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Flint Hills Resources Alaska, LLC

First Semiannual 2015 Onsite Groundwater Monitoring Report

North Pole Terminal
North Pole, Alaska
DEC File Number: 100.38.090

July 31, 2015

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Acronyms and Abbreviations

4Q 2014 Onsite GWMR	Fourth Quarter 2014 Onsite Groundwater Monitoring Report
AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
amsl	above mean sea level
API	American Petroleum Institute
ARCADIS	ARCADIS U.S., Inc.
Barr	Barr Engineering Company
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and total xylenes
bwt	below the water table
CCV	continuing calibration verification
city	North Pole, Alaska
COC	constituent of concern
CSM	conceptual site model
DPE	dual-phase extraction
DQO	data quality objective
DRO	total petroleum hydrocarbons as diesel range organics
Environmental Standards	Environmental Standards, Inc.
FHRA	Flint Hills Resources Alaska, LLC
ft/ft	foot per foot
ft^2/day	square foot per day
g/day	grams per day
GAC East	original treatment system
GAC West	expanded groundwater recovery and treatment system

gpm	gallons per minute
GRO	total petroleum hydrocarbons as gasoline range organics
GRTS	groundwater remediation and treatment system
ITRC	Interstate Technology & Regulatory Council
lb/day	pound per day
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LNAPL	light nonaqueous phase liquid
LTM Plan	Long-Term Monitoring Plan
MAROS	Monitoring and Remediation Optimization System
MS	matrix spike
MSD	matrix spike duplicate
NGP	North Gravel Pit
NPT	North Pole Terminal
OCP	Final Onsite Cleanup Plan
OMM Plan	Operations, Maintenance, and Monitoring Plan
Onsite RSAP	Revised Onsite Sampling and Analysis Plan
Onsite SCR – 2013	Onsite Site Characterization Report –2013 Addendum
QA	quality assurance
QC	quality control
report	First Semiannual 2015 Onsite Groundwater Monitoring Report
reporting period	first and second quarters of 2015
RPD	relative percent difference
SGP	South Gravel Pit
SGS	SGS Laboratories

site	Flint Hills Resources Alaska, LLC North Pole Terminal, a petroleum terminal located on H and H Lane in North Pole, Alaska
SOP	standard operating procedure
Startup Aquifer Testing Report	Evaluation of Recovery Well Replacement, Startup Aquifer Testing for Recovery System Hydraulic Capture Performance Monitoring Report
sulfolane-d8	sulfolane internal standard
SWI	Shannon & Wilson, Inc.
toolkit	Mass Flux Toolkit
VPT	vertical profiling transect
WO	work order
µg/L	micrograms per liter
°C	degrees Celsius

1. Introduction

On behalf of Flint Hills Resources Alaska, LLC (FHRA), ARCADIS U.S., Inc. (ARCADIS) prepared this First Semiannual 2015 Onsite Groundwater Monitoring Report (report) for the FHRA North Pole Terminal (NPT), located on H and H Lane in North Pole, Alaska (site). This report summarizes onsite field activities completed during the first and second quarters of 2015 (reporting period) as described in Section 3 and Table 1-1. A separate First Semiannual 2015 Offsite Groundwater Monitoring Report is being submitted concurrently with this report.

The data, analyses, and conclusions presented in this report are the product of a collaborative effort among FHRA's consulting team members. The team includes qualified professionals in a variety of technical disciplines from three environmental consulting firms: ARCADIS, Shannon & Wilson, Inc. (SWI), and Barr Engineering Company (Barr). FHRA engaged these consulting firms to perform various tasks for the project. Pursuant to 18 Alaska Administrative Code (AAC) 75.335, this report was prepared and submitted by a Qualified Person. The sampling and analyses for this quarter were completed in accordance with the following documents, which were prepared by a Qualified Person and approved by the Alaska Department of Environmental Conservation (ADEC):

- Final Onsite Cleanup Plan (OCP; ARCADIS 2014a)
- Long-Term Monitoring Plan (LTM Plan; ARCADIS 2014b)
- Operations, Maintenance, and Monitoring Plan (OMM Plan; Barr 2014)
- Revised Onsite Sampling and Analysis Plan (Onsite RSAP; ARCADIS 2015a)

Samples were collected and analyzed in accordance with 18 AAC 75.355(c).

