

Final Fourth Quarter 2015 - Quarterly Groundwater Monitoring Report Inside Tunnel Wells

**Red Hill Bulk Fuel Storage Facility
Joint Base Pearl Harbor-Hickam, Oahu, Hawaii**

DOH Facility ID No.: 9-102271

DOH Release ID No.: 990051, 010011, 020028, and 140010

January 2016

**Department of the Navy
Naval Facilities Engineering Command, Hawaii
400 Marshall Road
JBPHH HI 96860-3139**



Contract Number N62742-14-D-1884, CTO 0014

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Prepared for:



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Naval Facilities Engineering Command, Hawaii
400 Marshall Road
JBPHH HI 96860-3139**

Prepared by:

**Element Environmental, LLC
98-030 Hekaha Street, Unit 9
Aiea, HI 96701**

Prepared under:

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**Fourth Quarter 2015 - Quarterly Groundwater
Monitoring Report, Inside Tunnel Wells**

DOH Facility ID: 9-102271

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Prepared for:

**Naval Supply Systems Command
Fleet Logistics Center Pearl Harbor
1942 Gaffney Street, Building 475
Joint Base Pearl Harbor-Hickam , HI 96860-4549**

Prepared by:

**Element Environmental, LLC.
98-030 Hekaha Street, Suite 9
Aiea, Hawaii 96701**



Contract Number N62742-14-D-1884, CTO 0014

January 2016

A handwritten signature in black ink that reads "Matthew Neal".

Approval Signature:

Matthew Neal, E2 Project Manager

26 January 2016

Date

Approval Signature:

Marvin Heskett E2 Senior Chemist

26 January 2016

Date

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ACRONYMS AND ABBREVIATIONS

ACRONYMS/ ABBREVIATIONS	DEFINITION/MEANING
bgs	below ground surface
COPC	Contaminant of Potential Concern
DLNR	State of Hawaii Department of Land and Natural Resources
DoD	Department of Defense
DOH	State of Hawaii Department of Health
DON	Department of the Navy
E2	Element Environmental, LLC
EAL	Environmental Action Level
EPA	Environmental Protection Agency
ESI	Environmental Science International, Inc.
F-76	Marine Diesel Fuel
ID	Identification
JBPHH	Joint Base Pearl Harbor-Hickam
JP-5	Jet Fuel Propellant-5
JP-8	Jet Fuel Propellant-8
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LOD	Limit of Detection
LOQ	Limit of Quantitation
µg/L	micrograms per liter
MDL	Method Detection Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
NAVFAC	Naval Facilities Engineering Command
NAVSUP FLC	Naval Supply Systems Command Fleet Logistics Center
PAH	Polycyclic Aromatic Hydrocarbons
PARCCS	Precision, Accuracy, Representativeness, Completeness, Comparability, and Sensitivity
pH	hydrogen activity
QSM	Quality Systems Manual
QC	Quality Control
RHSF	Red Hill Bulk Fuel Storage Facility
RPD	Relative Percent Difference
SAP	Sampling and Analysis Plan
SSRBL	Site-Specific Risk-Based Level
TEC	The Environmental Company, Inc.
TPH	Total Petroleum Hydrocarbons
TPH-d	Total Petroleum Hydrocarbons as diesel
TPH-g	Total Petroleum Hydrocarbons as gasoline
TPH-o	Total Petroleum Hydrocarbons as oil
U.S.	United States of America
UST	Underground Storage Tank
VOC	Volatile Organic Compound
WP	Work Plan

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EXECUTIVE SUMMARY

This quarterly groundwater monitoring report presents the results of the fourth quarter 2015 groundwater sampling event, conducted on 20 October 2015, at the Red Hill Bulk Fuel Storage Facility [RHSF], Joint Base Pearl Harbor-Hickam [JBPHH], Hawaii. The RHSF is located in Halawa Heights on the Island of Oahu. There are 18 active and 2 inactive Underground Storage Tanks [USTs] located at the RHSF. The State of Hawaii Department of Health [DOH] Facility Identification [ID] number is 9-102271. The DOH Release ID numbers are 990051, 010011, 020028, and 140010.

The groundwater sampling was conducted as part of the long-term groundwater and soil vapor monitoring program at the RHSF and concurrent with release response activities initiated at Tank 5 in January 2014, for Naval Supply Systems Command Fleet Logistics Center [NAVSUP FLC] Pearl Harbor (formerly Fleet and Industrial Supply Center), under Naval Facilities Engineering Command [NAVFAC] Contract Number N62742-12-D-1853. The sampling was conducted in accordance with the approved 2012 Work Plan [WP]/Sampling and Analysis Plan [SAP] prepared by Environmental Science International, Inc. [ESI].

On 20 October 2015, E2 personnel collected groundwater samples from four monitoring wells at the RHSF (wells RHMW01, RHMW02, RHMW03, and RHMW05) and one sampling point at Red Hill Shaft (RHMW2254-01) during the Fourth Quarter 2015 groundwater monitoring event. One primary and one duplicate sample were collected from well RHMW02.

Analytical results from the Fourth Quarter 2015 groundwater monitoring event were compared to DOH Tier 1 Environmental Action Levels [EALs] specific to the sample locations' distance to the nearest surface water, whether greater or less than 150 meters. Wells RHMW01, RHMW02, RHMW03, and RHMW05 are each more than 150 meters from the nearest surface water (Halawa Stream). Sample point RHMW2254-01 is located within 150 meters of the nearest surface water (Halawa Stream). Analytical results for wells RHMW01, RHMW02, RHMW03, and RHMW05 were also compared to the Site-Specific Risk-Based Levels [SSRBLs] for total petroleum hydrocarbons [TPH] (4,500 micrograms per liter [$\mu\text{g/L}$]) and benzene (750 $\mu\text{g/L}$), established in the 2008 RHSF *Final Groundwater Protection Plan*. A summary of the analytical results is provided below:

- **RHMW01** – Analytes detected in groundwater were total petroleum hydrocarbons as diesel fuel [TPH-d] (330 $\mu\text{g/L}$), polycyclic aromatic hydrocarbons [PAHs] acenaphthene (0.027 $\mu\text{g/L}$), fluorene (0.026 $\mu\text{g/L}$) 1-methylnaphthalene (0.037 $\mu\text{g/L}$), 2-methylnaphthalene (0.024 $\mu\text{g/L}$), and naphthalene (0.20 $\mu\text{g/L}$), volatile organic compound (VOC) toluene (0.42 $\mu\text{g/L}$) and dissolved lead (0.166 $\mu\text{g/L}$). Toluene was also detected in the trip blank at a similar concentration (0.89 $\mu\text{g/L}$), likely indicating contamination from outside activities that occurred on the day of sampling (fuel system repair operations were being conducted within the tunnels during the 20 October sampling event). TPH-o and methylene chloride were also detected, but were found in the laboratory method blank at comparable levels, likely resulting from laboratory contamination. Likely lab contaminant detections are presented as non-detects (NDs) in the data summary tables within this report. The concentration of TPH-d exceeded the DOH Tier 1

EAL, but did not exceed the SSRBL. TPH-d concentrations have shown an overall decreasing trend from a high of 1,500 µg/L in February 2005.

- **RHMW02** – Concentrations of TPH-d (6,100 and 6,200 µg/L), TPH as oil (TPH-o) (310 and 320 µg/L), 1-methylnaphthalene (60 and 57 µg/L), 2-methylnaphthalene (27 and 24 µg/L), and naphthalene (120 and 88 µg/L) were detected in both the primary and duplicate samples exceeding their respective DOH Tier 1 EALs. Concentrations of TPH-d exceeded the SSRBL of 4,500 µg/L. Concentrations of TPH as gasoline (TPH-g) (47 µg/L in both primary and duplicate samples), several other PAHs, several VOCs and lead (0.08 and 0.039 µg/L) were detected below their respective DOH Tier 1 EALs. Toluene was also detected in the trip blank at a similar concentration (0.89 µg/L), likely indicating contamination from outside activities that occurred on the day of sampling (fuel system repair operations were being conducted within the tunnels during the 20 October sampling event). PAH benz(a)anthracene was also detected, but was found in the laboratory method blank at a comparable level, likely resulting from laboratory contamination. The benz(a)anthracene detection is presented as ND in the data summary tables within this report. Concentrations of 1-methylnaphthalene, 2-methylnaphthalene, and naphthalene decreased slightly from the July 2015 event.
- **RHMW03** – The only analytes detected in groundwater were TPH-d (130 µg/L), TPH-o (160 µg/L), 1-methylnaphthalene (0.0039 µg/L), 2-methylnaphthalene (0.0034 µg/L), naphthalene (0.0094 µg/L), toluene (0.40 µg/L) and dissolved lead (0.122 µg/L). Toluene was also detected in the trip blank at a similar concentration (0.89 µg/L), likely indicating contamination from outside activities that occurred on the day of sampling (fuel system repair operations were being conducted within the tunnels during the 20 October sampling event). The concentrations of TPH-d and TPH-o exceeded their respective DOH Tier 1 EALs, but TPH-d did not exceed the SSRBL.
- **RHMW05** – The only analytes detected were TPH-d (20 µg/L), PAHs 1-methylnaphthalene (0.005 µg/L), 2-methylnaphthalene (0.0066 µg/L), naphthalene (0.0074 µg/L), VOC toluene (0.59 µg/L) and dissolved lead (0.103 µg/L). Toluene, benz(a)anthracene and methylene chloride were also detected, but were found in the laboratory method blank at comparable levels, likely resulting from laboratory contamination. Likely lab contaminant detections are presented as ND in the data summary tables within this report. Toluene was also detected in the trip blank at a similar concentration (0.89 µg/L), likely indicating contamination from outside activities that occurred on the day of sampling (fuel system repair operations were being conducted within the tunnels during the 20 October sampling event). None of the detected concentrations exceeded the DOH Tier 1 EALs.
- **RHMW2254-01** – The only analytes detected in groundwater were toluene (0.99 µg/L) and total lead (0.253 µg/L). Toluene was also detected in the trip blank at a similar concentration (0.89 µg/L), likely indicating contamination from outside activities that occurred on the day of sampling (fuel system repair operations were being conducted within the tunnels during the 20 October sampling event). TPH-d, TPH-o, naphthalene and methylene chloride were also detected, but were found in the laboratory method blank at comparable levels, likely resulting from laboratory contamination. Likely lab contaminant detections are presented as ND in the

data summary tables within this report. None of the detected concentrations exceeded the DOH Tier 1 EALs.

During this quarterly event, the concentrations of TPH-d in RHMW01, RHMW02, and RHMW03; TPH-o in RHMW02 and RHMW03; and 1-methylnaphthalene, 2-methylnaphthalene, and naphthalene in RHMW02 were detected at concentrations exceeding the DOH Tier 1 EALs. The concentrations of TPH-d in RHMW02 were above the SSRBL. Groundwater contaminant concentrations in RHMW05, and RHMW2254-01 remained at low concentrations and did not change significantly from the previous event, or were not detected.

Concentrations of 1-methylnaphthalene, 2-methylnaphthalene, and naphthalene in RHMW02 decreased since the July 2015 event but continue to be elevated and have shown a generally increasing trend since March 2014. During the April 2015 event, the concentration of TPH-d in RHMW02 increased to its highest level since October 2008 and to a level similar to that reached in January 2014; during this October 2015 event the TPH-d concentration increased to its highest level since monitoring began in 2005 and exceeded the SSRBL. All other analytical results were generally consistent with historical data.

Based on the groundwater monitoring results and the reported release at Tank 5 in January 2014, continued groundwater monitoring at the wells inside the RHSF tunnel is recommended. The next quarterly event is tentatively scheduled for January 2016.

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SECTION 1 – INTRODUCTION

This quarterly groundwater monitoring report presents the results of the fourth quarter 2015 groundwater sampling conducted by Element Environmental, LLC (E2) on 20 October 2015 at the RHSF, JBPHH. The RHSF is located in Halawa Heights on the Island of Oahu. The purpose of the sampling is to (1) assess the condition of groundwater beneath the RHSF with respect to chemical constituents associated with jet fuel propellant and marine diesel fuel, and (2) to ensure the Navy remains in compliance with DOH UST release response requirements as described in Hawaii Administrative Rules Chapter 11-281 Subchapter 7, *Release Response Action* (DOH, 2013). The DOH Facility ID number for the RHSF is 9-102271. The DOH Release ID numbers are 990051, 010011, 020028, and 140010.

The groundwater sampling was conducted as part of the long-term groundwater and soil vapor monitoring program at the RHSF for NAVSUP FLC Pearl Harbor, under NAVFAC Contract Number N62742-14-D-1884. The sampling was conducted in accordance with the approved WP/SAP prepared by E2 (E2, 2015).

1.1 SITE DESCRIPTION

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

The RHSF contains 18 active and 2 inactive USTs that are operated by NAVSUP FLC Pearl Harbor. Each UST has a capacity of approximately 12.5 million gallons. The RHSF is located approximately 100 feet above the basal aquifer. The USTs contain Jet Fuel Propellant-5 [JP-5], Jet Fuel Propellant-8 [JP-8], and Marine Diesel Fuel [F-76]. The current status of each UST is summarized in Table 1.1.

Four groundwater monitoring wells (wells RHMW01, RHMW02, RHMW03, and RHMW05) and one sampling point at Red Hill Shaft (RHMW2254-01) are located within the RHSF lower access tunnel. Five groundwater monitoring wells (wells HDMW2253-03, OWDFMW01, RHMW04, RHMW06, and RHMW07) are located outside of the RHSF tunnel system. Monitoring data for the five wells located outside the tunnel are included in a separate report.

As noted, monitoring wells RHMW01, RHMW02, RHMW03, and RHMW05 are located inside the underground tunnels. Sampling point RHMW2254-01 is located inside the infiltration gallery of the Department of the Navy [DON] drinking water supply Well 2254-01. The DON Well 2254-01 is

located approximately 2,400 feet downgradient of the USTs and provides potable water to the JBPHH Water System, which serves approximately 65,200 military customers. NAVFAC Public Works Department operates the infiltration gallery and DON Well 2254-01.

TABLE 1.1
Current Status of the USTs
Red Hill Bulk Fuel Storage Facility

Tank Identification	Fuel Type	Status	Capacity
F-1	None	Inactive	12.5 million gallons
F-2	JP-8	Active	12.5 million gallons
F-3	JP-8	Active	12.5 million gallons
F-4	JP-8	Active	12.5 million gallons
F-5	JP-8	Active	12.5 million gallons
F-6	JP-8	Active	12.5 million gallons
F-7	JP-5	Active	12.5 million gallons
F-8	JP-5	Active	12.5 million gallons
F-9	JP-5	Active	12.5 million gallons
F-10	JP-5	Active	12.5 million gallons
F-11	JP-5	Active	12.5 million gallons
F-12	JP-5	Active	12.5 million gallons
F-13	F-76	Active	12.5 million gallons
F-14	F-76	Active	12.5 million gallons
F-15	F-76	Active	12.5 million gallons
F-16	F-76	Active	12.5 million gallons
F-17	JP-5	Active	12.5 million gallons
F-18	JP-5	Active	12.5 million gallons
F-19	None	Inactive	12.5 million gallons
F-20	JP-5	Active	12.5 million gallons

F-76 Marine Diesel Fuel
 JP-5 Jet Fuel Propellant-5
 JP-8 Jet Fuel Propellant-8

1.2 PHYSICAL SETTING

Climatological conditions in the area of the RHSF consist of warm to moderate temperatures and low to moderate rainfall. The RHSF is leeward of the prevailing northeasterly trade winds. The average annual precipitation is approximately 40 inches, which occurs mainly between November and April (State of Hawaii Department of Land and Natural Resources [DLNR], 1986). Annual pan evaporation is approximately 75 inches (DLNR, 1985). Average temperatures range from the low 60's to high 80's (degrees Fahrenheit) (Atlas of Hawaii, 1983).

Oahu consists of the eroded remnants of two shield volcanoes, Waianae and Koolau. The RHSF is located on the southwest flank of the Koolau volcanic shield. Lavas erupted during the shield-building phase of the volcano belong to the *Koolau Volcanic Series* (Stearns and Vaksvik, 1935). Following formation of the Koolau shield, a long period of volcanic quiescence occurred, during which the shield was deeply eroded. Following this erosional period, eruptive activity resumed. Lavas and pyroclastic material erupted during this period belong to the *Honolulu Volcanic Series*

(Stearns and Vaksvik, 1935).

In the immediate area of the RHSF, Koolau Volcanic Series lavas dominate, although there are consolidated and unconsolidated non-calcareous deposits in the vicinity that consist of alluvium generated during erosion of the Koolau volcanic shield. South-southwest of the RHSF, and in isolated exposures to the west, are pyroclastic deposits formed during eruptions from three Honolulu Volcanic Series vents, Salt Lake, Aliamanu, and Makalapa (Stearns and Vaksvik, 1935). Based on established geology and records of wells drilled at the RHSF (Stearns and Vaksvik, 1938), the RHSF is underlain by Koolau Volcanic Series basalts. The area of the RHSF is classified as *Rock Land*, where 25-90% of the land surface is covered by exposed rock and there are only shallow soils (Foote, et al., 1972).

Groundwater in Hawaii exists in two principal aquifer types. The first and 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 Oahu, 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 second 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. However, in the area of the RHSF, there is no discernible caprock.

Groundwater in the area of the RHSF is part of the *Waimalu Aquifer System* of the *Pearl Harbor Aquifer Sector*. The aquifer is classified as a basal, unconfined, flank-type; and is currently used as a drinking water source. The aquifer is considered fresh, with less than 250 milligrams per liter of chloride, and is considered an irreplaceable resource with a high vulnerability to contamination (Mink and Lau, 1990).

The nearest drinking water supply well is DON Well 2254-01, located in the infiltration gallery within the RHSF lower tunnel. The DON Well 2254-01 is located approximately 2,400 feet hydraulically and topographically downgradient of the USTs.

The nearest body of surface water is Halawa Stream, an ephemeral stream that is present along the north side of the RHSF. Except for the portion to the east of the Halawa Correctional Facility, the stream is contained by a concrete culvert. The stream is usually dry, but flows after periods of significant rainfall.

Wells RHMW01, RHMW02, RHMW03, and RHMW05 are all located greater than 150 meters of any portion of Halawa Stream. Sampling point RHMW2254-01 is located within 150 meters of a

portion of Halawa Stream. The distance of each well and sample point to Halawa Stream is presented in Table 1.2

TABLE 1.2
Distance of Wells/Sample Point to Halawa Stream
Red Hill Bulk Fuel Storage Facility

Well/Sample Point	Distance to Halawa Stream (meters)
RHMW2254-01	84.67
RHMW01	231.77
RHMW02	298.61
RHMW03	270.53
RHMW05	225.14

1.3 BACKGROUND

The RHSF was constructed by the U.S. Government in the early 1940s. Twenty USTs and a series of tunnels were constructed. The USTs were constructed of steel, and in the past have stored DON special fuel oil, DON distillate, aviation gasoline, and motor gasoline (Environet, 2010). The tanks currently contain JP-5, JP-8, and F-76. The fueling system is a self-contained underground unit that was installed into native rock comprised primarily of basalt with some interbedded tuffs and breccias (Environet, 2010). Each UST measures approximately 250 feet in height and 100 feet in diameter. The upper domes of the tanks lie at a depth varying between 100 feet and 200 feet below ground surface [bgs].

In 1998, Earth Tech conducted a Phase II Remedial Investigation/Feasibility Study for the Oily Waste Disposal Facility located within the RHSF. The study included the installation of well OWDFMW01 (which was originally MW08) (Earth Tech, 1999).

In February 2001, the DON installed groundwater monitoring well RHMW01 to monitor for contamination in the basal aquifer beneath the RHSF. Well RHMW01 was installed approximately 100 feet below grade within the lower access tunnel. The depth to water was measured at 86 feet below the tunnel floor at the time of the well completion. In February 2001, a groundwater sample was collected from the well. TPH and total lead were detected in the sample. Total lead was detected at a concentration above the DOH Tier 1 groundwater action level of 5.6 µg/L (The Environmental Company, Inc. [TEC], 2009; DOH, 2000).

In 2005, the RHSF groundwater monitoring program was initiated. It involved routine groundwater sampling of well RHMW01 and sampling point RHMW2254-01. Samples were collected in February, June, September, and December of 2005. Lead was detected at concentrations above the DOH Tier 1 action level of 5.6 µg/L in samples collected in February and June. The samples collected in February and June were not filtered prior to analysis, whereas the samples collected in September and December were filtered prior to analysis. Since the samples collected in February and June were not filtered prior to analysis, the lead results were not considered appropriate for a risk assessment (TEC, 2008a).

Between June and September 2005, TEC installed three additional groundwater monitoring wells (wells RHMW02, RHMW03, and RHMW04) (TEC, 2008a). Well RHMW04 was installed hydraulically upgradient of the USTs to provide background geochemistry information for water moving through the basal aquifer beneath the RHSF. Wells RHMW02 and RHMW03 were installed approximately 125 feet below grade within the RHSF lower tunnel and well RHMW04 was installed to a depth of approximately 300 feet bgs outside of the RHSF tunnels. In September 2005, groundwater samples were collected from the three newly installed groundwater monitoring wells (wells RHMW02, RHMW03, and RHMW04) along with the existing well RHMW01 and sampling point RHMW2254-01. The contaminants of potential concern [COPCs] with concentrations that exceeded current DOH EALs are summarized below.

- **RHMW01** – TPH-d was detected at concentrations above the DOH EALs.
- **RHMW02** – TPH-g, TPH-d, naphthalene, trichloroethylene, 1-methylnaphthalene, and 2-methylnaphthalene were detected at concentrations above their respective DOH EALs.
- **RHMW03** – TPH-d was detected at concentrations above the DOH EALs.

In 2006, TEC installed dedicated sampling pumps in the four wells (wells RHMW01, RHMW02, RHMW03, and RHMW04) and one sampling point (RHMW2254-01). In July and December, groundwater samples were collected from the four wells and the sampling point. The COPCs with concentrations that exceeded current DOH EALs are summarized below.

