per analytical method | Precision | RPD ≤50% water [c]<br>RPD ≤100% soil [c] |
|  | VOCs | 10% of primary samples collected per matrix | Precision | RPD ≤50% water [c]<br>RPD ≤30% soil [c] |
| Field blank | VOCs, TPH-g, TPH-d, TPH-o, PAHs | Once per source of decontamination water per sampling event | Adequacy of the decontamination water quality | ≤1/2 of LOQ |
| Equipment rinsate | VOCs, TPH-g, TPH-d, TPH-o, PAHs | 5% of primary samples collected per matrix per analytical method | Adequacy of the decontamination process | ≤1/2 of LOQ |
| Trip blank | VOCs, TPH-g | One per cooler | Contamination during sample transport | ≤1/2 of LOQ |

| | |
|---|---|
| % | percent |
| DQI | data quality indicator |
| LOQ | limit of quantitation |
| RPD | relative percent difference |

[a] Refer to Section 2.2 for the list of analytes within analytical groups.

[b] Per *Project Procedures Manual* Procedure III-B, *Field QC Samples* (DON 2015); refer to Procedure III-B Section 5 for a summary of QC samples by project location, matrix, and analytical group.

[c] Per Project Procedures Manual Section II, Data Validation Procedures (DON 2015).

## 2.2 DATA EVALUATION (TIER 1)

The subsurface soil, potable water, and groundwater analytical data will be screened against the screening criteria, henceforth referred to as project action levels (PALs), identified in Section 2.3 to evaluate the nature of the contamination in subsurface soil (if present), potable water (for use as drilling fluid during monitoring well installation activities), and groundwater, and to inform the quarterly groundwater monitoring program. Additional groundwater data evaluation will be performed in the risk assessment, contaminant fate and transport model, and groundwater flow model.

### 2.2.1 Field Chemistry Data

Field parameters will include water level measurements, observations (e.g., weather conditions during sampling, presence of petroleum contamination in the subsurface soil (if any), water clarity and condition, presence of oil sheen), dissolved oxygen measurements, ferrous iron field test, and groundwater sampling parameters (e.g., oxidation-reduction potential, pH, temperature, specific conductance, turbidity).

### 2.2.2 Laboratory Analytical Data

Analytical data generated during this investigation will include the following:

- Subsurface soil:
  - TPH-g
  - TPH-d
  - TPH-o

  - PAHs (1-methylnaphthalene, 2-methylnaphthalene, naphthalene)
  - VOCs (benzene, ethylbenzene, toluene, xylenes)
- Potable water (for drilling activities):
  - TPH-g
  - TPH-d
  - TPH-o
  - PAHs (1-methylnaphthalene, 2-methylnaphthalene, naphthalene)
  - VOCs (benzene, ethylbenzene, toluene, xylenes)
- Groundwater:
  - TPH-g
  - TPH-d, with and without silica gel cleanup
  - TPH-o, with and without silica gel cleanup
  - PAHs (1-methylnaphthalene, 2-methylnaphthalene, naphthalene)
  - VOCs (benzene, ethylbenzene, toluene, xylenes)
  - Lead scavengers (1,2-dichloroethane, 1,2-dibromoethane)
  - NAPs (methane, nitrate, sulfate, ferrous iron, chloride)

Analytical data for the above parameters will be generated by an analytical chemistry laboratory. NAPs also include dissolved oxygen, which is a field parameter. Lead scavengers will be analyzed only for RHMW08, RHMW09, RHMW10, and RHMW11. Lead scavengers can be discontinued after 1 year of sampling if concentrations are below the groundwater action levels established by DOH. Silica gel cleanup will be performed only on sample extracts from RHMW01, RHMW02, RHMW03, and RHMW05 for the wet- and dry-season sampling events.

### 2.2.3 Data Management Tasks

All analytical data, field notes, data sheets, and other data necessary to support the project will be maintained in an AECOM electronic database. All hard copies of analytical data, field notes, data sheets, and other data necessary to support the project will be maintained in the AECOM Honolulu office (see Section 2.8).

#### *2.2.3.1 DOCUMENTATION AND RECORDS*

All field observations and measurements will be recorded in a field notebook and project-specific field data sheets. All samples will have global positioning system locations. Chain-of-custody (COC) forms, air bills, and sample logs will be prepared and retained for each sample. All data will be included in the investigation report.

#### *2.2.3.2 ASSESSMENT/AUDIT TASKS*

The project chemist, QA program manager, and field manager will be responsible for assessment and audit tasks (see Section 2.8). The contract task order (CTO) project manager will be responsible for coordinating the field audit.

#### 2.2.3.3 DATA REPORTING

The analytical laboratory will verify, reduce, and report data as specified in their Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP)-evaluated laboratory QA plan. Reported data will be provided as hard copy and electronic data deliverables. The laboratory deliverables will be consistent with Appendix A of the *Department of Defense Quality Systems Manual (QSM) for Environmental Laboratories Version 5.0* (DoD QSM) (DoD 2013) as provided in Attachment G.1.

Analytical data will be submitted by the laboratory to the data validation firm as hard copy and an electronic file. The electronic file will be created by transferring the analytical data package to a Microsoft Access database. The database will be parsed through internal verification and validation checks. Internal verification and validation checks are performed to identify data entries that exceed the specified QC criteria. If QC criteria are not met or if errors are identified due to an incorrect or incomplete laboratory submittal, the data package will be returned to the laboratory for correction and resubmittal.

The analytical data will be reviewed before it is validated to address time-critical issues such as re-extraction, matrix interference, and holding times. The data usage and the appropriate QA/QC level will be evaluated.

#### 2.2.3.4 DATA REVIEW TASKS

All analytical laboratory data results will be validated by a third-party data validation firm. Third-party data validation will consist of standard Level C validation (90 percent) and full Level D validation (10 percent). The first 10 percent of project field data (COPCs) generated by the laboratory will be validated at full Level D validation to establish a baseline, ensuring that the laboratory has complied with the requirements outlined in both the analytical methods and the DoD QSM 5.0 (DoD 2013). In addition, data quality checks (i.e., evaluating the precision and accuracy) will be performed once the analytical data are received from the laboratory. AECOM will verify the data against the specified limits of quantitation (LOQs) and limits of detection (LODs) in Section 2.2. All documents produced for the project will be kept in a secured facility for the life of the project. Upon closure of the project, laboratory documents will be archived with the project report in the administration record file at Naval Facilities Engineering Command (NAVFAC), Pacific.

In addition, all project analytical data will be validated by a third-party data validation firm in accordance with the following Data Validation Procedures from the *Project Procedures Manual, U.S. Navy Environmental Restoration Program, NAVFAC Pacific* (DON 2015):

- Procedure II-B, *Level C and Level D Data Validation Procedure for GC/MS Volatile Organics by SW-846 8260B*
- Procedure II-C, *Level C and Level D Data Validation Procedure for GC/MS Semivolatile Organics by SW-846 8270C (Full Scan and SIM)*
- Procedure II-H, *Level C and Level D Data Validation Procedure for Extractable Total Fuel Hydrocarbons by SW-846 8015B*
- Procedure II-R, *Level C and Level D Data Validation Procedures for Wet Chemistry Analyses*

For analyses that have no applicable Data Validation Procedures (DON 2015), data will be validated in accordance with the analytical methods and the DoD QSM 5.0 (DoD 2013). Data received from the validation firm will be uploaded into AECOM's Microsoft SQL server 2005, which is managed via EQuIS (Environmental Data Management Software).

## 2.3 LABORATORY OVERSIGHT AND ANALYTICAL CONSIDERATIONS

### 2.3.1 Project Chemist Oversight and Communication

The project chemist will oversee the procured laboratory to ensure, to the maximum extent practicable, that the reported laboratory limits are below the PALs. The project chemist will assess laboratory analytical capabilities prior to laboratory procurement and again prior to the start of field work. The project chemist will also oversee and review work done by the laboratory, and the laboratory and project chemist will ensure frequent communications.

### 2.3.2 Matrix Interference

Even if a laboratory is capable of achieving the LODs and LOQs required for a project, factors such as "matrix interference" and dilution can result in non-detect values that exceed the associated PALs.

Matrix interference can occur when a sample contains relatively high concentrations of non-target analytes that interfere with the detection of the target analytes (e.g., high levels of biogenic hydrocarbons in a sample analyzed for petroleum constituents, or samples with high concentrations of polychlorinated biphenyls masking smaller concentrations of pesticides). In order to manage matrix interference, laboratories may be required to modify sample preparation procedures or perform cleanup procedures on the sample extract to minimize the effect of non-target analyte and prevent the matrix interference from fouling the analytical instrument. However, in some cases cleanup procedures and/or modifying sample preparation procedures are not recommended or are insufficient to remove the matrix interference, which can lead to the laboratory being unable to detect or accurately quantify the target analyte. Additionally, the laboratory may need to dilute the sample extract to minimize the matrix interference from fouling the instrument (see further discussion on dilution below). In both of these cases, the laboratory may report a non-detect value that exceeds the LOQ and LOD goals.

### 2.3.3 Dilution

Analysis of samples containing high concentrations of a target analyte can also foul the analytical instrument, resulting in costly maintenance, analytical data report delays, and potentially resulting in elevated LODs for subsequent analyses. To prevent instrument fouling, historical data for the sample location will be reviewed and the procured laboratory will be informed of the concentrations of target analytes expected from the samples. If the laboratory's dilution is too high (i.e., yields a non-detect result of the target analyte), then re-analysis of the sample at a lower or no dilution must be required to achieve the lowest non-detect result ("< LOD U") below the PALs as much as possible.

In addition, dilution, which may be required for samples that contain high concentrations of a target analyte, will increase the LOD and LOQ. For example, if a 5-fold dilution is required, the LOD and LOQ will both increase by a factor of 5. For analyses that have multiple target analytes (e.g., PAHs, VOCs), it may be necessary for the laboratory to analyze the sample at multiple dilutions to achieve the lowest LODs for each of the target analytes. For example, in a VOC analysis with target analytes benzene and toluene, if a sample has high concentrations of benzene and low concentrations of toluene, it may be necessary for the laboratory to analyze for benzene at a 2-fold or higher dilution, then re-analyze the sample for toluene at a lower dilution factor or at no dilution (as long as this does not result in instrument fouling). Multiple dilutions, if required, may require additional laboratory costs.

#### 2.3.4 Quality Control for Silica-Gel-Cleaned TPH Analysis

Silica gel cleanup is not always fully effective at removing polar hydrocarbons (assumed to be wholly TPH biodegradation by-products) from a sample extract, resulting in some polar hydrocarbon compounds contributing to the reported non-polar hydrocarbon concentration (i.e., the silica-gel-cleaned TPH result). When silica gel cleanup is not fully effective, resultant concentrations of the silica-gel-cleaned TPH data may be biased high (concentrations similar to non-silica-gel-cleaned TPH analysis) and could lead to incorrect interpretations indicating that biodegradation is not occurring or has not occurred. Since degradation is presumed to be occurring, ineffective silica gel cleanups may generate data that conflicts with that presumption. To help mitigate this scenario, the efficiency of the cleanup is evaluated by adding known concentration surrogate compounds (e.g., usually deuterated compounds such as capric acid or similar) to samples prior to the cleanup step.

### 2.4 REFERENCE LIMITS AND EVALUATION TABLES

Prior to procuring the analytical laboratory, proposals will be submitted to multiple laboratories to determine their ability to perform the specified analytical methods and QC and their capability in meeting the PALs. The laboratories will be required to show that their analytical instruments is capable of achieving LOQs that do not exceed the LOQ goals set for each COPC. To minimize the chances of generating non-detect results that exceed the PALs, the laboratories' LODs and LOQs will be reviewed prior to procurement of the laboratory and before any samples are submitted for analysis. If necessary, the laboratory may be required to use a different method or modify the method as needed to achieve the required LOQ and LOD goals.

This subsection presents the subsurface soil, potable water, and groundwater PALs identified for the investigation:

- The subsurface soil PALs are based on the DOH Tier 1 EALs, Table A-1 (Potentially impacted groundwater is a current or potential drinking water resource; surface water body is not located within 150 meters of release site) (DOH 2011).
- The potable water and groundwater PALs are based on the following:
  - EALs stated in the regulator correspondence declaring completion of final scoping for Administrative Order on Consent (AOC) Statement of Work Sections 6 and 7 (EPA and DOH 2015)
  - EPA Maximum Contaminant Levels (MCLs) (EPA 2015)
  - The site-specific risk-based levels (SSRBLs) (DON 2014)

  COPC concentrations that exceed DOH EALs will also be compared to the EPA MCLs; for samples from groundwater monitoring wells RHMW01, RHMW02, and RHMW03, COPC concentrations will be compared to the SSRBLs.

Table 2-2 and Table 2-3 identify site COPCs for subsurface soil and potable water/groundwater, respectively. The tables present the PALs, the proposed LOD goals for the analytical laboratory, and the laboratory-specific limits for this project. Per DoD QSM 5.0 (DoD 2013), the LOQ is the lowest concentration that produces a quantitative result within specified limits of precision and bias. COPC results below the LOQ will be flagged and reviewed during data evaluation according to

Procedure II-A, *Data Validation Procedure* (DON 2015). The LOD is the smallest amount or concentration of a substance that must be present in a sample to be detected at a 99 percent confidence level. For the risk assessment, a non-detect for a particular COPC will be conservatively treated as indicating that the COPC is present at the LOD. Project LOQ Goals should not exceed approximately one-third of the PAL, and Project LOD Goals should not exceed approximately one-tenth of the PAL. Establishing the LOQ/LOD Goals must be done realistically with respect to currently available analytical capabilities. Once the laboratory-specific limits are known, the LOQ, LOD, and detection limit columns will be updated.

## 2.5 FIELD SAMPLING AND ANALYTICAL REFERENCE TABLES

The following tables detail field sampling and analytical requirements for the project:

- Table 2-4: Location-Specific Sampling Methods/SOP Requirements Table
- Table 2-5: Field Sampling Requirements Table
- Table 2-6: Field Quality Control Sample Summary Table
- Table 2-7: Analytical SOP References Table
- Table 2-8: Analytical Instrument Calibration Table
- Table 2-9: Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table

**Table 2-2: Reference Limits and Evaluation Table for Subsurface Soil**

| Analyte | CAS Number | PAL | Project LOQ Goal (µg/L) | Project LOD Goal (µg/L) | Laboratory-Specific Limits (µg/L) | | |
|---|---|---|---|---|---|---|---|
| | | DOH EAL [a] | | | LOQ | LOD | DL |
| **VOCs** | | | | | | | |
| Benzene | 71-43-2 | 1,000 | 333 | 100 | TBD | TBD | TBD |
| Ethylbenzene | 100-41-4 | 3.67 | 1.22 | 0.37 | TBD | TBD | TBD |
| Toluene | 108-88-3 | 3.19 | 1.06 | 0.32 | TBD | TBD | TBD |
| Xylenes | 1330-20-7 | 2.12 | 0.71 | 0.21 | TBD | TBD | TBD |
| **TPH** | | | | | | | |
| TPH-g (C5–C11) | -3547 | 100 | 33 | 10 | TBD | TBD | TBD |
| TPH-d (C10–C24) | -3527 | 100 | 33 | 10 | TBD | TBD | TBD |
| TPH-o (C24–C40) | -35 | 500 | 167 | 50 | TBD | TBD | TBD |
| **PAHs** | | | | | | | |
| 1-Methylnaphthalene | 90-12-0 | 1.77 | 0.59 | 0.18 | TBD | TBD | TBD |
| 2-Methylnaphthalene | 91-57-6 | 4.15 | 1.38 | 0.42 | TBD | TBD | TBD |
| Naphthalene | 91-20-3 | 4.40 | 1.47 | 0.44 | TBD | TBD | TBD |

| | |
|---|---|
| CAS | Chemical Abstracts Service |
| DL | detection limit |
| TBD | to be determined |

[a] DOH Tier 1 EALs, Table A-1, Soil Action Levels (Potentially impacted groundwater is a current or potential drinking water resource; surface water body is not located within 150 meters of release site) (DOH 2011).

**Table 2-3: Reference Limits and Evaluation Table for Potable Water and Groundwater**

| Analyte | CAS Number | PAL | | | Project LOQ Goal (µg/L) | Project LOD Goal (µg/L) | Laboratory-Specific Limits (µg/L) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Screening Criteria [a] | EPA MCL [b] | SSRBL [c,d] | | | LOQ | LOD | DL |
| **VOCs** | | | | | | | | | |
| Benzene | 71-43-2 | 5 | 5 | 750 | 1.3 | 0.5 | TBD | TBD | TBD |
| Ethylbenzene | 100-41-4 | 30 | 700 | N/A | 10 | 3.0 | TBD | TBD | TBD |
| Toluene | 108-88-3 | 40 | 1,000 | N/A | 13 | 4.0 | TBD | TBD | TBD |
| Xylenes | 1330-20-7 | 20 | 10,000 | N/A | 6.7 | 2.0 | TBD | TBD | TBD |
| **TPH** | | | | | | | | | |
| TPH-g (C5–C11) | -3547 | 100 | N/A | N/A | 33 | 10 | TBD | TBD | TBD |
| TPH-d (C10–C24) | -3527 | 100 | N/A | 4,500 | 33 | 10 | TBD | TBD | TBD |
| TPH-o (C24–C40) | -35 | 100 | N/A | N/A | 33 | 10 | TBD | TBD | TBD |
| **PAHs** | | | | | | | | | |
| 1-Methylnaphthalene | 90-12-0 | 4.7 | N/A | N/A | 1.6 | 0.47 | TBD | TBD | TBD |
| 2-Methylnaphthalene | 91-57-6 | 10 | N/A | N/A | 3.3 | 1.0 | TBD | TBD | TBD |
| Naphthalene | 91-20-3 | 17 | N/A | N/A | 5.7 | 1.7 | TBD | TBD | TBD |
| **Lead Scavengers** [e] | | | | | | | | | |
| 1,2-Dibromoethane | 106-93-4 | 0.04 | 0.05 | N/A | 0.013 | 0.004 | TBD | TBD | TBD |
| 1,2-Dichloroethane | 107-06-2 | 5.0 [f] | 5 | N/A | 1.7 | 0.5 | TBD | TBD | TBD |
| **NAPs** [g] | | | | | | | | | |
| Methane | 74-82-8 | N/A [h] | N/A [h] | N/A [h] | N/A | N/A | TBD | TBD | TBD |
| Ferrous Iron | 15438-31-0 | N/A [h] | N/A [h] | N/A [h] | N/A | N/A | TBD | TBD | TBD |
| Nitrate | 14797-55-8 | N/A [h] | N/A [h] | N/A [h] | N/A | N/A | TBD | TBD | TBD |
| Sulfate | 14808-79-8 | N/A [h] | N/A [h] | N/A [h] | N/A | N/A | TBD | TBD | TBD |
| Chloride | 16887-00-6 | N/A [h] | N/A [h] | N/A [h] | N/A | N/A | TBD | TBD | TBD |

N/A not applicable
TBD to be determined

[a] Screening criteria provided in the Regulatory Agencies’ February 4, 2016 scoping completion letter.

[b] EPA MCLs from EPA November 2015 Risk-Based Screening Level tables (EPA 2015).

[c] SSRBLs from the *Red Hill Bulk Fuel Storage Facility Groundwater Protection Plan* (DON 2014).

[d] SSRBLs apply only to groundwater sample results from monitoring wells RHMW01, RHMW02, and RHMW03.

[e] Lead scavengers will be analyzed only for groundwater monitoring wells RHMW08, RHMW09, RHMW10, and RHMW11.

[f] DOH EAL for 1,2-Dichloroethane is from the Regulatory Agencies’ February 4, 2016 letter and based on the EPA MCL.

[g] NAPs also include dissolved oxygen, which is a field parameter and therefore not included in this table.

[h] PALs are not applicable to the NAPs. NAP concentrations will be used to monitor natural attenuation in the subsurface.

**Table 2-4: Location-Specific Sampling Methods/SOP Requirements Table**

| Sampling Location/ID Number | Matrix | Depth (ft bgs) | Analytical Group | Number of Samples | Sampling SOP Reference |
|---|---|---|---|---|---|
| RHMW08, RHMW09 | Subsurface Soil | approx. 100–350 | VOCs, PAHs, TPH, | 1 primary per well (if found during installation activities)<br>1 duplicate (if enough soil is present) | Procedure I-B-1, *Soil Sampling* |
| RHMW01, RHMW02, RHMW03, RHMW04, RHMW05, RHMW06, RHMW07, RHMW08, RHMW09, RHMW10, RHMW11, RHMW2254-01, OWDFMW01, HDMW2253-03 | Groundwater | approx. 80–350 | VOCs, PAHs, TPH, NAPs | 1 primary per event<br>2 duplicate per event<br>1 MS/MSD pair per event<br>3 trip blanks per event [a] | Procedure I-C-3, *Monitoring Well Sampling* |
| RHMW01, RHMW02, RHMW03, RHMW05 | Groundwater | approx. 80–350 | TPH with Silica Gel Cleanup | 1 primary for one wet-season event<br>1 primary for one dry-season event | Procedure I-C-3, *Monitoring Well Sampling* |
| RHMW08, RHMW09 | Subsurface Soil | approx. 100–350 | VOCs, PAHs, TPH | 1 field blank [b]<br>1 equipment blank [b] | Procedure I-B-1, *Soil Sampling* |
| HDMW2253-03 | Groundwater | approx. 208 | | | Procedure I-C-3, *Monitoring Well Sampling* |
| RHMW08, RHMW09, RHMW10, RHMW11 | Groundwater | approx. 100–350 | Lead scavengers | 1 primary per event for 1 year of sampling only<br>1 duplicate per event for 1 year of sampling only<br>1 MS/MSD pair per event for 1 year of sampling only | Procedure I-C-3, *Monitoring Well Sampling* |

Note: Procedures are from the *Project Procedures Manua*l (DON 2015).

bgs below ground surface

ft feet

[a] Assume that each sampling event will span 3 field days, and one trip blank will be collected for each day.

[b] Rental pump equipment will be used during sampling of groundwater monitoring well HDMW2253-03, and field and equipment blanks will be collected during each sampling event at HDMW2253-03. All other monitoring wells have dedicated pumps installed; therefore, no field and equipment blanks will be collected for these wells.