2. Site Setting

The 240-acre site is located inside the city limits of North Pole, Alaska (the city). The city is located approximately 13 miles southeast of Fairbanks, Alaska, within the Fairbanks North Star Borough (Figure 2-1). Future land use of the site will remain consistent with an industrial manufacturing setting given its significant infrastructure and capabilities. Current site features are shown on Figure 2-2. An onsite site plan is presented on Figure 2-3.

Permafrost is largely absent under the developed portions of the site. Discontinuous permafrost is present in the northern portions of the site. Small discontinuous masses of permafrost are believed to be located at monitoring wells MW-154A-75/B-95 and MW-179A-15/B-50/ C-90/D-135 and along the vertical profiling transect (VPT), as suggested by installed monitoring wells and geophysical data (ARCADIS 2013a). The southern edge of a large, relatively continuous permafrost mass is present near the North Property Boundary.

The site (both offsite and onsite areas) and the site’s physical setting are described in the conceptual site model (CSM), which was presented as Appendix A of the Onsite Site Characterization Report – 2013 Addendum (Onsite SCR – 2013; ARCADIS 2013a).

3. Current Groundwater Monitoring Program and Methods

The current onsite groundwater monitoring programs were originally proposed in the Site Characterization and First Quarter 2011 Groundwater Monitoring Report (Barr 2011) and were subsequently revised in several iterations of site characterization reports. On October 20, 2014, the OCP (ARCADIS 2014a), LTM Plan (ARCADIS 2014b), and OMM Plan (Barr 2014) were approved by ADEC and implemented beginning January 1, 2015. General methods for sample collection are outlined in the Onsite RSAP, which was submitted as Appendix A to the Fourth Quarter 2014 Onsite Groundwater Monitoring Report (4Q 2014 Onsite GWMR; ARCADIS 2015a).

Table 1-1 summarizes the field activities completed during the reporting period. Tables 3-1a and 3-1b summarize monitoring well and piezometer construction details. The groundwater elevation monitoring network, light nonaqueous phase liquid (LNAPL) migration monitoring network, LNAPL thickness monitoring network, onsite sulfolane monitoring network, and other constituents of concern (COCs) monitoring networks are summarized in Tables 3-1 through 3-5 in the LTM Plan (ARCADIS 2014b). Other COC's are defined as benzene, toluene, ethylbenzene, and total xylenes (BTEX), total petroleum hydrocarbons as gasoline range organics (GRO) and total petroleum hydrocarbons as diesel range organics (DRO). The performance monitoring well network for the onsite groundwater remediation and treatment system (GRTS) is summarized in Table 1 and Figures 2 through 5 of the OMM Plan (Barr 2014). Well locations are shown on Figure 2-3.

Groundwater monitoring data are used to assess changes in COC concentrations and trends, and the efficacy of the onsite GRTS. Groundwater monitoring and sampling were performed as part of ongoing operations to monitor onsite LNAPL, dissolved-phase petroleum hydrocarbon impacts, and dissolved-phase sulfolane impacts.

Data from the monitoring wells has been evaluated and networks adjusted quarterly according to criteria presented in the LTM Plan (ARCADIS 2014b). Updated monitoring networks will be included in the annual revisions of the LTM and OMM plans.