- **RHMW01** – TPH-d and naphthalene were detected at concentrations above their respective DOH EALs.
- **RHMW02** – TPH-g, TPH-d, and naphthalene were detected at concentrations above their respective DOH EALs.
- **RHMW03** – TPH-d was detected at concentrations above the DOH EALs.

In 2007, SSRBLs were established for TPH (4,500 µg/L) and benzene (750 µg/L) based on the solubility of JP-5 and JP-8 in water (TEC, 2007). Groundwater samples were collected from wells RHMW01, RHMW02, and RHMW03, and sampling point RHMW2254-01 in March, June, and September. The COPCs with concentrations that exceeded current DOH EALs are summarized below.

- **RHMW01** – TPH-d was detected at concentrations above the DOH EALs, but below the SSRBL.
- **RHMW02** – TPH-g, TPH-d, naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene were detected at concentrations above their respective DOH EALs. The TPH-d concentrations were below the SSRBL.
- **RHMW03** – TPH-d was detected at concentrations above the DOH EALs, but below the SSRBL.

In 2008, groundwater samples were collected from wells RHMW01, RHMW02, and RHMW03, and sampling point RHMW2254-01. Samples were collected in January, April, July, and October. The COPCs with concentrations that exceeded current DOH EALs are summarized below. In addition, a groundwater protection plan (TEC, 2008a) was prepared.

- **RHMW01** – TPH-d was detected at concentrations above the DOH EALs, but below the SSRBL.
- **RHMW02** – TPH-d, naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene were detected at concentrations above their respective DOH EALs. The TPH-d concentrations detected in October 2008 were also above the SSRBL.
- **RHMW03** – TPH-d was detected at concentrations above the DOH EALs, but below the SSRBL.
- **RHMW2254-01** - Preliminary analytical results from the January 2008 sampling event indicated TPH-d was detected at an estimated concentration of 102 µg/l and above the DOH EAL. Upon review of the analytical data, the result was reported in the March 2008 *Quarterly Groundwater Monitoring Report* (TEC, 2008b) as rejected due to laboratory contamination observed in the associated laboratory blank. Well RHMW2254-01 was resampled, and split samples were sent to two laboratories (SGS Environmental Services in Anchorage, Alaska and Accutest Laboratories in Orlando, Florida) for analysis. Analytical results from both laboratories indicated TPH-d was not detected above the respective method detection limits of the laboratories, which were equal to or less than the DOH EAL.

Although rejected in the March 2008 *Quarterly Groundwater Monitoring Report*, the 15 January 2008 TPH-d concentration has previously been reported in project Cumulative Groundwater Results tables (Appendix A) as an estimated 102 µg/l, as reported by the analytical laboratory. With the *Second Quarter 2015 Quarterly Groundwater Monitoring Report, Inside Tunnel Wells*, the 15 January 2008 result was re-validated based on DON Procedure II-H, *Standard and Full Data Validation for Extractable Total Petroleum Hydrocarbons by SW-846 8015B*, (DON, 2007) and changed to “not detected” with a Limit of Detection [LOD] of 102 µg/l.

In April 2009, groundwater monitoring well RHMW05 was installed downgradient of the USTs, within the lower access tunnel between RHMW01 and RHMW2254-01. It was installed to identify the extent of contamination hydraulically downgradient of the USTs. Well RHMW05 was added to the quarterly groundwater sampling program. In 2009, quarterly groundwater samples were collected from wells RHMW01, RHMW02, RHMW03, and RHMW05, and sampling point RHMW2254-01. Samples were collected in February, May, July, and October. The COPCs with concentrations that exceeded current DOH EALs are summarized below. In addition, the Groundwater Protection Plan was revised to include well RHMW05.

- **RHMW01** – TPH-d and 1-methylnaphthalene were detected at concentrations above their respective DOH EALs. The TPH-d concentrations were below the SSRBL.

- **RHMW02** – TPH-d, naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene were detected at concentrations above their respective DOH EALs. The TPH-d concentrations were below the SSRBL.
- **RHMW03** – TPH-d was detected at a concentration above the DOH EALs, but below the SSRBL.
- **RHMW05** – TPH-d was detected at a concentration above the DOH EALs, but below the SSRBL.

In 2010, groundwater samples were collected from wells RHMW01, RHMW02, RHMW03, and RHMW05, and sampling point RHMW2254-01. Samples were collected in January, April, July, and October. The COPCs with concentrations that exceeded current DOH EALs are summarized below.

- **RHMW01** – TPH-d was detected at concentrations above the DOH EALs, but below the SSRBL.
- **RHMW02** – TPH-g, TPH-d, naphthalene, and 1-methylnaphthalene were detected at concentrations above their respective DOH EALs. The TPH-d concentrations were below the SSRBL.
- **RHMW03** – TPH-d was detected at a concentration above the DOH EALs, but below the SSRBL.
- **RHMW05** – TPH-d was detected at a concentration above the DOH EALs, but below the SSRBL.

In 2011, quarterly groundwater samples were collected from wells RHMW01, RHMW02, RHMW03, and RHMW05, and sampling point RHMW2254-01. Samples were collected in January, April, July, and October. In a Fall 2011 update, the DOH EALs were revised. The drinking water toxicity EAL for TPH-d decreased from 210 to 190 µg/L (DOH, 2011). The COPCs with concentrations that exceeded current DOH EALs are summarized below.

- **RHMW01** – TPH-d was detected at concentrations above the DOH EALs, but below the SSRBL.
- **RHMW02** – TPH-d, naphthalene, and 1-methylnaphthalene were detected at concentrations above their respective DOH EALs. The TPH-d concentrations were below the SSRBL.

In 2012, quarterly groundwater samples were collected from wells RHMW01, RHMW02, RHMW03, and RHMW05, and sampling point RHMW2254-01. Samples were collected in February, April, July, and November. The COPCs with concentrations that exceeded current DOH EALs are summarized below.

- **RHMW01** – TPH-d was detected at concentrations above the DOH EALs, but below the SSRBL.

- **RHMW02** – TPH-d, TPH-g, naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene were detected at concentrations above their respective DOH EALs. The TPH-d concentrations were below the SSRBL.

In 2013, quarterly groundwater samples were collected from wells RHMW01, RHMW02, RHMW03, and RHMW05, and sampling point RHMW2254-01. Samples were collected in January, April, July, and October. The COPCs with concentrations that exceeded current DOH EALs are summarized below.

- **RHMW01** – TPH-d was detected at concentrations above the DOH EALs, but below the SSRBL.
- **RHMW02** – TPH-d, TPH-g, naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene were detected at concentrations above their respective DOH EALs. The TPH-d concentrations were below the SSRBL.

In 2014, quarterly groundwater samples were collected from wells RHMW01, RHMW02, RHMW03, and RHMW05, and sampling point RHMW2254-01. Samples were collected in January, April, July, and October. The COPCs with concentrations that exceeded current DOH EALs are summarized below.

- **RHMW01** – TPH-d was detected at concentrations above the DOH EALs, but below the SSRBL.
- **RHMW02** – TPH-d, naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene were detected at concentrations above their respective DOH EALs. The TPH-d concentrations were below the SSRBL.

Between January and June 2014, additional groundwater sampling was conducted at wells RHMW01, RHMW02, RHMW05, and sampling point RHMW2254-01 in response to a reported release from Tank 5. The COPCs with concentrations that exceeded current DOH EALs are summarized below.

- **RHMW01** – TPH-d was detected at concentrations above the DOH EALs, but below the SSRBL.
- **RHMW02** – TPH-d, 1-methylnaphthalene, and naphthalene were detected at concentrations above their respective DOH EALs. The TPH-d concentrations were below the SSRBL.

Between August and October 2014, wells RHMW06 and RHMW07 were installed outside the RHSF tunnel system in order to develop a more robust groundwater monitoring network at the site (Battelle, 2015). The wells were sampled in October 2014 and January 2015, and subsequently included in the quarterly sampling conducted as part of the long-term groundwater and soil vapor monitoring program at the RHSF. Monitoring data for these wells are included in a separate report.

In January 2015, quarterly groundwater samples were collected from wells RHMW01, RHMW02, RHMW03, and RHMW05, and sampling point RHMW2254-01. The COPCs with concentrations that exceeded current DOH EALs are summarized below.

- **RHMW02** – TPH-d, naphthalene, and 1-methylnaphthalene were detected at concentrations above their respective DOH EALs. The TPH-d concentrations were below the SSRBL.

In April 2015, quarterly groundwater samples were collected from wells RHMW01, RHMW02, RHMW03, and RHMW05, and sampling point RHMW2254-01. The COPCs with concentrations that exceeded current DOH EALs are summarized below.

- **RHMW01** – TPH-d was detected at a concentration above the DOH EALs, but below the SSRBL.
- **RHMW02** – TPH-d, TPH-o, naphthalene, and 1-methylnaphthalene were detected at concentrations above their respective DOH EALs. The TPH-d concentrations exceeded the SSRBL.
- **RHMW03** – TPH-d and TPH-o were detected at concentrations above the DOH EALs, but below the SSRBL.

On 25 June 2015, ESI personnel collected groundwater samples from wells RHMW01, RHMW02, and RHMW05 at the RHSF as part of an additional groundwater sampling event. The additional sampling event was conducted in response to the results of the April 2015 groundwater sampling event. The samples were analyzed for TPH-d, TPH-o, 1-methylnaphthalene, 2-methylnaphthalene, and naphthalene. The COPCs with concentrations that exceeded current DOH EALs are summarized below.

- **RHMW01** – TPH-d was detected at concentrations above the DOH EALs, but below the SSRBL.
- **RHMW02** – TPH-d, TPH-o, naphthalene, 1-methylnaphthalene, 2-methylnaphthalene, and naphthalene were detected at concentrations above their respective DOH EALs. The TPH concentrations did not exceed the SSRBL.

On 20 and 21 July 2015, ESI personnel collected groundwater samples from wells RHMW01, RHMW02, RHMW03, and RHMW05 and sampling point RHMW2254-01 during the Third Quarter 2015 groundwater monitoring event. The COPCs with concentrations that exceeded current DOH EALs are summarized below.

- **RHMW01** – TPH-d was detected at a concentration that exceeded the DOH Tier 1 EAL, but did not exceed the SSRBL.
- **RHMW02** – Concentrations of TPH-d, TPH-o, 1-methylnaphthalene, 2-methylnaphthalene, and naphthalene were detected in both the primary and duplicate samples exceeding their respective DOH Tier 1 EALs. The concentrations of TPH did not exceed the SSRBL.

- **RHMW03** – Concentrations of TPH-d and TPH-o exceeded their respective DOH Tier 1 EALs, but did not exceed the SSRBL.

1.3.1 Previous Reports

The following groundwater monitoring reports for wells located inside the underground tunnels and infiltration gallery were previously submitted to DOH:

1. Groundwater Sampling Report, First Quarter 2005 (submitted April 2005).
2. Groundwater Sampling Report, Second Quarter 2005 (submitted August 2005).
3. Groundwater Sampling Report, Third Quarter 2005 (submitted November 2005).
4. Groundwater Sampling Report, Fourth Quarter 2005 (submitted February 2006).
5. Groundwater Monitoring Results, July 2006 (submitted September 2006).
6. Groundwater Monitoring Results, December 2006 (submitted January 2007).
7. Groundwater Monitoring Results, March 2007 (submitted May 2007).
8. Groundwater Monitoring Results, June 2007 (submitted August 2007).
9. Groundwater Monitoring Results, September 2007 (submitted October 2007).
10. Groundwater Monitoring Report, January 2008 (submitted March 2008).
11. Groundwater Monitoring Report, April 2008 (submitted May 2008).
12. Groundwater Monitoring Report, July 2008 (submitted October 2008).
13. Groundwater Monitoring Report, October and December 2008 (submitted February 2009).
14. Groundwater Monitoring Report, February 2009 (submitted May 2009).
15. Groundwater Monitoring Report, May 2009 (submitted July 2009).
16. Groundwater Monitoring Report, July 2009 (submitted September 2009).
17. Groundwater Monitoring Report, October 2009 (submitted December 2009).
18. Groundwater Monitoring Report, January, February, and March 2010 (submitted April 2010).
19. Groundwater Monitoring Report, April 2010 (submitted May 2010).
20. Groundwater Monitoring Report, July 2010 (submitted August 2010).
21. Groundwater Monitoring Report, October 2010 (submitted December 2010).
22. Groundwater Monitoring Report, January 2011 (submitted March 2011).
23. Groundwater Monitoring Report, April 2011 (submitted June 2011).
24. Groundwater Monitoring Report, July 2011 (submitted September 2011).
25. Groundwater Monitoring Report, October 2011 (submitted December 2011).
26. Groundwater Monitoring Report, January-February 2012 (submitted March 2012).

27. Groundwater Monitoring Report, April 2012 (submitted July 2012).
28. Groundwater Monitoring Report, October 2012 (submitted January 2013).
29. Groundwater Monitoring Report, January 2013 (submitted April 2013).
30. Groundwater Monitoring Report, April 2013 (submitted July 2013).
31. Groundwater Monitoring Report, July 2013 (submitted September 2013).
32. Groundwater Monitoring Report, October 2013 (submitted January 2014).
33. Groundwater Sampling Report for Additional Sampling, January 2014 (submitted January 2014).
34. Groundwater Monitoring Report, January 2014 (submitted April 2014).
35. Groundwater Sampling Report for Tank 5 Release Response on March 5 and 6, 2014 (submitted March 2014).
36. Groundwater Sampling Report for Tank 5 Release Response on March 10, 2014 (submitted March 2014).
37. Groundwater Sampling Report for Tank 5 Release Response on March 25 and 26, 2014 (submitted April 2014).
38. Groundwater Sampling Report for Tank 5 Release Response on April 7, 2014 (submitted April 2014).
39. Groundwater Monitoring Report, April 2014 (submitted June 2014).
40. Groundwater Sampling Report for Tank 5 Release Response on May 27 and 28, 2014 (submitted June 2014).
41. Groundwater Sampling Report for Tank 5 Release Response on June 23 and 24, 2014 (submitted July 2014).
42. Groundwater Monitoring Report, July 2014 (submitted September 2014).
43. Groundwater Monitoring Report, October 2014 (submitted January 2015).
44. Groundwater Monitoring Report, January 2015 (submitted March 2015).
45. Groundwater Monitoring Report, April 2015 (submitted August 2015).
46. Groundwater Monitoring Report, July 2015 (submitted November 2015).

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SECTION 2 – GROUNDWATER SAMPLING

On 20 October 2015, E2 personnel collected groundwater samples from four monitoring wells at the RHSF (wells RHMW01, RHMW02, RHMW03, and RHMW05) and one sampling point at Red Hill Shaft (RHMW2254-01). All samples were collected in accordance with the 2015 WP/SAP. The WP/SAP is consistent with DOH UST release response requirements (DOH, 2000); DON Procedure I-C-3, *Monitoring Well Sampling* (DON, 2007); and the Interim Update, RHSF Final Groundwater Protection Plan (TEC, 2014). Prior to purging and sampling, the depth to groundwater and the depth to the bottoms of the wells were measured using a Solinst oil/water interface probe. No measurable product, sheen, or petroleum hydrocarbon odor was detected in any of the wells.

2.1 GROUNDWATER SAMPLING

Prior to collecting groundwater samples, the monitoring wells were purged of standing water in the well casings. Each well contains a dedicated bladder pump which was used to purge the well and to collect samples. The groundwater wells were purged at flow rates of approximately 0.08 to 0.26 liters per minute.

To operate the pump, a portable air compressor with an in-line filter was connected to a QED MP50 MicroPurge[®] Basics Controller box, which was then connected to the pump. The compressor was turned on to power the pump and the controller was used to adjust the pumping rate to less than one liter of water per minute.

Water quality parameters were monitored on a periodic basis during well purging. The water quality parameters that were measured included hydrogen activity [pH], temperature, conductivity, dissolved oxygen, and oxidation reduction potential. The water quality parameters were evaluated to assess whether the natural characteristics of the aquifer formation water were present within the monitoring wells before collecting the samples. At least four readings were collected during the purging process. Purging was considered complete when at least three consecutive water quality measurements stabilized within approximately 10%. The readings were recorded on groundwater monitoring logs. The groundwater monitoring logs are included in Appendix B. In addition, field notes were taken to document the sampling event. The field notes are included in Appendix C.

When the water quality parameters stabilized, groundwater samples were collected from the wells using the bladder pumps. The groundwater samples were collected no more than two hours after purging was completed to decrease groundwater interaction with the monitoring well casing and atmosphere. Prior to collecting the sample, the water level in the monitoring wells was measured and recorded to ensure that excessive drawn down had not occurred. Samples collected for dissolved lead analysis were filtered in the field using new, 0.45-micron filters.

All samples were labeled and logged on the Sample Inventory Log, placed in Ziploc[™] bags and sealed, custody sealed, sealed with tape, placed in a cooler with wet ice, and logged onto the Chain-of-Custody form. The samples were labeled and logged in accordance with DON Procedure III-E, *Record Keeping, Sample Labeling, and Chain-of-Custody Procedures* (DON, 2007). All

samples were shipped under Chain-of-Custody to the analytical laboratory and analyzed for the COPCs as described in Section 2.2.

2.2 ANALYTICAL RESULTS

The samples were analyzed for TPH-g, TPH-d, and TPH-o using Environmental Protection Agency [EPA] Method 8015C; VOCs using EPA Methods 8260C, 8260-SIM, and 8011; PAHs using EPA Method 8270D SIM; dissolved lead using EPA Method 6020; and total lead using EPA Method 200.8. The sample collected from sampling point RHMW2254-01 was analyzed for total lead (unfiltered) as the sampling point is a drinking water supply infiltration shaft. A copy of the laboratory report is included as Appendix D.

Analytical results were compared to DOH Final Groundwater Tier 1 EALs specific to the sample locations' distance to the nearest surface water, whether greater or less than 150 meters. Wells RHMW01, RHMW02, RHMW03, and RHMW05 are each more than 150 meters from the nearest surface water (Halawa Stream). Sample point RHMW2254-01 is located within 150 meters of the nearest surface water (Halawa Stream). Analytical results for wells RHMW01, RHMW02, RHMW03, and RHMW05 were also compared to the SSRBLs for TPH (4,500 µg/L) and benzene (750 µg/L), established in the RHSF *Final Groundwater Protection Plan* (TEC, 2008a). The results of the third quarter groundwater sampling event are summarized in Table 2.1 and described below. For ease of reading, only analytical results for chemicals that have been detected since 2010 are presented in Table 2.1. A description of laboratory data qualifiers, definitions of the terms Method Detection Limit [MDL], LOD, and Limit of Quantitation [LOQ], and basic concepts of those terms are presented in the Fact Sheet included as Appendix D.

- **RHMW01** – Analytes detected in groundwater were TPH-d (330 µg/L), PAHs acenaphthene (0.027 µg/L), fluorene (0.026 µg/L) 1-methylnaphthalene (0.037 µg/L), 2-methylnaphthalene (0.024 µg/L), and naphthalene (0.20 µg/L), VOC toluene (0.42 µg/L) and dissolved lead (0.166 µg/L). Toluene was also detected in the trip blank at a similar concentration (0.89 µg/L), likely indicating contamination from outside activities that occurred on the day of sampling (fuel system repair operations were being conducted within the tunnels during the 20 October sampling event). TPH-o and methylene chloride were also detected, but were found in the laboratory method blank at comparable levels, likely resulting from laboratory contamination. Likely lab contaminant detections are presented as NDs in the data summary tables within this report. The concentration of TPH-d exceeded the DOH Tier 1 EAL, but did not exceed the SSRBL. TPH-d concentrations have shown an overall decreasing trend from a high of 1,500 µg/L in February 2005.
- **RHMW02** – Concentrations of TPH-d (6,100 and 6,200 µg/L), TPH-o (310 and 320 µg/L), 1-methylnaphthalene (60 and 57 µg/L), 2-methylnaphthalene (27 and 24 µg/L), and naphthalene (120 and 88 µg/L) were detected in both the primary and duplicate samples exceeding their respective DOH Tier 1 EALs. Concentrations of TPH-d exceeded the SSRBL of 4,500 µg/L. Concentrations of TPH-g (47 µg/L in both primary and duplicate samples), several other PAHs, several VOCs and lead (0.08 and 0.039 µg/L) were detected below their respective DOH Tier 1

EALs. Toluene was also detected in the trip blank at a similar concentration (0.89 µg/L), likely indicating contamination from outside activities that occurred on the day of sampling (fuel system repair operations were being conducted within the tunnels during the 20 October sampling event). PAH benz(a)anthracene was also detected, but was found in the laboratory method blank at a comparable level, likely resulting from laboratory contamination. The benz(a)anthracene detection is presented as ND in the data summary tables within this report. Concentrations of 1-methylnaphthalene, 2-methylnaphthalene, and naphthalene decreased slightly from the July 2015 event.

- **RHMW03** – The only analytes detected in groundwater were TPH-d (130 µg/L), TPH-o (160 µg/L), 1-methylnaphthalene (0.0039 µg/L), 2-methylnaphthalene (0.0034 µg/L), naphthalene (0.0094 µg/L), toluene (0.40 µg/L) and dissolved lead (0.122 µg/L). Toluene was also detected in the trip blank at a similar concentration (0.89 µg/L), likely indicating contamination from outside activities that occurred on the day of sampling (fuel system repair operations were being conducted within the tunnels during the 20 October sampling event). The concentrations of TPH-d and TPH-o exceeded their respective DOH Tier 1 EALs, but TPH-d did not exceed the SSRBL.
- **RHMW05** – The only analytes detected were TPH-d (20 µg/L), PAHs 1-methylnaphthalene (0.005 µg/L), 2-methylnaphthalene (0.0066 µg/L), naphthalene (0.0074 µg/L), VOC toluene (0.59 µg/L) and dissolved lead (0.103 µg/L). Toluene, benz(a)anthracene and methylene chloride were also detected, but were found in the laboratory method blank at comparable levels, likely resulting from laboratory contamination. Likely lab contaminant detections are presented as ND in the data summary tables within this report. Toluene was also detected in the trip blank at a similar concentration (0.89 µg/L), likely indicating contamination from outside activities that occurred on the day of sampling (fuel system repair operations were being conducted within the tunnels during the 20 October sampling event). None of the detected concentrations exceeded the DOH Tier 1 EALs.
- **RHMW2254-01** – The only analytes detected in groundwater were toluene (0.99 µg/L) and total lead (0.253 µg/L). Toluene was also detected in the trip blank at a similar concentration (0.89 µg/L), likely indicating contamination from outside activities that occurred on the day of sampling (fuel system repair operations were being conducted within the tunnels during the 20 October sampling event). TPH-d, TPH-o, naphthalene and methylene chloride were also detected, but were found in the laboratory method blank at comparable levels, likely resulting from laboratory contamination. Likely lab contaminant detections are presented as ND in the data summary tables within this report. None of the detected concentrations exceeded the DOH Tier 1 EALs.