1 **Table 2-5: Field Sampling Requirements Table**

| Matrix | Analytical Group | Preparation Reference/Method SOP Analytical Reference/Method SOP | Containers | Sample Volume | Preservation Requirement | Maximum Holding Time (preparation/analysis) |
|---|---|---|---|---|---|---|
| **Soil (Subsurface Soil)** | | | | | | |
| Soil | VOCs | Preparation Method: EPA 5035A<br>Preparation SOP: TBD<br>Analysis Method: EPA 8260C<br>Analysis SOP: TBD | 2 x 10-mL water-preserved 40-mL vials with stir bar, Teflon-lined septum caps<br>1 x 10-mL methanol-preserved 40-mL vial, Teflon-lined septum caps | 3 x 5 g | Cool to ≤6°C | Maximum holding time is 7 days for water-preserved and 14 days for methanol-preserved. |
| | TPH-g | Preparation Method: EPA 5035A<br>Preparation SOP: TBD<br>Analysis Method: EPA 8015C<br>Analysis SOP: TBD | 1 x 10-mL methanol-preserved 40-mL vial, Teflon-lined septum caps | 5 g | Cool to ≤6°C | Maximum holding time is 14 days. |
| | TPH-d, TPH-o | Preparation Method: EPA 3550B/3541A<br>Preparation SOP: TBD<br>Analysis Method: EPA 8015C<br>Analysis SOP: TBD | 4-oz glass jar | 30 g | Cool to ≤6°C | Samples extracted within 14 days and analyzed within 40 days following extraction. |
| | PAHs | Preparation Method: EPA 3550B/3541A<br>Preparation SOP: TBD<br>Analysis Method: EPA 8270D SIM<br>Analysis SOP: TBD | 4-oz glass jar | 30 g | Cool to ≤6°C | Samples extracted within 14 days and analyzed within 40 days following extraction. |
| **Water (Potable Water, Groundwater, QC Water)** | | | | | | |
| Water | VOCs and Lead Scavengers | Preparation Method: EPA 5030B<br>Preparation SOP: TBD<br>Analysis Method: EPA 8260C<br>Analysis SOP: TBD | 3 x 40-mL vials, Teflon-lined septum caps | 40 mL | No headspace, cool to ≤6°C and adjust to pH <2 with $H_2SO_4$, HCl, or solid $NaHSO_4$ | Maximum holding time is 7 days if pH >2 or 14 days if pH <2. |
| | TPH-g | Preparation Method: EPA 5030B<br>Preparation SOP: TBD<br>Analysis Method: EPA 8015C<br>Analysis SOP: TBD | 3 x 40-mL vials, Teflon-lined septum caps | 40 mL | No headspace, cool to ≤6°C and adjust to pH <2 with HCl | Maximum holding time is 7 days if pH >2 or 14 days if pH <2. |
| | TPH-d, TPH-o | Preparation Method: EPA 3510C<br>Preparation SOP: TBD<br>Analysis Method: EPA 8015C<br>Analysis SOP: TBD | 2 x 1-L amber glass, Teflon-lined lid | 1 L | Cool to ≤6°C | Samples extracted within 7 days and analyzed within 40 days following extraction. |
| | TPH-d, TPH-o with Silica Gel Cleanup | Preparation Method: EPA 3510C/EPA 3630<br>Preparation SOP: TBD<br>Analysis Method: EPA 8015C<br>Analysis SOP: TBD | 1 x 1-L amber glass, Teflon-lined lid | 1 L | Cool to ≤6°C | Samples extracted within 7 days and analyzed within 40 days following extraction. |

| Matrix | Analytical Group | Preparation Reference/Method SOP<br>Analytical Reference/Method SOP | Containers | Sample Volume | Preservation Requirement | Maximum Holding Time (preparation/analysis) |
|---|---|---|---|---|---|---|
| Water (cont.) | PAHs | Preparation Method: EPA 3510C<br>Preparation SOP: TBD<br>Analysis Method: EPA 8270D SIM<br>Analysis SOP: TBD | 2 x1-L amber glass, Teflon-lined lid | 1 L | Cool to ≤6°C | Samples extracted within 7 days and analyzed within 40 days following extraction. |
| | Methane | Preparation Method: RSK 175<br>Preparation SOP: TBD<br>Analysis Method: RSK 175<br>Analysis SOP: TBD | 3 × 40-mL vials, rubber-lined septum caps | 40 mL | No headspace, cool to ≤6°C and adjust to pH <2 with HCl | 14 days |
| | Ferrous Iron | Preparation Method: SM 3500-Fe<br>Preparation SOP: TBD<br>Analysis Method: SM 3500<br>Analysis SOP: TBD | 2 x 250 mL amber glass | 250 mL | Field filtered and adjust to pH <2 with HCl or $H_2SO_4$, and cool to ≤6°C and no headspace | 7 days |
| | Nitrate, Sulfate and Chloride | Preparation Method: EPA 300.0<br>Preparation SOP: TBD<br>Analysis Method: EPA 300.0<br>Analysis SOP: TBD | 2 x 125 mL plastic | 125 mL | Cool to ≤6°C | 48 hours (nitrate)<br>28 days (sulfate and chloride) |

| | |
|---|---|
| g | gram |
| $H_2SO_4$ | sulfuric acid |
| HCl | hydrogen chloride |
| L | liter |
| mL | milliliter |
| $NaHSO_4$ | sodium bisulfate |
| oz | ounce |
| TBD | to be determined |

**Table 2-6: Field Quality Control Sample Summary Table**

| Matrix | Analytical Group | No. of Sampling Locations | No. of Field Duplicates | No. of MS/MSD Pairs | No. of Field Blanks | No. of Equipment Blanks | No. of VOA Trip Blanks |
|---|---|---|---|---|---|---|---|
| Subsurface Soil | VOCs (BTEX), TPH-g | 2 | 1 | 1 | 1 | 1 | 2 |
| | TPH-d, TPH-o, PAHs (1-methylnaphthalene, 2-methylnaphthalene, naphthalene) | 2 | 1 | 1 | 1 | 1 | — |
| Potable Water | VOCs (BTEX), TPH-g | 1 | — | — | — | — | 1 |
| | TPH-d, TPH-o, PAHs (1-methylnaphthalene, 2-methylnaphthalene, naphthalene) | 1 | — | — | — | — | — |
| Groundwater[a] | VOCs (BTEX), TPH-g | 14 | 2 | 1 | 1 | 1 | 3 |
| | TPH-d, TPH-o, PAHs (1-methylnaphthalene, 2-methylnaphthalene, naphthalene) | 14 | 2 | 1 | 1 | 1 | — |
| | TPH-d and TPH-o with silica gel cleanup | 4[b] | 1[b] | 1[b] | — | — | — |
| | Lead scavengers (1,2-dibromoethane, 1,2-dichloroethane) | 4[c] | 1[c] | 1[c] | — | — | — |
| | NAPs (dissolved oxygen, methane, ferrous iron, nitrate, sulfate, chloride) | 14 | — | — | — | — | — |

| | |
|---|---|
| no. | number |
| VOA | volatile organic analysis |

[a] Groundwater sample counts are based on a per sampling event basis.

[b] Samples collected from RHMW01, RHMW02, RHWM03, and RHMW05 only for one wet-season and one dry-season sampling event.

[c] Samples collected from RHMW08, RHMW09, RHMW10, and RHMW11 only for at least 1 year of sampling.

**Table 2-7: Analytical SOP References Table**

Laboratory: TBD
Point of Contact: TBD
Point of Contact Phone Number: TBD

| Lab SOP Number | Title, Revision Date, and/or Number | Definitive or Screening Data | Matrix and Analytical Group | Instrument | Variance to QSM (Yes/No) | Modified for Project Work? (Yes/No) |
|---|---|---|---|---|---|---|
| **Preparatory Methods** | | | | | | |
| TBD | TBD | Definitive | VOCs<br>(Soil) | Preparation | No | No |
| TBD | TBD | Definitive | TPH-g<br>(Soil) | Preparation | No | No |
| TBD | TBD | Definitive | TPH-d, TPH-o<br>(Soil) | Preparation | No | No |
| TBD | TBD | Definitive | PAHs<br>(Soil) | Preparation | No | No |
| TBD | TBD | Definitive | VOCs<br>(Water) | Preparation | No | No |
| TBD | TBD | Definitive | TPH-g<br>(Water) | Preparation | No | No |
| TBD | TBD | Definitive | TPH-d, TPH-o<br>(Water) | Preparation | No | No |
| TBD | TBD | Definitive | TPH-d, TPH-o<br>Silica Gel Cleanup<br>(Water) | Preparation | No | No |
| TBD | TBD | Definitive | PAHs<br>(Water) | Preparation | No | No |
| TBD | TBD | Definitive | Lead Scavengers<br>(Water) | Preparation | No | No |
| **Analytical Methods** | | | | | | |
| TBD | TBD | Definitive | VOCs<br>(Soil, Water) | GC-MS | No | No |
| TBD | TBD | Definitive | TPH-g<br>(Soil, Water) | GC-FID | No | No |
| TBD | TBD | Definitive | TPH-d, TPH-o<br>(Soil, Water) | GC-FID | No | No |
| TBD | TBD | Definitive | PAHs<br>(Soil, Water) | GC-MS | No | No |
| TBD | TBD | Definitive | Lead Scavengers<br>(Water) | GC-MS | No | No |

| Lab SOP Number | Title, Revision Date, and/or Number | Definitive or Screening Data | Matrix and Analytical Group | Instrument | Variance to QSM (Yes/No) | Modified for Project Work? (Yes/No) |
|---|---|---|---|---|---|---|
| TBD | TBD | Definitive | Methane (Water) | GC-FID | No | No |
| TBD | TBD | Definitive | Ferrous Iron (Water) | Spectrophotometer | No | No |
| TBD | TBD | Definitive | Nitrate (Water) | Lachat | No | No |
| TBD | TBD | Definitive | Sulfate (Water) | Ion chromatograph | No | No |
| TBD | TBD | Definitive | Chloride (Water) | Ion chromatograph | No | No |

Note: The laboratory SOPs listed in the table are the most current revisions at the time of publication of this WP/SOW. AECOM will review the laboratory SOPs immediately prior to sample submittal to ensure that the laboratory uses SOPs that are in compliance with the DoD QSM annual review requirement.

| | |
|---|---|
| GC-FID | gas chromatography-flame ionization detector |
| GC-MS | gas chromatography-mass spectrometry |
| TBD | to be determined |

**Table 2-8: Analytical Instrument Calibration Table**

| Instrument | Calibration Procedure | Frequency of Calibration | Acceptance Criteria | Corrective Action | Person Responsible for Corrective Action | SOP Reference [a] |
|---|---|---|---|---|---|---|
| GC-MS<br>EPA Methods 8260C, 8720D SIM | Tuning | Prior to ICAL and at the beginning of each 12-hour period | Refer to method for specific ion criteria. | Retune instrument and verify. Rerun affected samples. | Lab Manager/Analyst or certified instrument technician | TBD |
| | Breakdown check (DDT-Method 8270 only) | At the beginning of each 12-hour period, prior to analysis of samples | Degradation ≤20% for DDT. Benzidine and pentachlorophenol should be present at their normal responses, and should not exceed a tailing factor of 2. | Correct problem, then repeat breakdown checks. | Lab Manager/Analyst or certified instrument technician | |
| | Minimum 5-point ICAL for linear calibration<br>Minimum 6-point ICAL for quadratic calibration | Prior to sample analysis | RSD for each analyte ≤15% or least square regression ≥0.995. Non-linear least squares regression (quadratic) for each analyte ≤0.995. | Correct problem then repeat ICAL. | Lab Manager/Analyst or certified instrument technician | |
| | Second source calibration verification | After ICAL | All analytes within ±20% of expected value. | Correct problem and verify second source standard; rerun second source verification. If fails, correct problem and repeat ICAL. | Lab Manager/Analyst or certified instrument technician | |
| | RT window position for each analyte and surrogate | Once per ICAL | Position will be set using the midpoint standard for the ICAL. | N/A | Lab Manager/Analyst or certified instrument technician | |
| | RRT | With each sample | RRT of each target analyte in each calibration standard within ±0.06 RRT units of ICAL. | Correct problem, then reanalyze all samples analyzed since the last RT check. If fails, then rerun ICAL and samples. | Lab Manager/Analyst or certified instrument technician | |
| | CCV | Daily, before sample analysis, unless ICAL performed same day and after every 10 samples and at the end of the analysis sequence | All analytes within ±20% of expected value (%D).<br>All reported analytes and surrogates within ± 50% for end of analytical batch CCV. | Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV. | Lab Manager/Analyst or certified instrument technician | |
| | IS | Each CCV and sample | RT ± 10 seconds from RT of the ICAL mid-point standard. EICP area within -50% to +100% of area from IS in ICAL mid-point standard. | Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed during failure is mandatory. | Lab Manager/Analyst or certified instrument technician | |

| Instrument | Calibration Procedure | Frequency of Calibration | Acceptance Criteria | Corrective Action | Person Responsible for Corrective Action | SOP Reference [a] |
|---|---|---|---|---|---|---|
| GC-FID<br>EPA Method 8015C | Minimum 5-point ICAL for linear calibration<br>Minimum 6-point ICAL for quadratic calibration | Prior to sample analysis | RSD for each analyte ≤20% or least square regression ≥0.995. Non-linear least squares regression (quadratic) for each analyte ≤0.995. | Correct problem then repeat ICAL. | Lab Manager/Analyst or certified instrument technician | TBD |
| | Second source calibration verification | Once after each ICAL | Analytes within ±20% of expected value (initial source), and within established RT windows. | Correct problem and verify second source standard. Rerun second source verification. If fails, correct problem and repeat ICAL. | Lab Manager/Analyst or certified instrument technician | |
| | RT window width | At method set-up and after major maintenance | RT width is ± 3 times standard deviation for each analyte RT from 72-hour study. For TPH-d: calculate RT based on C12 and C25 alkanes. | N/A | Lab Manager/Analyst or certified instrument technician | |
| | Establishment and verification of the RT window for each analyte and surrogate | Once per ICAL and at the beginning of the analytical shift for establishment of RT; and with each CCV for verification of RT | Using the midpoint standard or the CCV at the beginning of the analytical shift for RT establishment; and analyte must fall within established window during RT verification. | N/A | Lab Manager/Analyst or certified instrument technician | |
| | Run second source calibration verification (ICV) | ICV: Daily, before sample analysis, unless ICAL performed same day | All analytes within ±20% of expected value (%D). | Correct problem and rerun ICV. If fails, repeat ICAL. | Lab Manager/Analyst or certified instrument technician | |
| | CCV | Daily, before sample analysis, unless ICAL performed same day and after every 10 samples and at the end of the analysis sequence | All analytes within ±20% of expected value (%D). | Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV. | Lab Manager/Analyst or certified instrument technician | |
| Water Bath | Measure water temperature against a calibrated thermometer | Annually | In accordance with unit model and manufacturer's recommendation or laboratory SOP. | Terminate analysis, recalibrate, and verify before sample analysis. | Lab Manager/Analyst or certified instrument technician | TBD |
| Drying Oven | Measure oven temperature against a calibrated thermometer | Annually | In accordance with unit model and manufacturer's recommendation or laboratory SOP. | Terminate analysis, recalibrate, and verify before sample analysis. | Lab Manager/Analyst or certified instrument technician | TBD |

| Instrument | Calibration Procedure | Frequency of Calibration | Acceptance Criteria | Corrective Action | Person Responsible for Corrective Action | SOP Reference [a] |
|---|---|---|---|---|---|---|
| Analytical Balance | Calibrate against verified (NIST) mass | Daily or prior to analyzing samples | In accordance with unit model and manufacturer's recommendation or laboratory SOP. | Terminate analysis, recalibrate, and verify before sample analysis. | Lab Manager/Analyst or certified instrument technician | TBD |
| pH Meter | Run a minimum 3-point calibration; run CCV | Daily or prior to analyzing samples; one CCV for every 10 samples | ±0.05 unit. | Terminate analysis, recalibrate, and verify before sample analysis. | Lab Manager/Analyst or certified instrument technician | TBD |

| | |
|---|---|
| %D | percent difference |
| CA | corrective action |
| CCV | continued calibration verification |
| D | difference |
| DDT | dichlorodiphenyltrichloroethane |
| ICAL | initial calibration |
| ICV | initial calibration verification |
| IS | internal standard |
| NIST | National Institute of Standards and Technology |
| RRT | relative retention time |
| RSD | relative standard deviation |
| RT | retention time |

[a] See Analytical SOP References table (Table 2-7).

**Table 2-9: Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table**

| Instrument/ Equipment | Maintenance Activity | Testing Activity | Inspection Activity | Frequency | Acceptance Criteria | Corrective Action | Responsible Person | SOP Reference [a] |
|---|---|---|---|---|---|---|---|---|
| GC-FID and GC-MS | Change gas purifier. | N/A | Visually inspect if traps are changing color. | Every 6–12 months | No moisture | Replace indicating traps. | Analyst or certified instrument technician | TBD |
| | Change syringes/syringe needles. | N/A | Visually inspect for wear or damage. | Every 3 months | N/A | Replace syringe if dirt is noticeable in the syringe. | Analyst or certified instrument technician | |
| | Change inlet liner, liner O-rings, and inlet septum. | N/A | Visually inspect for dirt or deterioration. | Weekly for liner<br>Monthly for O-rings<br>Daily for septum | N/A | Replace and check often. | Analyst or certified instrument technician | |
| | Change front-end column. | N/A | Check peak tailing, decreased sensitivity, retention time changes, etc. | Weekly, monthly, or when needed | N/A | Remove 1/2 to 1 meter from the front of the column when experiencing problems. | Analyst or certified instrument technician | |
| | Clean injector ports. | N/A | N/A | As needed | N/A | N/A | Analyst | |
| | Replace trap on purge-and-trap systems. | N/A | N/A | Bi-monthly or as needed | N/A | N/A | Analyst | |
| | Replace columns. | N/A | N/A | If chromatograms indicate possible contamination | N/A | N/A | Analyst | |
| GC-FID | Replace detector jets. | N/A | N/A | As needed | N/A | N/A | Analyst | TBD |
| | Replace hydrocarbon traps and oxygen traps on helium and hydrogen gas lines. | N/A | N/A | Every 4–6 months | N/A | N/A | Analyst | |
| | Replace chemical trap. | N/A | N/A | Yearly or as needed | N/A | N/A | Analyst | |
| | Replace converter tube in gas purifier system. | N/A | N/A | Yearly or as needed | N/A | N/A | Analyst | |
| GC-MS | Change tune MSD, check the calibration vial, and replace the foreline pump oil. | N/A | Visually inspect and monitor the fluid becoming discolored. | As needed or every 6 months | In accordance with manufacturer's recommendation or lab SOP | Keep plenty of PFTBA; refill the vial and check the fluid; change when the fluid becomes discolored. | Analyst or certified instrument technician | TBD |
| | Run tuning program to determine if source is functioning properly. | N/A | N/A | Daily | N/A | Cool system, vent, disassemble, and clean. | Analyst | |

| Instrument/ Equipment | Maintenance Activity | Testing Activity | Inspection Activity | Frequency | Acceptance Criteria | Corrective Action | Responsible Person | SOP Reference [a] |
|---|---|---|---|---|---|---|---|---|
| GC-MS (cont.) | N/A | Tune instrument. | N/A | Daily or every 12 hours | Per method | Liner and septa are replaced; tune file used is manually adjusted. | Analyst | TBD |
| | Vacuum rough pump oil level is checked. | N/A | N/A | Every 4-6 weeks | N/A | Add oil if needed. | Analyst | |
| | Replace/refill carrier gas line oxygen and moisture traps. | N/A | N/A | Yearly or as needed | N/A | N/A | Analyst | |
| Water Bath (Precision Microprocessor controlled) | Check instrument connections, water level, and thermometer. | Measure water temperature against a calibrated thermometer. | Visually inspect for wear or damage and indicator from computer controls. | Daily and annual maintenance from manufacturer | Refer to manufacturer's recommendation | Return to manufacturer for recalibration or call for maintenance service. | Analyst or certified instrument technician | TBD |
| Drying Oven | Thermometer indicator. | Measure oven temperature against a calibrated thermometer. | Visually inspect for wear or damage and indicator from computer controls. | Daily and annual maintenance from manufacturer | Refer to manufacturer's recommendation | Return to manufacturer for recalibration or call for maintenance service. | Analyst or certified instrument technician | TBD |
| Analytical Balance | Check digital LCD display and ensure a flat base for the Instrument. | Calibrate against verified (NIST) mass. | Visually inspect for wear or damage and indicator from computer controls. | Daily and annual maintenance from manufacturer | Refer to manufacturer's recommendation | Return to manufacturer for recalibration or call for maintenance service. | Analyst or certified instrument technician | TBD |
| pH Meter | Check LCD display and pH probe. | 3 point calibration using known standards. | Visually inspect for wear or damage and indicator from computer controls. | Daily and annual maintenance from manufacturer | ± 0.05 units | Return to manufacturer for recalibration or call for maintenance service. | Analyst or certified manufacture instrument technician | TBD |

N/A not applicable
PFTBA perfluorotributylamine
[a] See Analytical SOP References table (Table 2-7).

## 2.6 SAMPLE HANDLING SYSTEM

Sample handling specifics are presented in Table 2-10.

**Table 2-10: Sample Handling System**

| Item | Personnel/Organization/Time Limit |
|---|---|
| **Sample Collection, Packaging, and Shipment** | |
| Sample Collection | Field manager, field QC coordinator, field geologist/AECOM |
| Sample Packaging | Field manager, field QC coordinator, field geologist/AECOM |
| Coordination of Shipment | Field QC coordinator, field geologist/AECOM |
| Type of Shipment/Carrier | Insulated cooler/FedEx Corporation or equivalent |
| **Sample Receipt and Analysis** | |
| Sample Receipt | Sample custodian/Designated analytical laboratory |
| Sample Custody and Storage | Sample custodian/Designated analytical laboratory |
| Sample Preparation | Laboratory analyst/Designated analytical laboratory |
| Sample Determinative Analysis | Laboratory analyst/Designated analytical laboratory |
| **Sample Archiving** | |
| Field Sample Storage | 90 days from sample receipt |
| Sample Extract/Digestate Storage | 90 days from extraction/digestion |
| Biological Sample Storage | Not applicable or per project scope |
| **Sample Disposal** | |
| Personnel/Organization | Sample custodian/Designated analytical laboratory |
| Number of Days from Analysis | 90 days |

## 2.7 SAMPLE CUSTODY REQUIREMENTS

Each sample will be assigned a COC sample identification (ID) number and a descriptive ID number in accordance with Procedure I-A-8, *Sample Naming* (DON 2015). All sample ID numbers will be recorded in the field logbook in accordance with Procedure III-D, *Logbooks* (DON 2015). The COC sample ID number (the only ID number submitted to the analytical laboratory) is used to facilitate data tracking and storage. The COC sample ID number allows all samples to be submitted to the laboratory without providing information on the sample type or source. The descriptive ID number is linked to the COC sample ID number, which provides information regarding sample type, origin, and source.

### 2.7.1 COC Sample Identification Number

A COC sample ID number will be assigned to each sample as follows, to facilitate data tracking and storage:

**ERHzzz**

Where:

| | |
|---|---|
| **ERH** | Designating the samples for the Red Hill Bulk Fuel Storage Facility Groundwater Long-Term Monitoring program |
| **zzz** | Chronological number, starting with next consecutive number (will be determined prior to field work and is dependent on the last number used in the most recent monitoring event) |

QC samples will be included in the chronological sequence.

### 2.7.2 Descriptive Identification Number

A descriptive ID number (for internal use only) will identify the sampling location, type, sequence, matrix, and depth. The descriptive ID number is used to provide sample-specific information (e.g., location, sequence, and matrix). The descriptive identifier is not revealed to the analytical laboratory. The descriptive ID number for all samples is assigned as follows:

**Aaaaaa-bbcc-d-eeeeee**

Where:

| | |
|---|---|
| **Aaaaaa** | Site area (see Table 2-11) |
| **bb** | Sample type and matrix (see Table 2-12) |
| **cc** | consecutive sampling location number |
| **d** | Field QC sample type (see Table 2-13) |
| **eeeeee** | Month, date and year of collection for water samples (e.g., 021716 to designate February 17, 2016); sample depth for subsurface soils (e.g., 80.0ft to designate 80.0 feet [ft] below ground surface [bgs]). |

For example, the sample number RHMW08-GW01-N-060116 would indicate that the sample is the primary groundwater sample collected from RHMW08 on June 1, 2016. The duplicate sample would be designated as RHMW08-GW01-D-060116. The sample number RHMW08-SB01-N-80.0ft indicates that the sample is the primary subsurface sample collected from RHMW08 at a depth of 80.0 ft bgs. The sample number RHMW08-IDW01-S-060116 would indicate the first soil IDW sample associated with RHMW08 collected on June 1, 2016. These characters will establish a unique descriptive identifier that will be used during data evaluation.

**Table 2-11: Area Identifiers**

| Identifier | Site Area |
|---|---|
| RHMW01 | Inside-tunnel groundwater monitoring well RHMW01 |
| RHMW02 | Inside-tunnel groundwater monitoring well RHMW02 |
| RHMW03 | Inside-tunnel groundwater monitoring well RHMW03 |
| RHMW04 | Background groundwater monitoring well RHMW04 |
| RHMW05 | Inside-tunnel groundwater monitoring well RHMW05 |
| RHMW06 | Outside-tunnel groundwater monitoring well RHMW06 |
| RHMW07 | Outside-tunnel groundwater monitoring well RHMW07 |
| RHMW08 | Outside-tunnel groundwater monitoring well RHMW08 |
| RHMW09 | Outside-tunnel groundwater monitoring well RHMW09 |
| RHMW10 | Outside-tunnel groundwater monitoring well RHMW10 |
| RHMW11 | Outside-tunnel groundwater monitoring well RHMW11 |
| RHMW2254 | Inside-tunnel groundwater sampling point RHMW2254-01; infiltration gallery well |
| OWDFMW01 | Oily Waste Disposal Facility monitoring well OWDFMW01 |
| HDMW2253 | Hālawa Deep Monitor Well HDMW2253-03 located at the Hālawa Correctional Facility |

**Table 2-12: Sample Type and Matrix Identifiers**

| Identifier | Sample Type | Matrix |
|---|---|---|
| GW | Groundwater | Water |
| WQ | Water Blanks | Water |
| SB | Subsurface Soil | Soil |
| PW | Potable Water | Water |
| IDW | IDW Sample | Soil/Water |

**Table 2-13: Field QC Sample Type Identifiers**

| Identifier | Field or QC Sample Type | Description |
|---|---|---|
| N | Primary Sample | All field samples, except QC samples |
| D | Duplicate | Replicate for water/Co-located sample for soil |
| E | Equipment Blank | Water QC |
| B | Field Blank | Water QC |
| T | Trip Blank | Water QC |
| S | Soil (for IDW samples only) | Soil matrix IDW sample |
| W | Water (for IDW samples only) | Water matrix IDW sample |

### 2.7.3 Handling, Shipping, and Custody

All samples collected for analysis will be recorded in the field logbook in accordance with Procedure III-D, *Logbooks* (DON 2015). All samples will be labeled and recorded on COC forms in accordance with Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody Procedures* (DON 2015). Samples will be handled, stored, and shipped in accordance with Procedure III-F, *Sample Handling, Storage, and Shipping* (DON 2015). All samples collected on this project will be shipped to the analytical laboratory via overnight airfreight.

All samples received at the analytical laboratory will be managed in accordance with laboratory SOPs for receiving samples, archiving data, and sample disposal and waste collection, as well as, storage and disposal per Section 5.8, “Handling of Samples” of the DoD QSM 5.0 (DoD 2013).