3.1 Groundwater Elevation and Light Nonaqueous Phase Liquid Monitoring

The first and second quarter 2015 groundwater elevation monitoring events were conducted on March 18 and 19, 2015 and June 10, 11 and 12, 2015, respectively, at an extensive network of onsite wells and two surface water staff gauges. Monthly groundwater measurements with concurrent surveying of the tops of the well casings were taken from the vertical gradient network on January 21 and 28; February 2, 16, 17, and 25; March 18 and 19; April 14 and 16; May 18 and 21; and June 4, 10, and 11, 2015. Six additional groundwater elevation monitoring events (January 21, February 25, March 18 and 26, April 16, May 21, and June 10, 2015) were completed during the reporting period to monitor the hydraulic capture of the GRTS. Groundwater elevation measurements collected as part of the hydraulic capture performance monitoring are presented in Section 6.1.

LNAPL measurements were collected to determine the LNAPL thicknesses and to confirm the stability of the LNAPL plume. During the reporting period, LNAPL thicknesses in monitoring, observation, and recovery wells were measured monthly on January 21, February 25, and March 10, 2015 during the first quarter and April 16, May 18 and 21, and June 10, 2015 during the second quarter. Wells on a quarterly schedule were measured on March 10, 2015 during the first quarter and May 18 and 21, 2015 during the second quarter. Wells on a semiannual schedule were measured on March 10, 2015.

In addition to manual water-level measurements, automated measurements were collected from a network of wells using pressure transducers to observe hydrogeological conditions between wells screened at various locations and depths within the suprapermafrost aquifer. The wells with deployed pressure transducers are listed in the Onsite RSAP (ARCADIS 2015a). Groundwater elevation measurements were downloaded from the deployed transducers on March 11, 19, and 24, 2015 during the first quarter and May 26, 27, and June 4, 2015 during the second quarter.

The standard operating procedure (SOP) for groundwater elevation monitoring (SWI 2013) was used to evaluate vertical hydraulic gradients within well nests and horizontal hydraulic gradients and groundwater flow directions between groups of wells (Appendix K).

3.2 Light Nonaqueous Phase Liquid Transmissivity Testing

Semiannual LNAPL baildown tests are conducted during periods when groundwater levels are at or near seasonal lows (water table minima), which have typically been historically observed in March and late October (ARCADIS 2014b). Baildown testing was completed at select wells with measureable LNAPL thickness greater than 0.5 foot during the reporting period as per the OMM plan (Barr 2014). Further discussion on the hydrographs and water table minima at these locations is included in Section 4.3.3.

LNAPL baildown tests are initiated by quickly removing LNAPL accumulated in a well in accordance with procedures outlined in the Onsite RSAP. Results of LNAPL baildown testing completed during the reporting period are discussed in Section 4.3.3. The LNAPL transmissivity results are used to quantify relative LNAPL recoverability in order to focus LNAPL recovery efforts in areas that have higher recovery potential and to establish practical limits of recovery.

Dual-phase extraction (DPE) systems typically operate year-round at various recovery wells based on the presence and thickness of LNAPL. Groundwater extraction-enhanced LNAPL recovery results are analyzed semiannually; results from the first and second quarters of 2015 are included in Section 4.3.4.

3.3 Groundwater Sampling Deviations

The following deviations from the LTM Plan (ARCADIS 2014b) were noted during the reporting period:

- LNAPL was encountered in wells MW-115-15, MW-176A-15, MW-186A-15, MW-334-15, O-2, O-19, S-44, S-50, and S-51 during planned monitoring events within the reporting period; therefore, samples were not collected from these wells for BTEX, GRO, and DRO analysis.

- Wells MW-116-15, MW-138-20, MW-336-15, MW-336-20, MW-336-35, MW-336-55, and MW-337-20 were frozen during the first and second quarters. Samples were not collected from these wells for BTEX, GRO, and DRO analysis.

- Well MW-113-15 was frozen during the first quarter but thawed and samples were collected from this well for BTEX, GRO, and DRO analysis during second quarter.

- Wells MW-116-15, MW-138-20, MW-178A-15, MW-178B-50, MW-179A-15, MW-179B-50, MW-336-15, MW-336-20, MW-336-35, MW-336-55, MW-337-20, MW-345-75, and O-1 were frozen during the first and second quarters and samples were not collected from these wells for sulfolane analysis.