2.3 GROUNDWATER CONTAMINANT TRENDS

The historical groundwater contaminant concentration trends for TPH-g, TPH-d, and COPCs that exceeded the DOH Tier 1 EALs are illustrated in Appendix F. A summary of groundwater contaminant trends is provided below.

- **RHMW01** – The COPCs detected during this round of quarterly sampling were 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** – The COPCs detected during this round of quarterly sampling were generally consistent with the historical data for 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 event, concentrations of TPH-d were again detected exceeding the SSRBL after a decrease to just below the SSRBL during the July 2015 event. Concentrations of 1-methylnaphthalene, 2-methylnaphthalene, and naphthalene in RHMW02 decreased since the July 2015 event but continue to be elevated and have shown a generally increasing trend since March 2014. The concentrations of TPH-g remained below the DOH Tier 1 EALs and were comparable to the concentrations detected during the previous event. Trichloroethylene was detected once in RHMW02 in September 2005 in the primary sample at a concentration above the DOH EAL for drinking water toxicity; however, trichloroethylene was not detected in the duplicate sample, and this may have been an anomalous result.
- **RHMW03** – COPCs detected during this round of quarterly sampling were consistent with the historical data for RHMW03. TPH-d has historically been detected at concentrations above the DOH Tier 1 EALs. The TPH-d concentration detected in RHMW03 during this event (130 µg/L) exceeded the DOH Tier 1 EAL and matched the July 2015 event concentration, the highest concentration detected since October 2010.
- **RHMW05** – COPCs detected during this round of quarterly sampling were consistent with the historical data for RHMW05. TPH-d has historically been detected in RHMW05 at concentrations above the DOH Tier 1 EAL; however, it has not been detected at concentrations above the DOH Tier 1 EAL since January 2010.
- **RHMW2254-01** – COPCs detected during this round of quarterly sampling were consistent with the historical data for RHMW2254-01. Although the method reporting limits for TPH-d were above the DOH Tier 1 EAL in several results prior to August 2010, TPH-d has not been detected in RHMW2254-01 at a concentration above the DOH Tier 1 EAL.

2.4 WASTE DISPOSAL

The purged groundwater and decontamination water generated during sampling of the inside tunnel wells were placed in two 55-gallon drums along with the purged water and decontamination water from the outside tunnel wells. The drums will be properly profiled and manifested following the next quarterly sampling event, or when they reach 90% full.

TABLE 2.1
Analytical Results for Groundwater Sampling (20 October 2015)
Red Hill Bulk Storage Facility
October 2015 Quarterly Monitoring Report

Method	Chemical	DOH EAL	Units	RHMW01 (ERH011) >150 meters from surface water					RHMW02 (ERH012) >150 meters from surface water					RHMW03 (ERH014) >150 meters from surface water					RHMW05 (ERH010) >150 meters from surface water					RHMW2254-01 (ERH009) <150 meters from surface water				
				Result	Q	LOQ	LOD	DL	Result	Q	LOQ	LOD	DL	Result	Q	LOQ	LOD	DL	Result	Q	LOQ	LOD	DL	Result	Q	LOQ	LOD	DL
EPA 8015C	TPH-g	100	ug/L	ND	U	50	25	13	47	J	50	25	13	ND	U	50	25	13	ND	U	50	25	13	ND	U	50	25	13
	TPH-d	100	ug/L	330	B,Y	54	22	12	6100	B,Y	59	24	13	130	B,Y	58	23	13	20	B,J	54	22	12	16	B,J	53	22	12
	TPH-o	100	ug/L	ND	B,U	110	54	21	310	B,L	120	59	23	160	B,L	120	58	22	ND	B,U	110	54	21	ND	B,U	110	53	21
EPA 8270D SIM	Acenaphthene	20	ug/L	0.027		0.019	0.0050	0.0044	0.33		0.019	0.0050	0.0044	ND	U	0.020	0.0050	0.0044	ND	U	0.020	0.0050	0.0044	ND	U	0.019	0.0050	0.0044
	Acenaphthylene	30/240	ug/L	ND	Ui	0.019	0.0050	0.0050	ND	Ui	0.20	0.20	0.20	ND	U	0.020	0.0050	0.0034	ND	U	0.020	0.0050	0.0034	ND	U	0.019	0.0050	0.0034
	Benz(a)anthracene	0.27/0.092	ug/L	ND	B,U	0.019	0.0050	0.0026	ND	B,U	0.019	0.0050	0.0026	ND	B,U	0.020	0.0050	0.0026	ND	U,B	0.020	0.0050	0.0026	ND	B,U	0.019	0.0050	0.0026
	Fluoranthene	8/130	ug/L	ND	U	0.020	0.020	0.010	ND	U	0.020	0.020	0.010	ND	U	0.020	0.020	0.010	ND	U	0.020	0.020	0.010	ND	U	0.020	0.020	0.010
	Fluorene	3.9/240	ug/L	0.026		0.019	0.0050	0.0038	0.19		0.019	0.0050	0.0038	ND	U	0.020	0.0050	0.0038	ND	U	0.020	0.0050	0.0038	ND	U	0.019	0.0050	0.0038
	1-Methylnaphthalene	2.1/4.7	ug/L	0.037		0.019	0.0050	0.0035	60	D	0.38	0.100	0.070	0.0039	J	0.020	0.0050	0.0035	0.0050	J	0.020	0.0050	0.0035	ND	U	0.019	0.0050	0.0035
	2-Methylnaphthalene	2.1/10	ug/L	0.024	B	0.019	0.0050	0.0023	27	B,D	0.38	0.100	0.046	0.0034	B,J	0.020	0.0050	0.0023	0.0066	B,J	0.020	0.0050	0.0023	ND	B,U	0.019	0.0050	0.0023
	Naphthalene	17	ug/L	0.20	B	0.019	0.0050	0.0038	120	B,D	0.38	0.100	0.076	0.0094	B,J	0.020	0.0050	0.0038	0.0074	B,J	0.020	0.0050	0.0038	ND	B,U	0.019	0.0050	0.0038
	Phenanthrene	4.6/240	ug/L	ND	U	0.019	0.0050	0.0050	0.017	J	0.019	0.0050	0.0050	ND	U	0.020	0.0050	0.0050	ND	U	0.020	0.0050	0.0050	ND	U	0.019	0.0050	0.0050
Pyrene	2/68	ug/L	ND	U	0.019	0.010	0.0053	ND	U	0.019	0.010	0.0053	ND	U	0.020	0.010	0.0053	ND	U	0.020	0.010	0.0053	ND	U	0.019	0.010	0.0053	
EPA 8260C/ 8260-SIM/ 8011	1,1,1,2-Tetrachloroethane	0.067	ng/L	ND	U,*	20	15	8.7	ND	U,*	20	15	8.7	ND	U,*	20	15	8.7	ND	U,*	20	15	8.7	ND	U,*	20	15	8.7
	1,2,3-Trichloropropane	0.6	ug/L	ND	U,*	0.50	0.50	0.20	ND	U,*	0.50	0.50	0.20	ND	U,*	0.50	0.50	0.20	ND	U,*	0.50	0.50	0.20	ND	U,*	0.50	0.50	0.20
	1,2-Dibromo 3-Chloropropane	0.04	ug/L	ND	U,*	2.0	0.80	0.22	ND	U,*	2.0	0.80	0.22	ND	U,*	2.0	0.80	0.22	ND	U,*	2.0	0.80	0.22	ND	U,*	2.0	0.80	0.22
	1,2-Dibromoethane (EDB)	0.04	ug/L	ND	U,*	0.010	0.0040	0.0030	ND	U,*	0.010	0.0040	0.0030	ND	U,*	0.010	0.0040	0.0030	ND	U,*	0.010	0.0040	0.0030	ND	U,*	0.010	0.0040	0.0030
	1,2-Dichloroethane	0.15	ng/L	ND	U	20	15	5.8	ND	U	20	15	5.8	ND	U	20	15	5.8	ND	U	20	15	5.8	ND	U	20	15	5.8
	Acetone	1500	ug/L	ND	U,*	20	10	3.3	ND	U,*	20	10	3.3	ND	U,*	20	10	3.3	ND	U,*	20	10	3.3	ND	U,*	20	10	3.3
	Benzene	5	ug/L	ND	U,*	0.50	0.10	0.062	0.090	J,*	0.50	0.10	0.062	ND	U,*	0.50	0.10	0.062	ND	U,*	0.50	0.10	0.062	ND	U,*	0.50	0.10	0.062
	Chloroform	70	ug/L	ND	U,*	0.50	0.20	0.072	ND	U,*	0.50	0.20	0.072	ND	U,*	0.50	0.20	0.072	ND	U,*	0.50	0.20	0.072	ND	U,*	0.50	0.20	0.072
	Ethylbenzene	30	ug/L	ND	U,*	0.50	0.10	0.050	0.29	J,*	0.50	0.10	0.050	ND	U,*	0.50	0.10	0.050	ND	U,*	0.50	0.10	0.050	ND	U,*	0.50	0.10	0.050
	Methylene Chloride	4.8	ug/L	ND	B,U,*	2.0	0.20	0.10	ND	B,U,*	2.0	0.20	0.10	ND	B,U,*	2.0	0.20	0.10	ND	B,U,*	2.0	0.20	0.10	ND	B,U,*	2.0	0.20	0.10
	Toluene	40	ug/L	0.42	J,*Tb	0.50	0.10	0.054	0.30	J,*Tb	0.50	0.10	0.054	0.40	J,*Tb	0.50	0.10	0.054	0.59	*Tb	0.50	0.10	0.054	0.99	Tb	0.50	0.10	0.054
	Trichloroethene (TCE)	5	ug/L	ND	U,*	0.50	0.10	0.10	ND	U,*	0.50	0.10	0.10	ND	U,*	0.50	0.10	0.10	ND	U,*	0.50	0.10	0.10	ND	U,*	0.50	0.10	0.10
Xylenes, Total	20	ug/L	ND	U,*	1.0	0.20	0.18	0.32	J,*	1.0	0.20	0.18	ND	U,*	1.0	0.20	0.18	ND	U,*	1.0	0.20	0.18	ND	U,*	1.0	0.20	0.18	
EPA 6020A	Lead, Dissolved	5.6/15	ug/L	0.166		0.020	0.010	0.0040	0.080		0.020	0.010	0.0040	0.122		0.020	0.010	0.0040	0.103		0.020	0.010	0.0040					
EPA 200.8	Lead	5.6/15	ug/L																					0.253		0.020	0.010	0.0040

Only chemicals that have been detected since 2010 are included in this table.
Shaded values exceeded the DOH Tier 1 EALs.

- J The result is an estimated value.
- U The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL.
- Z The chromatographic fingerprint does not resemble a petroleum product.
- D The reported result is from a dilution.
- i The MRL/MDL or LOQ/LOD is elevated due to a chromatographic interference.
- L The chromatographic fingerprint of the sample resembles a petroleum product, but the elution pattern indicates the presence of a greater amount of lighter molecular weight constituents than the calibration standard.
- Y The chromatographic fingerprint of the sample resembles a petroleum product eluting in approximately the correct carbon range, but the elution pattern does not match the calibration standard.
- DOH EAL DOH Tier 1 Environmental Action Levels for groundwater where groundwater is a current drinking water source (DOH, FALL 2011). Where two values are listed, the first is for sites less than (<) 150 meters from surface water and the second is for sites greater than (>) 150 meters from surface water.
- B Compound identified during validation in the blank. Result was changed to ND if the reported concentration was below the concentration detected in the blank. Results remain reported in the laboratory provided report.
- EPA Environmental Protection Agency
- LOD Limit of Detection
- LOQ Limit of Quantitation
- ND Not Detected
- Q Qualifiers
- * Sample was analyzed passed the EPA recommended holding time.
- Tb The analyte was also detected in the associated trip blank at a similar concentration

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SECTION 3 – DATA QUALITY ASSESSMENT

A data quality assessment, which consists of a review of the overall groundwater sample collection and analysis process, was performed in order to determine whether the analytical data generated met the quality objectives for the project. The data quality assessment was performed in accordance with the approved WP/SAP (E2, 2015). The field quality control (QC) program consisted of standardized sample collection and management procedures, and the collection of field duplicate samples, matrix spike samples, and trip blank samples. The laboratory quality assurance program consisted of the use of standard analytical methods and the preparation and analyses of Matrix Spike [MS]/Matrix Spike Duplicate [MSD] samples, surrogate spikes, blanks, and Laboratory Control Samples [LCSs]/Laboratory Control Sample Duplicates [LCSDs].

3.1 DATA VALIDATION AND ASSESSMENT

The objective of data validation is to provide data of known quality for project decisions. Data quality is judged in terms of Precision, Accuracy, Representativeness, Completeness, Comparability, and Sensitivity [PARCCS]. A number of factors may affect the quality of data, including: sample collection methods, sample analysis methods, and adherence to established procedures for sample collection, preservation, management, shipment, and analysis.

Precision

Precision is defined as the reproducibility of replicate measurements. Precision is evaluated by Relative Percentage Difference [RPD] of field duplicates, LCS/LCSD, and MS/MSD results. Field duplicate and MS/MSD samples were collected at a rate of approximately 10% of primary samples. Field duplicates were sent to the laboratory along with the primary samples.

The RPDs of detected analytes for the primary and field duplicate samples (ERH012 and ERH013) are provided in Table 3.1. An RPD of less than 50% for duplicate pairs is required by the DON *Project Procedures Manual* to be considered acceptable (DON, 2007). The duplicate RPD for lead exceeded the acceptable maximum. The concentrations of lead detected in any of the associated samples were near the LOQ and at least one order of magnitude below the DOH EAL. Therefore, the lack of precision at this concentration level should not have a significant impact on the use of the data for the comparison to project action levels. All other RPDs fell within the acceptable limit of less than 50%.

RPDs for MS/MSD and LCS/LCSD pairs for all other analytes were within the control limits, and the data precision is considered acceptable.

Accuracy

Accuracy is defined as the degree of conformity of a measurement to a standard or true value. Accuracy is evaluated through measurement of the percent recovery of an analyte in a reference standard or spiked sample. Accuracy limits for surrogates, laboratory control spike, MS, and MSD samples are either prescribed by the Department of Defense [DoD] or established by the individual

laboratory. The acceptance criteria for accuracy are dependent on the analytical method and are based on historical laboratory or DoD data.

Between July 2006 and July 2010, naphthalene was analyzed by both EPA Methods 8260B and 8270C, and both results were reported. In September 2005 and in all data beginning in October 2010, only results using EPA Method 8270C were reported. Naphthalene has historically only been detected at concentrations above the DOH Tier 1 EALs in well RHMW02. In this well, concentrations of naphthalene detected in each sample by EPA Method 8260B were generally two to three times higher than those detected by EPA Method 8270C. This is likely due to the better preservation of VOCs associated with the use of EPA Method 8260B. This suggests that the naphthalene results provided by EPA Method 8270C may be biased low. Since March 2014, naphthalene concentrations in RHMW02 have exceeded the DOH Tier 1 EAL. Therefore, a low bias is unlikely to affect project decisions.

Similarly, the large error inherent to the analysis of diesel- and oil-range hydrocarbons by EPA method 8015 should be considered when results are compared to each other, to action levels, and to results from previous sampling events. Any comparative analysis of the results should take into consideration the fairly wide method acceptance limits as per DoD Quality Systems Manual [QSM] Version 5.0 (36-132%) (DoD 2013).

Results for TPH-d in samples ERH011, ERH012, ERH013 and ERH014 were flagged "Y" to indicate that the chromatographic fingerprint of the samples resembled a petroleum product but did not match the calibration standard. Results for TPH-o in samples ERH012 and ERH013 were flagged "L" to indicate that the results in this range were likely due to tailing of the diesel range product into the heavier oil range, and not due to the presence of an oil range petroleum product. Mismatches of this type are not uncommon and a review of sample chromatograms confirmed the flagging applied by the laboratory. The chromatograms of groundwater samples from RHMW02 did not indicate any significant changes in the type of petroleum product present in the well compared to data from previous sampling events.

All MS and/or MSD recoveries met the control limit criteria, indicating that negative matrix effects were negligible with all analysis.

All surrogate spike recoveries met the control limit criteria indicating that Laboratory procedures were meeting method analyte recovery criteria.

The LOD and LOQ for acenaphthylene were elevated in samples ERH011, ERH012 and ERH013 due to matrix interference. The limits were still well below the DOH EALs, and project decisions should not be affected.

Representativeness

Representativeness is the degree that data accurately and precisely represents a characteristic of a population, parameter variations at a sampling point, or an environmental condition.

Representativeness was achieved by conducting sampling in accordance with the sample collection procedures described in the project WP/SAP, including standardized sample collection methods (ESI, 2012).

Representativeness is also evaluated through the compliance with the standardized sample holding time and sample preservation methods, and through the analysis of blank samples, including method blank and trip blank samples. For this sampling event, all sample holding times and sample preservation were consistent with EPA guidance.

Samples analyzed for volatile organic compounds by EPA 8260C were run passed the EPA recommended holding time of 14 days. Samples were preserved and kept chilled. The data appear to indicate that volatile concentrations do not demonstrate an overall low bias as seen by consistent concentrations of ethylbenzene and xylenes in RHMW02 as compared to past sampling rounds, however a low bias may exist.

For this sampling event, one trip blank was included with the cooler containing samples for VOC and TPH-g analysis to assess the potential for contamination during sample transport. Chloroform, methylene chloride and toluene were detected in the trip blank at concentrations below their respective LOQs.

Additionally, methylene chloride, toluene, TPH-d, TPH-o, benz(a)anthracene, benzo(g,h,i)perylene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, 2-methylnaphthalene and naphthalene were detected in the method blank at concentrations below their respective LOQs. Presence of these compounds at comparable levels in project samples likely indicate positive interference from laboratory procedures (laboratory contamination). Subsequently, detections for compounds identified in the method blank were changed to ND in Tables 2-1 and 3-1.

Based on the assessment of representativeness, groundwater sample data are considered representative of the groundwater quality on site with the exception of the potential low bias of volatile organic compounds due to the holding time exceedence.

Completeness

Completeness is defined as the overall percentage of valid analytical results (including estimated results) compared to the total number of analytical results reported by the analytical laboratory. No data were rejected for this project, and therefore the completeness goal for this project (90%) was successfully met.

Comparability

Comparability expresses the confidence with which one data set can be compared to another data set. Comparability can be related to accuracy and precision because these quantities are measures of data reliability. Data with acceptable precision and accuracy are considered comparable if collection techniques, analytical procedures, methods and reporting are equivalent.

All samples collected from October 2010 to and including February 2015 were analyzed by Calscience Environmental Laboratories in Garden Grove, CA (now Eurofins Calscience). Samples starting April 2015 were analyzed by ALS Environmental in Kelso, WA. Analytical MDLs, LODs, and LOQs were lower for most analytes than they had been during previous events and several VOCs and PAHs were detected during the April 2015 event at concentrations that would have been below previous LODs and therefore not detected. The method used to analyze 1,2-dichloroethane, bromodichloromethane, dibromochloromethane, and 1,1,2,2-tetrachloroethane was changed from 8260 to 8260-SIM to improve sensitivity. Correspondingly, analysis of 1,2-dibromo-3-chloropropane and 1,2-dibromoethane was switched from 8260 to 8011 for the same reason. The significantly improved reporting limits should be considered when results are compared to data from previous events.

Additionally, during the April 2015 event, TPH-o was added to the analyte list. There are very few previous TPH-o results to compare this data to.

The TPH-g analysis of project samples through July 2010 was performed using EPA Method 8015. Between October 2010 and January 2015, TPH-g analysis was performed using EPA Method 8260. Beginning in April 2015, the use of EPA Method 8015 was reestablished. There was no event where both methods were used; consequently, there is no way to directly compare the results obtained by the two methods and to assess potential bias. However, there is no reason to believe that using either method should bias the data significantly, and the TPH-g data for all events should be comparable with respect to the limits of the analytical method.

Other than the lower detection limits, the addition of TPH-o to the analyte list, the large uncertainty inherent to EPA method 8015, and the naphthalene bias discussed above, no other issues with comparability were identified. The results are considered comparable within this data set and with the data collected from recent sampling events.

Sensitivity

The LOQs are established by the laboratory based on the LODs or instrument detection limits, historical data, and EPA limits established for the various methods. The LOQs and LODs for samples may require adjustment by the laboratory due to matrix interference or if high levels of target analytes necessitate dilution before analysis. Matrix interference and sample dilutions have the effect of decreasing sensitivity and increasing the LOQs/LODs. There are no results with increased LOQs or LODs in this data set that have impacted sensitivity and data usability.

3.2 DATA ASSESSMENT AND USABILITY CONCLUSIONS

The PARCCS criteria were evaluated, and with some exceptions, all criteria were met. Results associated with QC data that failed acceptance criteria are discussed in detail in Section 3.1 of this report. Data quality issues that need to be taken into account for project decisions are summarized below.