## 2.8 QUALITY MANAGEMENT TABLES

The following tables detail the data quality control and management system for the project:

- Table 2-14: Laboratory QC Samples Table
- Table 2-15: Project Documents and Records Table
- Table 2-16: Analytical Services Table
  - Data packages will be due 21 days after samples are received at the laboratory.
  - Data packages will be prepared according to Procedure I-A-7, *Analytical Data Validation Planning and Coordination* (DON 2015). Data packages must include, at a minimum, the following sections:
    - Cover sheet
    - Table of contents

        - Case narrative
        - Analytical results
        - Sample management records
        - QA/QC information
        - Information for third-party review
    - For complete details of hard copy and electronic data deliverable data package requirements, see Attachment G.1.
- Table 2-17: Planned Project Assessments Table
- Table 2-18: Assessment Findings and Corrective Action Responses
- Table 2-19: Quality Assurance Management Reports Table
- Table 2-20: Data Verification and Validation (Steps I and IIa/IIb) Process Table

## Table 2-14: Laboratory QC Samples Table

| | |
|---|---|
| **Matrix** | **Potable Water, Groundwater, and Subsurface Soil** |
| **Analytical Group** | **VOCs** |
| **Analytical Method/SOP Reference** | Analytical Method: SW-846 8260C<br>Preparation Method: EPA 5030B or EPA 5035A<br>Laboratory SOPs: TBD |
| **Analytical Organization** | TBD |

| QC Sample | Frequency & Number | Method/SOP QC Acceptance Limits | Corrective Action | Personnel Responsible for Corrective Action | DQI | Measurement Performance Criteria |
|---|---|---|---|---|---|---|
| LOD determination and verification | At initial set-up and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each. | The apparent signal to noise ratio must be at least 3 and the results must meet all method requirements for analyte identification. | If the LOD verification fails, the laboratory must:<br>1) Repeat the detection limit determination and LOD verification at a higher concentration; or<br>2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration. | Analyst<br>Lab QA Officer<br>Project Chemist | Bias/ Representativeness | QC acceptance criteria as specified by Lab SOP TBD. |
| LOQ establishment and verification | At initial setup:<br>1) Verify LOQ; and<br>2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each. | 1) The LOQ and associated precision and bias must meet client requirements and must be reported; or<br>2) In the absence of client requirements, must meet control limits of the LCS.<br>3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Volume 1, Module 4, Section 1.5.2 of the DoD QSM 5.0 (DoD 2013). | If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias. | Analyst<br>Lab QA Officer<br>Project Chemist | Sensitivity/Bias | QC acceptance criteria as specified by Lab SOP TBD and at least as stringent as specified by DoD QSM 5.0 (DoD 2013). |
| Tune check | Prior to the ICAL and prior to each 12-hour period of sample analysis. | Specific ion abundance criteria of BFB or DFTPP from method. | Retune instrument and verify. | Analyst<br>Lab QA Officer<br>Project Chemist | Sensitivity/Bias | No samples may be analyzed without a passing tune. |

| | |
|---|---|
| **Matrix** | **Potable Water, Groundwater, and Subsurface Soil** |
| **Analytical Group** | **VOCs** |
| **Analytical Method/SOP Reference** | Analytical Method: SW-846 8260C<br>Preparation Method: EPA 5030B or EPA 5035A<br>Laboratory SOPs: TBD |
| **Analytical Organization** | TBD |

| QC Sample | Frequency & Number | Method/SOP QC Acceptance Limits | Corrective Action | Personnel Responsible for Corrective Action | DQI | Measurement Performance Criteria |
|---|---|---|---|---|---|---|
| CCV | Before sample analysis, after every 10 field samples, after every 12 hours of analysis time, and at the end of the analysis sequence. | All reported analytes and surrogates within established RT windows. All reported analytes and surrogates within ± 20% of true value. All reported analytes and surrogates within ± 50% for the end of the analytical batch CCV. | Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV. | Analyst<br>Lab QA Officer<br>Project Chemist | Accuracy/Precision | Results may not be reported without a valid CCV. If reanalysis cannot be performed, data must be qualified and explained in the case narrative. If the specific version of a method requires additional evaluation (e.g., average response factors) these additional requirements must also be met. |
| MB | Each time analytical batch. | No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common lab contaminants, no analytes detected >LOQ. | Correct problem. If required, re-prep and reanalyze MB and all samples processed with the contaminated blank. | Analyst<br>Lab QA Officer<br>Project Chemist | Bias | No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ. |
| LCS | One per batch of at most 20 samples analyzed of similar matrix per analytical method. | Per DoD QSM Appendix C Limits, Method SW-846 8260C and Lab SOP ANA8260C. | Correct problem. If required, re-prep and reanalyze the LCS and all samples processed in the associated preparatory batch for the failed analytes. Results may not be reported without a valid LCS. | Analyst<br>Lab QA Officer<br>Project Chemist | Accuracy | QC acceptance criteria at least as stringent as specified by DoD QSM 5.0 (DoD 2013). |
| MS/MSD pair | One per analytical method for each batch of at most 20 samples. | Per DoD QSM Appendix C Limits, Method SW-846 8260C and Lab SOP TBD.<br>MSD or Matrix Duplicate: RPD of all analytes ≤20%. | Examine the PQOs. Notify Lab QA officer and project chemist about additional measures to be taken. | Analyst<br>Lab QA Officer<br>Project Chemist | Accuracy/Precision | For matrix evaluation, use QC acceptance criteria at least as stringent as specified by DoD QSM 5.0 (DoD 2013). |
| Internal standards verification | Every field sample, standard, and QC sample. | Retention time ± 10 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard. | Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory. | Analyst<br>Lab QA Officer<br>Project Chemist | Accuracy/Precision/ Representativeness | Laboratory in-house method manual to be followed for acceptance criteria. |

|  |  |
|---|---|
| **Matrix** | **Potable Water, Groundwater, and Subsurface Soil** |
| **Analytical Group** | **VOCs** |
| **Analytical Method/SOP Reference** | Analytical Method: SW-846 8260C<br>Preparation Method: EPA 5030B or EPA 5035A<br>Laboratory SOPs: TBD |
| **Analytical Organization** | TBD |

| QC Sample | Frequency & Number | Method/SOP QC Acceptance Limits | Corrective Action | Personnel Responsible for Corrective Action | DQI | Measurement Performance Criteria |
|---|---|---|---|---|---|---|
| Surrogate spike | All field and QC samples. | Per DoD QSM Appendix C Limits, Method SW-846 8260C and Lab SOP TBD. | For QC and field samples, correct problem then re-prep and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary. | Analyst<br>Lab QA Officer<br>Project Chemist | Accuracy/Precision/ Representativeness | QC acceptance criteria at least as stringent as specified by DoD QSM 5.0 (DoD 2013). |
| Trip blank | 1 per cooler. | Target analytes ≤1/2 LOQ. | Reanalyze for confirmation through a second analysis of the trip blank. Examine the PQOs. | Analyst<br>Lab QA Officer<br>Project Chemist | Accuracy/Bias, Representativeness/ Contamination | Target analytes ≤1/2 LOQ. |

| | |
|---|---|
| **Matrix** | **Potable Water, Groundwater, and Subsurface Soil** |
| **Analytical Group** | **TPH-g** |
| **Analytical Method/SOP Reference** | Analytical Method: EPA Method 8015C<br>Preparation Method: EPA 5030B or EPA 5035A<br>Laboratory SOPs: TBD |
| **Analytical Organization** | TBD |

| QC Sample | Frequency & Number | Method/SOP QC Acceptance Limits | Corrective Action | Personnel Responsible for Corrective Action | DQI | Measurement Performance Criteria |
|---|---|---|---|---|---|---|
| LOD determination and verification | At initial set-up and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each. | The apparent signal to noise ratio must be at least 3 and the results must meet all method requirements for analyte identification. | If the LOD verification fails, the laboratory must:<br>1) Repeat the detection limit determination and LOD verification at a higher concentration; or<br>2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration. | Analyst<br>Lab QA Officer<br>Project Chemist | Bias/ Representativeness | QC acceptance criteria as specified by Lab SOP TBD. |
| LOQ establishment and verification | At initial setup:<br>1) Verify LOQ; and<br>2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each. | 1) The LOQ and associated precision and bias must meet client requirements and must be reported; or<br>2) In the absence of client requirements, must meet control limits of the LCS.<br>3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Volume 1, Module 4, Section 1.5.2 of the DoD QSM 5.0 (DoD 2013). | If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias. | Analyst<br>Lab QA Officer<br>Project Chemist | Sensitivity/Bias | QC acceptance criteria as specified by Lab SOP TBD and at least as stringent as specified by DoD QSM 5.0 (DoD 2013). |
| CCV | Before sample analysis, after every 10 field samples, and at the end of the analysis sequence. | All reported analytes and surrogates within established RT windows. All reported analytes and surrogates within ± 20% of true value. | Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV. | Analyst<br>Lab QA Officer<br>Project Chemist | Accuracy/Precision | Results may not be reported without a valid CCV. If reanalysis cannot be performed, data must be qualified and explained in the case narrative. |
| MB | Each time samples are extracted and one per matrix per analytical method for each batch of at most 20 samples. | No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common lab contaminants, no analytes detected >LOQ. | Correct problem. If required, re-prep and reanalyze MB and all samples processed with the contaminated blank. | Analyst<br>Lab QA Officer<br>Project Chemist | Sensitivity/Bias | No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ. |

| | |
|---|---|
| **Matrix** | **Potable Water, Groundwater, and Subsurface Soil** |
| **Analytical Group** | **TPH-g** |
| **Analytical Method/SOP Reference** | Analytical Method: EPA Method 8015C<br>Preparation Method: EPA 5030B or EPA 5035A<br>Laboratory SOPs: TBD |
| **Analytical Organization** | TBD |

| QC Sample | Frequency & Number | Method/SOP QC Acceptance Limits | Corrective Action | Personnel Responsible for Corrective Action | DQI | Measurement Performance Criteria |
|---|---|---|---|---|---|---|
| LCS | One per batch of at most 20 samples analyzed of similar matrix per analytical method. | Per DoD QSM Appendix C Limits, Method 8015C and Lab SOP TBD. | Correct problem. If required, re-prep and reanalyze the LCS and all samples processed in the associated preparatory batch for the failed analytes. | Analyst<br>Lab QA Officer<br>Project Chemist | Accuracy | QC acceptance criteria at least as stringent as specified by DoD QSM 5.0 (DoD 2013). |
| Internal standards verification | Every field sample, standard, and QC sample. | Retention time ± 30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard. | Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory. | Analyst<br>Lab QA Officer<br>Project Chemist | Accuracy/Precision/ Representativeness | Laboratory in-house method manual to be followed for acceptance criteria. |
| Surrogate spike | All field and QC samples. | Per DoD QSM Appendix C Limits, Method 8015C and Lab SOP TBD. | For QC and field samples, correct problem then re-prep and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary. | Analyst<br>Lab QA Officer<br>Project Chemist | Accuracy/Precision/ Representativeness | QC acceptance criteria at least as stringent as specified by DoD QSM 5.0 (DoD 2013). |
| MS/MSD pair | One per analytical method for each batch of at most 20 samples. | Per DoD QSM Appendix C Limits, Method 8015C and Lab SOP TBD.<br>MSD or Matrix Duplicate: RPD of all analytes ≤30%. | Examine the PQOs. Notify Lab QA officer and project chemist about additional measures to be taken. | Analyst<br>Lab QA Officer<br>Project Chemist | Accuracy/Precision | For matrix evaluation, use QC acceptance criteria at least as stringent as specified by DoD QSM 5.0 (DoD 2013). |
| Trip blank | One per cooler. | Target analytes ≤1/2 LOQ. | Reanalyze for confirmation through a second analysis of the trip blank. Examine the PQOs. | Analyst<br>Lab QA Officer<br>Project Chemist | Accuracy/Bias, Representativeness/ Contamination | Target analytes ≤1/2 LOQ. |

| | |
|---|---|
| **Matrix** | **Potable Water, Groundwater, and Subsurface Soil** |
| **Analytical Group** | **TPH-d, TPH-o** |
| **Analytical Method/SOP Reference** | Analytical Method: EPA Method 8015C<br>Preparation Method: EPA 3510C/3630C or EPA 3550C/3541A<br>Laboratory SOPs: TBD |
| **Analytical Organization** | TBD |

| QC Sample | Frequency & Number | Method/SOP QC Acceptance Limits | Corrective Action | Personnel Responsible for Corrective Action | DQI | Measurement Performance Criteria |
|---|---|---|---|---|---|---|
| LOD determination and verification | At initial set-up and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each. | The apparent signal to noise ratio must be at least 3 and the results must meet all method requirements for analyte identification. | If the LOD verification fails, the laboratory must:<br>1) Repeat the detection limit determination and LOD verification at a higher concentration; or<br>2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration. | Analyst<br>Lab QA Officer<br>Project Chemist | Bias/ Representativeness | QC acceptance criteria as specified by Lab SOP TBD. |
| LOQ establishment and verification | At initial setup:<br>1) Verify LOQ; and<br>2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each. | 1) The LOQ and associated precision and bias must meet client requirements and must be reported; or<br>2) In the absence of client requirements, must meet control limits of the LCS.<br>3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Volume 1, Module 4, Section 1.5.2 of the DoD QSM 5.0 (DoD 2013). | If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias. | Analyst<br>Lab QA Officer<br>Project Chemist | Sensitivity/Bias | QC acceptance criteria as specified by Lab SOP TBD, and at least as stringent as specified by DoD QSM 5.0 (DoD 2013). |
| CCV | Before sample analysis, after every 10 field samples, and at the end of the analysis sequence. | All reported analytes and surrogates within established RT windows. All reported analytes and surrogates within ± 20% of true value. | Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV. | Analyst<br>Lab QA Officer<br>Project Chemist | Accuracy/Precision | Results may not be reported without a valid CCV. If reanalysis cannot be performed, data must be qualified and explained in the case narrative. |
| MB | Each time samples are extracted and one per matrix per analytical method for each batch of at most 20 samples. | No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common lab contaminants, no analytes detected >LOQ. | Correct problem. If required, re-prep and reanalyze MB and all samples processed with the contaminated blank. | Analyst<br>Lab QA Officer<br>Project Chemist | Sensitivity/Bias | No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ. |

| | |
|---|---|
| **Matrix** | **Potable Water, Groundwater, and Subsurface Soil** |
| **Analytical Group** | **TPH-d, TPH-o** |
| **Analytical Method/SOP Reference** | Analytical Method: EPA Method 8015C<br>Preparation Method: EPA 3510C/3630C or EPA 3550C/3541A<br>Laboratory SOPs: TBD |
| **Analytical Organization** | TBD |

| QC Sample | Frequency & Number | Method/SOP QC Acceptance Limits | Corrective Action | Personnel Responsible for Corrective Action | DQI | Measurement Performance Criteria |
|---|---|---|---|---|---|---|
| LCS | One per batch of at most 20 samples analyzed of similar matrix per analytical method. | Per DoD QSM Appendix C Limits, Method 8015C and Lab SOP TBD. | Correct problem. If required, re-prep and reanalyze the LCS and all samples processed in the associated preparatory batch for the failed analytes. | Analyst<br>Lab QA Officer<br>Project Chemist | Accuracy | QC acceptance criteria at least as stringent as specified by DoD QSM 5.0 (DoD 2013). |
| Internal standards verification | Every field sample, standard, and QC sample. | Retention time ±30 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard. | Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory. | Analyst<br>Lab QA Officer<br>Project Chemist | Accuracy/ Precision/ Representativeness | Laboratory in-house method manual to be followed for acceptance criteria. |
| Surrogate spike | All field and QC samples. | Per DoD QSM Appendix C Limits, Method 8015C and Lab SOP TBD. | For QC and field samples, correct problem then re-prep and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary. | Analyst<br>Lab QA Officer<br>Project Chemist | Accuracy/Precision/ Representativeness | QC acceptance criteria at least as stringent as specified by DoD QSM 5.0 (DoD 2013). |
| Surrogate spike for silica gel cleanup procedure | All field and QC samples. | Acceptable recovery range of 0 to 1% of spiked amount of polar hydrocarbon surrogate. | For QC and field samples, if sufficient sample extract is available, re-run extracts through silica gel cleanup procedure and reanalyze all failed samples for failed surrogates in the associated preparatory batch. Otherwise, re-extract samples and re-run silica gel cleanup on re-extract prior to re-analysis, if sufficient sample material is available. | Analyst<br>Lab QA Officer<br>Project Chemist | Accuracy/Precision/ Representativeness | Polar hydrocarbon surrogate recovered at ≤1% of spiked amount. |
| MS/MSD pair | One per analytical method for each batch of at most 20 samples. | Per DoD QSM Appendix C Limits, Method 8015C and Lab SOP TBD.<br>MSD or Matrix Duplicate: RPD of all analytes ≤30%. | Examine the PQOs. Notify Lab QA officer and project chemist about additional measures to be taken. | Analyst<br>Lab QA Officer<br>Project Chemist | Accuracy/Precision | For matrix evaluation, use QC acceptance criteria at least as stringent as specified by DoD QSM 5.0 (DoD 2013). |

| | |
|---|---|
| **Matrix** | **Potable Water, Groundwater, and Subsurface Soil** |
| **Analytical Group** | **PAHs** |
| **Analytical Method/SOP Reference** | Analytical Method: EPA Method 8270D SIM<br>Preparation Method: EPA 3510C or EPA 3550B/3541A<br>Laboratory SOPs: TBD |
| **Analytical Organization** | TBD |

| QC Sample | Frequency & Number | Method/SOP QC Acceptance Limits | Corrective Action | Personnel Responsible for Corrective Action | DQI | Measurement Performance Criteria |
|---|---|---|---|---|---|---|
| LOD determination and verification | At initial set-up and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each. | The apparent signal to noise ratio must be at least 3 and the results must meet all method requirements for analyte identification. | If the LOD verification fails, the laboratory must:<br>1) Repeat the detection limit determination and LOD verification at a higher concentration; or<br>2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration. | Analyst<br>Lab QA Officer<br>Project Chemist | Bias/ Representativeness | QC acceptance criteria as specified by Lab SOP TBD. |
| LOQ establishment and verification | At initial setup:<br>1) Verify LOQ; and<br>2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each. | 1) The LOQ and associated precision and bias must meet client requirements and must be reported; or<br>2) In the absence of client requirements, must meet control limits of the LCS.<br>3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Volume 1, Module 4, Section 1.5.2 of the DoD QSM 5.0 (DoD 2013). | If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias. | Analyst<br>Lab QA Officer<br>Project Chemist | Sensitivity/Bias | QC acceptance criteria as specified by Lab SOP TBD, and at least as stringent as specified by DoD QSM 5.0 (DoD 2013). |
| Performance check | Before ICAL and sample analysis, and at the beginning of each 12-hour shift. | Degradation of DDT must be ≤20%. Benzidine and pentachlorophenol will be present at their normal responses, and will not exceed a tailing factor of 2. | Correct problem, then repeat performance checks. | Analyst<br>Lab QA Officer<br>Project Chemist | Sensitivity/Bias | Degradation of DDT must be ≤20%; and benzidine and pentachlorophenol must be present at normal responses and tailing factor is ≤2. No samples must be analyzed until performance check is within criteria. |
| Tune Check | Prior to the ICAL and prior to each 12-hour period of sample analysis. | Specific ion abundance criteria of BFB or DFTPP from method. | Retune instrument and verify | Analyst<br>Lab QA Officer<br>Project Chemist | Sensitivity/Bias | No samples may be analyzed without a passing tune. |

| | |
|---|---|
| **Matrix** | **Potable Water, Groundwater, and Subsurface Soil** |
| **Analytical Group** | **PAHs** |
| **Analytical Method/SOP Reference** | Analytical Method: EPA Method 8270D SIM<br>Preparation Method: EPA 3510C or EPA 3550B/3541A<br>Laboratory SOPs: TBD |
| **Analytical Organization** | TBD |

| QC Sample | Frequency & Number | Method/SOP QC Acceptance Limits | Corrective Action | Personnel Responsible for Corrective Action | DQI | Measurement Performance Criteria |
|---|---|---|---|---|---|---|
| CCV | Before sample analysis, after every 10 field samples, after every 12 hours of analysis time, and at the end of the analysis sequence. | All reported analytes and surrogates within established RT windows. All reported analytes and surrogates within ± 20% of true value. | Immediately analyze two additional consecutive CCVs. If both pass, samples may be reported without reanalysis. If either fails, take corrective action(s) and re-calibrate; then reanalyze all affected samples since the last acceptable CCV. | Analyst<br>Lab QA Officer<br>Project Chemist | Accuracy/Precision | Results may not be reported without a valid CCV. If reanalysis cannot be performed, data must be qualified and explained in the case narrative. |
| MB | Each time samples are extracted and one per matrix per analytical method for each batch of at most 20 samples. | No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common lab contaminants, no analytes detected >LOQ. | Correct problem. If required, re-prep and reanalyze MB and all samples processed with the contaminated blank. | Analyst<br>Lab QA Officer<br>Project Chemist | Sensitivity/Bias | No analytes detected >1/2 LOQ or >1/10 the amount measured in any sample or 1/10 the regulatory limit, whichever is higher. For common laboratory contaminants, no analytes detected >LOQ. |
| LCS | One per batch of at most 20 samples analyzed of similar matrix per analytical method. | Per DoD QSM Appendix C Limits, Method 8270D SIM and Lab SOP TBD. | Correct problem. If required, re-prep and reanalyze the LCS and all samples processed in the associated preparatory batch for the failed analytes. | Analyst<br>Lab QA Officer<br>Project Chemist | Accuracy | QC acceptance criteria at least as stringent as specified by DoD QSM 5.0 (DoD 2013). |
| Internal standards verification | Every field sample, standard, and QC sample. | Retention time ± 10 seconds from retention time of the midpoint standard in the ICAL; EICP area within -50% to +100% of ICAL midpoint standard. | Inspect mass spectrometer and GC for malfunctions. Reanalysis of samples analyzed while system was malfunctioning is mandatory. | Analyst<br>Lab QA Officer<br>Project Chemist | Accuracy/Precision/ Representativeness | Laboratory in-house method manual to be followed for acceptance criteria. |

| | |
|---|---|
| **Matrix** | **Potable Water, Groundwater, and Subsurface Soil** |
| **Analytical Group** | **PAHs** |
| **Analytical Method/SOP Reference** | Analytical Method: EPA Method 8270D SIM<br>Preparation Method: EPA 3510C or EPA 3550B/3541A<br>Laboratory SOPs: TBD |
| **Analytical Organization** | TBD |

| QC Sample | Frequency & Number | Method/SOP QC Acceptance Limits | Corrective Action | Personnel Responsible for Corrective Action | DQI | Measurement Performance Criteria |
|---|---|---|---|---|---|---|
| Surrogate spike | All field and QC samples. | Per DoD QSM Appendix C Limits, Method 8270D SIM and Lab SOP TBD. | For QC and field samples, correct problem then re-prep and reanalyze all failed samples for failed surrogates in the associated preparatory batch, if sufficient sample material is available. If obvious chromatographic interference with surrogate is present, reanalysis may not be necessary. | Analyst<br>Lab QA Officer<br>Project Chemist | Accuracy/Precision/ Representativeness | QC acceptance criteria at least as stringent as specified by DoD QSM 5.0 (DoD 2013). |
| MS/MSD pair | One per analytical method for each batch of at most 20 samples. | Per DoD QSM Appendix C Limits, Method 8270D SIM and Lab SOP TBD.<br>MSD or Matrix Duplicate: RPD of all analytes ≤20%. | Examine the PQOs. Notify Lab QA Officer and project chemist about additional measures to be taken. | Analyst<br>Lab QA Officer<br>Project Chemist | Accuracy/Precision | For matrix evaluation, use QC acceptance criteria at least as stringent as specified by DoD QSM 5.0 (DoD 2013). |

| | |
|---|---|
| **Matrix** | **Groundwater** |
| **Analytical Group** | **Methane** |
| **Analytical Method/SOP Reference** | Analytical Method: RSK 175<br>SOP Reference: TBD |

| QC Sample | Frequency & Number | Method/SOP QC Acceptance Limits | Corrective Action | Person(s) Responsible for Corrective Action | DQI | Measurement Performance Criteria |
|---|---|---|---|---|---|---|
| LOD determination and verification | At initial set-up and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each. | The apparent signal to noise ratio must be at least 3 and the results must meet all method requirements for analyte identification. | If the LOD verification fails, the laboratory must:<br>1) Repeat the detection limit determination and LOD verification at a higher concentration; or<br>2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration. | Analyst<br>Lab QA Officer<br>Project Chemist | Bias/ Representativeness | QC acceptance criteria as specified by Lab SOP TBD. |
| LOQ establishment and verification | At initial setup:<br>1) Verify LOQ; and<br>2) Determine precision and bias at the LOQ. Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each. | 1) The LOQ and associated precision and bias must meet client requirements and must be reported; or<br>2) In the absence of client requirements, must meet control limits of the LCS.<br>3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Volume 1, Module 4, Section 1.5.2 of the DoD QSM 5.0 (DoD 2013). | If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias. | Analyst<br>Lab QA Officer<br>Project Chemist | Sensitivity/Bias | QC acceptance criteria as specified by Lab SOP TBD, and at least as stringent as specified by DoD QSM 5.0 (DoD 2013). |
| MB | One per preparation/analytical batch | No target compounds ≥1/2 LOQ | Re-extract or re-analyze samples associated with the MB. | Analyst<br>Lab QA Officer | Accuracy/Bias | No target compounds ≥1/2 LOQ |
| LCS | One per preparation/analytical batch | 90–110 | Re-extract or re-analyze samples associated with the LCS. | Analyst<br>Lab QA Officer | Precision/Accuracy | 90–110 |
| Laboratory Duplicates | One per 20 samples | ±20 | Associated samples will be qualified, if appropriate, during validation. | Data Validator/Project Chemist | Precision | ±20 |