- Well MW-113-15 was frozen during first quarter but thawed and samples were collected from this well for sulfolane analysis during second quarter.

- Well MW-304-CMT-10 was frozen during first quarter and dry during second quarter; therefore, samples were not collected from this well for sulfolane analysis.

- Samples were collected for sulfolane analysis from wells MW-345-15, MW-345-55, and O-20 during the first quarter; however, a sample was not collected during the second quarter because the wells were frozen.

- Wells MW-305-CMT-8 and S-39 were dry during the first and second quarters and samples were not collected from these wells for sulfolane analysis.

- Well MW-141-20 is scheduled to be sampled semiannually during first quarter; however, the well was inadvertently sampled early in the second quarter rather than first quarter during this reporting period.

- Samples collected from wells MW-355-15 and S-50 exhibited sulfolane detections above the 15 µg/L ; therefore, following the LTM Plan (ARCADIS 2014b)the monitoring frequency was increased from semiannually to quarterly.

4. Groundwater Monitoring Results

Groundwater impacts have been characterized, and continue to be monitored, through the analysis of water-level gauging data and groundwater samples collected from onsite monitoring wells. This section presents results of water-level gauging and groundwater analyses of onsite well samples (analyzed for sulfolane and/or other onsite COCs [BTEX, GRO, and DRO]). Groundwater field parameters, groundwater elevations, vertical gradient network groundwater elevations, hydraulic capture performance monitoring, LNAPL thickness measurements, LNAPL migration measurements, LNAPL baildown test results, and groundwater extraction-enhanced LNAPL recovery results are presented in Tables 4-6 through 4-7c. Tables 4-8 through 4-11 present results of BTEX, GRO, and DRO analysis; sulfolane analysis (including at the VPT); and sulfolane mass flux. Historical groundwater elevation and LNAPL thickness measurements, and BTEX, GRO, DRO, sulfolane, and geochemical analytical results are included as Appendix A. Analytical laboratory reports and ADEC quality assurance (QA)/quality control (QC) checklists are included as Appendices B and C, respectively. Field data sheets are included as Appendix D.

4.1 Groundwater Elevation

Depth to water measurements were collected from monitoring wells for the first semiannual monitoring event on March 18 and 19, 2015 during the first quarter; and June 10, 11 and 12 2015 during the second quarter. Potentiometric maps are included for each monitoring zone: water table, 10 to 55 feet below the water table (bwt), 55 to 90 feet bwt, and 90 to 160 feet bwt (Figures 4-1 through 4-8). During the reporting period, the general direction of the horizontal hydraulic gradient was interpreted to be to the north-northwest, which is consistent with historical groundwater data. Groundwater elevations and horizontal hydraulic gradients were within the range of historical groundwater data.

Groundwater elevations are summarized in Table 4-2. Vertical gradient network groundwater elevations are provided in Tables 4-3a through 4-3f. Vertical head difference estimates based on these data are presented in Appendix K. Groundwater elevation measurements collected as part of the hydraulic capture performance monitoring are presented in Section 6. Groundwater elevations near the GRTS are discussed in Section 6.

Groundwater elevations for wells completed at or near the water table listed in Table 3-1 of the LTM Plan (ARCADIS 2014b) are contoured on Figure 4-1, with the following exceptions. Recovery well R-40 was brought back online in late December 2014 to provide additional capture near R-45 (ARCADIS 2015b); therefore, data from this well were not used in preparing Figure 4-1. Three other actively pumped recovery wells (R-21, R-35R, and R-42) are listed in Table 3-1 of the LTM Plan (ARCADIS 2014b) and were not used for contouring on these figures. Data from monitoring well MW-344-15, located approximate 12 feet from well R-42, were used instead of data from R-42. Data from recovery wells R-21 and R-35R were not used in preparing Figure 4-1.