Finally, it should be noted that analytical MDLs, LODs, and LOQs decreased for the April and July 2015 sampling events compared to monitoring data from October 2010 through February 2015 due to a change of laboratories and the utilization of alternative methods. Analytes that were detected during the current event and were not detected at or above the higher MDLs during past events include acenaphthene, benz[a]anthracene, fluorene, phenanthrene, naphthalene, 1-methylnaphthalene, and 2-methylnaphthelene in RHMW01; 1,2,3-trichloropropane, benzene and toluene in RHMW02; benzo[a]anthracene, phenanthrene, and lead in RHMW03; and naphthalene, 1-methylnaphthalene, 2-methylnaphthelene, and lead in RHMW05. Consequently, these analytes may have been present at the currently detected concentrations during previous events without being detected and do not necessarily indicate any trend. Furthermore, it should be noted that these compounds were also identified in the method blank and may indicate that at these very low levels, laboratory contamination may lead to false low level hits.

The data assessment concludes that all data generated during this event are usable for the intended purpose, with the limitations described above.

TABLE 3.1
Quality Control Results for Groundwater Sampling (20 October 2015)
Red Hill Bulk Storage Facility
October 2015 Quarterly Monitoring Report

Method	Chemical	DOH EAL	RHMW02 (ERH012) >150 meters from surface water					RHMW02 (ERH013) >150 meters from surface water					RPD Duplicate %	Trip Blank				
			Result	Q	LOQ	LOD	DL	Result	Q	LOQ	LOD	DL		Result	Q	LOQ	LOD	DL
EPA 8015C	TPH-g	100	47	J	50	25	13	47	J	50	25	13	0.0%	ND	U	50	25	13
	TPH-d	100	6100	B,Y	59	24	13	6200	B,Y	54	22	12	1.6%	-	-	-	-	-
	TPH-o	100	310	B,L	120	59	23	320	B,L	110	54	21	3.2%	-	-	-	-	-
EPA 8270D SIM	Acenaphthene	20	0.33		0.019	0.0050	0.0044	0.36		0.019	0.0050	0.0044	8.7%	-	-	-	-	-
	Acenaphthylene	30/240	ND	Ui	0.20	0.20	0.20	ND	Ui	0.22	0.22	0.22	NA	-	-	-	-	-
	Benz(a)anthracene	0.27/0.092	ND	B,U	0.019	0.0050	0.0026	ND	B,U	0.019	0.0050	0.0026	NA	-	-	-	-	-
	Fluoranthene	8/130	ND	U	0.020	0.020	0.010	ND	U	0.020	0.020	0.010	NA	-	-	-	-	-
	Fluorene	3.9/240	0.19		0.019	0.0050	0.0038	0.22		0.019	0.0050	0.0038	14.6%	-	-	-	-	-
	1-Methylnaphthalene	2.1/4.7	60	D	0.38	0.10	0.07	57	D	0.38	0.10	0.070	5.1%	-	-	-	-	-
	2-Methylnaphthalene	2.1/10	27	B,D	0.38	0.10	0.046	24	B,D	0.38	0.10	0.046	11.8%	-	-	-	-	-
	Naphthalene	17	120	B,D	0.38	0.10	0.076	88	B,D	0.38	0.10	0.076	30.8%	-	-	-	-	-
	Phenanthrene	4.6/240	0.017	J	0.019	0.0050	0.0050	0.019	J	0.019	0.0050	0.0050	11.1%	-	-	-	-	-
Pyrene	2/68	ND	U	0.019	0.010	0.0053	ND	U	0.019	0.010	0.0053	NA	-	-	-	-	-	
EPA 8260C/ 8260-SIM/ 8011	1,1,1,2-Tetrachloroethane	0.067	ND	U	0.20	0.15	0.087	ND	U	20	15	8.7	NA	ND	U,*	0.020	0.015	0.0087
	1,2,3-Trichloropropane	0.6	ND	U,*	0.50	0.50	0.20	ND	U,*	0.50	0.50	0.20	NA	ND	U,*	0.50	0.50	0.20
	1,2-Dibromo 3-Chloropropane	0.04	ND	U,*	2.0	0.80	0.22	ND	U,*	2.0	0.80	0.22	NA	ND	U,*	2.0	0.80	0.22
	1,2-Dibromoethane (EDB)	0.04	ND	U,*	0.010	0.004	0.0030	ND	U,*	0.0097	0.0040	0.0030	NA	ND	U,*	2.0	0.20	0.10
	1,2-Dichloroethane	0.15	ND	U	0.020	0.015	0.0058	ND	U	20	15	5.8	NA	ND	U	0.020	0.015	0.0058
	Acetone	1500	ND	U,*	20	10	3.3	ND	U,*	20	10	3.3	NA	ND	U,*	20	10	3.3
	Benzene	5	0.090	J,*	0.50	0.10	0.062	0.090	J,*	0.50	0.10	0.062	0.0%	ND	U,*	0.50	0.10	0.062
	Chloroform	70	ND	U,*	0.50	0.20	0.072	ND	U,*	0.50	0.20	0.072	NA	0.09	J,*	0.50	0.20	0.072
	Ethylbenzene	30	0.29	J,*	0.50	0.10	0.05	0.26	J,*	0.50	0.10	0.050	10.9%	ND	U,*	0.50	0.10	0.050
	Methylene Chloride	4.8	ND	B,U,*	2.0	0.20	0.10	ND	B,U,*	2.0	0.20	0.10	NA	0.16	J,*	2.0	0.20	0.10
	Toluene	40	0.30	J,* , Tb	0.50	0.10	0.054	0.49	J,* , Tb	0.50	0.10	0.054	48.1%	0.89	*	0.50	0.10	0.054
	Trichloroethene (TCE)	5	ND	U,*	0.50	0.10	0.10	ND	U,*	0.50	0.10	0.10	NA	ND	U,*	0.50	0.10	0.10
	Xylenes, Total	20	0.32	J,*	1.0	0.20	0.18	0.30	J,*	1.0	0.20	0.18	6.5%	ND	U,*	1.0	0.20	0.18
EPA 6020A	Lead, Dissolved	5.6/15	0.080		0.020	0.010	0.0040	0.039		0.020	0.010	0.0040	68.9%	-	-	-	-	-

Only chemicals that have been detected since 2010 are included in this table.
Data are reported in micrograms per liter (µg/L). Shaded values exceeded the DOH Tier 1 EALs.

B B - Compound identified during validation in the blank. Result was changed to ND if the reported concentration was below the concentration detected in the blank. Results remain reported in the laboratory provided report.

D The reported result is from a dilution.

DOH EAL DOH Tier 1 Environmental Action Levels for groundwater is a current drinking water source (DOH, FALL 2011). Where two values are listed, the first is for sites less than (<) 150 meters from surface water and the second is for sites greater than (>) 150 meters from surface water.

EPA Environmental Protection Agency

* Analyzed passed the EPA recommended holding time.

i The MRL/MDL or LOQ/LOD is elevated due to a chromatographic interference.

J The result is an estimated value.

L The chromatographic fingerprint of the sample resembles a petroleum product, but the elution pattern indicates the presence of a greater amount of lighter molecular weight constituents than the calibration standard.

LOD Limit of Detection

LOQ Limit of Quantitation

ND Not Detected

Q Qualifiers

U The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL.

Y The chromatographic fingerprint of the sample resembles a petroleum product eluting in approximately the correct carbon range, but the elution pattern does not match the calibration standard.

Z The chromatographic fingerprint does not resemble a petroleum product.

Tb The analyte was also detected in the associated trip blank at a similar concentration

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SECTION 4 – SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

On 20 October 2015, E2 personnel collected groundwater samples from four monitoring wells at the RHSF (wells RHMW01, RHMW02, RHMW03, and RHMW05) and one sampling point at Red Hill Shaft (RHMW2254-01).

The groundwater sampling was conducted as part of the long-term groundwater and soil vapor monitoring program at the RHSF for NAVSUP FLC Pearl Harbor, under NAVFAC Contract Number N62742-12-D-1853. The sampling was conducted in accordance with the approved WP/SAP prepared by E2. A summary of the analytical results is provided below:

- **RHMW01** – Analytes detected in groundwater were TPH-d (330 µg/L), PAHs acenaphthene (0.027 µg/L), fluorene (0.026 µg/L), 1-methylnaphthalene (0.037 µg/L), 2-methylnaphthalene (0.024 µg/L), and naphthalene (0.20 µg/L), VOC toluene (0.42 µg/L) and dissolved lead (0.166 µg/L). Toluene was also detected in the trip blank at a similar concentration (0.89 µg/L), likely indicating contamination from outside activities that occurred on the day of sampling (fuel system repair operations were being conducted within the tunnels during the 20 October sampling event). TPH-o and methylene chloride were also detected, but were found in the laboratory method blank at comparable levels, likely resulting from laboratory contamination. Likely lab contaminant detections are presented as NDs in the data summary tables within this report. The concentration of TPH-d exceeded the DOH Tier 1 EAL, but did not exceed the SSRBL. TPH-d concentrations have shown an overall decreasing trend from a high of 1,500 µg/L in February 2005.
- **RHMW02** – Concentrations of TPH-d (6,100 and 6,200 µg/L), TPH-o (310 and 320 µg/L), 1-methylnaphthalene (60 and 57 µg/L), 2-methylnaphthalene (27 and 24 µg/L), and naphthalene (120 and 88 µg/L) were detected in both the primary and duplicate samples exceeding their respective DOH Tier 1 EALs. Concentrations of TPH-d exceeded the SSRBL of 4,500 µg/L. Concentrations of TPH-g (47 µg/L in both primary and duplicate samples), several other PAHs, several VOCs and lead (0.08 and 0.039 µg/L) were detected below their respective DOH Tier 1 EALs. Toluene was also detected in the trip blank at a similar concentration (0.89 µg/L), likely indicating contamination from outside activities that occurred on the day of sampling (fuel system repair operations were being conducted within the tunnels during the 20 October sampling event). PAH benz(a)anthracene was also detected, but was found in the laboratory method blank at a comparable level, likely resulting from laboratory contamination. The benz(a)anthracene detection is presented as ND in the data summary tables within this report. Concentrations of 1-methylnaphthalene, 2-methylnaphthalene, and naphthalene decreased slightly from the July 2015 event.
- **RHMW03** – The only analytes detected in groundwater were TPH-d (130 µg/L), TPH-o (160 µg/L), 1-methylnaphthalene (0.0039 µg/L), 2-methylnaphthalene (0.0034 µg/L), naphthalene (0.0094 µg/L), toluene (0.40 µg/L) and dissolved lead (0.122 µg/L). Toluene was also detected in the trip blank at a similar concentration (0.89 µg/L), likely indicating contamination from outside activities that occurred on the day of sampling (fuel system repair

operations were being conducted within the tunnels during the 20 October sampling event). The concentrations of TPH-d and TPH-o exceeded their respective DOH Tier 1 EALs, but TPH-d did not exceed the SSRBL.

- **RHMW05** – The only analytes detected were TPH-d (20 µg/L), PAHs 1-methylnaphthalene (0.005 µg/L), 2-methylnaphthalene (0.0066 µg/L), naphthalene (0.0074 µg/L), VOC toluene (0.59 µg/L) and dissolved lead (0.103 µg/L). Toluene was also detected in the trip blank at a similar concentration (0.89 µg/L), likely indicating contamination from outside activities that occurred on the day of sampling (fuel system repair operations were being conducted within the tunnels during the 20 October sampling event). Toluene, benz(a)anthracene and methylene chloride were also detected, but were found in the laboratory method blank at comparable levels, likely resulting from laboratory contamination. Likely lab contaminant detections are presented as ND in the data summary tables within this report. Toluene was also detected in the trip blank at a similar concentration (0.89 µg/L), likely indicating contamination from outside activities that occurred on the day of sampling (fuel system repair operations were being conducted within the tunnels during the 20 October sampling event). None of the detected concentrations exceeded the DOH Tier 1 EALs.
- **RHMW2254-01** – The only analytes detected in groundwater were toluene (0.99 µg/L) and total lead (0.253 µg/L). Toluene was also detected in the trip blank at a similar concentration (0.89 µg/L), likely indicating contamination from outside activities that occurred on the day of sampling (fuel system repair operations were being conducted within the tunnels during the 20 October sampling event). TPH-d, TPH-o, naphthalene and methylene chloride were also detected, but were found in the laboratory method blank at comparable levels, likely resulting from laboratory contamination. Likely lab contaminant detections are presented as ND in the data summary tables within this report. None of the detected concentrations exceeded the DOH Tier 1 EALs.

The historical groundwater contaminant concentration trends for TPH-g, TPH-d, and COPCs that exceeded the DOH Tier 1 EALs are illustrated in Appendix E. A summary of groundwater contaminant trends is provided below.

- **RHMW01** – The COPCs detected during this round of quarterly sampling were 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** – The COPCs detected during this round of quarterly sampling were consistent with the historical data for 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 event, concentrations of TPH-d were again detected exceeding the SSRBL after a decrease to just below the SSRBL during the July 2015 event. Concentrations of 1-methylnaphthalene, 2-methylnaphthalene, and naphthalene in RHMW02 decreased since the July 2015 event but continue to be elevated and have shown a generally increasing trend since March 2014. The concentrations of TPH-g remained below the DOH Tier 1 EALs and were comparable to the concentrations detected during the previous event.

Trichloroethylene was detected once in RHMW02 in September 2005 in the primary sample at a concentration above the DOH EAL for drinking water toxicity; however, trichloroethylene was not detected in the duplicate sample, and this may have been an anomalous result.

- **RHMW03** – COPCs detected during this round of quarterly sampling were consistent with the historical data for RHMW03. TPH-d has historically been detected at concentrations above the DOH Tier 1 EALs. The TPH-d concentration detected in RHMW03 during this event (130 µg/L) exceeded the DOH Tier 1 EAL and matched the July 2015 event concentration, the highest concentration detected since October 2010.
- **RHMW05** – COPCs detected during this round of quarterly sampling were consistent with the historical data for RHMW05. TPH-d has historically been detected in RHMW05 at concentrations above the DOH Tier 1 EAL; however, it has not been detected at concentrations above the DOH Tier 1 EAL since January 2010.
- **RHMW2254-01** – COPCs detected during this round of quarterly sampling were consistent with the historical data for RHMW2254-01. Although the method reporting limits for TPH-d were above the DOH Tier 1 EAL in several results prior to August 2010, TPH-d has not been detected in RHMW2254-01 at a concentration above the DOH Tier 1 EAL.

Conclusions and Recommendations

During the sampling event conducted on 20 October 2015, TPH-d in RHMW01, RHMW02, and RHMW03; TPH-o in RHMW02 and RHMW03; and 1-methylnaphthalene, 2-methylnaphthalene, and naphthalene in RHMW02 were detected at concentrations exceeding the DOH Tier 1 EALs. Concentrations of TPH-d in RHMW02 exceeded the SSRBL. Groundwater contaminant concentrations in RHMW05, and RHMW2254-01 remained at low concentrations and did not change significantly from the previous event, or were not detected.

Concentrations of 1-methylnaphthalene, 2-methylnaphthalene, and naphthalene in RHMW02 decreased compared to the April 2015 event, but have shown a generally increasing trend since March 2014. During the April 2015 event, the concentration of TPH-d in RHMW02 increased to its highest level since October 2008 and to a level similar to that reached in January 2014; during this October 2015 event the TPH-d concentration increased even further to its highest level since October 2008. All other analytical results were generally consistent with historical data.

Based on the groundwater monitoring results and the reported release at Tank 5 in January 2014, continued groundwater monitoring at the wells inside the RHSF tunnel is recommended.

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SECTION 5 – FUTURE WORK

Future work includes the first quarter 2016 groundwater monitoring that is tentatively scheduled for January 2016. A quarterly groundwater monitoring report will be prepared to document the sampling event.

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APPENDIX A

Groundwater Sampling Logs

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**Figure 1-C-3-1
 Groundwater Sampling Log**

Project Number: 150037 Date: 10-20-2015

Location: RHFS Time: 12:27

Well Number: RHMW01 Climatic Conditions: _____

Initial Measurements: Static Water Level: 84 @ 12:42
 Total Depth: 97.35

Well Purging: Length of Saturated Zone: _____ linear feet
 Volume of Water to be Evacuated: _____ gals./linear ft. x
 Linear feet of Saturation x Casing Volumes* = _____ gallons
 Method of Removal: Bladder Pump
 Pumping Rate: Approx. 150 mL/mingallons/minute

Well Purge Data:

DATE/ TIME	GALLONS REMOVED	pH	(uS/cm) SP. COND.	(mg/L) D.O.	(mV) REDOX	(NTU) TURBIDITY
10/20/15 1311	0.2	6.99	332.0	2.40	-50.5	0.9
10/20/15 1316	0.5	6.95	330.9	1.23	-51.1	1.0
10/20/15 1319	0.6	6.94	331.2	1.08	-51.3	0.9
10/20/15 1323	0.8	6.93	331.3	0.94	-50.6	0.9
10/20/15 1327	1	6.92	331.2	0.88	-49.6	0.9
10/20/15 1330	1.1	6.92	330.9	0.84	-48.6	0.9
10/20/15 1333	1.2	6.91	330.1	0.80	-47.2	0.8
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____

Sample Withdrawal Method: Bladder Pump
 Appearance of Sample: Color Clear
 Turbidity _____
 Sediment Light/None
 Other _____

Laboratory Analysis Parameters and Preservatives: TPH-DRO/ORO/GRO (HCl); VOCs (HCl); PAHs (none); Total Dissolved Lead (HNO3); and EDB (Na2S2O3)

Number and Types of Sample Containers Used: (1) 1-L Amber glass jar; (2) 500-mL Amber glass jars (HCl); (1) 250-mL Poly (HNO3); (6) 40-mL VOA vials (HCl); and (1) 40-mL VOA vial (Na2S2O3)

Sample Identification Number(s): ERH011 @ 1335

Decontamination Procedures: Navy PPM I-F

Notes: Filtered in field for metals

Sampled by: Matt Neal, Austin Lutey, and Bernice Balete

Samples delivered to: _____

Date/Time: _____

Transporters: _____

* 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 1-C-3-1
 Groundwater Sampling Log**

Project Number: 150037 Date: 10-20-2015
 Location: RHFS Time: 14:12
 Well Number: RHMW02 Climatic Conditions: _____

Initial Measurements: Static Water Level: 90.38 @ 14:21
 Total Depth: _____

Well Purging: Length of Saturated Zone: _____ linear feet
 Volume of Water to be Evacuated: _____ gals./linear ft. x
 Linear feet of Saturation x Casing Volumes* = _____ gallons
 Method of Removal: Bladder Pump
 Pumping Rate: _____ gallons/minute

Well Purge Data:

DATE/ TIME	GALLONS REMOVED	pH	(uS/cm) SP. COND.	(mg/L) D.O.	(mV) REDOX	(NTU) TURBIDITY
10/20/15 1424	0.3	6.48	569	0.71	-51.1	20.1
10/20/15 1427	0.75	6.32	574	0.47	-3.3	6.4
10/20/15 1430	1.0	6.43	573	0.38	-17.6	3.6
10/20/15 1433	1.25	6.45	574	0.33	-20.1	2.8
10/20/15 1436	1.5	6.46	575	0.30	-21.8	2.3
10/20/15 1439	1.75	6.47	575	0.26	-24.0	1.9
10/20/15 1442	2	6.48	575	0.25	-24.5	1.9
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____

Sample Withdrawal Method: Bladder Pump
 Appearance of Sample: Color Clear
 Turbidity _____
 Sediment Light/None
 Other No Sheen, Moderate sulfur odor

Laboratory Analysis Parameters and Preservatives: TPH-DRO/ORO/GRO (HCl); VOCs (HCl); PAHs (none); Total Dissolved Lead (HNO3); and EDB (Na2S2O3)

Number and Types of Sample Containers Used: (1) 1-L Amber glass jar; (2) 500-mL Amber glass jars (HCl); (1) 250-mL Poly (HNO3); (6) 40-mL VOA vials (HCl); and (1) 40-mL VOA vial (Na2S2O3)

Sample Identification Number(s): ERH012@1450

Decontamination Procedures: Navy PPM I-F

Notes: Filtered in field for metals; Duplicate sample collected ERH013@1500

Sampled by: Matt Neal, Austin Lutey, and Bernice Balety
 Samples delivered to: _____
 Date/Time: _____
 Transporters: _____

* 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 1-C-3-1
 Groundwater Sampling Log**

Project Number: 150037 Date: 10-20-2015
 Location: RHFS Time: 15:10
 Well Number: RHMW03 Climatic Conditions: _____

Initial Measurements: Static Water Level: 103.38 @ 15:21
 Total Depth: _____

Well Purging: Length of Saturated Zone: _____ linear feet
 Volume of Water to be Evacuated: _____ gals./linear ft. x
 Linear feet of Saturation x Casing Volumes* = _____ gallons
 Method of Removal: Bladder Pump
 Pumping Rate: _____ gallons/minute

Well Purge Data:

DATE/ TIME	GALLONS REMOVED	pH	(uS/cm) SP. COND.	(mg/L) D.O.	(mV) REDOX	(NTU) TURBIDITY
<u>10/20/15 1527</u>	<u>0.3</u>	<u>6.83</u>	<u>809</u>	<u>2.14</u>	<u>110.7</u>	<u>9.9</u>
<u>10/20/15 1530</u>	<u>0.6</u>	<u>6.79</u>	<u>811</u>	<u>1.41</u>	<u>114.7</u>	<u>7.2</u>
<u>10/20/15 1533</u>	<u>1.0</u>	<u>6.77</u>	<u>809</u>	<u>1.35</u>	<u>113.2</u>	<u>4.9</u>
<u>10/20/15 1536</u>	<u>1.3</u>	<u>6.76</u>	<u>807</u>	<u>1.35</u>	<u>109.4</u>	<u>3.2</u>
<u>10/20/15 1539</u>	<u>1.6</u>	<u>6.77</u>	<u>806</u>	<u>1.28</u>	<u>102.5</u>	<u>3.1</u>
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____