| | |
|---|---|
| **Matrix** | **Groundwater** |
| **Analytical Group** | **Ferrous Iron, Nitrate, Sulfate, and Chloride** |
| **Analytical Method/SOP Reference** | Analytical Method: SM3500-Fe B.4.c, SM4500-NO3 E, and EPA 300.0<br>SOP Reference: TBD |

| QC Sample | Frequency & Number | Method/SOP QC Acceptance Limits | Corrective Action | Person(s) Responsible for Corrective Action | DQI | Measurement Performance Criteria |
|---|---|---|---|---|---|---|
| LOD determination and verification | At initial set-up and verified quarterly. If a laboratory uses multiple instruments for a given method, the LOD must be verified on each. | The apparent signal to noise ratio must be at least 3 and the results must meet all method requirements for analyte identification. | If the LOD verification fails, the laboratory must:<br>1) Repeat the detection limit determination and LOD verification at a higher concentration; or<br>2) Perform and pass two consecutive LOD verifications at a higher concentration. The LOD is set at the higher concentration. | Analyst<br>Lab QA Officer<br>Project Chemist | Bias/ Representativeness | QC acceptance criteria as specified by Lab SOP TBD. |
| LOQ establishment and verification | At initial setup:<br>1) Verify LOQ; and<br>2) Determine precision and bias at the LOQ.<br>Subsequently, verify LOQ quarterly. If a laboratory uses multiple instruments for a given method, the LOQ must be verified on each. | 1) The LOQ and associated precision and bias must meet client requirements and must be reported; or<br>2) In the absence of client requirements, must meet control limits of the LCS.<br>3) If the method is modified, precision and bias at the new LOQ must be demonstrated and reported. See Volume 1, Module 4, Section 1.5.2 of the DoD QSM 5.0 (DoD 2013). | If the LOQ verification fails, the laboratory must either establish a higher LOQ or modify method to meet the client-required precision and bias. | Analyst<br>Lab QA Officer<br>Project Chemist | Sensitivity/Bias | QC acceptance criteria as specified by Lab SOP TBD, and at least as stringent as specified by DoD QSM 5.0 (DoD 2013). |
| MB | One per preparation/analytical batch | No target compounds ≥1/2 LOQ. | Re-extract or re-analyze samples associated with the MB. | Analyst<br>Lab QA Officer | Accuracy/Bias | No target compounds ≥1/2 LOQ. |
| LCS | One per preparation/analytical batch | Ferrous Iron: 80-20<br>Nitrate/Nitrite: 90-110<br>Sulfide: 75-125 | Re-extract or re-analyze samples associated with the LCS. | Analyst<br>Lab QA Officer | Precision/Accuracy | Ferrous Iron: 80-20<br>Nitrate/Nitrite: 90-110<br>Sulfide: 75-125 |
| MS | One per analytical method for each batch of at most 20 samples. | Per Methods and Lab SOPs TBD. | Examine the project-specific DQOs. Notify Lab QA Officer and Project Chemist as to additional measures to be taken. | Analyst<br>Lab QA Officer<br>Project Chemist | Accuracy/Precision | Per Methods and Lab SOPs TBD. |
| MSD | One per analytical method for each batch of at most 20 samples. | Per Methods and Labs SOP TBD. RPD ≤30%. | Examine the project-specific DQOs. Notify Lab QA Officer and Project Chemist as to additional measures to be taken. | Analyst<br>Lab QA Officer<br>Project Chemist | Accuracy/Precision | Per Method and Lab SOP TBD. |

| | |
|---|---|
| **Matrix** | **Groundwater** |
| **Analytical Group** | **Ferrous Iron, Nitrate, Sulfate, and Chloride** |
| **Analytical Method/SOP Reference** | Analytical Method: SM3500-Fe B.4.c, SM4500-NO3 E, and EPA 300.0<br>SOP Reference: TBD |

| QC Sample | Frequency & Number | Method/SOP QC Acceptance Limits | Corrective Action | Person(s) Responsible for Corrective Action | DQI | Measurement Performance Criteria |
|---|---|---|---|---|---|---|
| Laboratory Duplicates | One per 20 samples | ±20 | Associated samples will be qualified, if appropriate, during validation. | Data Validator/Project Chemist | Precision | ±20 |

| | |
|---|---|
| BFB | 4-bromofluorobenzene |
| DFTPP | decafluorotriphenylphosphine |
| DQO | data quality objective |
| EICP | extracted ion current profile |
| GC | gas chromatography |
| LCS | laboratory control sample |
| MB | method blank |
| PQO | project quality objective |

1 **Table 2-15: Project Documents and Records Table**

| Document [a] | Storage/Archive Location |
|---|---|
| **Sample Collection Documents and Records** | Storage: AECOM Technical Services, Inc.<br>1001 Bishop Street Suite 1600<br>Honolulu, HI 96813<br>Telephone: 808-523-8874<br><br>Archive: Naval Facilities Engineering Command, Pacific<br>258 Makalapa Drive, Suite 100<br>JBPHH HI 96860-3134<br>Telephone: 808-472-1008 |
| Field logbook (and sampling notes) | |
| Field sample forms (e.g., boring logs, sample log sheets, drilling logs) | |
| Chain of custody records | |
| Air Bills | |
| Photographs | |
| Field task modification forms | |
| Field sampling SOPs | |
| Laboratory documents and records | |
| Sample collection logs | |
| Health and safety sign in sheets | |
| Health and safety plan acknowledgement | |
| Surveyed locations | |
| Communication logs | |
| Documentation of deviation from methods | |
| Corrective action forms/documentation of the audits | |
| Documentation of internal QA review | |
| Identification of QC samples | |
| Sampling instrument calibration logs | |
| Sampling location and sampling plan | |
| Sampling report | |
| **Analytical Records** | |
| Chain of custody records | |
| Sample receipt forms and sample tracking forms | |
| Preparation and analysis forms and/or logbooks | |
| Tabulated data summary forms and raw data for field samples, standards, QC checks, and QC samples | |
| Case narrative | |
| Sample chronology (time of receipt, extraction, and analysis) | |
| Identification of QC samples | |
| Communication logs | |
| Corrective action reports | |
| Definitions of laboratory qualifiers | |
| Documentation of corrective action results | |
| Documentation of laboratory method deviations | |
| Electronic data deliverables | |

| Document [a] | Storage/Archive Location |
|---|---|
| Instrument calibration reports | Storage: AECOM Technical Services, Inc.<br>1001 Bishop Street Suite 1600<br>Honolulu, HI 96813<br>Telephone: 808-523-8874<br>Archive: Naval Facilities Engineering Command, Pacific<br>258 Makalapa Drive, Suite 100<br>JBPHH HI 96860-3134<br>Telephone: 808-472-1008 |
| Laboratory sample identification numbers | |
| Reporting forms, completed with actual results | |
| Signatures for laboratory sign-off (e.g., laboratory QA manager) | |
| Standards traceability records | |
| **Project Data Assessment Records** | |
| Field sampling audit checklists | |
| Analytical audit checklists | |
| Data review reports | |
| Telephone logs | |
| Corrective action reports | |
| Laboratory assessment | |
| Laboratory QA plan | |
| LOD study information | |
| DoD ELAP accreditation | |
| **Offsite Analysis Documents and Records** | |
| Chain of custody documents | |
| Laboratory Data Reports | |
| Third-Party Data Validation Reports | |

[a] All documents produced for the project will be kept in a secured facility for the life of the project. Upon closure of the project, laboratory documents will be archived in the administration record file at Naval Facilities Engineering Command, Pacific and AECOM Technical Services, Inc. will retain copies of the project documentation for 10 years.

**Table 2-16: Analytical Services Table**

| Matrix | Analytical Group | Sampling Locations/ ID Numbers | Analytical SOP | Data Package Turnaround Time | Laboratory/Organization [a] (name and address and telephone number) | Backup Laboratory/Organization (name and address and telephone number) |
|---|---|---|---|---|---|---|
| Subsurface Soil | VOC (BTEX),<br>TPH-g, TPH-d, TPH-o,<br>PAHs (1-methylnaphthalene, 2-methylnaphthalene, naphthalene) | RHMW08,<br>RHMW09 | TBD | 21 days after samples are received at laboratory | TBD | TBD |
| Potable Water | VOC (BTEX),<br>TPH-g, TPH-d, TPH-o,<br>PAHs (1-methylnaphthalene, 2-methylnaphthalene, naphthalene) | Source Water for Drilling | TBD | 7 days after samples are received at laboratory | TBD | TBD |
| Groundwater | VOC (BTEX),<br>TPH-g, TPH-d, TPH-o,<br>PAHs (1-methylnaphthalene, 2-methylnaphthalene, naphthalene),<br>Lead scavengers, and<br>NAPs (ferrous iron, methane, nitrate, sulfate, chloride) | RHMW01,<br>RHMW02,<br>RHMW03,<br>RHMW04,<br>RHMW05,<br>RHMW06,<br>RHMW07,<br>RHMW08,<br>RHMW09,<br>RHMW10,<br>RHMW11,<br>RHMW2254-01,<br>OWDFMW01,<br>HDMW2253-03 | TBD | 21 days after samples are received at laboratory | TBD | TBD |

[a] Laboratory meets accreditation requirements to support project needs.

1 **Table 2-17: Planned Project Assessments Table**

| Assessment Type | Frequency | Internal or External | Organization Performing Assessment | Person(s) Responsible for Performing Assessment | Person(s) Responsible for Responding to Assessment Findings | Person(s) Responsible for Identifying and Implementing Corrective Action | Person(s) Responsible for Monitoring Effectiveness of Corrective Action |
|---|---|---|---|---|---|---|---|
| Review of field procedures | Daily | Internal | AECOM | Field Manager | Field Team Members | Field Manager | CTO Project Manager |
| Review of field notes/logbook | Weekly | Internal | AECOM | Field Manager/Field QC Coordinator | Field Team Members | Field Manager | CTO Project Manager |
| Review of field instrument calibration sheets | Daily | Internal | AECOM | Field Manager | Field Team Members | Field Manager | CTO Project Manager |
| Review of COC forms | Daily | Internal | AECOM | Project Chemist | Field QC Coordinator | Field Manager/Field QC Coordinator | CTO Project Manager |
| Field audit | Once | Internal | AECOM | QA Manager | CTO Project Manager/ Field Manager | Field Manager | CTO Project Manager/Field Manager |
| Laboratory data assessment | Once per SDG | External/ Internal | TBD/AECOM | Third-Party Data Validator/Project Chemist | Laboratory Project Manager | Laboratory Project Manager | Third-Party Data Validator/Project Chemist |

2 SDG sample delivery group

**Table 2-18: Assessment Findings and Corrective Action Responses**

| Assessment Type | Nature of Deficiencies Documentation | Individual(s) Notified of Findings | Timeframe of Notification | Nature of Corrective Action Response Documentation | Individual(s) Receiving Corrective Action Response [a] | Timeframe for Response |
|---|---|---|---|---|---|---|
| Review of field procedures | Verbal communication/logbook record | CTO Project Manager | Immediate | Logbook entry | CTO Project Manager | 24 hours after notification |
| Review of field notes/logbook | Logbook record | CTO Project Manager | Immediate | Logbook entry | CTO Project Manager | 24 hours after notification |
| Review of field instrument calibration sheets | Logbook record | CTO Project Manager | Immediate | Logbook entry | CTO Project Manager | 24 hours after notification |
| Review of COC forms | Logbook record | Field Manager | Immediate | E-mail | QC Coordinator/<br>Field Manager, AECOM | 24 hours after notification |
| Field audit | Written audit report | CTO Project Manager/ Field Manager | 72 hours after audit | Letter | QA Manager | 24 hours after notification |
| Laboratory data assessment | Verbal communication or e-mail | CTO Project Manager/Laboratory Project Manager | 24 hours after notification | Letter or e-mail | Third-Party Data Validator/Project Chemist | 24 hours after notification |

[a] Copies of all assessment findings and corrective action responses will be provided to the NAVFAC Hawaii CTO Contracting Officer’s Representative (COR).

**Table 2-19: Quality Assurance Management Reports Table**

| Type of Report | Frequency | Projected Delivery Date(s) | Person(s) Responsible for Report Preparation | Report Recipient(s) |
|---|---|---|---|---|
| Third-Party Data Validation Report | Once, after submission of each sampling delivery group from the analytical laboratory | 21 days after receipt of laboratory SDG data package | Data Validator, TBD | CTO Project Manager (AECOM) and Navy CTO COR (NAVFAC Pacific/Hawaii) |
| Third-Party DQA Report | Once, after all data are generated | 21 days after receipt of final laboratory data package | Data Validator, TBD | CTO Project Manager (AECOM) and Navy CTO COR (NAVFAC Pacific/Hawaii) |
| Field Audit Report | Once, during the initial 3 weeks of the field work | 21 days after audit (if performed) | QA Manager, AECOM | CTO Project Manager (AECOM), CTO Field Manager (AECOM), and QA Manager (NAVFAC Pacific/Hawaii) |

| | |
|---|---|
| DQA | data quality assessment |

1 **Table 2-20: Data Verification and Validation (Steps I and IIa/IIb) Process Table**

| Data Review Input | Description | Responsible for Verification (name, organization) | Step I/IIa/IIb [a] | Internal/External |
|---|---|---|---|---|
| Laboratory system audits | Determine whether the laboratory holds a current DoD ELAP certification for all analyses to be performed for the project. | Project Chemist (AECOM) | Step I | Internal |
| Field procedures | Determine whether field procedures are performed in accordance with this WP/SOW and prescribed procedures. | QA Program Manager (AECOM) | Step I | Internal |
| Field logbook and notes | Review the field logbook and any field notes on a weekly basis and place them in the project file.<br>Copies of the field logbook and field notes will be provided to the CTO manager and included in the Field Audit Report. | Field Manager (AECOM) | Step I | Internal |
| Instrument calibration sheets | Determine whether instruments are calibrated and used in accordance with manufacturer’s’ requirements. | Project Chemist (AECOM) &<br>Data Validator (TBD) | Step I | Internal & External |
| COC forms | Review COC completed forms and verify them against the corresponding packed sample coolers.<br>A copy of each COC will be placed in the project file. The original COC will be taped inside the cooler for shipment to the analytical laboratory. | Project Chemist (AECOM) | Step I | Internal |
| Sampling analytical data package | Verify all analytical data packages for completeness prior to submittal of the data to the data validator. | Laboratory Project Manager (TBD) | Step I | External |
| Analytes | Determine whether all analytes specified in Table 2-2 and Table 2-3 were analyzed and reported on by the laboratory. | Project Chemist (AECOM) | Step IIa | Internal |
| COC and field QC logbook | Examine data traceability from sample collection to project data generation. | Project Chemist (AECOM) | Step IIa | Internal |
| Laboratory data and WP/SOW requirements | Assess and document the performance of the analytical process.<br>A summary of all QC samples and results will be verified for measurement performance criteria and completeness. Full Validation will be performed on 10% of the data and Standard Validation will be performed on 90% of the data. A report will be prepared within 21 days of receipt. | Data Validator (TBD) &<br>Project Chemist (AECOM) | Steps IIa & IIb | Internal & External |
| VOCs | Complete Procedure II-B, *Standard and Full Data Validation Procedure for GC/MS Volatile Organics by SW-846 8260B* (DON 2015). | Data Validator (TBD) | Step IIa | External |

| Data Review Input | Description | Responsible for Verification (name, organization) | Step I/IIa/IIb [a] | Internal/External |
|---|---|---|---|---|
| PAHs | Complete Procedure II-C, *Standard and Full data Validation Procedure for GC/MS Semivolatile Organics by SW-846 8270C* (Full Scan and SIM) (DON 2015). | Data Validator (TBD) | Step IIa | External |
| TPH | Complete Procedure II-H, *Standard and Full Data Validation Procedure for Extractable Total Petroleum Hydrocarbons by SW-846 8015B* (DON 2015). | Data Validator (TBD) | Step IIa | External |
| Wet Chemistry | Complete Procedure II-R, *Standard and Full Data Validation Procedure for Wet Chemistry Analyses* (DON 2015). | Data Validator (TBD) | Step IIa | External |
| Sampling plan | Determine whether the number and type of soil and groundwater samples specified in Section 5 of the WP/SOW were collected and analyzed. | Project Chemist (AECOM) & Field Manager (AECOM) | Step IIb | Internal |
| Field QC samples | Establish that the number of QC samples specified in Table 2-6 were collected and analyzed. | Project Chemist (AECOM) | Step IIb | Internal |
| Project quantitation limits and data qualifiers | Establish that sample results met the project quantitation limits and qualify the data in accordance with Procedure II-A, *Data Validation Procedure* (DON 2015). | Data Validator (TBD) & Project Chemist (AECOM) | Step IIb | Internal & External |
| Validation report | Summarize outcome of data comparison to MPC in the WP/SOW. Include qualified data and an explanation of all data qualifiers. | Data Validator (TBD) | Step IIa | External |

MPC measurement performance criteria

[a] IIa Compliance with methods, procedures, and contracts. See Table 10, page 117, UFP-QAPP manual, V.1 (DoD 2005).

IIb Comparison with measurement performance criteria in the WP/SOW. See Table 11, page 118, UFP-QAPP manual, V.1 (DoD 2005).

## 2.9 USABILITY ASSESSMENT

### 2.9.1 Summary of the Data Usability Assessment Process

A systematic data quality assessment (DQA) process involving data verification steps and third-party data validation, as specified in Table 2-19 will be implemented to assess the usability of environmental sample data generated for this investigation. The evaluation will consider any deviations from proposed field activities or sampling and handling procedures. The analytical results of the groundwater sampling will be compared to the project quality objectives (PQOs) to determine whether the measurement performance criteria (MPC) were met. Upon completion of the verification and validation processes the data quality indicators will be evaluated for each analytical group in terms of meeting MPC goals as expressed by the precision, accuracy, representativeness, comparability, and completeness (PARCC) criteria. Variances in QC parameters will be assessed in relation to the potential impacts upon the usability of the affected data and interpretation of field sampling results. The investigation report will include discussions of any limitations on the use of project data from this assessment as well as potential impacts on the project decision statement process.

### 2.9.2 Field Activity and Data Verification Summary

The AECOM field manager will be responsible for periodic internal reviews to verify that field sampling procedures, instrument calibrations, and other relevant activities are performed in accordance with the WP/SOW. A bound field logbook will be used to document deviations in the proposed field activities, changes in sampling locations, sample types, and other relevant issues.

The data verification process will include onsite data review against the WP/SOW requirements for completeness and accuracy. In addition, the review process will verify that SOPs for field sampling and analysis were followed.

The COC records and field QC logbook will be examined for traceability of data from sample collection to the planned and requested analyses for environmental field and field QC samples.

Upon receipt from the designated analytical laboratory, electronic data will be assessed for proper reporting format with respect to data fields and content.

### 2.9.3 Data Validation and Data Quality Assessment Process

All subsurface and groundwater analytical laboratory data results will be validated by a third-party data validation firm to assess method compliance, calibration frequency and acceptability, QC frequency and acceptability, and data usability. Potable water analytical data results will not be validated prior to use of the potable water as drilling fluid during monitoring well installation activities. Approximately 10 percent of the subsurface soil and groundwater analytical data will be validated according to NAVFAC Pacific Full Data Validation procedures (Level D) and 90 percent of the analytical data will be validated according to NAVFAC Pacific Standard Data Validation procedures (Level C). The analytical data will be evaluated for QA and QC based on the *Project Procedures Manual* (DON 2015) and DoD QSM 5.0 (DoD 2013).

Sample data not meeting the NAVFAC Pacific procedures and DoD QSM (DoD 2013) acceptance criteria will be qualified with an abbreviation, or flag, to indicate a deficiency with the data. These qualifier flags include: "J" as estimated; "U" as non-detected; "UJ" as estimated/non-detected; and "R" as rejected. Qualification codes will also be applied to the data to explain why the various data qualifiers (flags) were applied. The complete definitions of data qualifier flags and qualification codes are presented in Procedure II-A, *Data Validation Procedure* (DON 2015).

Once the data are reviewed and qualified according to the NAVFAC Pacific procedures and DoD QSM (DoD 2013), a DQA process will summarize the QA/QC evaluation of the data according to the PARCC criteria relative to the MPCs or PQOs in accordance with Procedure II-S, *Data Quality Assessment Report Procedure* (DON 2015). Precision is a measure of the agreement between or reproducibility of analytical results under a given set of conditions. Accuracy in the analytical sense is defined by the agreement between a determined concentration and the true value of the parameter and is used to identify bias in a given measurement system. Representativeness is a qualitative expression of the degree to which the sample data are characteristic of a population. Comparability is a qualitative measure of the equivalence between analytical data sets that is influenced by factors such as sample collection and handling techniques, matrix type, and analytical method. Completeness is defined as the percentage of acceptable sample results compared to the total number of sample results. The goal for completeness for target analytes in each analytical fraction is 90 percent.

A quantitative and qualitative assessment of the data will identify potential sources of error, uncertainty, and bias that may affect the overall usability. The PARCC criteria are then evaluated for each analytical fraction in relation to specific QC deviations and their effects on both individual data points and the analyses as a whole.

### 2.9.4 Interpreting Exceedances of PALs

Reported data that exceed the PALs are evaluated and discussed in the data usability assessment and in the risk assessment. Generally:

1. For U-flagged results (non-detect):
    a. Non-detects below the PALs will be considered “Definitive Data,” and can be interpreted to indicate that the analyte does not present any risk.
    b. Non-detects above the PALs do not allow the drawing of any conclusions. The analyte may or may not be present, and may or may not exceed the PALs. Other lines of evidence (e.g., historical data, analytical results of the whole site, field observations) may be necessary to determine any conclusions for that sample location, and are typically discussed in the sensitivity sections of the data usability assessment and in the uncertainty section of the risk assessment.
2. For detected results with a J-flag (present but not quantitative):
    a. If a J-flagged result (detected result < LOQ) marginally exceeds the PALs, the analyte is probably present, but it cannot be said with certainty whether or not the reported numerical result reflects the actual concentration. Therefore, the actual concentration may or may not exceed the PALs. It is very likely, however, that the actual concentration lies between the DL and the LOQ; therefore, these numbers can be compared to the PALs.

       DOH EALs are set conservatively, much lower than the EPA’s MCLs. While the groundwater data will be compared to the EALs, the EPA MCLs are the enforceable limits for drinking water.

   b. Despite the uncertainty in the precise numerical value of J-flagged data, the J flag does not mean the results are significantly inaccurate, and these values are routinely used in risk assessment calculations and in comparisons to PALs.

   c. If J-flagged results produce an unacceptable level of uncertainty for a site-specific risk assessment, it may be necessary to re-analyze the sample using a different or modified analytical method to provide the required level of data quality.

3. Non-flagged numerical results are considered "Definitive Data" and may be directly compared to PALs and used in risk assessment calculations.

## 3. References

Department of Defense, United States (DoD). 2005. *Uniform Federal Policy for Quality Assurance Project Plans, Part 1: UFP-QAPP Manual*. Final Version 1. DoD: DTIC ADA 427785, EPA-505-B-04-900A. In conjunction with the U.S. Environmental Protection Agency and the Department of Energy. Washington: Intergovernmental Data Quality Task Force. March.

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# Attachment G.1:
# Analytical Data Package Requirements

## GC/FID Stage 4 Deliverables

| Item no. | Deliverable |
|---|---|
| 1 | Chain of Custody |
| 2 | Sample results with analysis and extraction/preparation dates |
| 3 | Summary of MS/MSD/Duplicate recoveries and control limits (listing or link with associated samples) |
| 4 | Summary of LCS/LCSD recoveries and control limits (listing or link with associated samples) |
| 5 | Method blanks (listing or link with associated samples) |
| 6 | Summary of surrogate recoveries |
| 7 | Summary of initial calibration data (RF and %RSD, or r if applicable) |
| 8 | Summary of continuing calibration (%D) |
| 9 | Injection logs |
| 10 | Extraction/preparation logs |
| 11 | Case narrative to discuss anomalies |
| 12 | Raw data associated with the summary forms listed above |
| 13 | Raw data for item #2 which includes chromatograms, log books, quantitation reports, and spectra. |

Note: The data deliverable package must have a table of contents and be paginated.

| | |
|---|---|
| %D | percent difference |
| %RSD | percent relative standard deviation |
| MS | matrix spike |
| MSD | matrix spike duplicate |
| LCS | laboratory control sample |
| LCSD | laboratory control sample duplicate |
| RF | response factor |

## GC/MS Stage 4 Deliverables

| Item no. | Deliverable |
|---|---|
| 1 | Chain of Custody |
| 2 | Sample results with analysis and extraction/preparation dates |
| 3 | Summary of MS/MSD/Duplicate recoveries and control limits (listing or link with associated samples) |
| 4 | Summary of LCS/LCSD recoveries and control limits (listing or link with associated samples) |
| 5 | Method blanks (listing or link with associated samples) |
| 6 | Summary of instrument blanks - metals only (listing or link with associated samples) |
| 7 | Summary of surrogate recoveries |
| 8 | Summary of initial calibration data (RRF and %RSD, or r if applicable) |
| 9 | Summary of continuing calibration (%D and RRF) |
| 10 | Summary of internal standards (area response and retention time) |
| 11 | Summary of instrument tuning (listing or link with associated samples, must show 12-hour clock) |
| 12 | Injection logs |
| 13 | Extraction/preparation logs |
| 14 | Case narrative to discuss anomalies |
| 15 | Raw data associated with the summary forms listed above |
| 16 | Raw data for item #2 which includes chromatograms, log books, quantitation reports, and spectra. |

Note: The data deliverable package must have a table of contents and be paginated.

| | |
|---|---|
| RRF | relative response factor |

**General Chemistry Stage 4 Deliverables**

| Item no. | Deliverable |
|---|---|
| 1 | Chain of custody |
| 2 | Sample results with analysis and extraction/preparation dates |
| 3 | Summary of MS/MSD/Duplicate recoveries and control limits (listing or link with associated samples) |
| 4 | Summary of LCS/LCSD recoveries and control limits (listing or link with associated samples) |
| 5 | Method blanks (listing or link with associated samples) |
| 6 | Summary of initial calibration data (correlation coefficient, r) |
| 7 | Summary of continuing calibration (%D or % recovery), if applicable |
| 8 | Injection logs |
| 9 | Extraction/preparation logs, if applicable |
| 10 | Case narrative to discuss anomalies |
| 11 | Raw data associated with the summary forms listed above |
| 12 | Raw data for item #2, which includes log books, quantitation reports, and spectra. |

Note: The data deliverable package must contain a table of contents and be paginated.