In addition to manual water-level measurements, automated measurements were collected with transducers from 62 individual wells and 17 well nests. Data from well nests were used to measure differences in groundwater elevations between wells screened at various depths within the suprapermafrost aquifer. Groundwater elevation hydrographs were prepared in accordance with the SOP (SWI 2013) using the most recent survey data. Error ranges, calculated in accordance with the method outlined in the SOP (SWI 2013), are shown on the well nest hydrographs presented in Appendix E. Data from eight monitoring wells were not retrieved for the reasons identified in the table below.

Monitoring Well	Reason for Omitted Data	Comments
MW-179A-15	Monitoring well was frozen; data logger could not be removed.	Data will be downloaded when location thaws.
MW-179B-50	Monitoring well was frozen; data logger could not be removed.	Data will be downloaded when location thaws.
MW-179C-90	Monitoring well was frozen; data logger could not be removed.	Data will be downloaded when location thaws.
MW-179D-135	Monitoring well was frozen; data logger could not be removed.	Data will be downloaded when location thaws.
MW-186A-15	The procedure for adjusting data to account for LNAPL in the well has not been established.	No data have been imported into the database.
MW-351-75	Data logger malfunction.	Data were not imported from May 8 to 16, 2015; no explanation for logger malfunction.
MW-351-150	Data logger malfunction.	Q2 data were not imported and the logger was removed for maintenance by the manufacturer.
PZ-1-20	Data logger malfunction.	Data were not imported and the logger was removed for maintenance by the manufacturer.

A detailed evaluation of transducer data and hydraulic gradients through 2013 is provided in Appendix 6-B of the Onsite SCR – 2013 (ARCADIS 2013a). An updated hydraulic gradient evaluation is discussed in Section 6 (Appendix K). The hydraulic gradient evaluations indicate that, although the hydrologic system at NPT is dynamic, the system variability has been reasonably captured by the monitoring program. For example, as the estimated average direction of horizontal hydraulic gradient is updates based on new information, the average value does not change markedly for a given group of wells.

The first and second quarter groundwater elevation monitoring results for this reporting period are summarized below.

The average magnitudes of the horizontal hydraulic gradients across each depth zone during the first quarter were calculated as follows: water table: 0.0010 foot per foot (ft/ft), 10 to 55 feet bwt: 0.00092 ft/ft, 55 to 90 feet bwt: 0.00081 ft/ft, and 90 to 160 feet bwt: 0.00089 ft/ft.

The average magnitudes of the horizontal hydraulic gradients across each depth zone during the second quarter were calculated as follows: water table: 0.00095 foot per foot (ft/ft), 10 to 55 feet bwt: 0.00094 ft/ft, 55 to 90 feet bwt: 0.00095 ft/ft, and 90 to 160 feet bwt: 0.00086 ft/ft.

4.2 Surface Water Elevation

Measurements were recorded from gauging points located at the North Gravel Pit (NGP) and South Gravel Pit (SGP) on March 18 and 19, 2015 during the first quarter and June 10, 2015 during the second quarter. At the NGP, the surface water elevation was measured at a surveyed mark on an I-beam above a grate in the fire pumphouse, which is situated over the water on the southeast end of the pit. At the SGP, the surface water elevation was measured at a 12-foot staff gauge in the pit. During the first quarter, the surface water elevations at the NGP and the SGP were 484.05 and 489.55 feet above mean sea level (amsl), respectively. During the second quarter, the surface water elevations at the NGP and the SGP were 484.55 and 489.71 feet amsl, respectively. Data are summarized in Table 4-2 and presented on Figures 4-1 and 4-5. Historical gauging data are summarized in Appendix A.

4.3 Light Nonaqueous Phase Liquid Monitoring Results

Observation wells were previously installed to better define LNAPL occurrence at the site. LNAPL thickness measurements were collected on January 21, February 25, and March 10, 2015 during the first quarter; and April 16, May 18 and 21, and June 10, 2015 during the second quarter from a network of monitoring, observation, and recovery wells screened across the water table.