Sample Withdrawal Method: Bladder Pump
 Appearance of Sample: Color Clear
 Turbidity _____
 Sediment None
 Other _____

Laboratory Analysis Parameters and Preservatives: TPH-DRO/ORO/GRO (HCl); VOCs (HCl); PAHs (none); Total Dissolved Lead (HNO3); and EDB (Na2S2O3)

Number and Types of Sample Containers Used: (1) 1-L Amber glass jar; (2) 500-mL Amber glass jars (HCl); (1) 250-mL Poly (HNO3); (6) 40-mL VOA vials (HCl); and (1) 40-mL VOA vial (Na2S2O3)

Sample Identification Number(s): ERH014@1550, Designate MS/MSD

Decontamination Procedures: Navy PPM I-F

Notes: Filtered in field for metals

Sampled by: Matt Neal, Austin Lutey, and Bernice Balete
 Samples delivered to: _____
 Date/Time: _____
 Transporters: _____

* 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 1-C-3-1
 Groundwater Sampling Log**

Project Number: 150037 Date: 10-20-2015
 Location: RHFS Time: 11:27
 Well Number: RHMW05 Climatic Conditions: _____

Initial Measurements: Static Water Level: Unable to Measure
 Total Depth: _____

Well Purging: Length of Saturated Zone: _____ linear feet
 Volume of Water to be Evacuated: _____ gals./linear ft. x
 Linear feet of Saturation x Casing Volumes* = _____ gallons
 Method of Removal: Bladder Pump
 Pumping Rate: Approx. 400 mL/min gallons/minute

Well Purge Data:

DATE/ TIME	GALLONS REMOVED	pH	(uS/cm) SP. COND.	(mg/L) D.O.	(mV) REDOX	(NTU) TURBIDITY
<u>10/20/15 1153</u>	<u>0.3</u>	<u>7.93</u>	<u>675</u>	<u>8.35</u>	<u>103.3</u>	<u>4.0</u>
<u>10/20/15 1156</u>	<u>1.5</u>	<u>7.70</u>	<u>816</u>	<u>8.30</u>	<u>114.0</u>	<u>1.9</u>
<u>10/20/15 1159</u>	<u>2.5</u>	<u>7.68</u>	<u>840</u>	<u>8.31</u>	<u>117.3</u>	<u>1.3</u>
<u>10/20/15 1202</u>	<u>3.0</u>	<u>7.67</u>	<u>848</u>	<u>8.32</u>	<u>119.7</u>	<u>1.3</u>
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____

Sample Withdrawal Method: Bladder Pump
 Appearance of Sample: Color Clear
 Turbidity _____
 Sediment Light/None
 Other No odor/sheen

Laboratory Analysis Parameters and Preservatives: TPH-DRO/ORO/GRO (HCl); VOCs (HCl); PAHs (none); Total Dissolved Lead (HNO3); and EDB (Na2S2O3)

Number and Types of Sample Containers Used: (1) 1-L Amber glass jar; (2) 500-mL Amber glass jars (HCl); (1) 250-mL Poly (HNO3); (6) 40-mL VOA vials (HCl); and (1) 40-mL VOA vial (Na2S2O3)

Sample Identification Number(s): ERH010@1210

Decontamination Procedures: Navy PPM I-F

Notes: Filtered in field for metals

Sampled by: Matt Neal, Austin Lutey, and Bernice Balete

Samples delivered to: _____

Date/Time: _____

Transporters: _____

* 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 1-C-3-1
 Groundwater Sampling Log**

Project Number: 150037 Date: 10-20-2015

Location: RHFS Time: 10:10

Well Number: RHMW2254-01 Climatic Conditions: _____

Initial Measurements: Static Water Level: 82.34 @ 1050
 Total Depth: _____

Well Purging: Length of Saturated Zone: _____ linear feet
 Volume of Water to be Evacuated: _____ gals./linear ft. x
 Linear feet of Saturation x Casing Volumes* = _____ gallons
 Method of Removal: Bladder Pump
 Pumping Rate: _____ gallons/minute

Well Purge Data:

DATE/ TIME	GALLONS REMOVED	pH	(uS/cm) SP. COND.	(mg/L) D.O.	(mV) REDOX	(NTU) TURBIDITY
10/20/15 1034	0.1	7.64	595	8.34	112.8	1.0
10/20/15 1037	1.25	7.53	618	8.54	122.5	0.9
10/20/15 1040	2.50	7.49	620	8.54	127.3	1.0
10/20/15 1045	4.50	7.44	624	8.53	131.4	0.9
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____

Sample Withdrawal Method: Bladder Pump
 Appearance of Sample: Color Clear
 Turbidity _____
 Sediment None
 Other _____

Laboratory Analysis Parameters and Preservatives: TPH-DRO/ORO/GRO (HCl); VOCs (HCl); PAHs (none); Total Dissolved Lead (HNO3); and EDB (Na2S2O3)

Number and Types of Sample Containers Used: (1) 1-L Amber glass jar; (2) 500-mL Amber glass jars (HCl); (1) 250-mL Poly (HNO3); (6) 40-mL VOA vials (HCl); and (1) 40-mL VOA vial (Na2S2O3)

Sample Identification Number(s): ERH009@1050

Decontamination Procedures: Navy PPM I-F

Notes: Strong Petroleum Odor in Ambient Air

Sampled by: Matt Neal, Austin Lutey, and Bernice Balety

Samples delivered to: _____

Date/Time: _____

Transporters: _____

* Capacity of casing (gallons/linear foot): 2"-0.16, 4"-0.65, 6"-1.47, 8"-2.61, 10"-4.08, 12"-5.87

APPENDIX B

Field Notes

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Activity: GW Monitoring (INSIDE TUNNELS)

TEAM LEAD: M. NEAL, A. LUTEY, B. BALETE

NAVFAAC: D. UCHIMA

PRE: LEVEL D

WEATHER: SUNNY

REPS: WP/SAP, PPM, HSP

0730 MEET DU @ 0.1757 FUELS DEPT. TO OBTAIN BADGES

0900 ARRIVE ON-SITE / PACK TOOLS / EQUIPMENT ON CART

0905 HS BRIEFING / CALIBRATE YSI WATER QUALITY METER

0920 ARRIVE @ ENTRANCE TO RHMW2254-01 (INSIDE ADIT 3)

WAIT FOR ESCORT FROM POTABLE WATER, NAVFAAC

1005 ESCORT ARRIVES

1010 SETUP @ WELL (HAS DEDICATED PUMP/TUBING) (WL @ 82.34)

1030 START PUMPING / 1045 END PURGING (STRONG ODOR IN AMBIENT AIR)

1050 COLLECT SAMPLE ERH009 (UNFILTERED) ~35 PPM

1112 LEAVE SHAFT / CLOSE DOOR BEHIND

1127 ARRIVE @ RHMW05 (HAS DEDICATED PUMP/TUBING)

COULD NOT MEASURE GW LEVEL, PROBE ^{HIT AN} WAS OBSTRUCTION IN WELL

1147 START PURGING (~~COULD NOT MEASURE WL DUE TO~~ ^{SS})

1205 END PURGING

1210 COLLECT SAMPLE ERH010 (FILTERED)

1221 LEAVE WELL

1227 ARRIVE @ RHMW01 (DOES NOT HAVE DEDICATED PUMP/TUBING)

1254 START PURGING (WL = 84.60)

* RHMW01 controller box settings: Pressure: 50 psi
Fill time: 10 s
Discharge: 10 s

1333 END PURGING

1335 COLLECT SAMPLE ERH011 (FILTERED)

1407 LEAVE WELL

1412 ARRIVE @ RHMW02 (HAS DEDICATED PUMP/TUBING)

1422 START PURGING (WL = 90.38)

CONTROLLER BOX SETTINGS: PRESSURE 55 PSI
FILL TIME 20 S
DISCHARGE 14 S

1445 END PURGING

10-20-15 TUESDAY

SAMPLE LOG:

<u>EPA ID:</u>	<u>SAMPLE ID:</u>	<u>DATE:</u>	<u>TIME:</u>	<u>NO. CONTAINERS</u>
ERH009	RH-MW2254-01- ^{GW} 415	10-20-15	1050	11
ERH010	RH-MW05-GW415	10-20-15	1210	11
ERH011	RH-MW01-GW415	10-20-15	1335	11
ERH012	RH-MW02-GW415	10-20-15	1450	11
ERH013	RH-MW02-GW415-DUP	10-20-15	1500	11
ERH014	RH-MW03-GW415 (MS/MSD)	10-20-15	1550	11

10-20-15 TUESDAY

- 1450 COLLECT SAMPLE ERH012
COLLECT DUPLICATE SAMPLE ERH013 WITH TIME OF 1500
- 1505 LEAVE WELL
- 1510 ARRIVE @ RHMW03 (HAS DEDICATED PUMP/TUBING), (B ARRIVES/AC LEAVES)
- 1521 WL = 103.38
- 1525 START PURGING
UTILIZE THE SAME CONTROLLER BOX SETTINGS
- 1539 END PURGING
- 1550 COLLECT SAMPLE ERH014
DESIGNATE SAMPLE FOR MS/MSD ANALYSES
- 1605 LEAVE WELL
- 1618 EXIT THROUGH ADIT 5 (BB, CB), WHILE MN RETURNS THROUGH TUNNEL
TO RETRIEVE TRUCK
- 1638 MN arrives w/ Truck - load up and proceed to
EDW storage @ Adit 3 to dump EDW
in drum.
- 1710 leave RHPs - 4th Q GW monitoring complete

* Note: ALS rep. Traci Sober will pick
samples from E₂ office Wednesday
AM and pack/ship to ALS Wets.

MJD
10-20-15

APPENDIX C

**Laboratory Reports
(included on attached CD)**

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APPENDIX D

Fact Sheet, Quantitation & Detection

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As a Project Manager or decision-maker, you may use environmental data to accomplish one or more of the following tasks:

- Determine whether a chemical substance is present in an environmental sample at or above some threshold value or action level;
- Verify that a pollutant concentration remains below a permit limit;
- Evaluate potential risks to human health or the environment;
- Monitor changes in concentrations of contaminants; or
- Determine the effectiveness of remediation activities.

Making correct decisions in these cases often depends on the ability of an analytical method to detect and measure extremely low concentrations of a substance.

This fact sheet has been prepared to: 1) provide Project Managers and data users with basic information about detection and quantitation concepts; and 2) acquaint the reader with detection and quantitation terminology and requirements contained in the *DoD Quality Systems Manual for Environmental Laboratories (DoD QSM)*, Version 4.1. This information should help clarify the uncertainty associated with reporting low-concentration data. It should also help project teams understand the importance of selecting analytical methods that are sensitive enough for their intended uses, i.e., capable of generating reliable data (data of known precision and bias) at the project-specific decision levels.

Measures of Sensitivity — Basic Concepts

The following terms are used to describe the routine sensitivity of analytical procedures:

- DL – Detection Limit
- LOD – Limit of Detection
- LOQ – Limit of Quantitation

All measures of sensitivity are specific to the analyte, sample matrix, test method, instrumentation, and analyst/laboratory performance. Therefore, analytical performance must be demonstrated for each variable (e.g., it is possible that two “identical” instruments from the same manufacturer may exhibit different sensitivities).

The Detection Limit (DL) is the smallest analyte concentration that can be demonstrated to be different from zero or a blank concentration at the 99% level of confidence. In other words, if a substance is detected at or above the DL, it can be reliably stated (with 99% confidence) that the analyte is present (there is a 1% chance that the analyte is not present (a false positive)). Note that for reporting purposes, any result at or above the DL must also meet qualitative identification criteria required by the test method. Although a result at or above the DL indicates that the analyte is present, the absence of a result at or above the DL is inconclusive (i.e., one cannot confidently state whether the analyte is present or absent), because the false negative rate at the DL is 50%.

The Limit of Detection (LOD) is the smallest amount or concentration of a substance that must be present in a sample in order to be detected at a 99% confidence level. In other words, if a sample has a true concentration at the LOD, there is a minimum probability of 99% of reporting a “detection” (a measured value \geq DL) and a 1% chance of reporting a non-detect (a false negative).

The failure to obtain a “detection” should be reported as “<LOD,” because the false negative rate at the LOD is 1%. Reporting the sample result as “<DL” is inappropriate because, as stated above, the false negative rate at the DL is 50%.

The Limit of Quantitation (LOQ) is the lowest concentration of a substance that produces a quantitative result within specified limits of precision and bias. The LOQ is typically larger than the LOD (but may be equal to the LOD, depending upon the acceptance limits for precision and bias); therefore, the following is true:

$$DL < LOD \leq LOQ$$

Quantitative results can only be achieved at or above the LOQ. Measurements between the DL and the LOQ assure the *presence* of the analyte with confidence, but their numeric values are estimates.

Types of Procedures for Estimating Sensitivity

Numerical estimates of the DL, LOD, or LOQ for a specific analyte, matrix, and method can be calculated using various statistical procedures, which involve spiking reagent water or other specific matrix with low concentrations of the analyte of interest. At this time, unfortunately, universally accepted statistical procedures do not exist.

The estimator that has been most commonly used by environmental laboratories is the EPA Method Detection Limit (MDL), which is an approximation of the DL. EPA has defined the MDL as the “minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero, and is determined from analysis of a sample in a given matrix containing the analyte.”¹ Calculating the MDL at 99% confidence means there is a 1% probability that a sample having a result at or above the MDL is a false positive. The EPA MDL was designed to protect against false positives.

Uses and Limitations of the MDL

When performed correctly and consistently, MDLs determined using the EPA procedure can be useful for comparing different laboratories’ performance using the same methods, or the performance of different methods within the same laboratory. Laboratories typically determine the MDL in reagent water, resulting in a “best-case” MDL, which provides limited information about method performance on real-world samples.

The EPA MDL procedure has been criticized as a poor estimator of the DL for the following reasons:

1. It is a single laboratory, short-term estimator that fails to account for analytical bias, changing instrument conditions, or analyst skill.
2. It assumes uniform variance across all possible spike concentrations, failing to account for the fact that variance increases at higher concentrations.
3. It assumes that measured values at the spike concentration are normally distributed. By using this procedure and spiking at very low concentrations, laboratories have been able to calculate MDLs that cannot be achieved in practice.

DoD QSM Requirements

For the reasons discussed in the previous paragraph, the DoD QSM requires that laboratories verify measures of method sensitivity, in terms of the LOD and LOQ, at least quarterly. Requirements for the LOD and the LOQ are contained in DoD QSM Boxes D-13 and D-14, respectively, which follow:

¹ 40 Code of Federal Regulations (CFR) Part 136, Appendix B, rev. 1.11.

Box D-13

Limit of Detection (LOD): Determination and Verification (Requirement)

A laboratory shall establish a detection limit (DL) using a scientifically valid and documented procedure for each suite of analyte-matrix-method, including surrogates. The detection limit shall be used to determine the LOD for each analyte and matrix as well as for all preparatory and cleanup methods routinely used on samples, as follows:

After each detection limit determination, the laboratory must immediately establish the LOD by spiking a quality system matrix at approximately two to three times the detection limit (for a single-analyte standard) or one to four times the detection limit (for a multi-analyte standard). This spike concentration establishes the LOD. It is specific to each combination of analyte, matrix, method (including sample preparation), and instrument configuration. The LOD must be verified quarterly. The following requirements apply to the initial detection limit/LOD determinations and to the quarterly LOD verifications.

- The apparent signal to noise ratio at the LOD must be at least three and the results must meet all method requirements for analyte identification (e.g., ion abundance, second-column confirmation, or pattern recognition.) For data systems that do not provide a measure of noise, the signal produced by the verification sample must produce a result that is at least three standard deviations greater than the mean method blank concentrations.
- If a laboratory uses multiple instruments for a given method the LOD must be verified on each.
- If the LOD verification fails, then the laboratory must repeat the detection limit determination and LOD verification at a higher concentration or perform and pass two consecutive LOD verifications at a higher concentration and set the LOD at the higher concentration.
- The laboratory shall maintain documentation for all detection limit determinations and LOD verifications.

Box D-14

Limit of Quantitation (LOQ): Establishment and Verification of LOQ (Requirement)

For DoD projects, the LOQ must be set within the calibration range prior to sample analysis. At a minimum, the LOQ must be verified quarterly.

The laboratory procedure for establishing the LOQ must empirically demonstrate precision and bias at the LOQ. The LOQ and associated precision and bias must meet client requirements and must be reported. If the method is modified, precision and bias at the new LOQ must be demonstrated and reported.

Establishing Project-Specific Requirements for Method Sensitivity

Project teams should establish their project-specific requirements for method sensitivity in terms of a Reporting Limit (RL) for each analyte and matrix. As defined in the DoD QSM, the RL is the lowest concentration value specified by the client that meets project requirements for reporting quantitative data with known precision and bias for a specific analyte in a specific matrix. The LOQ cannot be greater than the RL, if precision and bias of the RL and LOQ are the same. If the LOQ for a particular analytical method or laboratory cannot meet the RL, then a project team has three options:

1. Improve analyst performance or modify the method to achieve a lower LOQ.
2. Select a different method with an LOQ less than or equal to the RL.
3. Raise the RL.

Please note that precision and bias must be taken into consideration when assessing the LOQ versus the RL. Also note that data below the RL can be reported; however they are estimated values if less than the LOQ.

Reporting and Flagging Analytical Data

Although data reporting and flagging requirements are project-specific, all reported LOD and LOQ shall be adjusted for the size of sample aliquots, concentration/dilution factors, and percent solids. In addition, the following example (based on Box 47 of DoD QSM Version 4.1) illustrates the proper use of the “U” and “J” data qualifier flags for non-detect and estimated analytical results, respectively.

- U – Analyte was not detected and is reported as less than the LOD or as defined by the client. The LOD has been adjusted for any dilution or concentration of the sample (* see Example, below).
- J – The reported result is an estimated value (e.g., matrix interference was observed or the analyte was detected at a concentration outside the quantitation range, see Box 33).

Example: DL = 2, LOD = 4, LOQ = 20, and RL = 30 with the precision and bias of the LOQ meeting those of the RL and all samples are undiluted.

Sample #1: Analytical result: Non-detect	Reported result: <4 U
Sample #2: Analytical result: 3	Reported result: 3 J
Sample #3: Analytical result: 10	Reported result: 10 J
Sample #4: Analytical result: 20	Reported result: 20
Sample #5: Analytical result: 30	Reported result: 30

Understanding and Documenting Uncertainty for Low-Concentration Data

As mentioned above, detection and quantitation limits are laboratory specific. Following are some steps Project Managers can take to document measurement uncertainty for low concentration data.

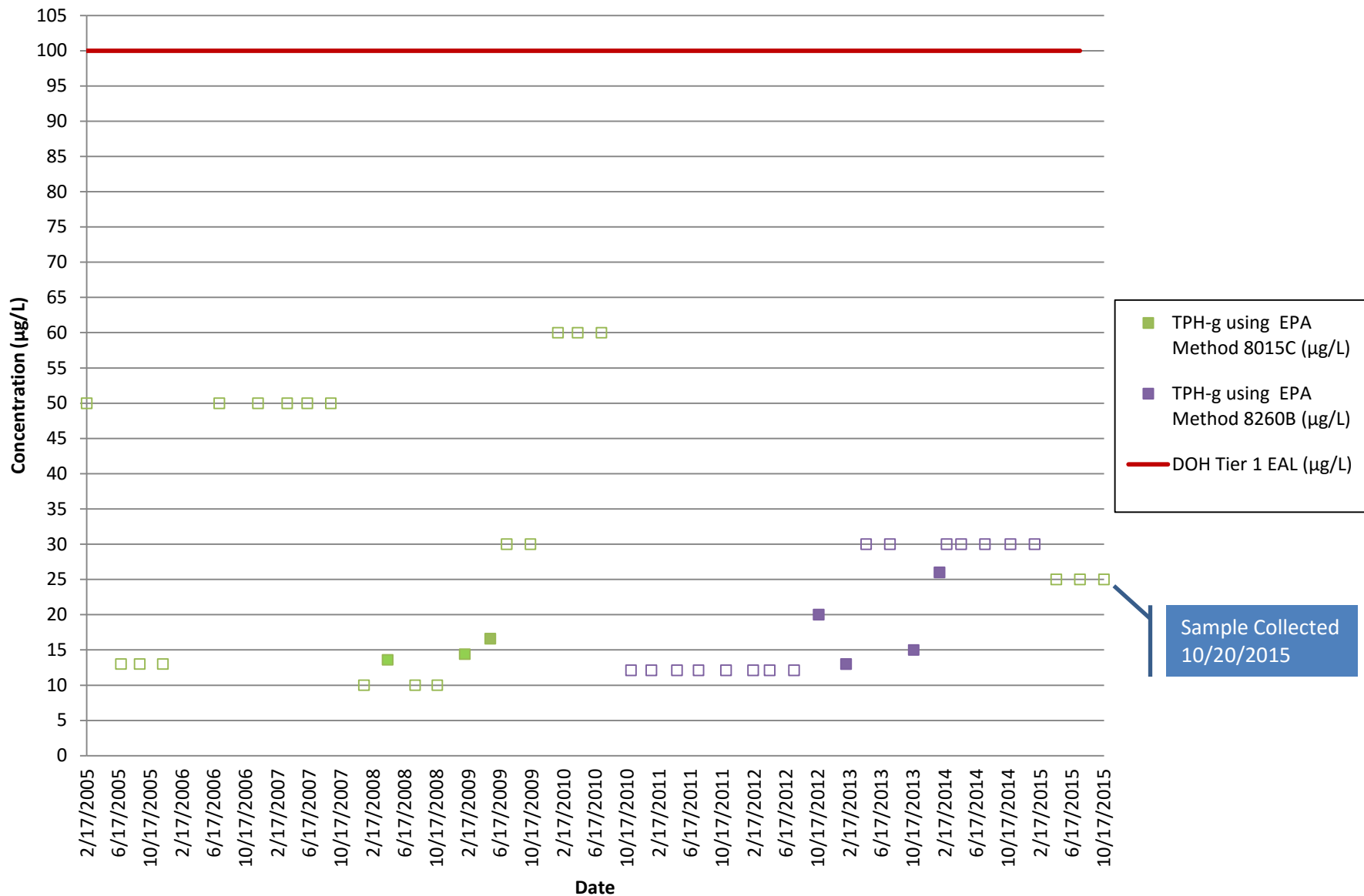
- As part of the laboratory selection process, provide the laboratory with project-specific RLs, including precision and bias, for each analyte and matrix. Ask the laboratory to provide its DL, LOD, and LOQ with associated precision and bias for each target analyte, in each matrix of concern (e.g., reagent water, clean sand, etc.), and verify that these values meet project-specific RLs. Request laboratory SOPs for establishing the DL and for establishing and verifying the LOD and LOQ.
- Ask the laboratory to verify the LOD by processing an LOD verification check sample with each batch of samples. This is a quality control sample that is spiked at a concentration at or slightly above the LOD to evaluate whether the analyte of interest is in fact “detectable” in the matrix of interest. To confidently report non-detects, set the reporting for non-detects to less than the LOD.
- If the project involves the collection of unusual or difficult matrices, or if the project-specific RL is near the LOQ, ask the laboratory to verify the LOQ in the project-specific matrix by analyzing a minimum of four replicate samples with known concentrations at the LOQ.
- Review the raw data (e.g., chromatograms) for low-concentration data. If a result is reported above the DL, make sure that the signal-to-noise ratio is at least 3.
- Compare sample results with blank results. If sample results (including chromatograms) cannot be distinguished from blank results, then they are not meaningful.