## HARD COPY DATA DELIVERABLES COMPACT DISK REQUIREMENTS

The compact disk (CD) shall contain exactly the same information as the hard copy data deliverables (HDD) including amended and additional pages requested during data review and validation. Upon completion of data review and validation by AECOM Technical Services, Inc. or third-party, the laboratory shall be required to provide the CD with the following:

- The images shall be clear and legible.
- The images shall be right side up.
- The images shall be straight.
- The images shall be in the same order as the HDD.
- Images may be submitted in pdf, tif, or other equivalent imaging format. Files shall be burned for each page and each CD shall be indexed. The laboratory shall log in samples based on project number, project name and sample delivery group (also known as batch or work order).
- If the images are not clear, legible, right side up, straight or in order, then the laboratory shall resubmit the CD.
- The CD label shall contain the following information:
  - Navy contract number
  - Contract task order name and number
  - Sample delivery group number
  - Matrices and methods
  - Date of submittal

# Appendix H:
# Work Plan / Scope of Work, Groundwater Flow and Contaminant Fate and Transport Modeling

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## CONTENTS

**FIGURES**

## TABLES

# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| µg/L | microgram per liter |
| AOC | Administrative Order on Consent |
| AVGAS | aviation gasoline |
| BTEX | benzene, toluene, ethylbenzene, and xylenes |
| BWS | Board of Water Supply, City and County of Honolulu |
| CF&T | contaminant fate and transport |
| COPC | chemical of potential concern |
| CSM | conceptual site model |
| DOH | Department of Health, State of Hawaiʻi |
| DON | Department of the Navy, United States |
| EAL | Environmental Action Level |
| EPA | Environmental Protection Agency, United States |
| EPM | equivalent porous medium |
| F-76 | Marine Diesel Fuel |
| ft | foot or feet |
| ft/d | foot/feet per day |
| ft/ft | foot per foot |
| GMS | Groundwater Modeling System |
| JBPHH | Joint Base Pearl Harbor-Hickam |
| JP | Jet Fuel Propellant |
| LNAPL | light non-aqueous-phase liquid |
| m | meter |
| MAE | mean absolute error |
| MCL | Maximum Contaminant Level |
| ME | mean error |
| MG | million gallons |
| mg/L | milligram per liter |
| mgd | million gallons per day |
| MOGAS | motor gasoline |
| msl | mean sea level |
| MtBE | methyl tertiary-butyl ether |
| NAP | natural attenuation parameter |
| Navy | Department of the Navy, United States |
| No. | number |
| NSFO | Navy Special Fuel Oil |
| PEST | Parameter Estimation |
| RHSF | Red Hill Bulk Fuel Storage Facility |
| RMSE | root mean squared error |
| RT3D | Reactive Multispecies Transport in 3-Dimensions |
| SOW | scope of work |
| SWAP | Source Water Assessment Program |
| TPH | total petroleum hydrocarbons |
| TPH-d | total petroleum hydrocarbons – diesel range organics |
| TPH-g | total petroleum hydrocarbons – gasoline range organics |
| TPH-o | total petroleum hydrocarbons – residual range organics (i.e., TPH-oil) |
| U.S. | United States |

| | |
|---|---|
| USGS | United States Geological Survey |
| UST | underground storage tank |
| VOC | volatile organic compound |
| WP | work plan |

# 1. Background

This Groundwater Flow and Contaminant Fate and Transport (CF&T) Work Plan and Scope of Work (the "Modeling WP/SOW") describes the groundwater flow and CF&T modeling activities planned as part the investigation to be conducted at the Red Hill Bulk Fuel Storage Facility (RHSF), which is operated by the Navy Supply Systems Command Fleet Logistics Center, Joint Base Pearl Harbor-Hickam (JBPHH), O'ahu, Hawai'i. This Modeling WP is included as Appendix H of the *Work Plan / Scope of Work, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, Red Hill Bulk Fuel Storage Facility* (the "Investigation WP/SOW"). The investigation will be performed by the United States (U.S.) Department of the Navy (DON; "Navy") and Defense Logistics Agency to address the objectives and requirements of the Administrative Order on Consent (AOC) issued by the U.S. Environmental Protection Agency and the State of Hawai'i Department of Health (EPA and DOH 2015).

As described in the AOC Statement of Work Section 7, the overall objective of this investigation is protection of the groundwater resource, specifically the complex basalt aquifers that supply water systems in the site vicinity. An important component of the investigation is the groundwater flow and CF&T modeling described in this Modeling WP/SOW. Findings from the groundwater flow and CF&T modeling will be used to prepare the AOC Statement of Work Section 7.1.3 Groundwater Flow Model Report and Section 7.2.3 Contaminant Fate and Transport Model Report.

RHSF includes twenty 12.5-million-gallon (MG) underground storage tanks (USTs) located within the Red Hill Ridge, Hālawa Valley, O'ahu, Hawai'i (Figure H-1). Two of the twenty USTs are out of use. RHSF also includes a series of tunnels and pipelines that deliver fuel to and from JBPHH. RHSF was constructed from 1940 to 1943 to support naval activities in the Pacific. According to records, the main fuel types historically stored at RHSF have been diesel oil, Navy Special Fuel Oil (NSFO), Navy Distillate, Jet Fuel Propellant (JP)-5 and JP-8, and Marine Diesel Fuel (F-76). In addition, Tank 17 contained aviation gasoline (AVGAS) and motor gasoline (MOGAS) between 1964 and 1969; and Tank 18 contained AVGAS between 1964 and 1968. Since the early 2000s, however, RHSF has stored only JP5, JP-8, and F-76 fuels.

RHSF was constructed in the field, entirely underground within the Red Hill Ridge, and was activated in 1943. The tank storage system consists of two parallel rows of vertical tanks sloping southwest toward Pearl Harbor. The tanks are installed in native basalt, each measuring 245 feet (ft) in height and 100 ft in diameter. The tanks are located approximately 100–120 ft above mean sea level (msl), and the ground surface elevation ranges from approximately 420 ft msl above Tank 1 to 560 ft msl above Tank 20. The tanks are accessed by interconnected tunnels. The pipelines extend approximately 2.5 miles from the tanks to Pearl Harbor.

The bottoms of the USTs are located approximately 100 ft above the groundwater table near the boundary of the Waimalu and Moanalua Aquifer Systems of the Pearl Harbor and Honolulu Aquifer Sector, respectively. These aquifer systems supply potable water to the City and County of Honolulu Board of Water Supply (BWS) and JBPHH. Navy Supply Well 2254-01 pumps approximately 4.6 million gallons per day (mgd) of water from a water tunnel (infiltration gallery) that extends approximately 1,270 ft across the water table, southwest of RHSF (Figure H-2). The BWS Hālawa Shaft well 2354-01 is located approximately 4,400 ft northwest of RHSF; on average, 11.8 mgd of potable water is withdrawn from this location, approximately 12 percent of the total supply that serves more than 600,000 people on O'ahu. The BWS Moanalua Supply Wells (2153-10, 2153-11, 2153-12) are located approximately 6,650 ft south of RHSF and deliver potable water to the BWS (DON 2014).

At the same time that RHSF was constructed, the Navy Supply Well 2254-01 was installed approximately 2,700 ft downgradient from the USTs, within an infiltration gallery that extends 1,270 ft across the water table to within 1,550 ft of the USTs. Navy Supply Well 2254-01 currently provides approximately 24 percent of the potable water to the JBPHH, which serves approximately 52,200 military consumers. Approximately 2.4–4.4 mgd, depending on season, are withdrawn from Navy Supply Well 2254-01 (DON 2014). Previous model simulations did not indicate contaminants entering the infiltration gallery at measurable concentrations under anticipated pumping scenarios (DON 2007).

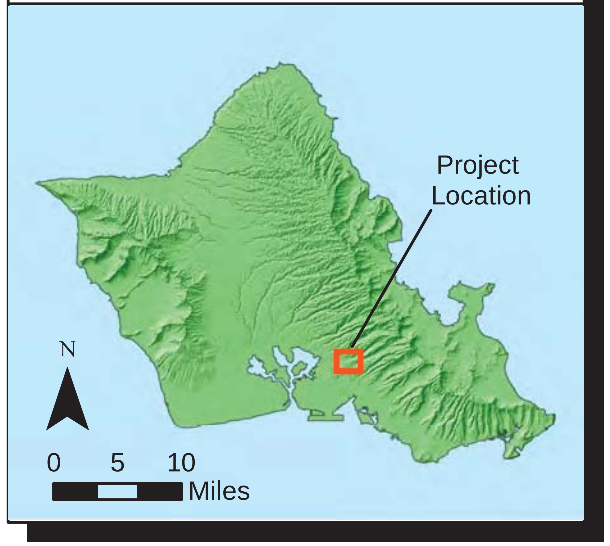
A release of an estimated 27,000 gallons of JP-8 from Tank 5 occurred in December 2014, prompting the AOC and this investigation.

## 2. Objectives of the Planned Groundwater Modeling

The activities described in this Modeling WP/SOW are intended to satisfy the AOC Section 7 objectives and provide a decision tool that can be used into the future. After installing and sampling new wells to further characterize the hydrogeology and nature and extent of impacted groundwater, the numerical models will be used to support a health risk assessment and evaluate remedial alternatives. The specific modeling activities and objectives are as follows:

- Refine the existing groundwater flow model and improve the understanding of the direction and rate of groundwater flow within the aquifers surrounding RHSF. Update the existing groundwater flow model using the same software platform. Calibrate the model to match new groundwater data obtained since the previous modeling efforts, including transient calibration to match available pumping rate and drawdown data. Perform predictive modeling runs to simulate the effects of future water supply well pumping, including hypothetical increased usage scenarios. Conduct a sensitivity analysis of matrix and groundwater parameter values to evaluate uncertainties, including those potentially associated with hydrogeologic barriers that may be presented by valley fill alluvium and underlying saprolite, the caprock formation, and other volcanics (e.g., the Honolulu Volcanic Series).
- Use the refined groundwater flow model to improve the understanding of the potential fate and transport of contaminants from RHSF. Update the existing CF&T model. Apply a particle tracking model to delineate well capture zones, and estimate groundwater velocity. Predict migration rates and degradation rates of dissolved hydrocarbon compounds. Evaluate how close a hypothetical light non-aqueous-phase liquid (LNAPL) plume can get to the Red Hill Shaft, should one reach the groundwater table, without exceeding the Maximum Contaminant Levels (MCLs) or Environmental Action Levels (EALs). Provide input to update the health risk assessment and the AOC Statement of Work Section 8 Risk and Vulnerability Assessment.
- Apply the calibrated site-specific numerical groundwater flow model to simulate the effects of feasible remedial alternatives on groundwater flow, if warranted, and drawdown capture zones.

## Location Map



## Legend

- ● Existing Monitoring Well Location
- ● Existing Water Supply Sampling Point
- ❶ Red Hill UST
- — Stream
- —400— Topographic Contour (feet above mean sea level)
- ▭ Red Hill Installation Boundary

## Notes

1. Map projection: NAD 1983 UTM Zone 4N
2. Base Map: http://hawaii.wr.usgs.gov/oahu/earthdata.html (USGS 1-foot orthoimagery)
3. Acronyms and Abbreviations:
   UST Underground Storage Tank

**Figure H-1**
**Site Location Map**
**WP/SOW**
**Groundwater Flow and Contaminant Fate and Transport Modeling**
**Red Hill Bulk Fuel Storage Facility**
**JBPHH, O‘ahu, Hawai‘i**

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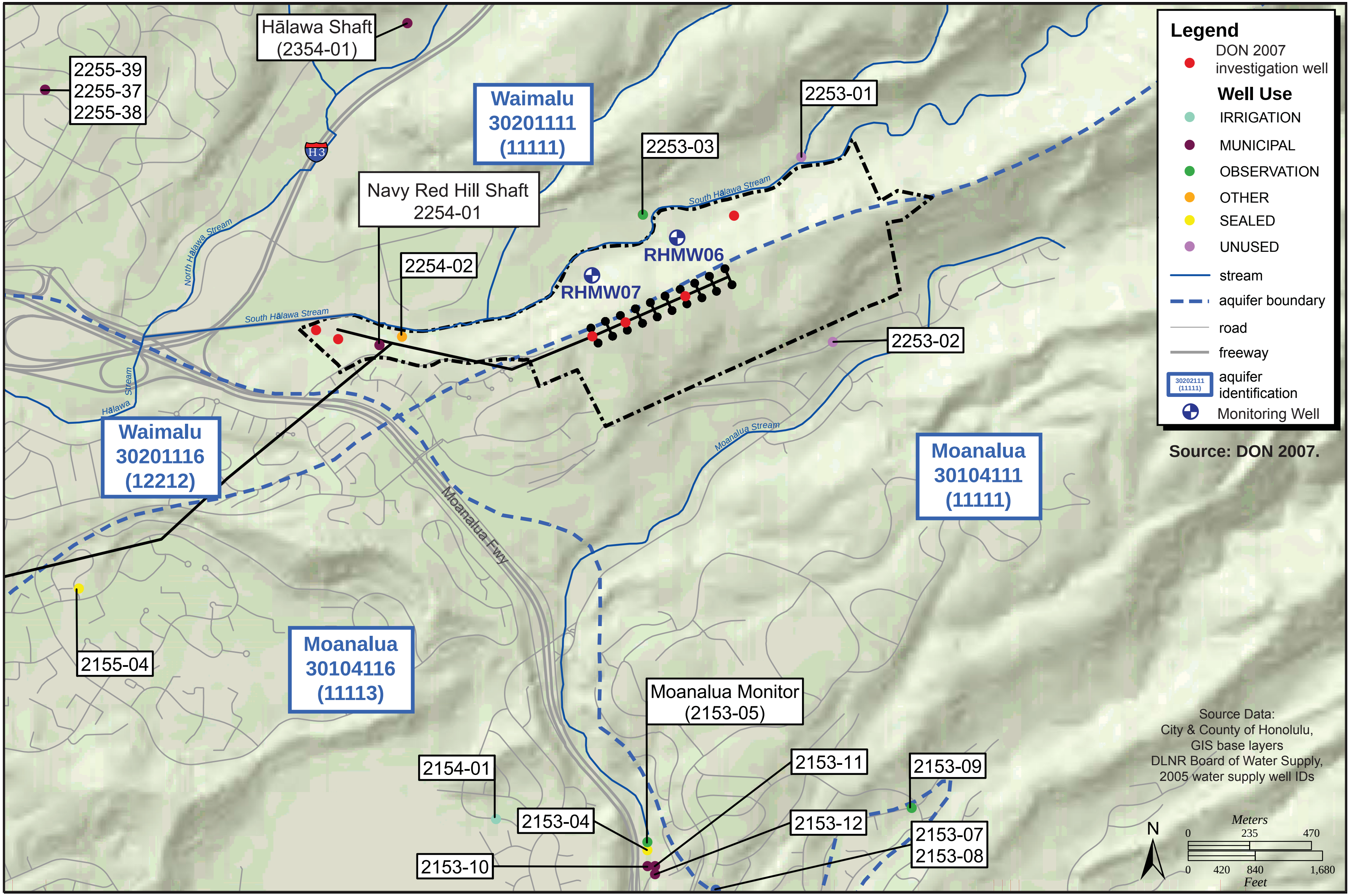

Figure H-2
Area Wells and Aquifer Systems
WP/SOW
Groundwater Flow and Contaminant Fate and Transport Modeling
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, Hawai‘i

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# 3. Previous Groundwater Studies

RHSF lies along a topographic ridge (Red Hill Ridge) between the Hālawa and Moanalua Valleys. This ridge, a remnant of the original Koʻolau shield volcano flank, is composed primarily of basaltic lava flows.

## 3.1 CONCEPTUAL SITE MODEL

The principal aquifer beneath RHSF area consists of highly permeable zones in the basaltic lava of the Koʻolau Formation, which is hydrologically interconnected to various degrees across the site. The Koʻolau Formation consists almost entirely of basaltic lava flows, including both pāhoehoe and aʻā lava. The basalt formation also contains unfractured basalt flows and dikes that have extremely low permeability, which form barriers to groundwater flow. The aʻā lava flows may also act as localized confining layers in the basal aquifer system with unconfined conditions present just a few ft away. In addition, dikes may be present, impeding flow in some areas, and compartmentalizing local regions of groundwater. Rock core logs and photos indicate that interbedded flows of different types of lava likely flowed from different directions at different times, and may have been weathered between flow events, potentially forming weathered soil horizons. These processes can result in the presence of sizable voids and relatively impermeable regions or zones in unpredictable locations, causing heterogeneous and anisotropic groundwater flow.

The valleys on either side of the ridge are a result of fluvial erosion of lava flows and are filled with alluvium and colluvium, which are typically underlain by saprolite (clayey, highly weathered basalt) and basaltic lava. Valley fill sediments are generally fine grained and are of relatively low hydraulic conductivity compared to the basalt aquifer. Where deep cut valleys extend well below the water table, they act as barriers to groundwater flow and contaminant transport. Where exposed to weathering, especially beneath the valley fill and streams, fine-grained saprolite zones also create barriers to groundwater flow and contaminant transport.

Red Hill Ridge is not thought to be a true hydrogeologic boundary, because there are no geochemical or physical attributes that separate the two aquifers at this location (DON 2007). Rather, the likely physical boundary between the Moanalua and Waimalu Aquifer systems is the North Hālawa Valley fill located the northwest of RHSF, which extends below the water table in the vicinity of RHSF and consists of low-permeability sediments underlain by saprolite (DON 2007).

RHSF is located upgradient of the Hawaiʻi State Underground Injection Control Line, which indicates the border between groundwater that is, and is not, considered a potential source of drinking water. The nearest municipal drinking water well (Hālawa Shaft, well 2354-01) is located hydrologically cross-gradient of RHSF (DON 2007). This drinking water well is approximately 5,000 ft to the northwest of RHSF and pumps water from the basal aquifer.

Navy Supply Well 2254-01 is located near RHSF. This well consists of a pumping station, located in the lower access tunnel, approximately 2,400 ft west of the USTs; and an infiltration gallery that extends from the pump station approximately 1,280 ft along the water table, toward the USTs. The infiltration gallery is located hydraulically downgradient from the USTs and intercepts most of the water that would be affected by releases from RHSF (DON 2007). This well operates at variable flow rates, extracting between 4 and 18 mgd of groundwater from the basal aquifer.

The previously developed conceptual site model (CSM) is illustrated on Figure H-3 (DON 2007). Although the existing CSM will be updated as part of the current investigation, the basic features remain relevant. As suggested by the CSM, the migration pathways of potential concern were identified at the outset of the previous investigation to be:

- Migration of soil vapor from LNAPL in unsaturated zone and basal groundwater through fractured bedrock to indoor air.
- Migration of basal groundwater to a stream or ground surface via seeps.
- Migration of leachate through contaminated unsaturated bedrock to the basal aquifer.
- Migration of LNAPL through unsaturated zone to basal aquifer, dissolution into basal groundwater from LNAPL plume on water table.
- Migration of petroleum dissolved in groundwater to nearby potable water wells.

The previous investigations ultimately concluded that the migration of petroleum dissolved in groundwater to nearby potable water wells was the only pathway considered to be potentially complete and capable of exposing potential sensitive receptors, namely consumers of drinking water.

## 3.2 GROUNDWATER MONITORING, WATER LEVELS, AND HYDRAULIC GRADIENTS

The groundwater elevations measured in monitoring wells completed directly beneath the tanks have generally ranged from approximately 17.0 to 21.9 ft msl. The ground surface at the USTs is approximately 420–560 ft msl, thus the water table lies approximately 400–540 ft below ground surface, and approximately 100 ft below the bottoms of the USTs. As illustrated on Figure H-3, the bottoms of the tanks and the groundwater beneath the USTs are deeper than the adjacent valley floors and streams (DON 2007), indicating that transport of groundwater or LNAPL to the valley streams will not occur.

Three existing wells (RHMW01, RHMW02, and RHMW03) were installed into the basal aquifer within the lower access tunnel in the vicinity of the USTs (Figure H-1). Although measurable levels of NAPL have never been detected in any of the vicinity wells, dissolved petroleum compounds have been detected in samples collected from each well, with the highest concentrations measured at RHMW02, which is located adjacent to Tanks 5 and 6. No dissolved petroleum constituent concentrations, however, have been detected at concentrations approaching the solubility limit of JP-5 (previously reported to be approximately 5 milligrams per liter [mg/L]), suggesting that LNAPL is not present on the groundwater surface. Total petroleum hydrocarbons (TPH) in groundwater from RHMW02 has, however, been detected at concentrations greater than 2.5 mg/L. Low concentrations detected at the downgradient well RHMW01, and even lower concentrations at the further downgradient well RHMW05, suggest that dissolved petroleum compounds are not migrating off site at levels of concern (DON 2007).

Methane was observed in groundwater samples collected from sampling locations RHMW2254-01, RHMW01, RHMW02, and RHMW03. Methane is an indicator compound for active anaerobic biodegradation of petroleum. Methane's presence can imply that natural microbial activity upgradient from each of these locations is anaerobically degrading the petroleum dissolved in groundwater. Anaerobic degradation is expected to occur only after aerobic degradation has used up all the available dissolved oxygen in the groundwater. The presence of methane suggests that biodegradation (a component of natural attenuation) is actively occurring in the groundwater beneath the USTs.

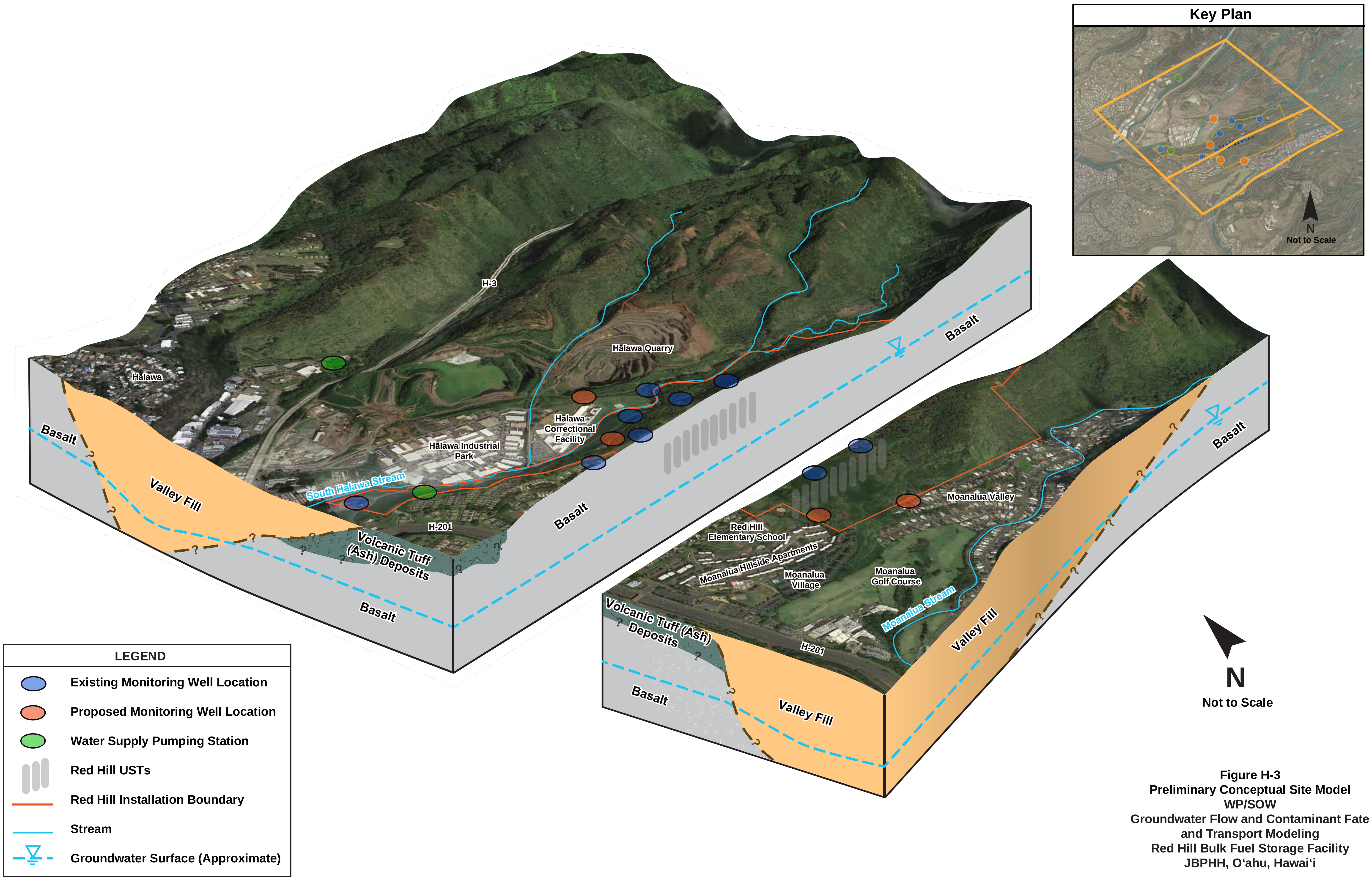

Figure H-3
Preliminary Conceptual Site Model
WP/SOW
Groundwater Flow and Contaminant Fate
and Transport Modeling
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, Hawai‘i

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Groundwater levels near RHSF are strongly influenced by supply well pumping. Groundwater level measurements taken in May 2006 were re-evaluated in 2010 (DON 2010) to prepare revised water table potentiometric maps for the site area for pumping and non-pumping conditions. When pumps at Navy Supply Well 2254-01 were operating at normal capacity (approximately 4 mgd), the hydraulic gradients indicated possible components of groundwater flow to both the west-northwest and the southwest. The gradient to the northwest was approximately 0.00028 (foot per foot [ft/ft]), and the gradient to the southwest was approximately 0.00022 (ft/ft). When the pumps in Navy Supply Well 2254-01 were pumping at an increased rate of approximately 10 mgd, this substantially increased the drawdown near the pumping well and created a hydraulic capture zone centered at the infiltration gallery, which increased the southwesterly groundwater flow gradient in and around RHSF. During the May 2006 pumping test period, the highest pumping rates reported for Navy Supply Well 2254-01 approached 20 mgd for several periods for as long as 1 day. During those periods, the largest drawdown measured at Navy Supply Well 2254-01 was approximately 7 ft (DON 2007).