4.3.1 Light Nonaqueous Phase Liquid Extent

Per the LTM Plan, LNAPL migration measurements were collected from wells along the perimeter of the LNAPL plume on January 21, February 25, and March 10, 2015 during the first quarter; and April 16, May 18 and 21, and June 10, 2015 during the second quarter. LNAPL was not observed in any of the LNAPL migration monitoring wells during the reporting period. The LNAPL footprint observed during the reporting period is similar to historical footprints.

4.3.2 Light Nonaqueous Phase Liquid Thickness

A measurable LNAPL thickness was recorded in 40 of 59 wells gauged during the first quarter and in 32 of 43 wells gauged during the second quarter as part of the LNAPL thickness monitoring well network. A visible sheen or trace detection (LNAPL thickness not measureable in the field) was recorded in seven wells during the first quarter and in one well during the second quarter.

Additionally, LNAPL thicknesses were measured in wells MW-135-20, MW-136-20, MW-176A-15, MW-186A-15, MW-334-15, MW-348-15, MW-354-15, MW-366-15, O-2, O-19, O-27, O-31, O-32, O-33, O-34, O-35, O-37, O-38, R-32R, S-21, S-43, S-44, S-50 and S-51 during BTEX, GRO, DRO and sulfolane sampling activities. These wells are included in the LNAPL Thickness Monitoring Network in the LTM Plan (ARCADIS 2014b) and will continue to be monitored in accordance with the OMM and LTM plans.

LNAPL thicknesses are similar to historical results. LNAPL thickness and migration data are summarized in Tables 4-4 and 4-5, respectively and maximum thickness data measured during the reporting period are presented on Figures 4-9 and 4-10. Additional LNAPL data measured during the comprehensive groundwater sampling event are summarized in Table 4-2, while LNAPL encountered during BTEX and sulfolane sampling activities is recorded in Table 4-1. LNAPL thickness measurements from the hydraulic capture performance monitoring network are tabulated in Appendix K. Additional LNAPL gauging events are conducted by facility operators as part of the operation and maintenance of the facility and LNAPL recovery efforts. Recovery data are discussed in Section 5 (Appendix L).

4.3.3 Light Nonaqueous Phase Liquid Baildown Tests

The objective for transmissivity testing is to ensure the overall effectiveness of LNAPL removal actions and continue to make adjustments to maximize LNAPL capture at the site. LNAPL recovery efforts are discussed in the OMM plan (Barr 2014) and in further detail in Section 5.

FHRA completed LNAPL baildown tests at eight monitoring wells during the reporting period in which the LNAPL thicknesses observed during the first quarter LNAPL monitoring event (Table 4-4), as per the OMM plan (Barr 2014). LNAPL baildown tests and data analyses were conducted according to procedures outlined in the Onsite RSAP (ARCADIS 2015a).

Appendix E includes hydrographs developed using data retrieved from pressure transducers in MW-113-15 and MW-179-15. The hydrograph for MW-113-15 shows that the water table minima during the reporting period occurred in February 2015 (483.91 feet amsl on February 13, 2015). Based on the occurrence of the water table minima, the LNAPL baildown testing timeframe continues to be accurate for achieving the target hydrogeologic minima criterion. LNAPL baildown tests should continue to be completed in March based on these data.

Figure 4-11 includes historical LNAPL baildown tests results. Transmissivity results from LNAPL baildown tests completed at the site through the reporting period are presented in Table 4-6 and shown on Figure 4-12. Table 4-6 also lists the monitoring well with a pressure transducer located closest to the wells where LNAPL baildown tests were completed, as well as the month when water table minima was observed in order to ensure LNAPL baildown tests were completed at appropriate times to meet conditions laid out in the Onsite RSAP. Appendix F presents the LNAPL baildown test input and output data.

LNAPL transmissivity estimates at wells O-11, O-34, S-50, and S-51 were within, and at well S-44 the estimate was below the lower limit of 0.8 square foot per day (ft^2/day) as defined in the OMM plan (Barr 2014). Transmissivity results for the tested wells indicate limited potential for LNAPL recovery in the area near these well locations.