APPENDIX E

Historical Groundwater Exceedance Trends

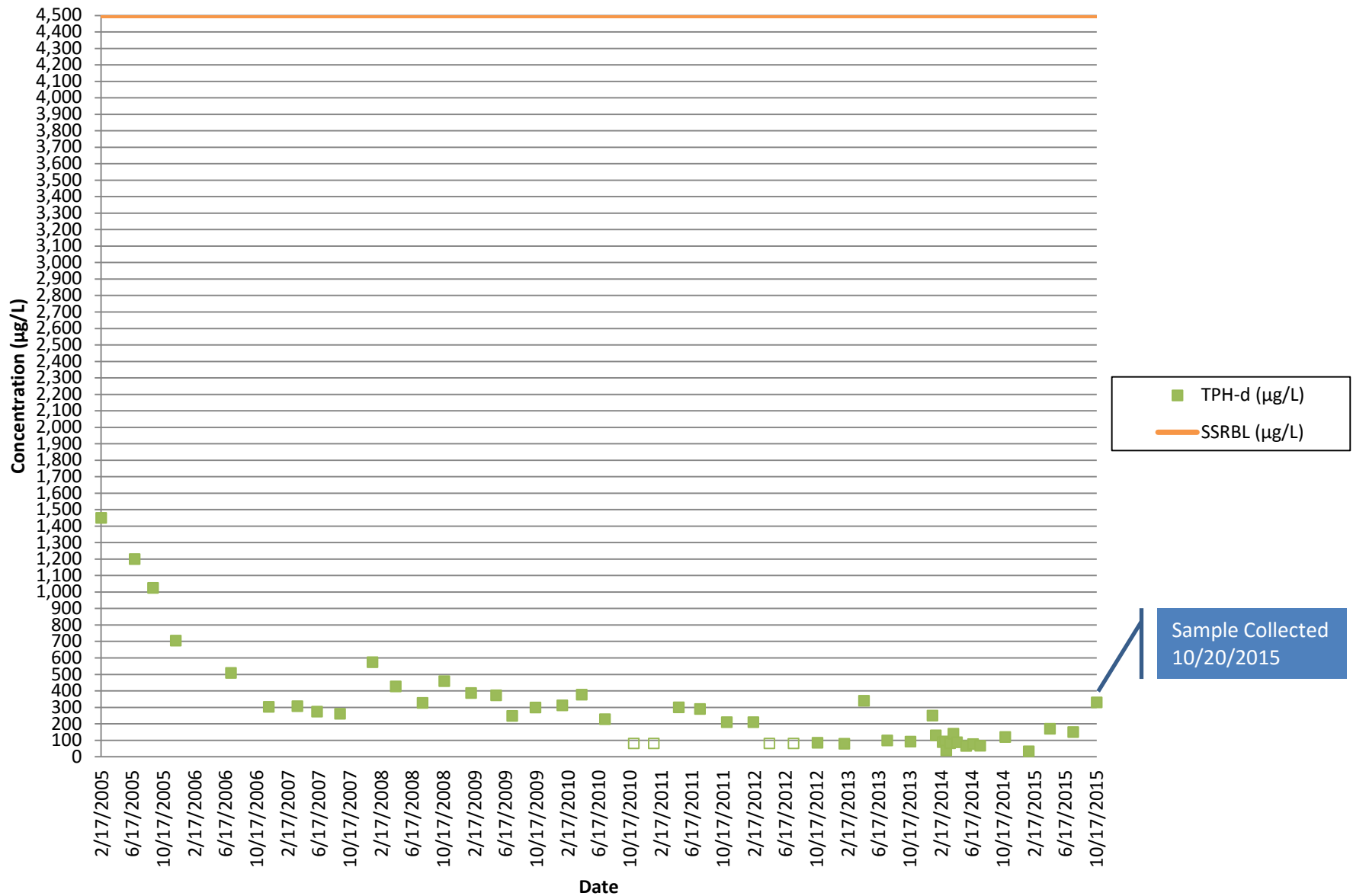
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TPH-g Concentrations for RHMW01



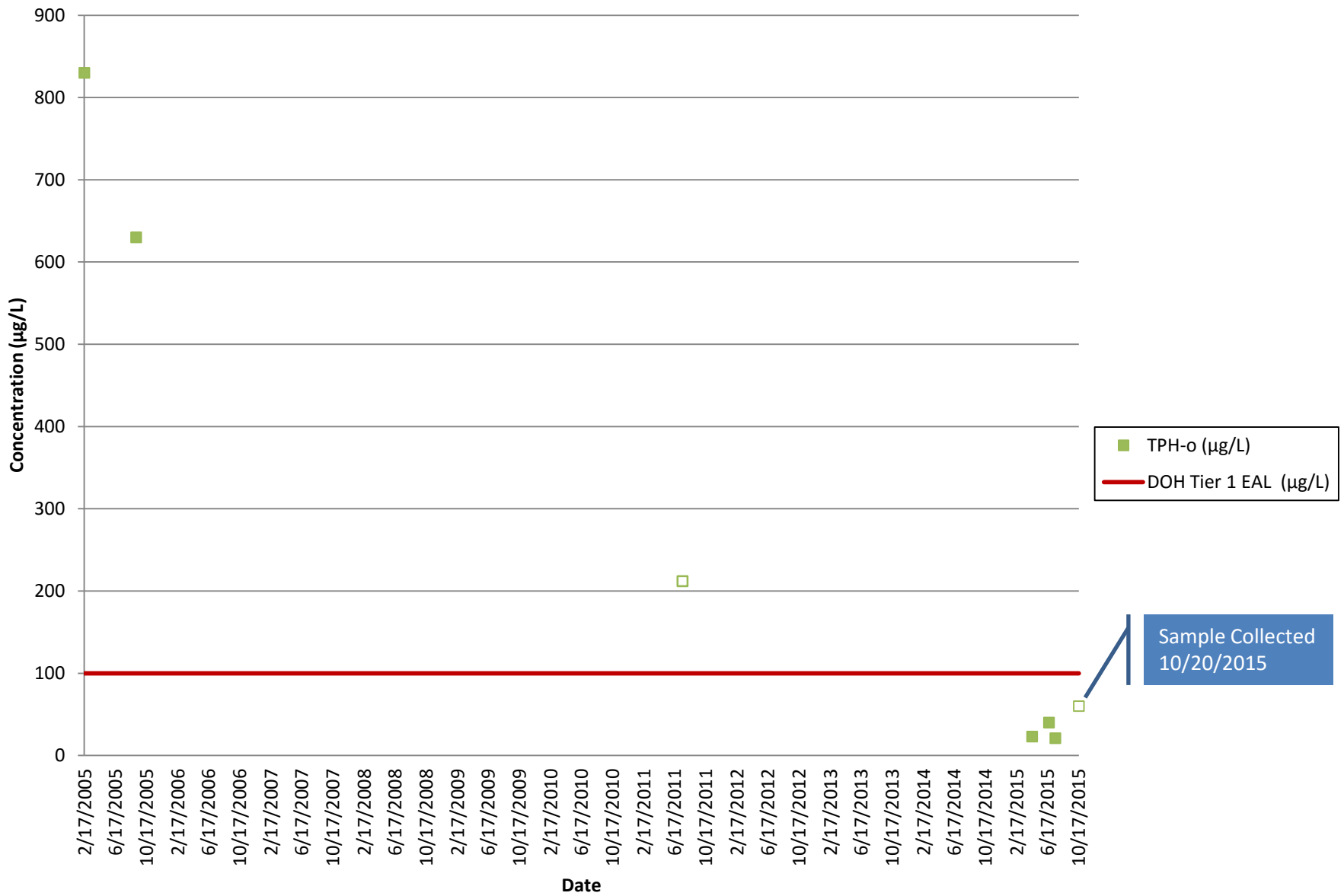
Unfilled boxes indicate non-detections. Data points for 2/17/2005 through 9/8/2005 and 12/6/2005 are the average of the primary and duplicate samples. Possible laboratory contamination for 10/22/2012, 10/21/2013, and 1/28/2014 sampling events. Method reporting limits (MRLs) are shown for February 2005, method detection limits (MDLs) are shown for June 2005 through October 2009, and limits of detection (LODs) are shown from January 2010 on.

TPH-d Concentrations for RHMW01



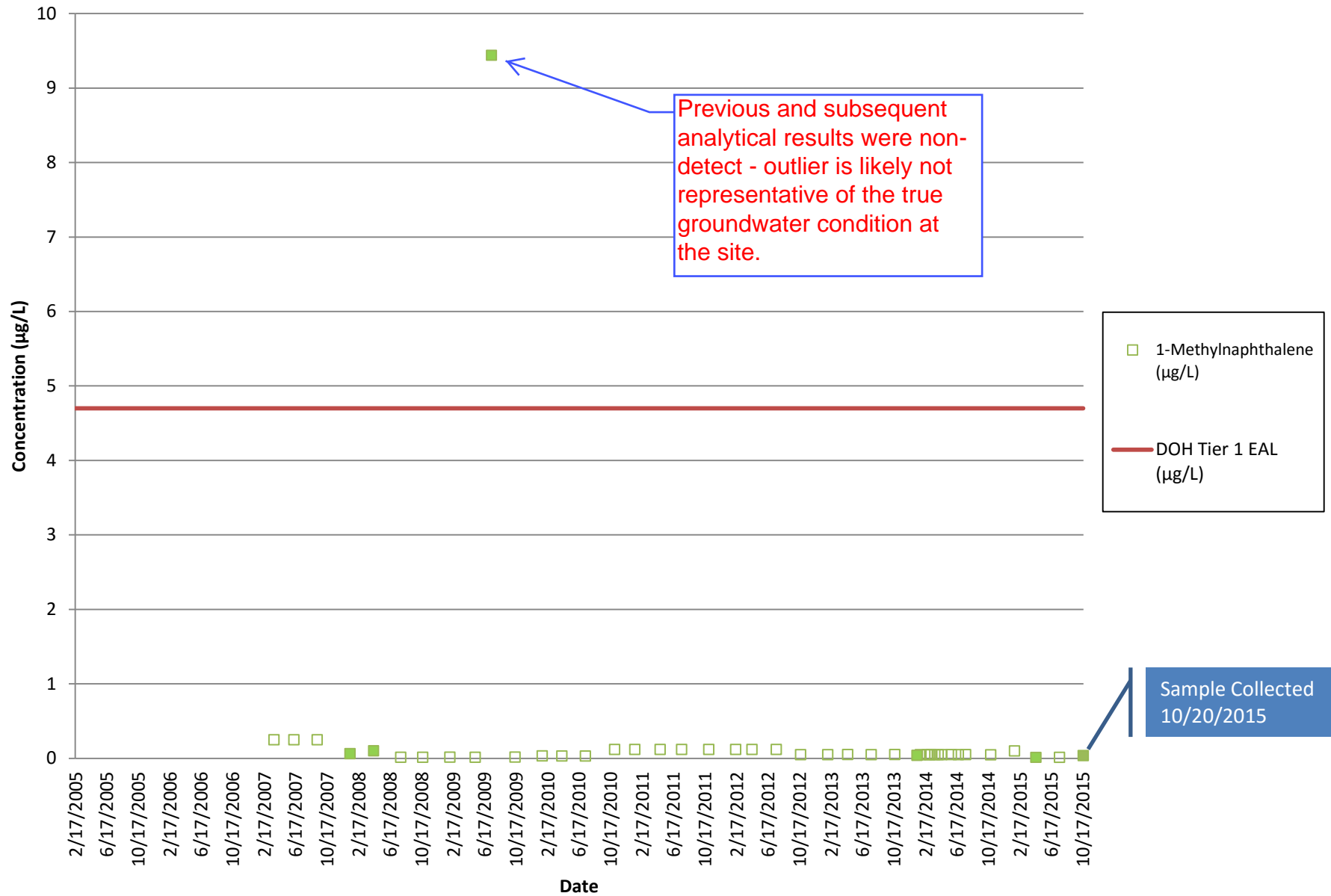
Unfilled boxes indicate non-detections. LODs are shown. Numerous sample results had a chromatographic pattern that did not match the calibration standard. The relatively high TPH-d values may not necessarily be indicative that there is diesel fuel or other petroleum products in the well. Data points 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



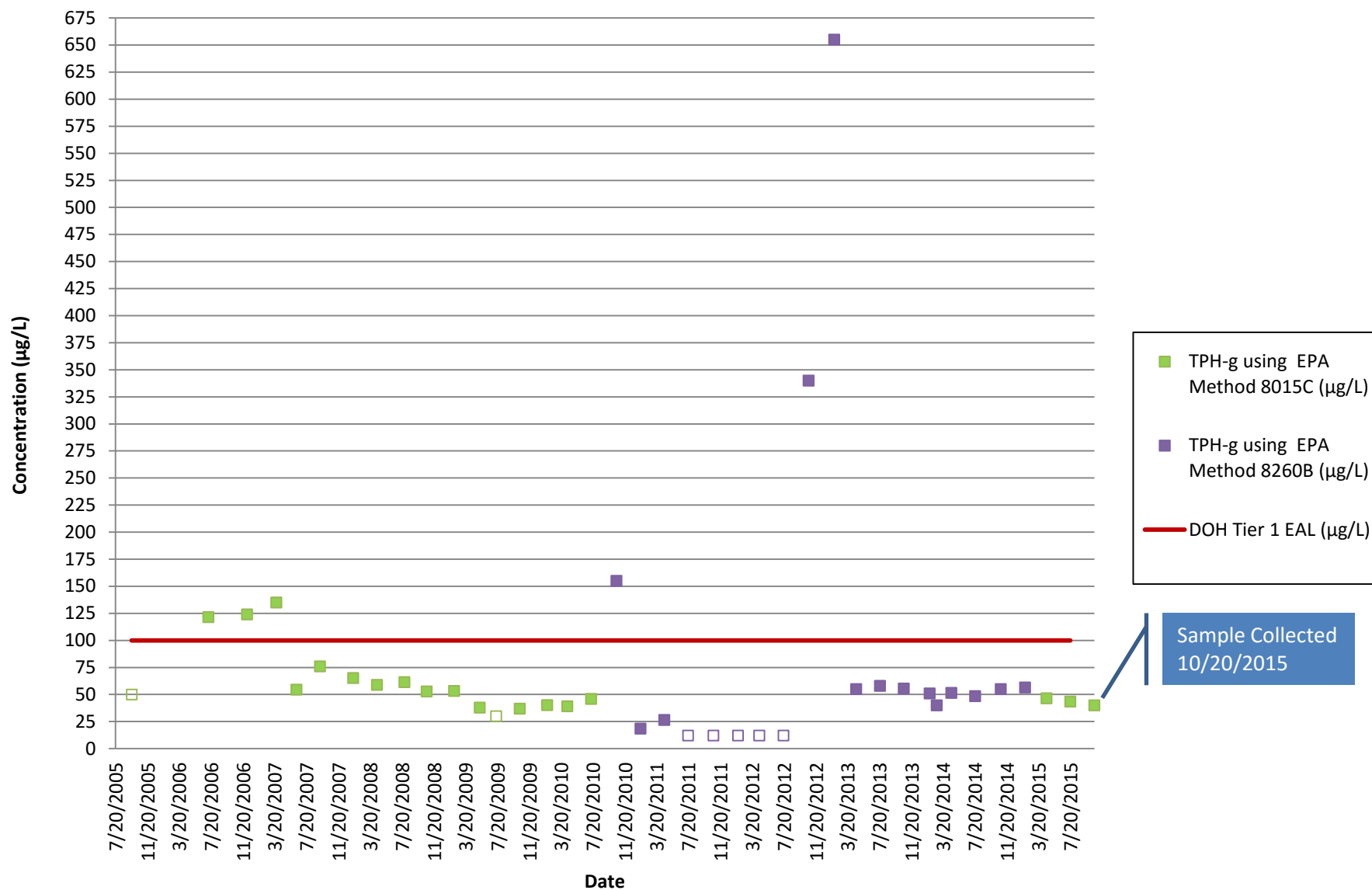
Unfilled boxes indicate non-detections.

1-Methylnaphthalene Concentrations for RHMW01



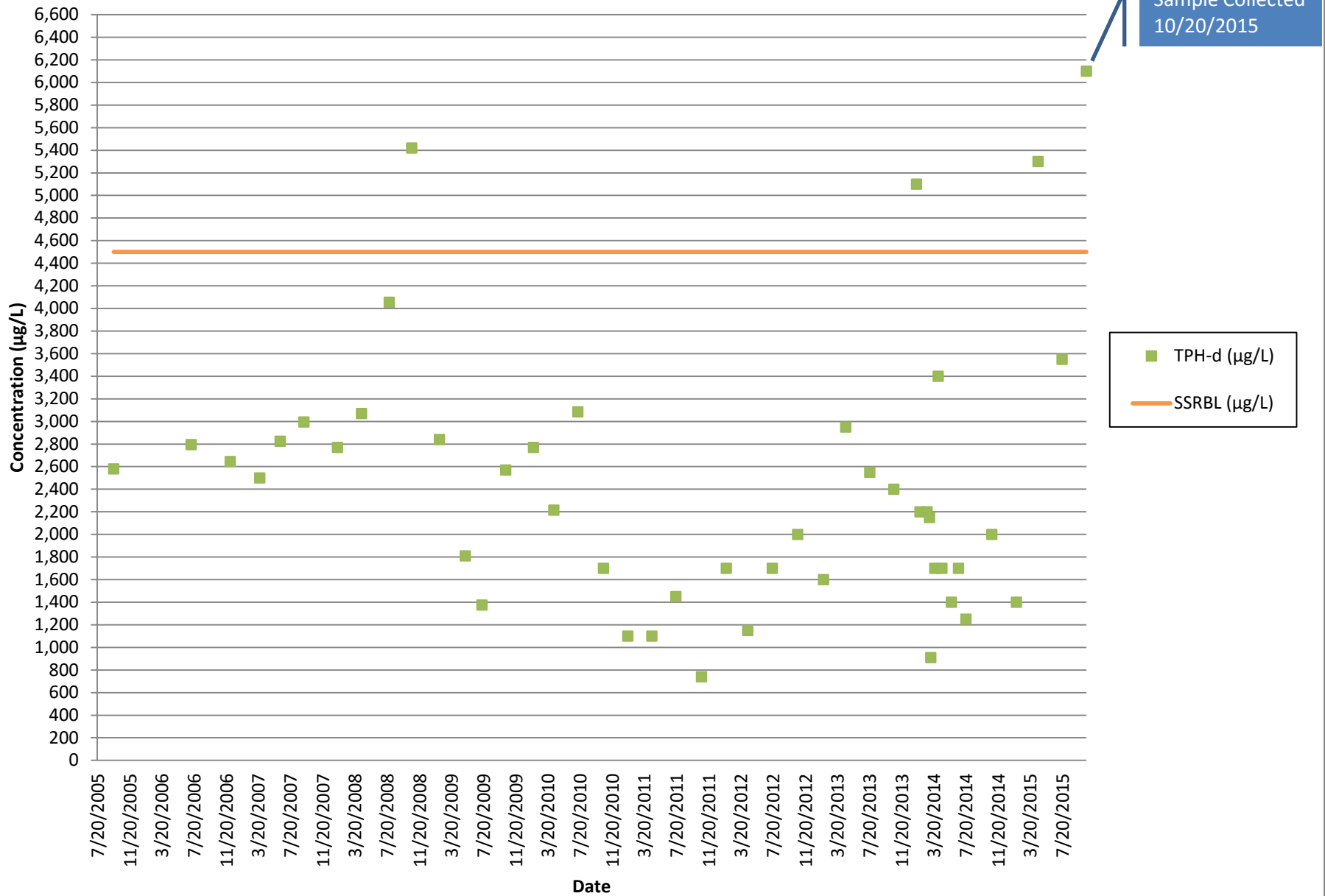
Unfilled boxes indicate non-detections. MDLs are shown for June 2005 through October 2009, and LODs are shown from January 2010 on.