Farther northwest of RHSF, the BWS Hālawa Shaft is a municipal drinking water source for south O‘ahu. The results from a regional groundwater pumping test conducted in May 2006 did not indicate any hydraulic response in wells on the northern edge of Hālawa Valley during pumping of Navy Supply Well 2254-01 (DON 2007). Conversely, wells monitored near RHSF did show a clear hydraulic response to pumping of Navy Supply Well 2254-01. Based on those results, it has been suggested that the valley fill sediments in North Hālawa Valley and South Hālawa Valley, which likely extend to depths below the water table, may act as barriers to groundwater flow (DON 2010). Saprolite beneath the valley fills probably further impedes flow toward the municipal supply wells.

## 3.3 HYDRAULIC CONDUCTIVITY

The groundwater flow properties of the aquifers and aquitards in the vicinity of RHSF depend mainly on the material composition and origin.

### 3.3.1 Basal Aquifer

The basal aquifer is composed of igneous rock in these forms: lava flows, dikes, pyroclastic deposits, and saprolite. The lava flows are either pāhoehoe or a‘ā. Massive a‘ā flow beds of low permeability alternate with thin rubbly clinker beds of high permeability (also referred to as hydraulic conductivity), commonly forming preferential flow paths along interflow boundaries.

The hydraulic conductivity of flank lavas is dependent on such features as thickness of the flows, thickness of clinker zones associated with a‘ā flows, frequency and extension of fractures, and occurrence of lava tubes associated with pāhoehoe flows. Hydraulic conductivity ranges from several hundred to several thousand feet per day (ft/d) in highly permeable dike-free flank lavas, and is typically orders of magnitude higher in the horizontal direction than in the vertical direction (DON 2007). Rotzoll et al. (2007) analyzed 238 aquifer tests of wells in Central Maui and found that hydraulic conductivity is log-normally distributed and ranges over several orders of magnitude, from 1 to 8,000 ft/d. The arithmetic mean, geometric mean, and median values of hydraulic conductivity for dike-free volcanic rocks were respectively 1,700, 900, and 1,200 ft/d (DON 2007). The U.S. Geological Survey (USGS) groundwater model (Oki 2005) used a value of 1,500 ft/d for horizontal hydraulic conductivity in the Pearl Harbor area. Horizontal hydraulic conductivity tends to be several times greater parallel to lava flows than perpendicular to the flows (Nichols, Shade, and Hunt Jr. 1996). Souza and Voss (1987) estimated the ratio of vertical to horizontal hydraulic conductivity to be 0.05.

Dikes are thin, near-vertical sheets of massive, low-permeability rock that intrude existing rocks and have cooled beneath the surface. Dikes are generally less than 10 ft wide and can extend vertically and laterally for long distances. They impede the flow of groundwater due to their lower permeability. Within a dike complex, dikes intersect at various angles. Dikes tend to channel groundwater flow parallel to the general trend of the dikes. Hydraulic conductivity is greater along the strike of the dike than perpendicular to the strike and the average conductivity decreases as the number of dikes increases toward the center of the rift zone. The overall hydraulic conductivity of an entire dike complex can be as low as 0.01 ft/d. The hydraulic conductivity of a single intrusive dike was estimated to be even several orders of magnitude lower (DON 2007).

The number of dikes can exceed 1,000 per mile in the center of the rift zone, but it sharply decreases in the outer part. However, single, widely scattered dikes can extend farther from the designated dike complex (Takasaki and Mink 1985). Pyroclastic rocks include ash, cinder, spatter, welded tuff, and larger blocks, and typically have significantly lower permeability and may affect localized groundwater flow directions. Saprolite is a soft, clay-rich, thoroughly weathered volcanic rock which may be from 100 ft to as much as 300 ft thick and has very low hydraulic conductivity (DON 2007).

### 3.3.2 Valley Fill Sediments

Sedimentary deposits are also important in influencing groundwater flow in the basal aquifers in some areas, particularly deep-cut alluvium-filled streams valleys (DON 2007). Following periods of extensive erosion, the larger valleys were deeply incised. Some of these valleys were filled in by marine and terrestrial sediments in times when the relative sea level was substantially lower or higher than today. The bottoms of the sediments in many stream valleys extend significantly below the water table, and since the fills have a lower overall permeability than the underlying lava flows, they can act as barriers to groundwater flow and contaminant transport (DON 2007). Hydraulic conductivity estimates of the alluvium range from 0.019 to 0.37 ft/d (Wentworth 1938). The USGS groundwater model (Oki 2005) used 0.058 ft/d for both horizontal and vertical hydraulic conductivity in the Pearl Harbor area (note that these values are several orders of magnitude lower than those reported for the basaltic aquifer, above). In most cases, the lower range of this estimate reflects the effective hydraulic conductivity, which contrasts with that of the surrounding flank lavas, making the valley-fill deposits a barrier to groundwater flow. Underlying the valley fills are layers of highly weathered basalt (saprolite), which are low permeability units that further impede groundwater flow and contaminant transport.

### 3.3.3 Caprock

To the west of RHSF, there are substantial thicknesses of heterogeneous sediments occurring on the coastal plains in southern O‘ahu around Pearl Harbor. These terrestrial and marine sediments and reef limestone deposits form a 1,000-foot-thick wedge, commonly referred to as caprock, and overlie the lava flows of the basalt aquifer. Overall, the caprock has lower hydraulic conductivity than the basaltic rocks, and it overlies and confines the basal aquifer in the Pearl Harbor and Honolulu areas. Hydraulic conductivity of the caprock spans several orders of magnitude depending on material type (DON 2007). The older alluvium, including fine-grained muds and saprolite, can have hydraulic conductivities ranging from approximately 0.01 to 1 ft/d. Sands have an estimated hydraulic conductivity ranging from 1 to 1,000 ft/d. Coral gravels and reef limestone deposits have hydraulic conductivities of several thousands of ft/d. Although the permeability of the components is diverse, the overall effect of the caprock is one of a low-permeability formation that acts as an overlying confining unit atop the basal aquifer near the coastline, as evidenced by artesian groundwater and springs around Pearl Harbor.

### 3.4 PREVIOUS NUMERICAL GROUNDWATER FLOW MODELING

Working with local experts, the Navy previously developed a local 3-D numerical groundwater flow model for the aquifers surrounding RHSF (DON 2007). This local model utilized the DOH regional Source Water Assessment Program (SWAP) model (Whittier et al. 2004) and MODFLOW 2000. The local model was set up based on hydrogeology information available at that time. Regional groundwater information and recharge estimates were obtained from Giambelluca (1983) and Shade and Nichols (1996), then updated for current land use (Rotzoll and El-Kadi 2006). Flow characteristics were also obtained from other literature (Nichols, Shade, and Hunt Jr. 1996; Oki 1998).

Hydraulic parameters of hydraulic conductivity and porosity for three main materials: basalt, valley fill and caprock were applied, and then the model was calibrated to dynamic flow conditions using the results of a regional pump test to estimate values for specific storativity and specific yield for the same materials. Calibration of the previous flow model was facilitated by using the parameter estimation algorithm PEST (Doherty 2000). Table 1 presents the hydraulic parameter values in the final calibrated numerical flow model (DON 2007). The longitudinal hydraulic conductivity values for the basalt aquifer were substantially higher in the calibrated model than the mean values reported by other relevant groundwater studies, which are described in Section 3.3.1.

**Table 1: Hydraulic Parameters Developed from Model Calibration**

| Hydrogeologic Unit | Horizontal, Transversal K [ft/d] | Horizontal, Longitudinal K [ft/d] | Vertical K [ft/d] | Effective Porosity | Specific Storativity [$ft^{-1}$] | Specific Yield |
|---|---|---|---|---|---|---|
| Caprock | 0.15 | 0.15 | 0.15 | 0.10 | 3.05 × 10-5 | 0.10 |
| Valley Fill | 0.066 | 0.066 | 0.066 | 0.15 | 1.52 × 10-5 | 0.12 |
| Basalt | 1,476 | 4,428 | 7.4 | 0.05 | 1.07 × 10-5 | 0.031 |

| | |
|---|---|
| K | hydraulic conductivity |
| $ft^{-1}$ | per foot |

Figure H-4 illustrates the local model-simulated 10-year capture zones for potable water wells in the vicinity of RHSF. These simulations indicate that Navy Supply Well 2254-01 captures upgradient groundwater flowing westward beneath the South Hālawa Valley, and that the BWS Hālawa Shaft (2354-01) captures upgradient groundwater flowing westward beneath the North Hālawa Valley. These simulations also show that the BWS Moanalua wells (2153-10, -12 and -22) capture upgradient groundwater flowing westward beneath Moanalua Valley. Figure H-3, the CSM, illustrates how the valley fills may act as barriers to groundwater flow.

As part of a 2005–2007 site investigation, a groundwater flow and contaminant transport model was developed to evaluate the threat to surrounding potable water wells and support a Tier 3 assessment of future risk to the potable water production wells (DON 2007). The USGS's three-dimensional finite-difference groundwater model (MODFLOW) was used to model groundwater flow in the aquifers surrounding RHSF. The Reactive Transport in 3-Dimensions (RT3D), a multi-species reactive transport model developed by the Battelle Pacific Northwest National Laboratory, was used to model solute (i.e., dissolved contaminant) transport and natural attenuation of hydrocarbons, including degradation of hydrocarbon compounds in both oxygenated and anaerobic groundwater.

The results of the Tier 3 Risk Assessment indicated that LNAPL would have to migrate to the groundwater surface in sufficient quantities to create a plume extending to within approximately 1,100 ft of the Navy Supply Well 2254-01 infiltration gallery before dissolved contaminants in groundwater could present a potentially unacceptable risk to the water supply (based on the EALs, which are considerably more stringent than the MCLs). The model indicated that TPH-diesel range organics (TPH-d) would be the first chemical of potential concern (COPC) to reach unacceptable concentrations in this scenario.

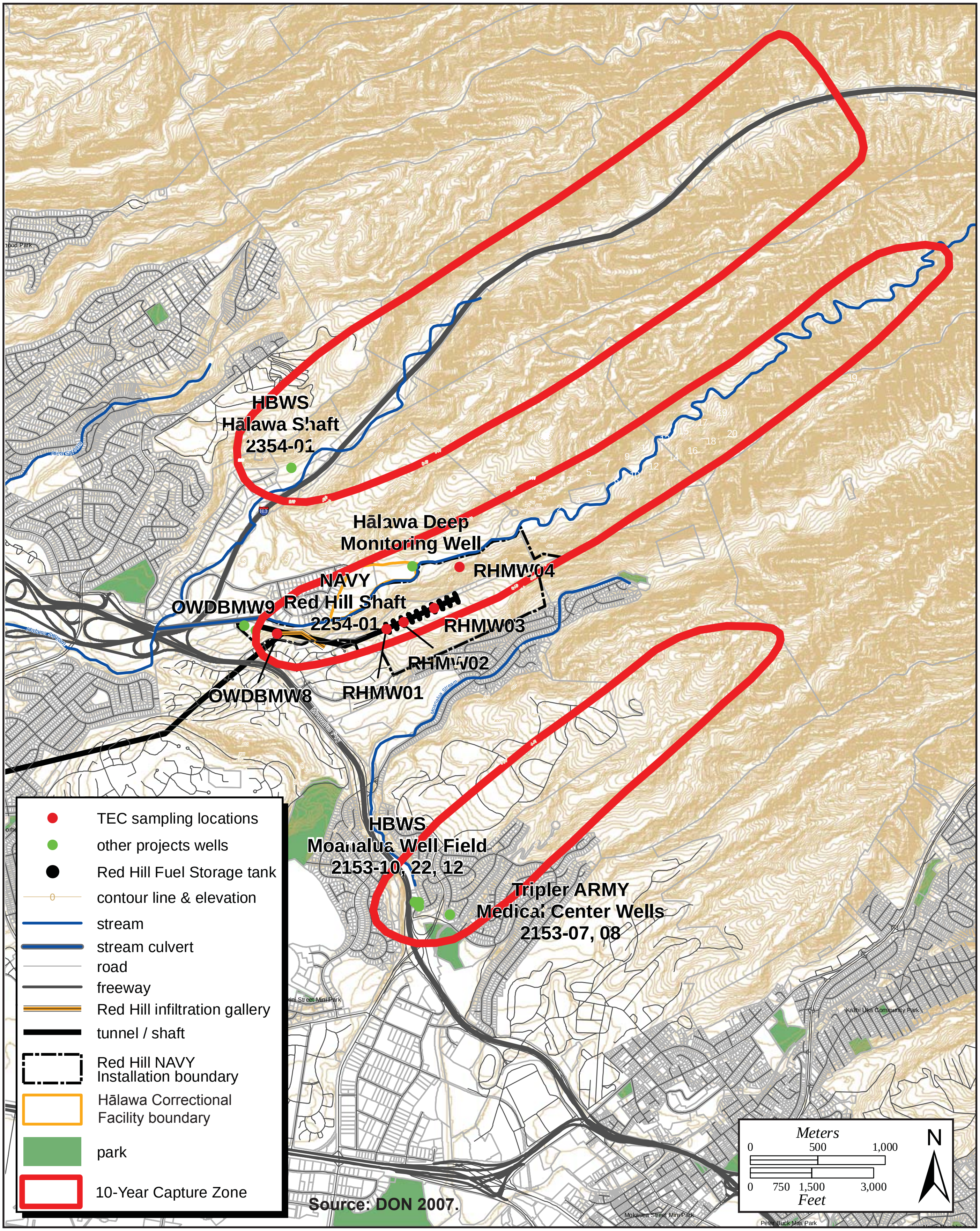
### 3.5 EVALUATION OF FUEL SOURCES

According to records, the main fuel types stored at RHSF have been diesel oil, NSFO, Navy Distillate, JP-5, JP-8, and F-76, except for Tank 17, which contained AVGAS and MOGAS between 1964 and 1969 and Tank 18, which contained AVGAS between 1964 and 1968. AVGAS and MOGAS are highly volatile, gasoline-based fuels, which present potential explosion concerns within the enclosed tunnels of RHSF. Both have a much higher concentration of highly soluble and mobile compounds known as aromatic hydrocarbons than do kerosene- and diesel-based fuels. Benzene, toluene, ethylbenzene, and xylenes (BTEX) are examples of aromatic hydrocarbons that can be easily degraded in groundwater at low concentrations, but will migrate large distances at higher concentrations. The Navy does not have current plans to store AVGAS or MOGAS at RHSF in the future. Since the early 2000s, only JP-5, JP-8, and F-76 have been stored at RHSF. Currently, JP-5, a kerosene-based fuel, is the most volatile and mobile fuel stored at RHSF.

Gasoline contains approximately 35 percent aromatic hydrocarbons, of which 19 percent is BTEX; comparatively, JP-5 contains approximately 6.8 percent aromatic hydrocarbons, less than 1 percent BTEX, and less than 0.02 percent benzene, and diesel-based fuels contain even less aromatic hydrocarbons (Potter and Simmons 1998). In addition, diesels and JP fuels do not contain lead or methyl tertiary-butyl ether (MtBE). An important transport mechanism is the solubility limit of a fuel at standard temperature and pressure, which is the highest concentration of petroleum hydrocarbons one can expect to dissolve in water. The solubility limits for gasoline and JP-5 are 93 mg/L and 4.5 mg/L, respectively. The solubility limit for benzene in JP-5 is 0.75 mg/L (Potter and Simmons 1998). These concentrations would be reached only if LNAPL were to migrate to the groundwater surface in sufficient quantities to come into direct contact and establish equilibrium with the groundwater. The lower dissolved concentration resulting from JP-5 allows the fuel to be degraded by natural attenuation mechanisms, such as by the metabolism of microbes naturally present in the groundwater.

### 3.6 PREVIOUS REACTIVE TRANSPORT SIMULATIONS

Previous modeling efforts included simulating natural attenuation mechanisms in groundwater using the localized MODFLOW groundwater model, MODPATH and RT3D (DON 2007). MODPATH was used to for computing groundwater flow velocity and delineating the 10-year capture zones, which were delineated for Navy Supply Well 2254-01, the Hālawa Shaft, and the Moanalua Wells. For those simulations, virtual particles were inserted in the cells intersected by well screens and the Red Hill infiltration gallery, and then tracked backward (upgradient) for 10 years to delineate the edge of the pumping well capture zones. Those modeling results indicated that, under normal hydrologic conditions, Navy Supply Well 2254-01 is the only drinking water source that would be impacted by contamination foreseeably migrating from RHSF.



Source: DON 2007.

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Figure H-4

Local Model Ten-Year Capture Zones for Area Wells

WP/SOW

Groundwater Flow and Contaminant Fate and Transport Modeling

Red Hill Bulk Fuel Storage Facility

JBPHH, Oʻahu, Hawaiʻi

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MODPATH was also used to compute groundwater flow velocity. RT3D simulates the degradation of hydrocarbons based on the availability of aerobic and anaerobic electron acceptors within the aquifer and the stoichiometry required for natural microbial degradation. The main electron acceptors evaluated were dissolved oxygen, nitrate, ferric iron, and sulfate. In addition, a process of anaerobic metabolism called methanogenesis was simulated, in which estimates of petroleum degradation can be made based on the amount of methane produced by the degradation process.

Measurements of dissolved oxygen, nitrate, sulfate, ferrous iron (a byproduct of ferric iron utilization) and methane were collected from the upgradient background well (RHMW04) and from the lower access tunnel wells (RHMW03, RHMW02, and RHMW01) to determine the availability of these natural attenuation parameters (NAPs). Petroleum constituent degradation rates for each NAP are considered site-specific characteristics that can be measured if sufficient monitoring points exist within the plume. However, measurable concentrations of petroleum constituents were limited to RHMW02, due to the limited number of wells beneath RHSF and the distance between them. For this reason, literature values were used for degradation rates, based on a case study conducted at Hill Air Force Base modeling BTEX degradation (Lu et al. 1999). Actual NAP concentrations were used to determine the amount of each available for biodegradation. The simulations modeled the fate and transport of benzene, and TPH using the RT3D model to evaluate natural attenuation (DON 2007).

In addition to natural attenuation, RT3D accounts for natural retardation and mixing due to hydrodynamic diffusion. In general, retardation is attributed to equilibrium partitioning of chemicals between the solid and liquid phase, and these mechanisms are driven by organic carbon content and clay content within the aquifer matrix. Since the aquifer of concern is within a fractured basalt matrix, retardation was not included in the simulation. (Although it was not modeled, retardation could be significant, however, within the valley fill alluvium and underlying saprolite.) Hydrodynamic diffusion was calculated by estimating the dispersivity of similar basalt cores from Central O'ahu, and comparing the results to the literature value (Souza and Voss 1987). Taking the geometric mean of these measurements gave a longitudinal dispersivity of 112 ft. The transverse and vertical dispersivities were set to 11.2 ft and 1.12 ft, respectively.

The RT3D simulations were conducted for benzene and TPH, with the goal of estimating the concentrations of these in RHSF monitoring wells that would result in exceedances of health based action levels at the downgradient Navy Supply Well 2254-01 infiltration gallery. One set of simulations assumed that infiltrating groundwater from precipitation recharge contained the maximum concentration of benzene (0.75 mg/L) for a JP-5 fuel source. Under this scenario, the modeled fuel plume did not exceed the RHSF boundary. Another set of simulations assumed a constant source of dissolved petroleum of varying lengths and widths in the upper 20 ft of the water table. These were meant to represent a hypothetical LNAPL plume on the groundwater surface with maximum concentrations (i.e., solubility) within the first 20 ft of the water table beneath the product. The result of these simulations indicated that a LNAPL plume would have to reach the groundwater surface and then migrate to within 500 ft of the infiltration gallery before the TPH concentrations would exceed 100 micrograms per liter (µg/L) in the infiltration gallery. These simulations indicated that:

- JP-5 dissolved in infiltrating leachate from RHSF will not impact Navy Supply Well 2254-01 due to natural attenuation and hydrodynamic dispersion.
- If evidence of LNAPL on the groundwater surface is detected, it may herald potential future degradation of the groundwater supplying Navy Supply Well 2254-01. Such evidence could include measurements of LNAPL in wells; dissolved concentrations of TPH exceeding

5 mg/L; or the absence of nitrate, sulfate, and dissolved oxygen plus increasing concentrations of methane and ferrous iron concentrations.

A letter report, *Re-evaluation of the Tier 3 Risk Assessment/Groundwater Model & Proposed Course of Action* (DON 2010), summarized the re-evaluation the groundwater model results and the Tier 3 risk assessment, as required by the RHSF *Final Groundwater Protection Plan* (DON 2008). The re-evaluation of groundwater flow direction and gradient verified a local flow direction from the USTs toward Navy Supply Well 2254-01, and also indicated, based on well data available at that time, a component flowing to the northwest that could be transporting dissolved hydrocarbons in a direction that was not then being monitored. (Subsequently, two new monitoring wells were installed by the Navy in South Hālawa Valley immediately north of RHSF to address this issue [DON 2015].) This 2010 letter report established that the Tier 3 risk assessment/groundwater model, while not reflecting the entire groundwater flow field, did simulate the most conservative flow direction. The re-evaluation recommended continued refinement of groundwater flow directions and gradients as appropriate following the collection of additional data and/or changing conditions in RHSF contaminant trends (DON 2010).

Facility risk-based modeling (DON 2007, 2010) determined that in order for DOH drinking water EALs to be exceeded at the Navy Supply Well 2254-01, a JP-5 LNAPL plume would need to migrate to within approximately 1,100 ft of the infiltration gallery. Based on this prediction, free product would need to be observed at RHMW01 before for DOH drinking water EALs could be exceeded at Navy Supply Well 2254-01.

The inside-tunnel wells quarterly groundwater monitoring reports note that in January 2008, a trace, unmeasurable quantity of fuel at a thickness of less than 0.01 foot was noted in monitoring wells RHMW01 and RHMW02; however, since January 2008, no evidence of LNAPL has been observed in any of the wells in the vicinity of RHSF (DON 2012).

In January 2014, an estimated 27,000 gallons of JP-5 leaked from Tank 5. JP-5 is a kerosene-based fuel, and as there is no standard formula for kerosene, the volatile organic compound (VOC) (and, specifically BTEX) content of JP-5 from Tank 5 is unknown because the VOC content of kerosene differs depending on the crude oil source (ATSDR 2016). However, the OSHA (2004) kerosene chemical profile shows benzene is a very small component of kerosene, which indicates benzene would also be a very minor component of JP-5. Thus benzene was present at much lower concentrations than those assumed in previous modeling efforts, which is consistent with the historical groundwater monitoring data for VOCs.

As of February 2016, the revised COPC list of compounds for groundwater monitoring includes TPH-gasoline range organics (TPH-g), TPH-d, TPH-residual range organics (TPH-o), BTEX (i.e., benzene, toluene, ethylbenzene, and total xylenes), 1-methylnaphthalene, 2-methylnaphthalene, and naphthalene. Although BTEX has been monitored continuously throughout the long-term monitoring program, it has been consistently non-detect in most of the groundwater monitoring well samples. For the few groundwater samples in which BTEX compounds have been detected, the concentrations are at very low levels, well below the screening criteria, even at monitoring well RHMW02, which is located adjacent to Tank 5.