TPH-g Concentrations for RHMW02



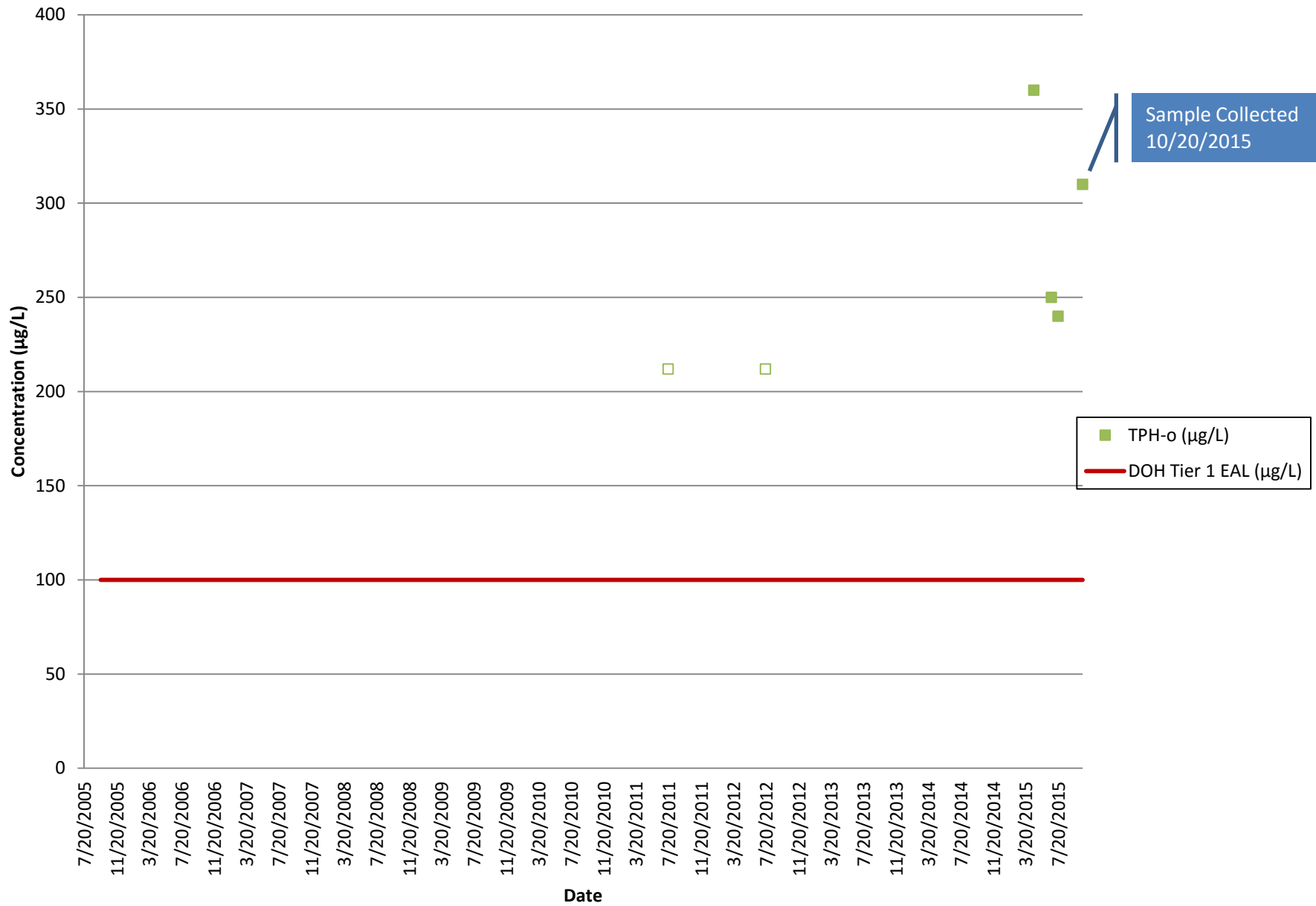
Unfilled boxes indicate non-detections. Data points for 9/20/2005 through 4/21/2014 are the average of the primary and duplicate samples. Possible laboratory contamination for 10/21/2013 and 1/28/2014 sampling events. MDLs are shown for July 2009, and LODs are shown for September 2005 and from July 2011 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.

TPH-d Concentrations for RHMW02



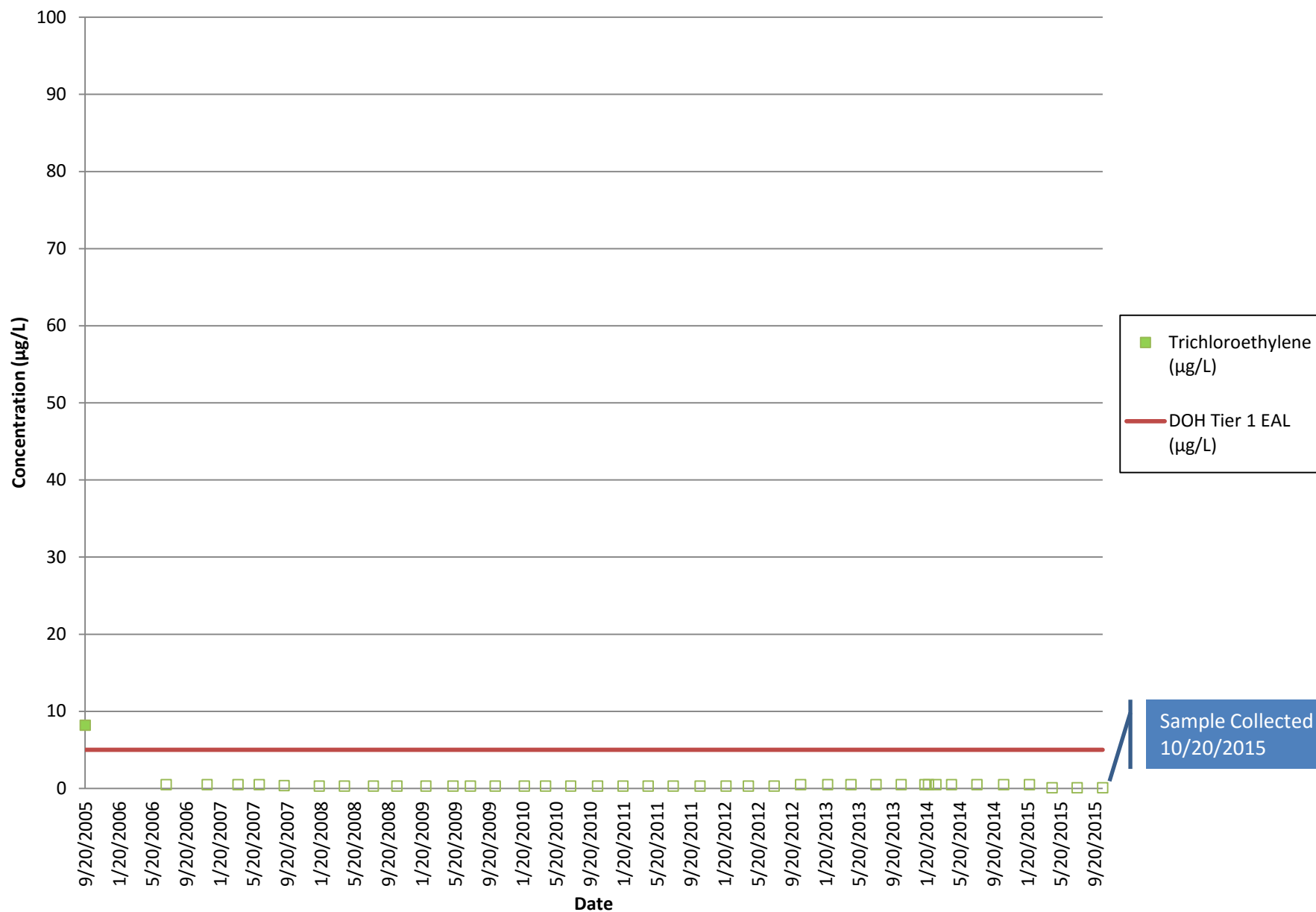
Data points for 9/20/2005 through 4/21/2014 are the average of the primary and duplicate samples. Numerous sample results had a chromatographic pattern that did not match the calibration standard. The relatively high TPH-d values may not necessarily be indicative that there is diesel fuel or other petroleum products in the well.

TPH-o Concentrations for RHMW02



Unfilled boxes indicate non-detections.

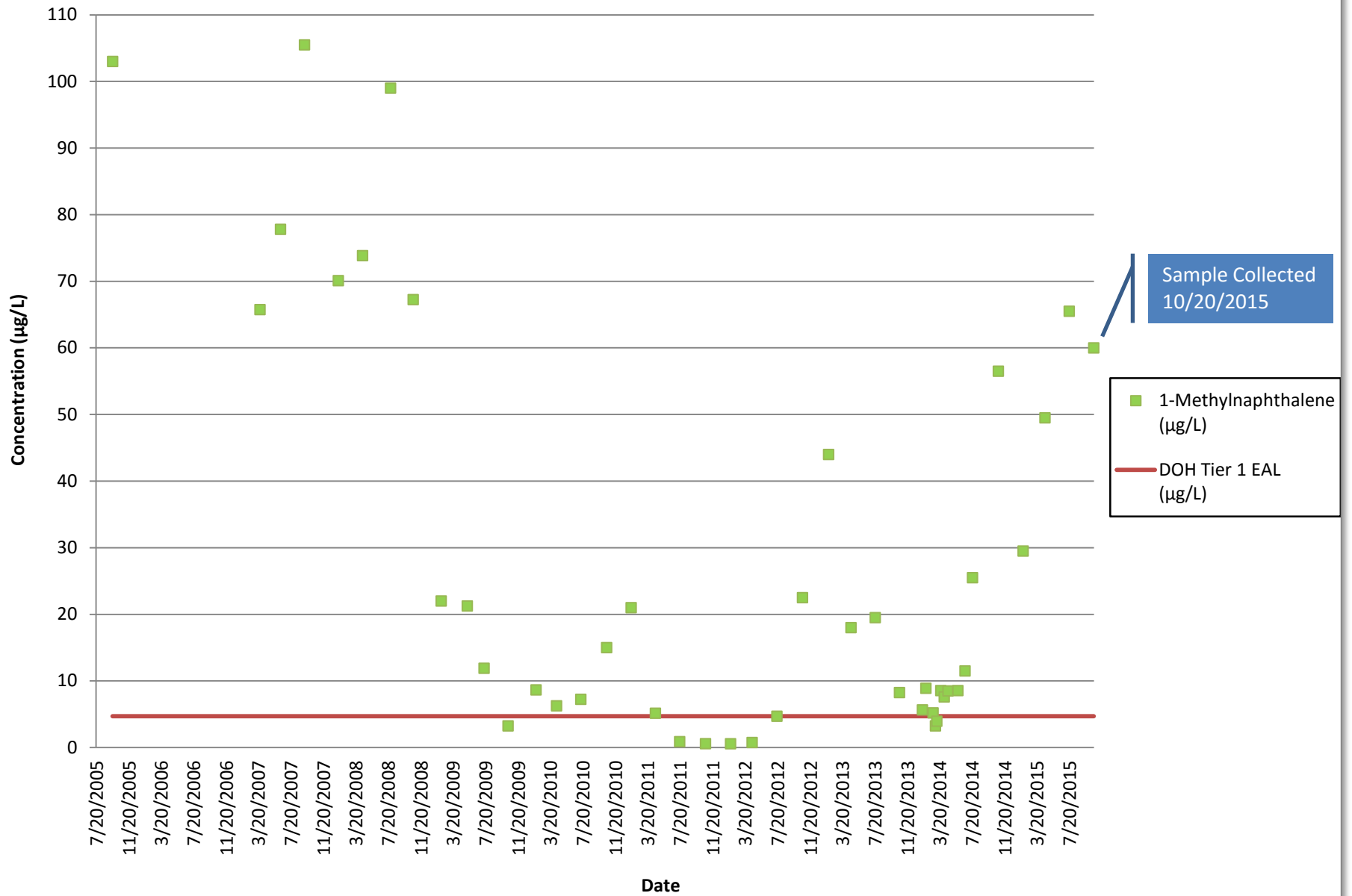
Trichloroethylene Concentrations for RHMW02



Data points for 9/20/2005 through 4/21/2014 are the average of the primary and duplicate samples.

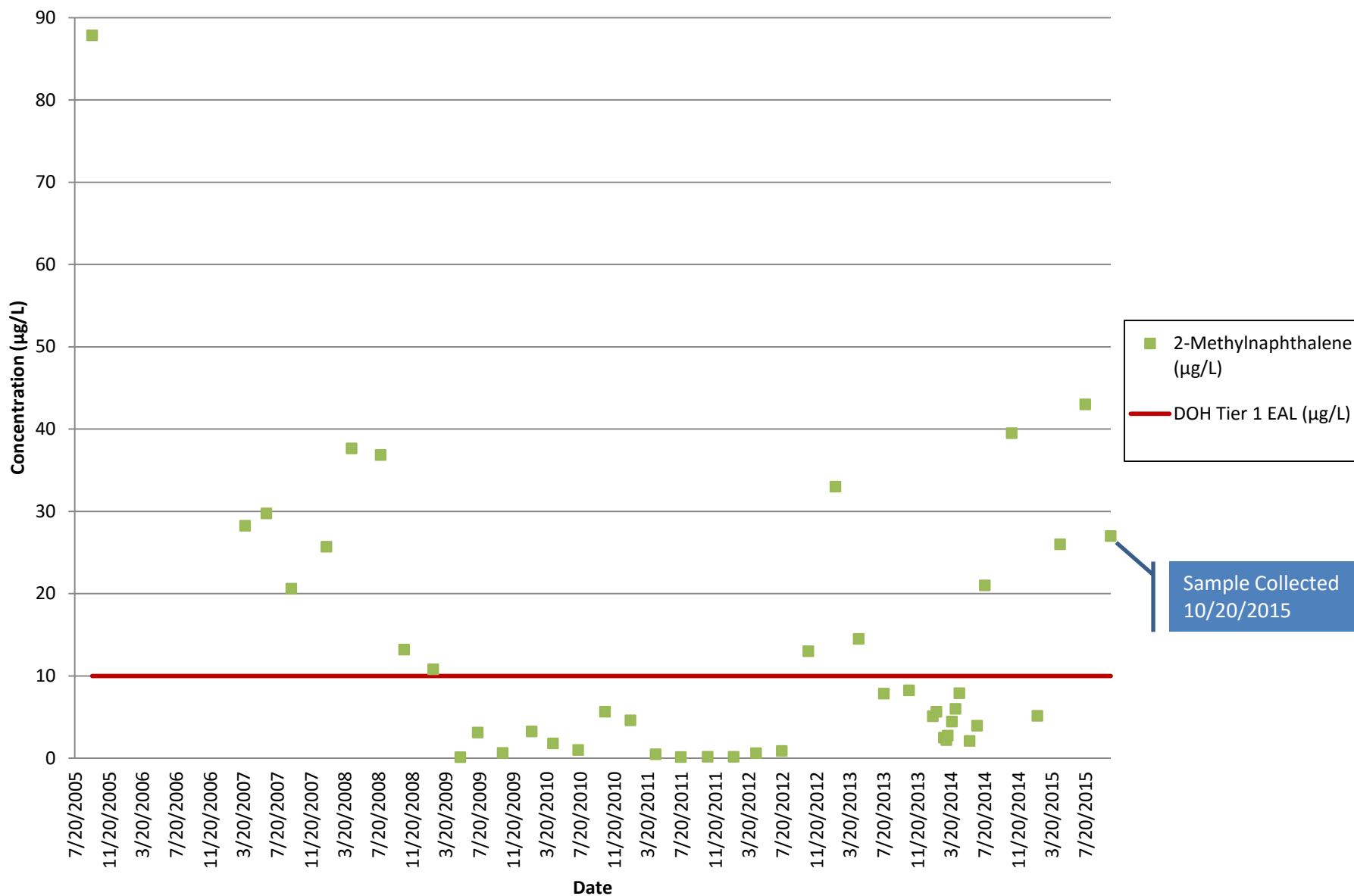
Unfilled boxes indicate non-detections. MDLs are shown for July 2006 through October 2009, and LODs are shown from January 2010 on.

1-Methylnaphthalene Concentrations for RHMW02



Data points for 9/20/2005 and 3/27/2007 through 4/21/2014 are the average of the primary and duplicate samples.

2-Methylnaphthalene Concentrations for RHMW02



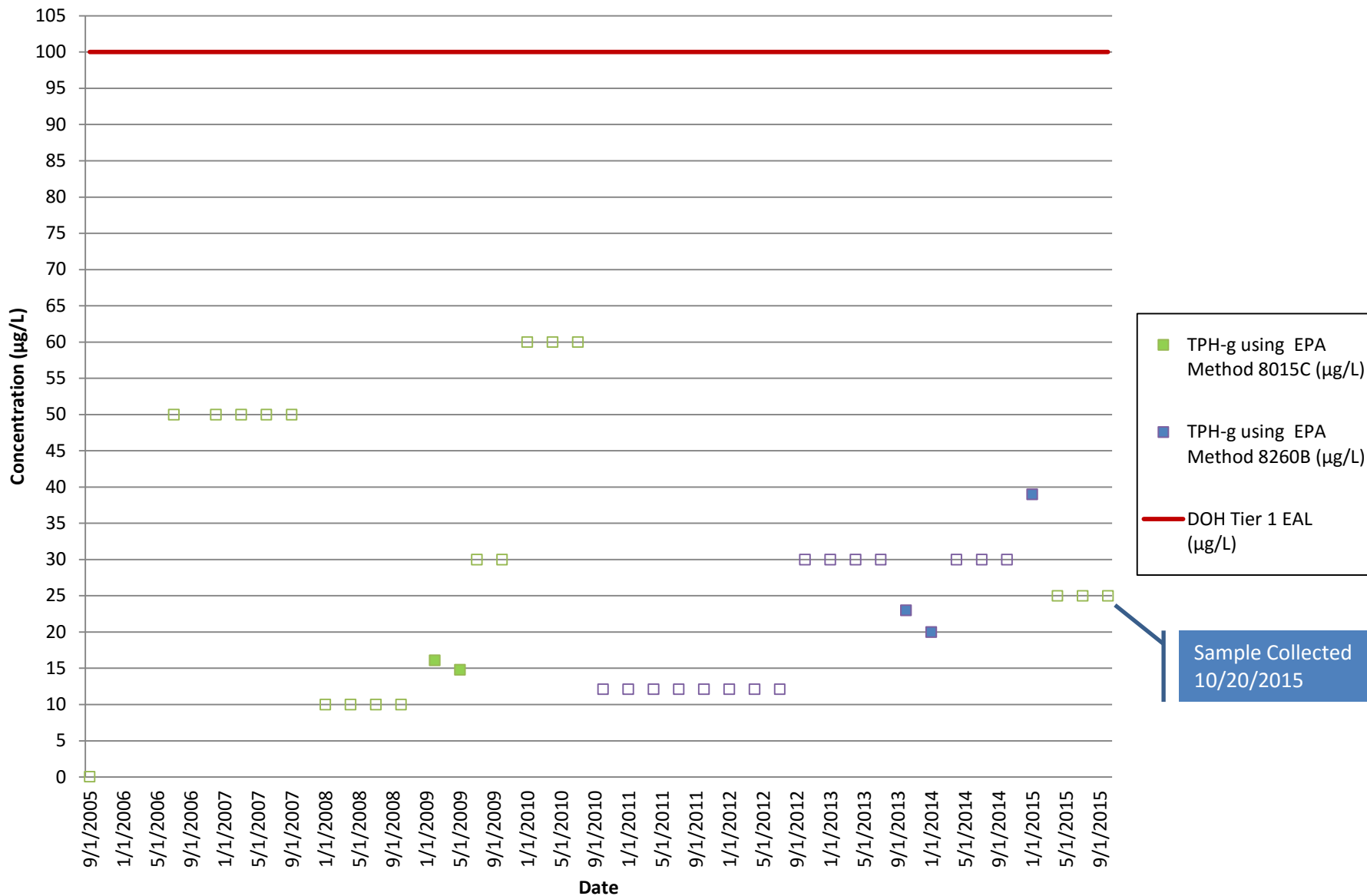
Data points for 9/20/2005 and 3/27/2007 through 4/21/2014 are the average of the primary and duplicate samples.

Naphthalene Concentrations for RHMW02



Possible laboratory contamination for 10/21/2013 and 1/28/2014 sampling events.
 Unfilled boxes indicate non-detections. LODs are shown.

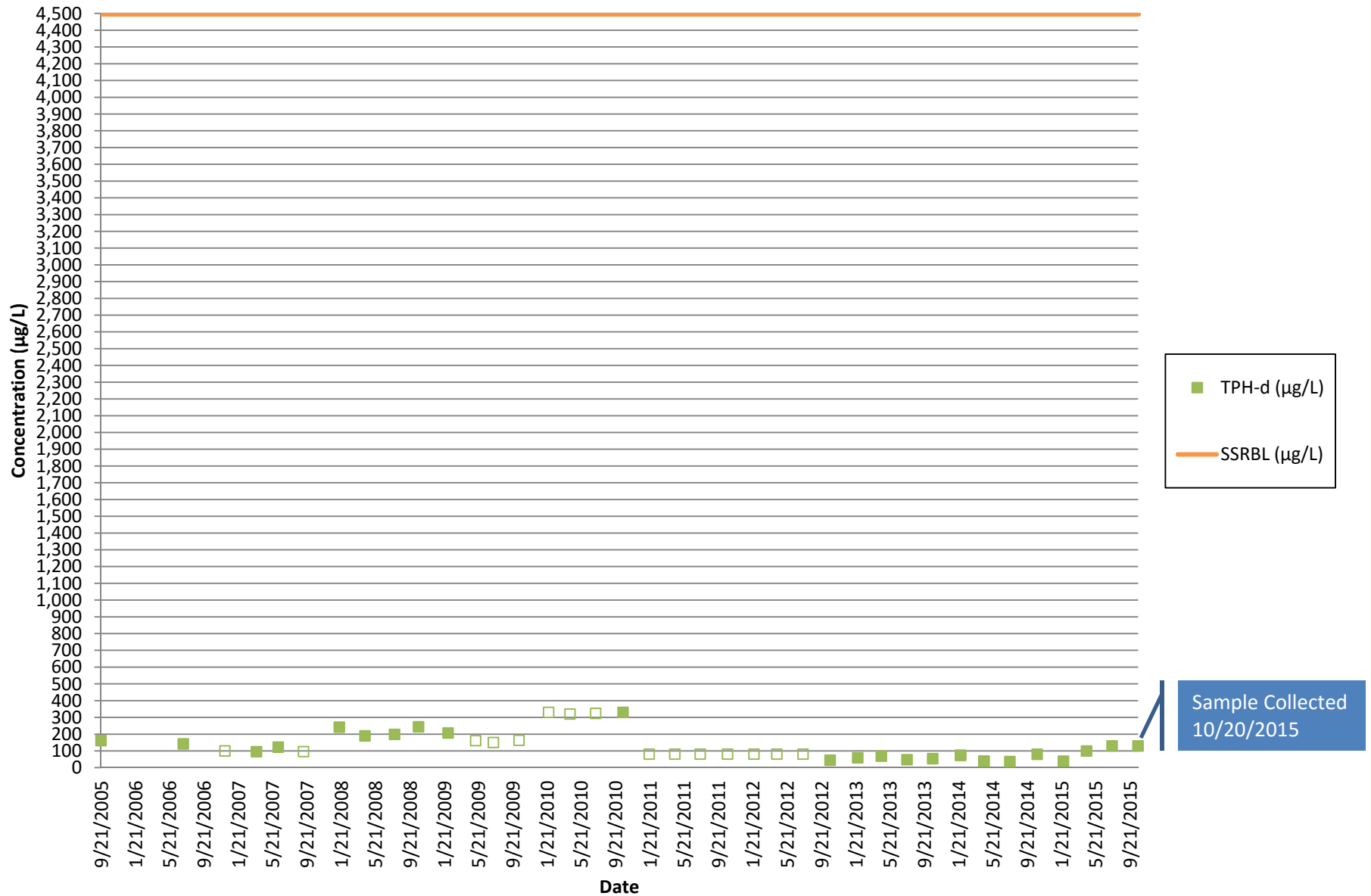
TPH-g Concentrations for RHMW03



Possible laboratory contamination for 10/21/2013 and 1/28/2014 sampling events.