# 4. Technical Approach for Refining the Groundwater Flow Model

Substantial effort has already been expended to develop and apply the existing groundwater models, which are based on time-tested models and accurately reflected the observed data (DON 2007). In accordance with the Scoping Meetings, this Modeling WP/SOW has been prepared to describe how those existing models will be refined and updated to incorporate available pertinent information gathered since previous modeling efforts, including the new hydrogeology data to be collected during the upcoming site investigations described in the Investigation WP/SOW. During preparation of this Modeling WP/SOW, the existing MODFLOW, MODPATH, and RT3D models were obtained and preliminarily evaluated to determine their usability for meeting the project objectives. Based on the initial review, the models appear to be suitable for the refined modeling proposed herein.

When this model refinement effort starts, the model input files will be compared with current geologic and hydrogeological data. Boundary conditions, model layers, aquifer properties, calibration data, and water budgets will be reviewed and revised as needed to be consistent with all the available data. The new site data, including any useful and reliable data that may be provided by other parties, will be incorporated into the numerical model to reflect known site features, hydrogeology, and groundwater conditions. After calibrating the updated MODFLOW model to match the newly available site data and conceptual hydrogeology model, the updated MODFLOW model will be applied to meet the modeling objectives for this project, as described in the following sections.

## 4.1 MODEL SELECTION

The finite-difference computer code MODFLOW 2000 (Harbaugh et al. 2000) will be used to simulate saturated groundwater flow. MODFLOW is a well-established and widely accepted numerical groundwater flow modeling program developed by the USGS. This computer model solves the groundwater flow equations in three dimensions using the finite-difference method and the following assumptions:

- Groundwater flow is laminar.
- All simulated wells fully penetrate the aquifer.
- No water is stored in the well (well bore storage).
- Head losses within the well (across the well screen or pump intake) are negligible.
- Groundwater density and viscosity are constant.
- The aquifer is compressible and elastic.
- Groundwater flow can be described by the Darcy's law.
- The bedrock aquifer layers (i.e., layers representing highly fractured and highly permeable bedrock) behave as equivalent porous media.

Although the site aquifer properties are highly heterogeneous, the available information from large-scale pumping tests and previous modeling results indicate that the MODFLOW equivalent porous medium (EPM) modeling approach reasonably simulates flow at the site in sufficient detail to address the project objectives. Previous modeling efforts confirmed that the model was able to match time-series drawdown data from the long-term area wide pumping test conducted in May 2006. If the EPM approach were not valid, it would not have been possible for the MODFLOW model to simulate the drawdown data so closely.

The MODFLOW model also provides several additional benefits that will help achieve the project objectives:

- It is in public domain; has been extensively tested, verified, and documented; and is widely accepted by regulatory agencies.
- It allows modification of the code and addition of new modules for specialty applications.
- The cell-by-cell flow feature of the code can be used to evaluate in detail flow and head changes associated with various withdrawal scenarios.
- Aquifer heterogeneity and anisotropy can be specified and calibrated to match site data.
- It can be coupled with latest available non-density-dependent solute transport models, e.g., MT3DMS and RT3D.
- The layer property flow module incorporated in MODFLOW 2000 is capable of simulating groundwater flow in heterogeneous-layered anisotropic aquifers and including recharge and extraction from wells.
- It solves for steady-state and transient conditions.

MODFLOW also has the advantage of being compatible with other finite-difference based numerical codes that will be useful for this project, including the particle tracking code of MODPATH (Pollock 1994) and common CF&T codes, such as MT3DMS (Zheng and Wang 1999), and RT3D (Clement 1997), a modified version of MT3DMS that utilizes alternate Chemical Reaction packages. MODPATH, MT3DMS, and RT3D all use the flow field computed by MODFLOW. In addition, the automated parameter estimation algorithm PEST (Doherty 2000) can be used to optimize the models’ hydraulic parameters. PEST is non-linear parameter estimator that iteratively minimizes the error between observed and computed features, such as water levels and fluxes, by adjusting selected parameters within preset bounds.

Another advantage of using MODFLOW is the availability of pre- and post-processors for managing model data and input data sets, and presenting graphical model outputs. The software platform of Groundwater Modeling System (GMS), version 6.0, was used as a graphical user interface to develop the existing groundwater model. This graphical user interface is capable of importing background images, scatter points, borehole data, and geographic information system spatial data. To refine the existing model, the latest GMS, version 10, will be used, which interfaces with MODFLOW, MODPATH version 5, MT3DMS, RT3D, and PEST, and can also integrate GIS data, facilitating data input and output, and improving the graphical display of model results.

The USGS is currently developing a regional groundwater model to simulate the effects of groundwater pumping on saline water present at the base of the Pearl Harbor aquifer and to provide a tool for managing groundwater pumping to minimize adverse effects of saline water intrusion on groundwater quality. To the extent this model is available within the AOC timeframe, data from that model may be incorporated into the proposed modeling effort.

## 4.2 MODEL DOMAIN, LAYERS, GRID, AND BOUNDARY CONDITIONS

Two flow models were created for the previous modeling effort (DON 2007). A regional groundwater flow model was developed to define the boundary conditions for the smaller, but more detailed, localized model of the RHSF area. The regional model was modified from the DOH’s SWAP model for the island of O‘ahu (Whittier et al. 2004), simulating steady-state conditions covering the 10-year period from 1996 to 2005. The local model was developed to simulate both steady state and transient conditions in the area of specific interest for the Red Hill project. The areas covered by both models are shown on Figure H-5.

For this upcoming model refinement effort, the regional model will likely remain the same, and the local MODFLOW model area (edges of the computational grid) will also remain the same, with the boundaries shown on Figure H-5 and illustrated in 3-D on Figure H-6. The refined local model will also utilize results from other more recent studies, such as the USGS regional modeling of saline groundwater noted above. Useful information and parameter values that become available to the Navy will be incorporated into the refined local MODFLOW model as appropriate to meet the objectives of this project. The refined MODFLOW model will likely consist of at least seven layers, similar to those in the existing model as shown on Figure H-7 and Figure H-8. Layer geometry, grid cells and parameter values will be refined to represent the updated conceptual model of groundwater flow and the new hydrogeology data to be collected from the site area. For instance, it may be necessary to revise the layers to more accurately represent important geologic features that influence groundwater flow, such as valley fill thickness or saprolite zones, which may extend far below the valley fill and impede the flow of groundwater and contaminants in the cross-valley directions. The constant-head boundary conditions along the perimeter of the existing MODFLOW model domain and the aerial recharge rates will remain the same unless new data are obtained to refine those values.

### 4.3 MODEL PARAMETERS

Hydraulic parameter values in the existing groundwater flow model (Table 1) will be refined as needed to incorporate the new information, including the groundwater monitoring data, new well logs, geologic mapping, and aquifer test data. The model parameter values will be adjusted during calibration to match the groundwater levels and hydraulic gradients at the site consistent with the updated CSM.

### 4.4 CALIBRATION

The hydraulic parameter values in the MODFLOW model will be calibrated following a systematic iterative process to match the available data, including the new data obtained since the existing model was developed in 2007. These new data will include geologic logs and groundwater levels from monitoring wells installed after 2007, hydraulic head data from pumping tests, and other available hydrogeology information. All this new information will be integrated to further develop the conceptual models for geology, hydrogeology, and groundwater, and then used to refine the numerical model structure as appropriate. Calibration will be performed using both manual trial-and-error matching water levels and automated parameter estimation code, PEST (Doherty 2014).

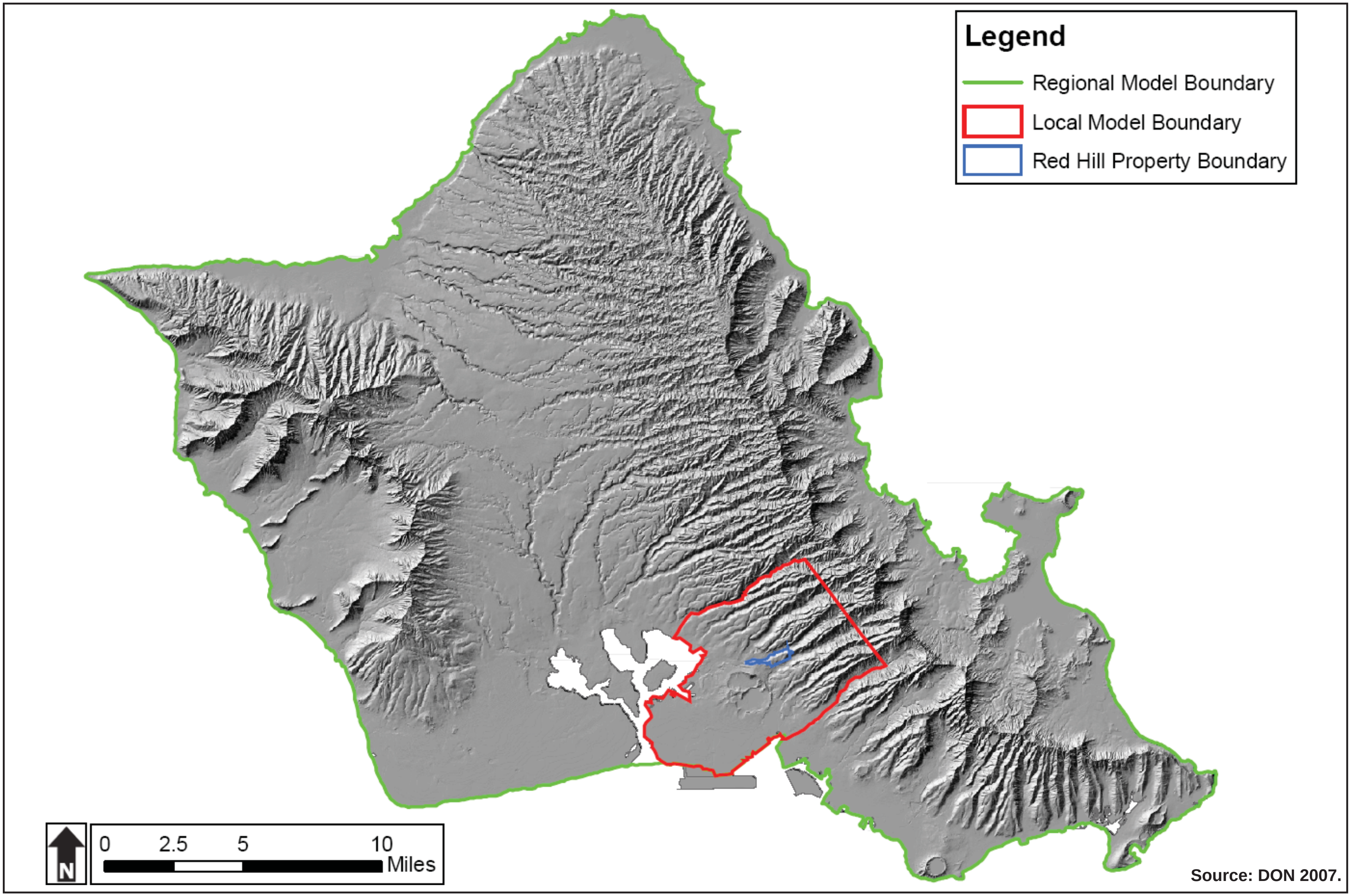
Prior to calibration, all wells in the data set will be assigned to a model layer based on the well-screen elevation and a review of geologic boring logs, where available. Wells with long screen lengths or screens that penetrate multiple layers, if present, will not be included in the calibration data set unless they are located in the undivided portion of the aquifer or no other water-level data are available. Once the wells have been assigned to model layers, water-level elevations (heads) collected over a period of time will be used as calibration targets.

Water-level data from both onsite and offsite wells will be used for calibration. Data will include the week-long water level study described in the Investigation WP/SOW. Data obtained from this study will be used to further evaluate groundwater flow directions during periods of pumping under normal operations in the nearby water supply wells at Red Hill Shaft and Hālawa Shaft. Data collection will include the measurement of groundwater elevation data from up to 20 monitoring wells while also collecting pumping rate data at each of the water supply wells. Hydrographs for each monitored well location, groundwater potentiometric surface maps, and groundwater temperature contour maps will be constructed to compare changes in groundwater elevations with discharge rates and volumes from water supply wells and to evaluate groundwater flow directions during various pumping conditions.

During the flow model calibration, model-simulated water levels will be compared to observed water levels. Initially, the refined model will be calibrated for steady-state conditions. Model inputs will be adjusted between simulations until the model realistically simulates groundwater level elevations and hydraulic gradients similar to those observed in the updated potentiometric map. Recharge rates, boundary conditions, and hydraulic conductivity values are expected to be adjusted during the calibration process. After the initial steady state calibration, transient calibrations will be performed to further refine the model to match available data.

Transient calibration of the model can further strengthen the predictive power of a numerical model, and reduce uncertainty compared to calibration using only static head targets. Therefore, this model refinement effort will also include calibration to match newly obtained hydrographs to model-simulated heads, including the 2015 USGS pumping test data from the Hālawa Well (April–May 2015), provided that usable data is obtained in timely fashion. In addition, the transient calibration will use new sets of groundwater level data from onsite monitoring wells that may reveal the influence of the supply wells. Model parameters will be calibrated considering available information, which may include data obtained through coordination with the USGS.

Statistical analyses of water levels and mathematical simulation residuals will be used to evaluate the quality of the calibration. Several statistical criteria will be used during the calibration, including minimizing the mean error (ME), mean absolute error (MAE), and root mean squared error (RMSE) or the standard deviation. The ME will simply provide the average of the residuals; information about the spatial trends will be provided by the MAE; and the RSME is most commonly reported measure of calibration of water levels, providing a measure of the overall spread of residuals, which is useful for describing model error on average basis. The RSME over the range of head values across the study area will be evaluated for the steady-state simulation, and selected stress periods from the transient simulation. Calibration is typically considered adequate if the RSME less than approximately 15 percent.



Source: DON 2007.

Figure H-5
Area Covered by the Red Hill Groundwater Model
WP/SOW
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Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, Hawai‘i

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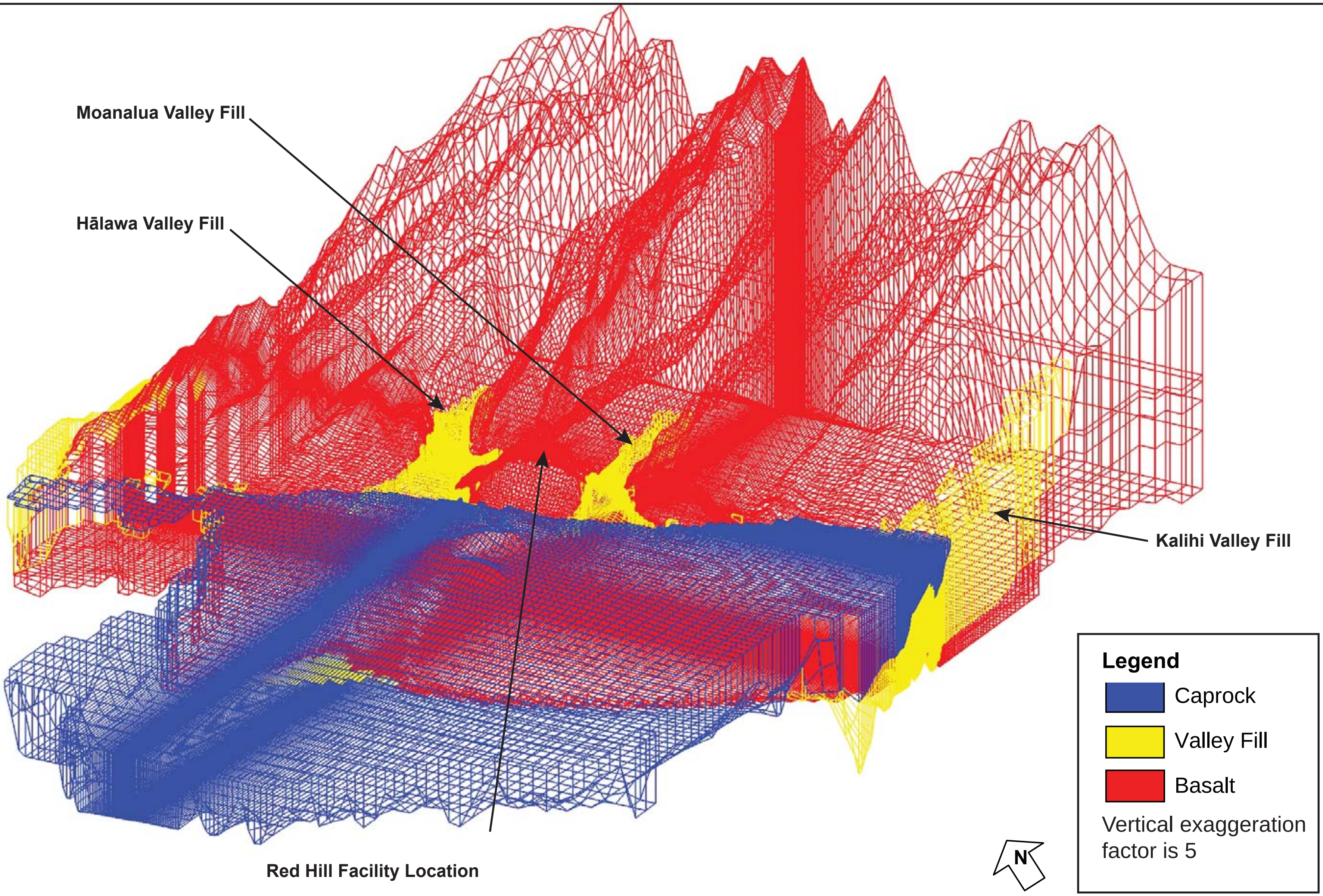

Source: DON 2007.

**Figure H-6**
**3-D View of Model Grid**
**WP/SOW**
**Groundwater Flow and Contaminant Fate and Transport Modeling**
**Red Hill Bulk Fuel Storage Facility**
**JBPHH, O‘ahu, Hawai‘i**

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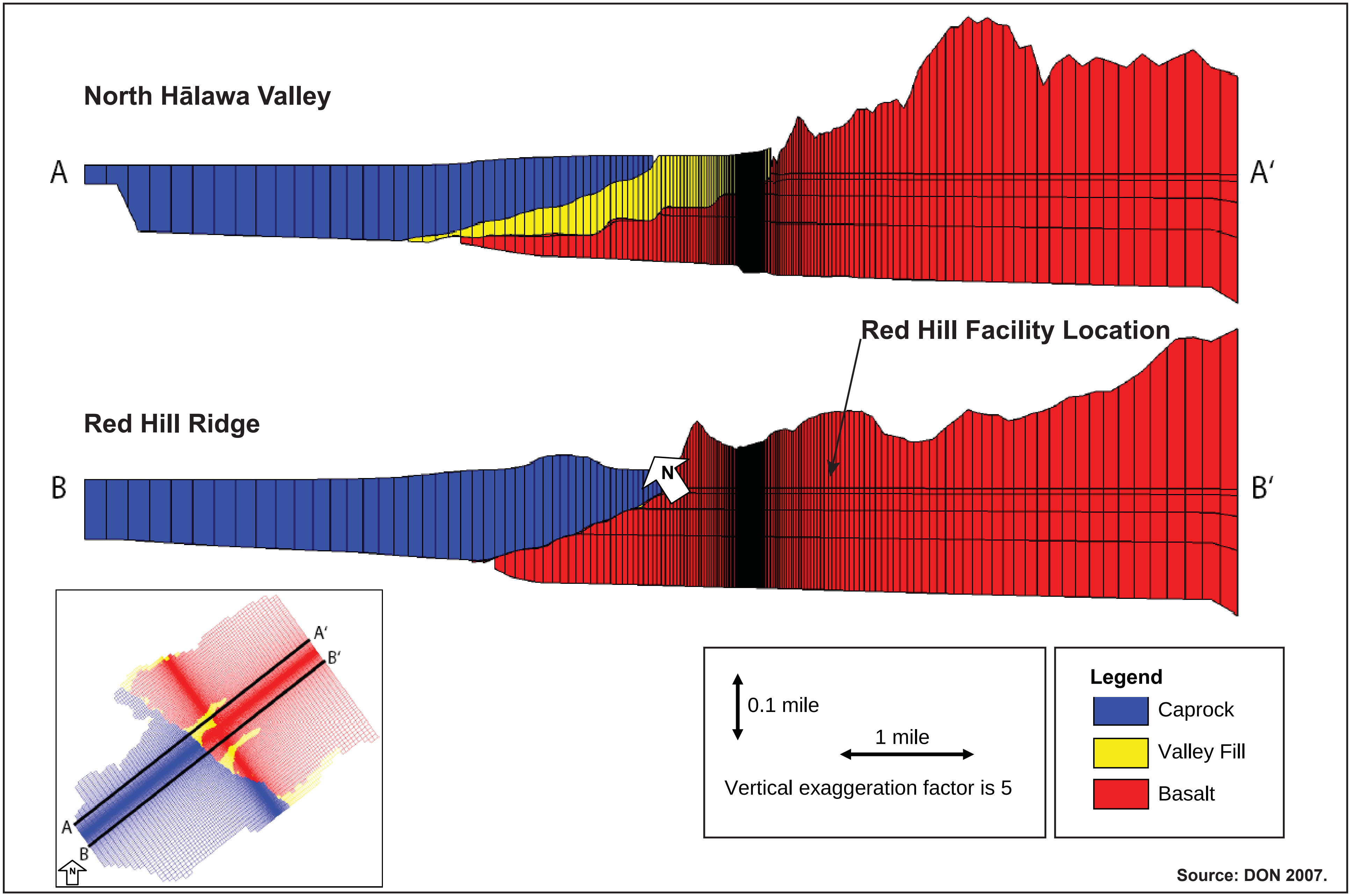

Source: DON 2007.

Figure H-7
Map View and Longitudinal Cross Section of Model Grid
WP/SOW
Groundwater Flow and Contaminant Fate and Transport Modeling
Red Hill Bulk Fuel Storage Facility
JBPHH, O‘ahu, Hawai‘i

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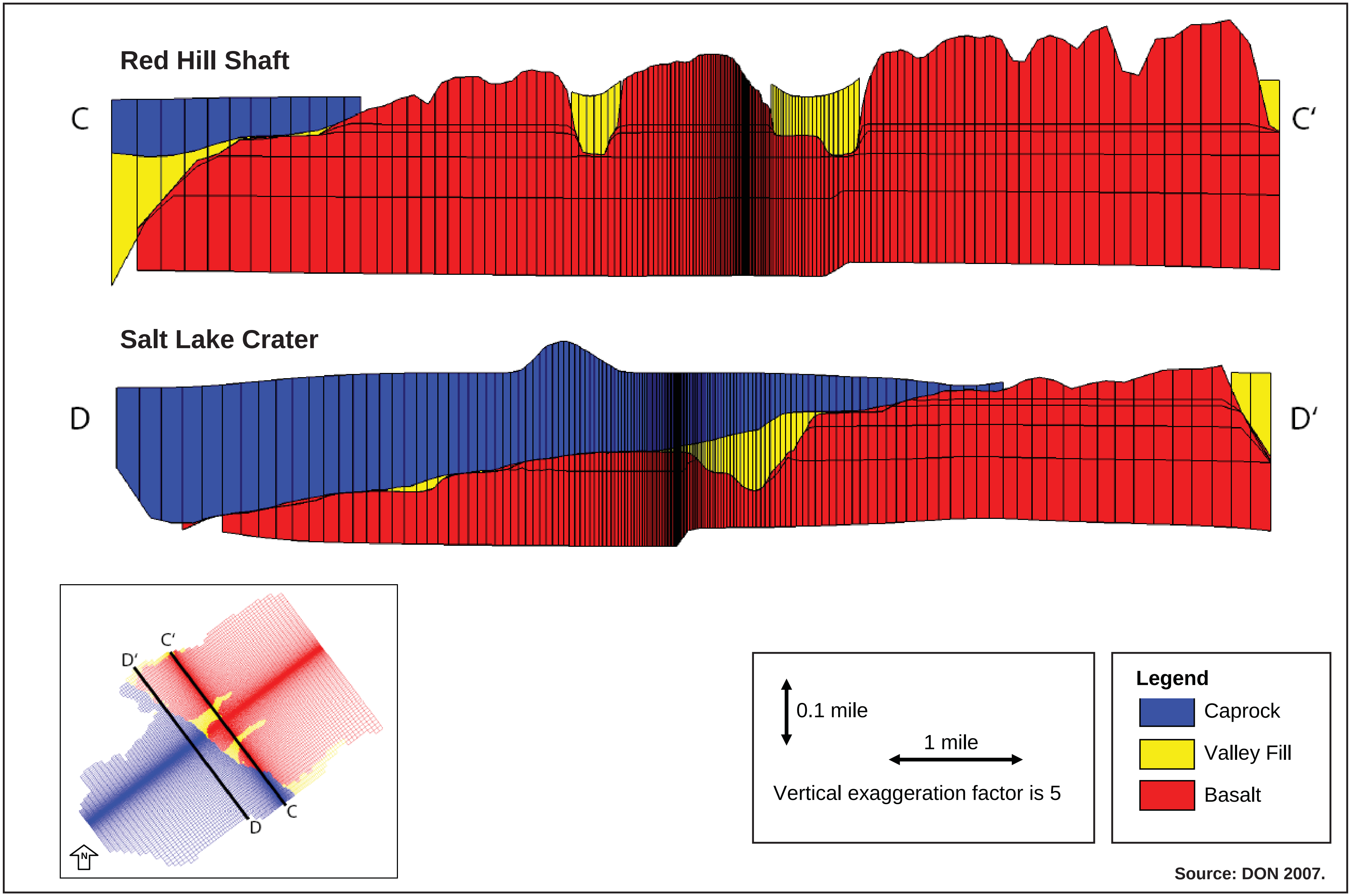

Source: DON 2007.

**Figure H-8**
**Map View and Transverse Cross Section of Model Grid**
**WP/SOW**
**Groundwater Flow and Contaminant Fate and Transport Modeling**
**Red Hill Bulk Fuel Storage Facility**
**JBPHH, O‘ahu, Hawai‘i**

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### 4.5 PREDICTIVE FLOW MODELING

The calibrated groundwater flow model will be used to simulate groundwater flow conditions that could be caused by increased pumping from existing supply wells, hypothetical new water supply wells, and potential extraction systems for remedial alternatives. These simulations will include future pumping rate scenarios for normal water demand conditions and high pumping rates during drought conditions. The flow model output will be processed to prepare simulated potentiometric maps of the water table, and particle tracking will be used to characterize groundwater flow paths, capture zones of production wells, and flow velocities.

The following model scenarios are anticipated:

- *Existing conditions* – The flow model will be calibrated to match the static hydraulic head data collected from all available wells in the vicinity of RHSF, and further refined and calibrated using data from the planned week-long synoptic monitoring of transducers in up to 20 area wells and all available supply well pumping rates. Model output will include time-series plots comparing water level hydrographs to actual measured levels in monitored wells and contour maps of the water table potentiometric surface, estimated model parameters, and model calibration statistics.
- *Base case conditions* – Based on a review of all available data, the base flow model will be established to represent hydraulic head data under anticipated normal long-term conditions. Model output will include hydraulic heads at specific locations and hydraulic gradients for comparison to the available site measurements.
- *Future Pumping Scenario 1, increased pumping from existing wells* – The calibrated flow model will evaluate groundwater levels, hydraulic gradients, and flow patterns for potential increased pumping rates representing high water demand from existing water supply wells during drought conditions. Model output will include time-series water level hydrographs and a water table potentiometric surface contour map.
- *Future Pumping Scenario 2, increased pumping from a hypothetical new supply well* – The calibrated flow model will evaluate hypothetical groundwater levels, hydraulic gradients, and groundwater flow patterns under normal climate and demand conditions if a new supply well was installed at a location and at an extraction rate to be determined. Model output will include time-series water level hydrographs and a water table potentiometric surface contour map.
- *Future Pumping Scenario 3: remedial alternative analysis* – The calibrated flow model will evaluate hypothetical groundwater levels, hydraulic gradients, and groundwater flow patterns under potential remedial alternative scenarios, which will be determined in the future. Model output will include time-series water level hydrographs and a water table potentiometric surface contour map.

The particular details of the Future Pumping Scenarios, such as extraction rates and hypothetical extraction well locations, will be recommended in the Groundwater Flow Progress Reports, and mutually agreed upon by the Parties to the AOC.

The groundwater flow, particle tracking, and CF&T models will also be used in supporting an updated site-specific risk assessment to establish risk-based levels for the COPCs.

As needed, this updated groundwater flow model will also be applied to simulate the effects of remedial alternatives on groundwater flow, drawdown capture zones and support the feasibility study. At this time, it is uncertain whether groundwater remediation will be required. However, the flow model would be useful in evaluating remedial alternatives that involve monitored natural attenuation or groundwater extraction.

### 4.6 SENSITIVITY ANALYSIS

After the calibration is complete, a sensitivity analysis will be performed to quantify the uncertainty of the calibrated model resulting from the estimated hydraulic properties, boundary conditions, and other modeling parameters. During the sensitivity analysis, calibrated values for the primary model input parameters will be varied to evaluate order-of-magnitude change of hydraulic heads and other model outputs. The model parameters to be evaluated include, but are not limited to: hydraulic conductivity, recharge, boundary conditions. In particular, the hydraulic conductivity will likely be a critical parameter controlling groundwater flow. This analysis will also include evaluating the potential effects of possible hydraulic barriers associated with the caprock formation and other lower permeability volcanics (i.e., Honolulu Volcanic Series, saprolite, valley fill), as well as evaluating hypothetical pumping rate scenarios. Recharge may also be evaluated if it appears to have a significant effect on model results. Specific parameters or boundary conditions for sensitivity analysis will be recommended in the Groundwater Flow Progress Reports once the updated models are up and running and based on the model calibration results.

## 5. Technical Approach for Refining the Contaminant Fate and Transport Model

Hydrocarbon compounds can migrate, primarily along groundwater flow lines. Transport processes include advection with moving groundwater, hydrodynamic dispersion causing mixing with the basal aquifer, retardation as equilibrium partitioning between solid and liquid phases, and degradation due to natural processes, known as natural attenuation. CF&T processes will be modeled using a 3-D solute transport model in conjunction with the flow model output.

The previous CF&T modeling study showed that both aerobic and anaerobic degradation are strong components of the geochemical groundwater system in the basal aquifer beneath RHSF. Natural attenuation was quantitatively evaluated to determine site-specific risk based levels for chemicals using a numerical transport model. Dissolved oxygen is the key aerobic NAP causing degradation of fuel hydrocarbons. Aromatic hydrocarbons, such as the BTEX group, can be broken down through biodegradation by microbes that are usually indigenous to the aquifer. These microbes require a carbon source, provided by the fuel hydrocarbons, electron donors and acceptors, mineral nutrients, and water (Wiedemeier et al. 1999). An emphasis of the previous modeling effort was to simulate the role of electron acceptors in the degradation of hydrocarbons. The electron acceptors are part of complex oxidation-reduction reactions involving transfer of an electron from one compound to another. The electron acceptors oxidize fuel hydrocarbons, thus reducing their oxidation state. Common electron acceptors include:

- Oxygen
- Nitrate
- Ferric iron

- Sulfate
- Carbon dioxide

Natural attenuation of hydrocarbons also produces byproducts. These include:

- Ferrous iron
- Methane

The electron acceptors and natural attenuation byproducts are collectively referred to as NAPs, since their presence and concentrations can be used to demonstrate that natural attenuation is occurring and estimate the mass of hydrocarbons being reduced by these processes.

In developing this Modeling WP/SOW, the available existing CF&T model input and output files were obtained and preliminarily reviewed to evaluate their usability for meeting the project objectives. Based on an initial review, the model files appear to be usable as the starting point for creating the refined model. When this CF&T model refinement effort starts, the model input files will be compared with the most current groundwater monitoring data, including planned measurements of NAPs in the new monitoring wells. The updated CF&T model will use the updated groundwater flow model. The new site data for groundwater quality will be used to update the CF&T model to reasonably represent the site groundwater conditions, then applied to meet the CF&T modeling objectives for this project as described below.

## 5.1 OBJECTIVES

The primary objective of the CF&T modeling is to assist in evaluating the potential water quality effects of groundwater migrating from areas affected by fuel leaks from RHSF, including a quantitative analysis of currently occurring natural attenuation processes. A second objective of the CF&T model is to support an updated site-specific risk assessment to establish risk-based levels for the COPCs. This risk assessment would address the potential migration of dissolved COPCs from RHSF during anticipated pumping scenarios. For this objective, the model would have the capability to incorporate the pumping of new hypothetical water supply wells. Another objective of the updated CF&T model is to support a feasibility study of remedial alternatives, including predicting the water quality changes of implementing potential feasible remedial alternatives. Relatedly, the model may also be useful to inform contingency planning that may be conducted under AOC Statement of Work Section 8.

## 5.2 MODEL SELECTION

The previous CF&T modeling study used RT3D to perform a series of simulations to estimate the distance dissolved fuel compounds would travel from a hypothetical LNAPL plume before degrading to less than regulatory limits. The model simulated contaminant transport and mass reduction by natural attenuation for two contaminants, TPH and benzene. TPH was selected because it had been detected at concentrations exceeding action levels in monitoring wells located near the USTs. Although it is only a minor constituent of JP-5, benzene was also selected for the previous modeling (DON 2007).

To apply RT3D, the previous CF&T modeling effort assumed stoichiometric coefficients that are pre-set in the RT3D module for kinetic-limited degradation for BTEX and the NAPs. Since TPH is a parameter that includes many compounds, RT3D has no reactive transport module for that parameter. The modeler attempted to calculate the reaction rates for BTEX by performing a series of RT3D simulations while adjusting the output values to try to replicate concentrations of NAPs measured in onsite monitoring wells. Unfortunately, the model results were found to be very sensitive to changes in NAP degradation rates and stoichiometric coefficients, and those values may vary greatly based on groundwater conditions at the site. Neither the stoichiometric coefficients nor the reaction rates could be determined from the site-specific data available at that time (DON 2007). Unknown variability in the stoichiometric coefficients for the NAPs TPH and BTEX created substantial uncertainties in the results of the reactive transport module of RT3D.

In the time since the previous modeling efforts, a substantial amount of additional groundwater chemistry data has been obtained from directly beneath RHSF as the groundwater monitoring program has progressed. Routine sampling and analysis has been conducted at three wells beneath fuel tanks (RHMW-01, RHMW-02, and RHMW-03), an upgradient well (RHMW-04), and downgradient locations (well RHMW-05 and sampling point RHMW2254-01). All these locations have been sampled on a quarterly basis since 2005.

An initial review of the data from RHSF monitoring wells reveals that TPH-d and naphthalene are the dissolved contaminants with the highest concentrations measured since 2005. TPH-d was detected at a maximum concentration of 6,300 µg/L at RHMW02 in 2008, and exceeded the EAL of 100 µg/L at this well at a frequency of approximately 82 percent of groundwater monitoring events since 2005; naphthalene was detected at a maximum concentration of 180 µg/L at RHMW02 in 2006, and exceeded the EAL of 17 µg/L at this well at a frequency of approximately 65 percent of monitoring events since 2005. Both of these constituents are substantial components of fuels stored in this Facility, including JP-5. These constituents have generally not, however, been detected in excess of the EALs in other site monitoring wells or the Navy Supply Well 2254-01. The time-series plots for these constituents in wells downgradient of historical tank leaks show concentrations peak following historical releases then decline through time, which can be attributed to natural attenuation.

Benzene, however, has not been detected at concentrations of concern in any of the wells monitoring RHSF. The highest benzene concentration was 1.3 µg/L, but that was detected in the downgradient Oily Waste Disposal Facility monitoring well (OWDFMW01). The ongoing groundwater monitoring program is expected to continue in the future at the ten existing sampling locations (RHMW01 through RHMW07, RHMW2254-01, HDMW2253-03, and OWDFMW01) and the four proposed monitoring wells (RHMW08 through RHMW11). Thus, additional time-series concentration data for these fuel-related parameters and the NAPs will become available from the wells downgradient of the tank that leaked in January 2014. The CF&T modeling will therefore begin with a detailed evaluation of those data to develop a conceptual model describing the natural attenuation processes. Any changes to the CF&T modeling suggested by the new data will be presented along with recommendations in a Groundwater Flow Progress Report, for regulator review.

The upcoming CF&T model refinement plans to utilize the MT3DMS model (Zheng and Wang 1999; Zheng 2010; Zheng, Weaver, and Tonkin 2010). The MT3DMS program is a modular three-dimensional multispecies transport model that uses the flow field generated by the MODFLOW model to solve the three-dimensional advection-dispersion equations to simulate groundwater flow by advection and dispersion. The MT3DMS model can also simulate sorption, degradation, and other chemical reactions of contaminants dissolved in groundwater.

The MT3DMS model is selected because it would be adequate to meet the current project objectives and because RT3D does not provide any technical advantage for simulating migration of the COPCs identified for this modeling, TPH-d and naphthalene. In reviewing the COPC migration predictions of the previous RT3D modeling, it appears those results were influenced mainly by the dominant transport processes of advection and dispersion. Advection and dispersion are simulated by MT3DMS in an identical manner to RT3D. Also, RT3D does not have reaction modules for TPH-d or naphthalene and thus cannot explicitly simulate degradation reaction rates for either of these COPCs. Consequently, MT3DMS appears equally capable to RT3D for simulating degradation of these COPCs. For either model, it would necessary to make assumptions for the COPC parameter degradation. However, it would be more straightforward to assign an appropriate yet conservative decay term in MT3DMS, as supported by the available data from the source area. Considering the uncertainties in the reaction rates noted above for the previous RT3D modeling (DON 2007), it appears there would not have been any practically significant difference between migration predictions based on RT3D compared to those if MT3DMS had been applied using the same parameter values for advection and dispersion, and decay rates obtained from published reports for other sites.

For these reasons, the CF&T model update will use MT3DMS as supported by available site-specific data to establish parameter values, including degradation rates for the modeling. In applying MT3DMS, the refined model will use conservative, technically defendable assumptions for decay rates of COPCs. Currently, the available time-series data appear to provide a reasonable basis for estimating degradation rates to model migration of TPH-d and naphthalene using MT3DMS.

## 5.3 MODEL SETUP

As described in Section 5.2, the refined CF&T model plans to utilize MT3DMS. The RT3D model will not be used unless it is needed to explicitly simulate the degradation reactions of other COPCs and new data obtained during the investigation provide a more definitive basis for estimating stoichiometric coefficients, reaction rates, and degradation rates for the NAPs and COPCs than were available for the previous modeling effort. The RT3D modeling package, developed by Battelle Pacific Northwest Laboratory as a sister code to MT3DMS, is capable of simulating three-dimensional, multi-species, reactive transport of chemical compounds (solutes) in groundwater. Both RT3D and MT3DMS are standalone solute transport software packages and share much core functionality. They significantly differ only in their capabilities of simulating chemical reaction rates for some chemical species, particularly BTEX, which is not anticipated to drive decision-making for RHSF. There are no reactive transport modules in RT3D for TPH-d or naphthalene, which currently appear to be the most important COPCs. Therefore, the CF&T modeling will employ MT3DMS, unless future data or information suggests otherwise.

The CF&T model area will be the same as the groundwater flow model area. As described in Section 4, the flow model layers, geometry, grid cells, and initial parameter values will be refined to represent the updated conceptual model of groundwater flow and the new hydrogeology data to be collected from the site vicinity.

## 5.4 CONTAMINANTS TO BE SIMULATED

The CF&T modeling will focus on one TPH constituent (likely TPH-d) plus one (non-benzene) fuel-related constituent such as naphthalene, because these compounds are known to be mobile, toxic, and present at elevated concentrations beneath RHSF. As described in Section 4.5, the base flow modeling scenario will be run based on current steady-state conditions. Selection of the two constituents for the CF&T modeling will be done in coordination with the Navy and other agency staff considering all available RHSF monitoring well data for the following COPCs: TPH-g, TPH-d, TPH-o, naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene.

Based on the results of the base case modeling scenario, the two compounds posing the most risk (including one TPH compound and one fuel-related compound such as naphthalene) will be selected based on mobility, toxicity, and detected concentrations for use in the subsequent modeling scenarios. Modeling of BTEX is not anticipated because these compounds are very small components of kerosene fuels, including JP-5, and because BTEX has been detected only sporadically at low concentrations, even at RHMW02, which is closest to Tank 5.

## 5.5 MODEL PARAMETERS

The existing CF&T model incorporated the parameter values shown in Table 2 (DON 2007). The proposed CF&T modeling will maintain these parameter values, unless more definitive site-specific data are collected to justify changes.

**Table 2: Transport Parameters Used in CF&T Model**

| Hydrogeologic Units | Longitudinal Dispersivity (m) | Transverse Dispersivity (m) | Vertical Dispersivity (m) | Effective Porosity (unitless) |
|---|---|---|---|---|
| Caprock | 5 | 0.5 | 0.05 | 0.10 |
| Valley Fill | 3 | 0.3 | 0.03 | 0.15 |
| Basalt | 20 | 2 | 0.2 | 0.05 |

m meter

### 5.5.1 Source Term

Within the transport model, source-area contributions can be simulated by either including a concentration over a specified area or a constant concentration in the same area. For active sources, it is anticipated the refined model would use a constant concentration or, if time-series data support it, a declining concentration. Each COPC concentration specified in the source term of the model would be based on the groundwater concentrations at those source areas that have exhibited elevated levels of the COPCs or high-end values estimated based on solubility.

### 5.5.2 Sorption

Sorption processes were not simulated in the previous CF&T modeling (DON 2007). This is reasonable in the basaltic formation underlying Red Hill because advection and dispersion are the dominant processes for contaminant migration in groundwater at this site. Sorption is expected to be only a minor natural attenuation process because the basalt lava material has very low reactivity with constituents dissolved in fresh groundwater. Attempting to realistically simulate sorption would likely not change the CF&T results, and thus this is not planned.

Sorption may, however, be a very important process influencing CF&T in the alluvium and underlying saprolite in Hālawa and Moanalua valleys. If contaminant transport in these directions is indicated, sorption may be modeled in these matrices.

### 5.5.3 Porosity

Effective porosity is important for solute transport because this parameter represents the interconnected pore space in the aquifer through which groundwater may flow. The total porosity of basaltic rocks represents all the void spaces in the rock, including vesicles, joints and cracks, separation at the contact between flows, and lava tubes. Total porosity of lava on Oʻahu ranges between 5 and 50 percent. However, the effective porosity is typically much lower because many of the pore spaces are not hydraulically interconnected. A common value used for effective porosity in Hawaiian basalt aquifers is 0.05 (Oki 1998; Whittier et al. 2004) or 0.04 (Oki 2005). Unless more definitive site-specific data become available, this upcoming modeling refinement will initially use the same values for effective porosity as those from the previous CF&T model (DON 2007), which are listed in Table 2.

### 5.5.4 Dispersivity

Dispersivity of dissolved constituents within the groundwater tends to spread out the plume, reducing dissolved contaminant concentrations. Values for dispersivity (which often varies in the longitudinal, transverse, and vertical directions) are dependent on the plume's length, width, and thickness, as well as matrix properties. Dispersivity values will be estimated based on the size of the plume being simulated (longitudinal < 20 percent of the plume length, transverse < 10 percent of the width, and vertical < 10 percent of the transverse dispersivity).

Hydrodynamic dispersion of a groundwater plume results from local variations in hydraulic conductivity and tortuous interstitial spaces through which groundwater migrates in porous media. Dispersion is the product of dispersivity and groundwater flow velocity. For the previous CF&T model, estimates of dispersivity were computed using stochastic analysis of rock core logs from the U.S. Air Force's environmental investigations at the Waikakalaua and Kīpapa Fuel Storage Annexes. In that case, rock cores taken from three drill holes 290–700 ft deep were used for a stochastic analysis to estimate a correlation between hydraulic conductivity and dispersion (TEC 2001) following the method described by Domenico and Schwartz (1990). The stratigraphy of the boreholes was divided into three different rock types and hydraulic conductivities:

- Massive basalts, which were assigned a horizontal hydraulic conductivity value of 3.9 ft/d, based on infiltration tests done on fractured flood basalts in the Snake River Plain of Idaho (Podgorney et al. 2013).
- Clinker zones, which were assigned a horizontal hydraulic conductivity of 5,250 ft/d, a value that is consistent with clean gravels (Freeze and Cherry 1979).
- Vesicular lavas, which were assigned a horizontal hydraulic conductivity of 2,460 ft/d; this value was calculated using the two previously described hydraulic conductivity values so the effective hydraulic conductivity of the entire formation was equal to the model calibrated value of 1,500 ft/d (TEC 2001).

The stochastic analysis indicated a dispersivity value of 50 ft. The upper limit of dispersivity was the value estimated by Souza and Voss (1987), who estimated a longitudinal value for unweathered basalt of 250 ft, based on the apparent thickness of the freshwater to saltwater transition zone. The existing transport model took the geometric mean of the upper and lower values of longitudinal dispersivity, for a final value of 112 ft.

Dispersivity is a property of the aquifer and is typically anisotropic. Near-horizontal layering of the lava flows in the site vicinity causes dispersion in the vertical direction to be significantly less than in the horizontal direction. Also, dispersion is greater in the direction of groundwater flow (longitudinal dispersion) than in the direction perpendicular to groundwater flow (transverse dispersion). Souza and Voss (1987) estimated a vertical to longitudinal ratio of 0.004, and stated that transverse dispersivity value varies between 0.05 and 0.33 of the longitudinal dispersivity value. In the previous transport model, values for longitudinal dispersivity were specified to be 5, 3, and 34 meters for caprock, sediment, and basalt, respectively. The model also applied the transverse to longitudinal dispersivity ratio of 0.1 and a vertical to longitudinal dispersivity ratio of 0.01 (DON 2007). Changes to these values are not recommended at this time.

### 5.5.5 Degradation

As discussed in Section 5.2, available time-series data for groundwater concentrations beneath RHSF indicate historical fuel leaks caused a release of petroleum-related constituents to the groundwater, notably TPH-d and naphthalene, in monitoring wells underlying the USTs and, to a lesser extent, in the nearby downgradient area. Available data also shows decreasing concentrations both over time, and with distance from the USTs, which may be attributable to ongoing natural attenuation. For example, concentrations of these constituents in monitoring wells RHMW-01 and RHMW-02 decreased steadily from 2005 to 2013. Together with the spatial distribution of NAP concentrations, these data indicate natural attenuation mechanisms have and continue to degrade the petroleum-related constituents in the groundwater.

Unless more definitive data become available to estimate degradation rates, these site-specific time-series concentration data will be used to estimate decay rates for these constituents in the CF&T model. It is anticipated that the updated model will be run initially using MODFLOW/MT3DMS with the advection and dispersion parameters held constant, and then the degradation rates will be adjusted to obtain a match with the time-series data from the onsite monitoring wells.

### 5.5.6 Initial Concentrations

The chemical parameter values in the CF&T model will be specified to be consistent with the available data and chemical characteristics of the groundwater, including NAPs and COPCs in the source area, and the conceptual model for groundwater, geology and LNAPL.

## 5.6 CALIBRATION

The CF&T modeling parameters will be adjusted to simulate observed groundwater concentrations over time. Calibration will be performed using a systematic, objective, iterative process. Parameters in both the flow and CF&T models will be adjusted to match the available site data. This may include adjustment of hydraulic parameters, transport parameters (e.g., dispersivity and porosity), and chemical parameters (e.g., degradation rates, and reaction rates if RT3D is used). Calibration of the CF&T model will include matching the available time-series concentration data at monitoring wells and the areal extent of the dissolved constituents, as defined by the anticipated new data. If discrepancies between the flow model and available groundwater quality data are identified, the flow model parameters may be adjusted during transport calibration, and vice versa. Contaminant source characterization is also important to achieve realistic predictions from the CF&T model. The calibrated flow and transport models will be used for the predictive transport simulations.

## 5.7 PREDICTIVE TRANSPORT SIMULATIONS

To assist in evaluating the potential water quality effects of groundwater migrating from areas potentially affected by fuel leaks from RHSF, hypothetical fuel release scenarios will be modeled to evaluate the water quality changes in downgradient supply wells. This modeling will proceed after calibrating the groundwater flow and CF&T model to available site data. The CF&T predictive modeling would be performed similar to that previously conducted (DON 2007), including conducting a series of model simulations assuming hypothetical source area plumes, with step-wise increases in the areal extent and concentrations of dissolved COPCs beneath the Red Hill tank area. The modeled concentrations at the potential receptor points will be compared to water quality criteria (MCLs and EALs). This evaluation will evaluate the size of a fuel plume, if it were to reach the water table beneath RHSF, which could cause dissolved COPC levels in groundwater to exceed the MCL or EAL in downgradient supply wells.

It is anticipated that the CF&T model predictions will be used to update the site-specific risk-based levels for the COPCs. This will include simulating the migration of dissolved COPCs from RHSF various pumping scenarios. The updated CF&T model will also be used to support a feasibility study of potential remedial alternatives, including monitored natural attenuation. The model may also help contingency planning conducted by others.

The CF&T model will be applied to the flow model scenarios listed in Section 4.5 of this Modeling WP/SOW, to predict groundwater concentrations of COPCs under those listed scenarios.

### 5.8 SENSITIVITY ANALYSIS

Sensitivity analyses will be performed for CF&T parameters to evaluate the uncertainty associated with the model input parameters, including hydraulic conductivity, recharge, porosity, dispersivity, and degradation. Results of the sensitivity analysis will be ranked and described qualitatively.

## 6. Reporting

A Groundwater Modeling Report and Contaminant Fate and Transport Model Report will be prepared to provide the following:

- Description of model construction, including boundary conditions, well details and flow rates
- Flow model calibration results
- Description of flow model sensitivity analyses
- Description of transport model calibration and sensitivity analysis, including parameter development
- Groundwater flow model predictive simulation results
- CF&T model predictive simulation results
- Conclusions and recommendations
- Pertinent model files will be included on a compact disc

In addition, predictive modeling results such as future plume migration to support the updated health risk assessment, remedial alternatives evaluation, and contingency planning may also be conducted.

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