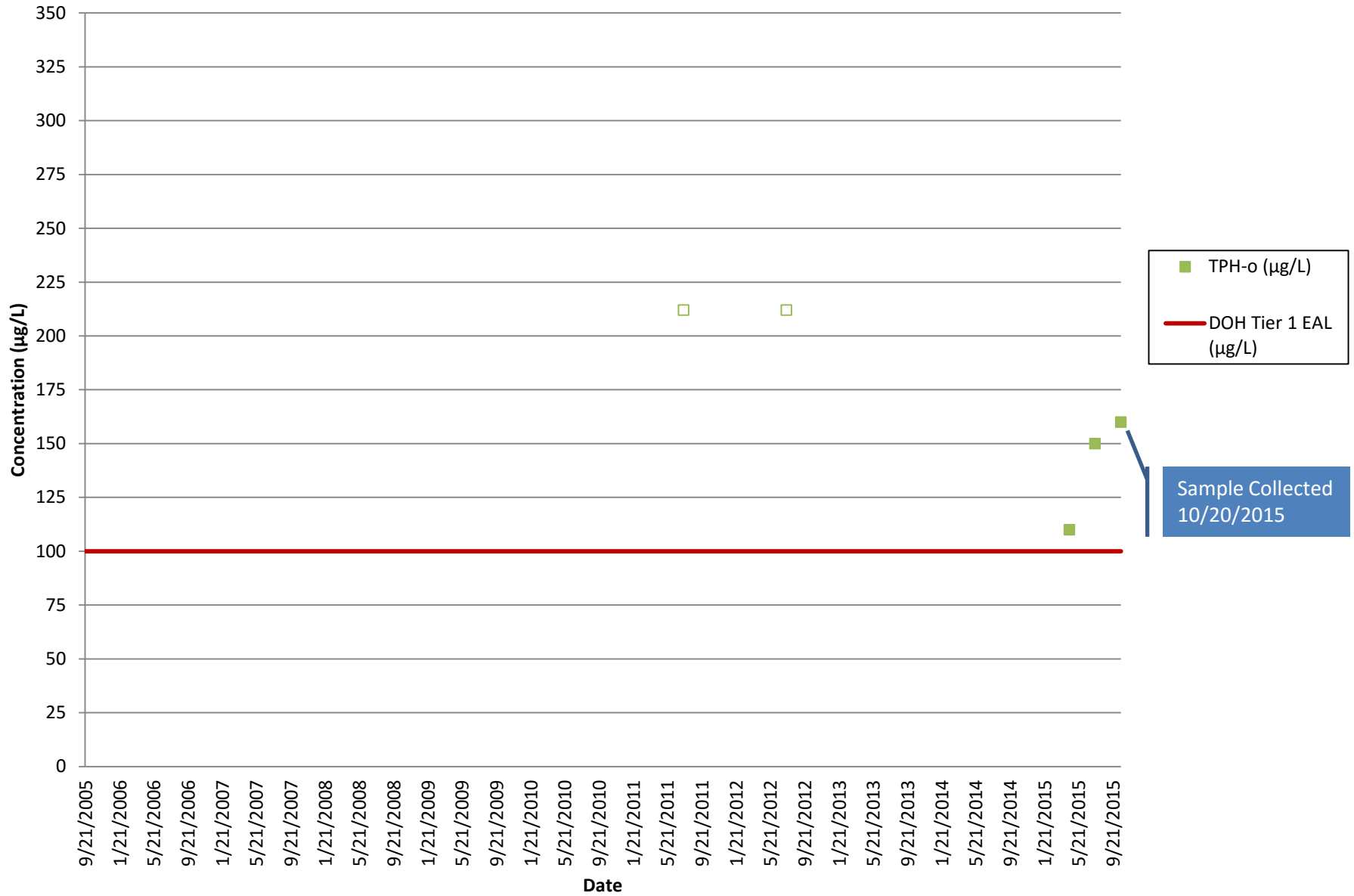
Unfilled boxes indicate non-detections. MDLs are shown for July 2006 through October 2009, and LODs are shown for September 2005 and from January 2010 on.

TPH-d Concentrations for RHMW03



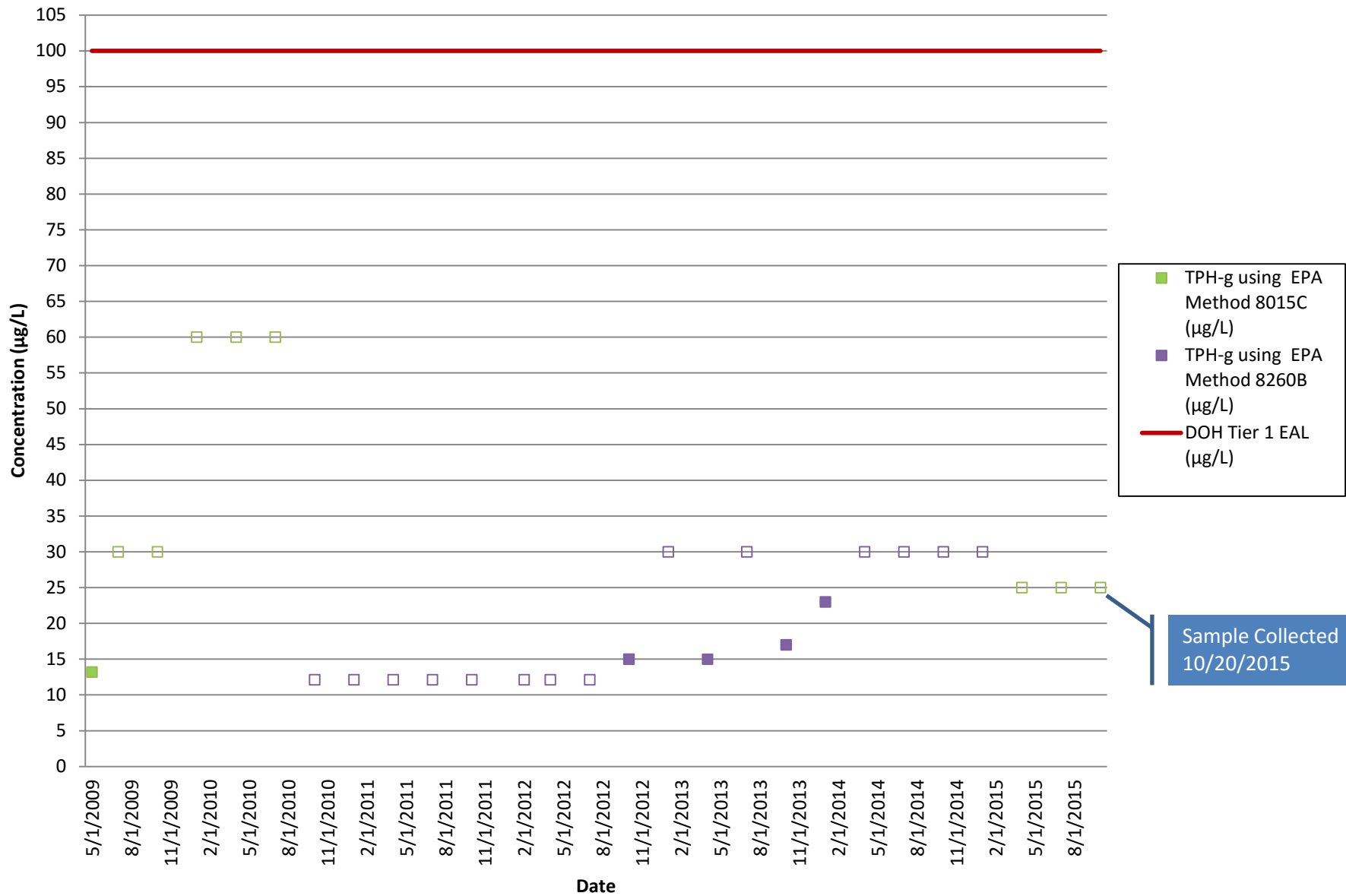
Unfilled boxes indicate non-detections. MDLs are shown for December 2006 through October 2009, and LODs are shown for September 2005 and from January 2010 on. Numerous sample results had a chromatographic pattern that didn't match the calibration standard. The relatively high TPH-d values may not necessarily be indicative that there is diesel fuel or other petroleum products in the well.

TPH-o Concentrations for RHMW03



Unfilled boxes indicate non-detections.

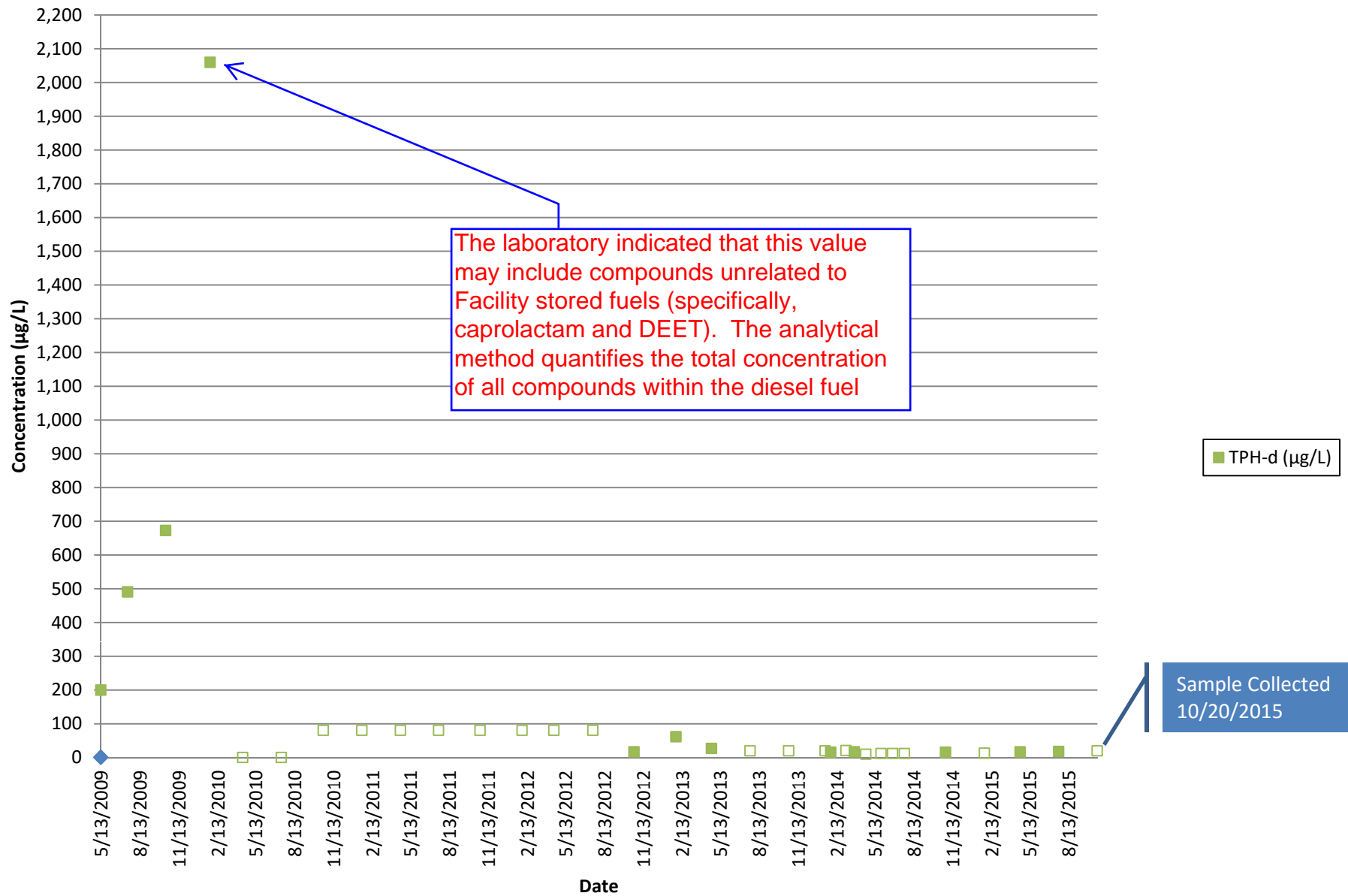
TPH-g Concentrations for RHMW05



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.

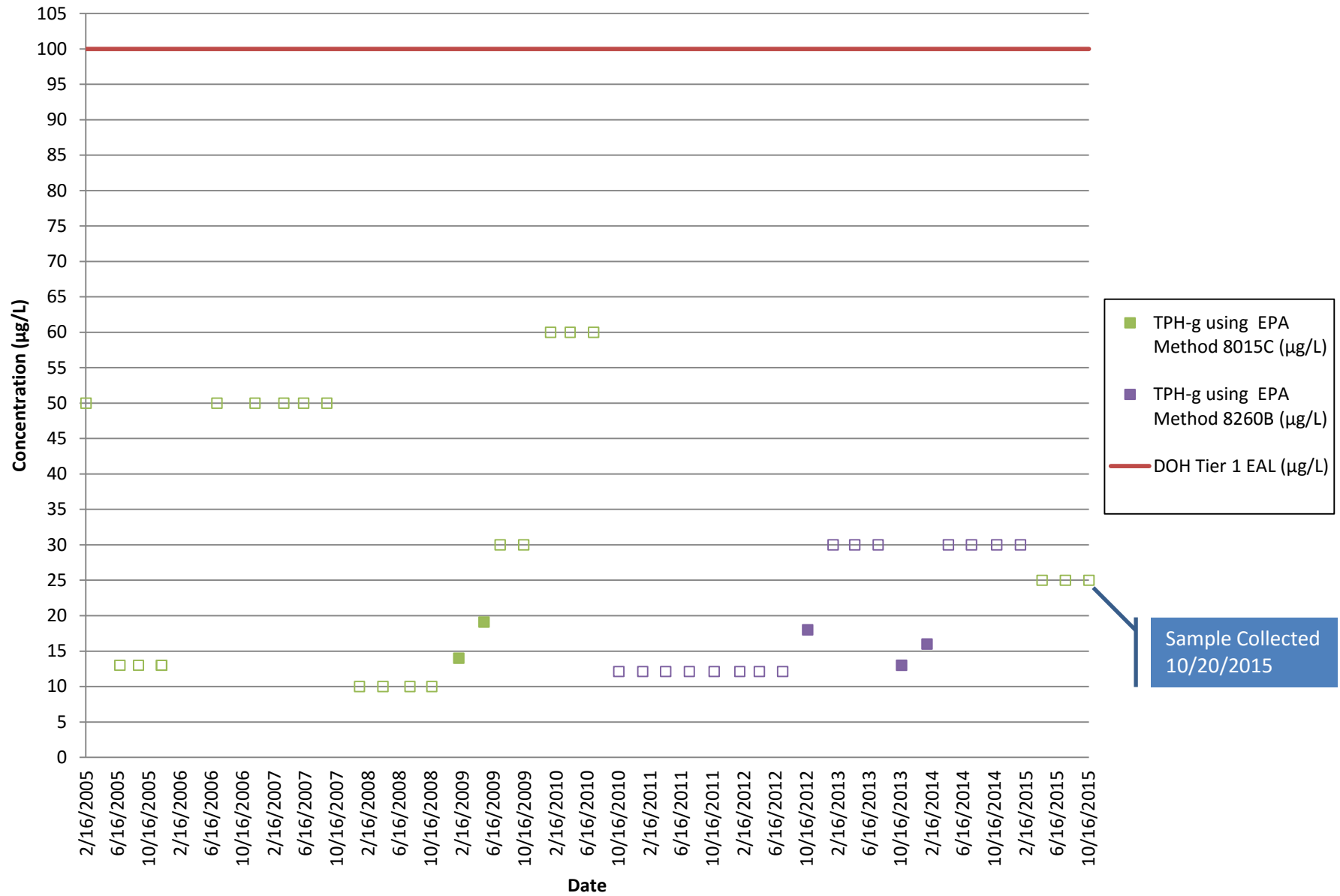
Possible laboratory contamination for 10/22/2012, 10/22/2013, and 1/29/2014 sampling events.

TPH-d Concentrations for RHMW05



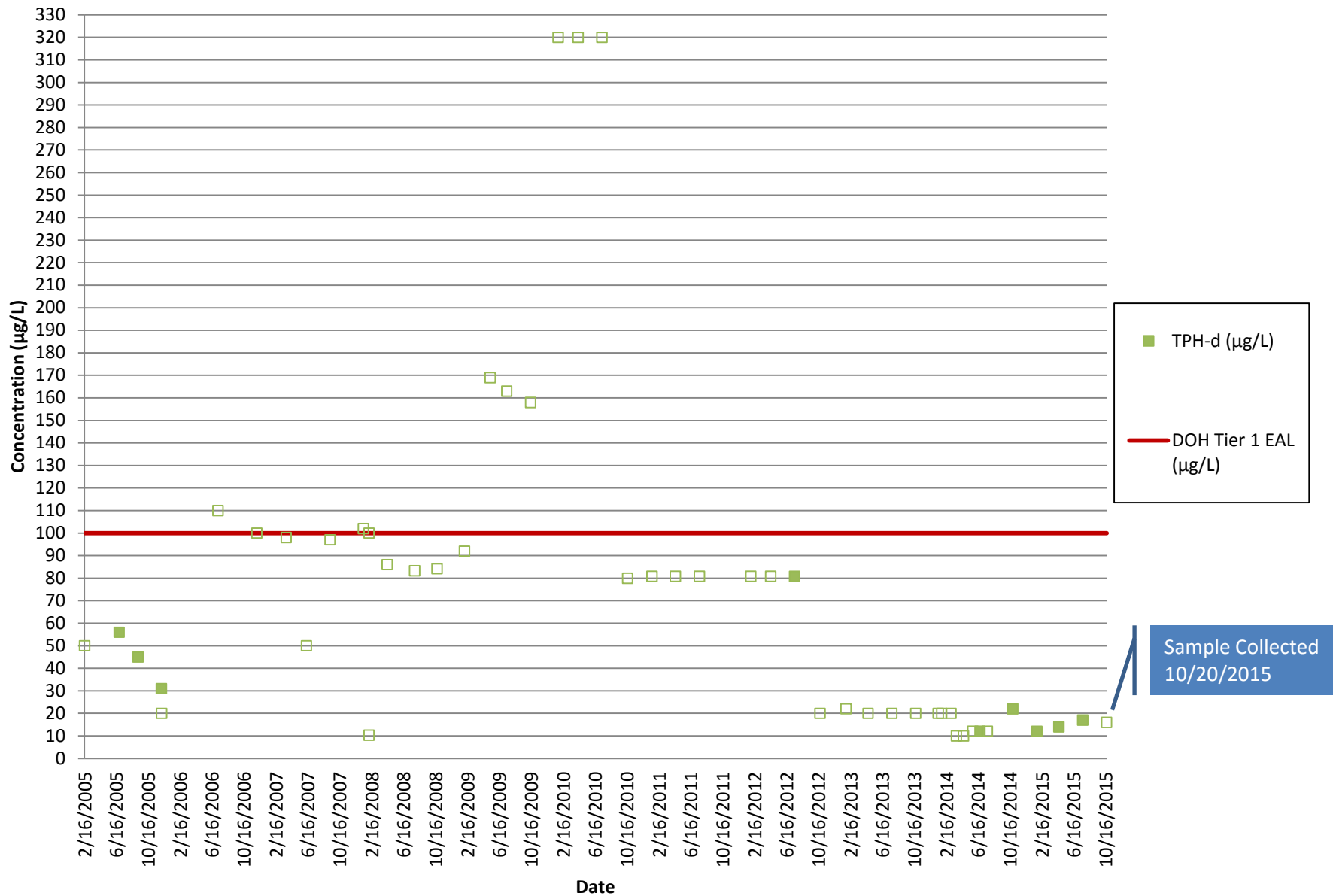
Unfilled boxes indicate non-detections. LODs are shown. Data point for 7/17/2012 is the average of the primary and duplicate samples. Numerous sample results had a chromatographic pattern that did not match the calibration standard. The relatively high TPH-d values may not necessarily be indicative that there is diesel fuel or other petroleum products in the well.

TPH-g Concentrations for RHMW2254-01



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.

TPH-d Concentrations for RHMW2254-01



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.