4.3.4 Groundwater Extraction-Enhanced Light Nonaqueous Phase Liquid Recovery

FHRA calculated the LNAPL transmissivity for recovery wells R-21 and R-40 using remediation system data collected during the reporting period. LNAPL and groundwater drawdowns are required input values for the LNAPL transmissivity calculation. Two simplifying assumptions were made to facilitate the LNAPL transmissivity calculations:

1. LNAPL drawdown used in the calculations was based on the observed thickness of LNAPL in the well during gauging and system data collection.

2. Groundwater drawdown can be reasonably calculated for R-21and R-40 by pairing the recovery well with a monitoring well outside the zone of capture.

Recovery wells R-21 and R-40 were paired with O-5 and MW-125-25, respectively, to complete the calculation. Groundwater drawdown was calculated for this location based on historical fluid gauging data. LNAPL transmissivity results from the groundwater extraction-enhanced LNAPL recovery at R-21 and R-40 are included in Tables 4-7a and 4-7b, respectively. Semiannual and overall results are summarized in Table 4-7c. Time series plots for groundwater extraction-enhanced LNAPL recovery at R-21 and R-40 are included on Figures 4-13a and 4-13b, respectively. Appendices G-1 and G-2 include data analysis output for groundwater extraction-enhanced LNAPL recovery at R-21 and R-40, respectively.

LNAPL transmissivities at R-21 for the reporting period ranged from 0.1 to 1.2 ft^2/day, with a cumulative overall transmissivity of 0.3 ft^2/day since 2010. The current reporting period LNAPL transmissivities at R-21 are below and above the lower limit of 0.8 ft^2/day and historically have been above the limit (except in 2013, when data were likely skewed low due to large drawdown observed in the well during the testing period). LNAPL transmissivities at R-40 for the reporting period ranged from 0.1 to 0.4 ft^2/day, with a cumulative overall transmissivity of 0.1 ft^2/day since 2010. These transmissivities are below the lower limit of 0.8 ft^2/day.

4.4 Onsite Monitoring Well Sampling

BTEX, GRO, and DRO results collected from 64 onsite wells during the reporting period are summarized in Table 4-8. Figure 4-14 presents analytical results for benzene, including the inferred extent of the dissolved-phase benzene distribution within the suprapermafrost aquifer at the site. Results for BTEX, GRO, and DRO are discussed in Section 4.4.1. Historical BTEX, GRO, and DRO analytical results are included in Appendix A.

Sulfolane data were collected from the wells identified in the LTM Plan (ARCADIS 2014b) and wells that are on a monthly performance monitoring schedule for the GRTS, as described in the OCP (ARCADIS 2014a). Groundwater samples collected from 182 onsite wells during the first quarter and 130 onsite wells during the second quarter were submitted for sulfolane analysis during the reporting period.

Sulfolane analytical results are summarized in Table 4-9 and presented on Figures 4-14 through 4-22, which show the inferred extent (based on current and past data) of the dissolved-phase sulfolane distribution at the water table, 10 to 55 feet bwt, 55 to 90 feet bwt, and 90 to 160 feet bwt within the suprapermafrost aquifer at the site. Onsite sulfolane analytical results are discussed in Section 4.4.2.

Twenty-nine samples were collected during the first quarter and 20 samples were collected during the second quarter from the VPT, which includes well clusters MW-301 through MW-306. Groundwater samples were analyzed for sulfolane and results are presented in Section 4.4.3, in Table 4-9, and on Figures 4-14 through 4-22. Sulfolane concentrations for VPT wells in each groundwater zone are also summarized in Table 4-10 and presented on Figures 4-25 and 4-26. Historical sulfolane analytical results are included as Appendix A.

4.4.1 Petroleum Hydrocarbons

During the reporting period, samples were collected from 47 wells screened across the water table and 17 wells screened from 10 to 55 feet bwt for petroleum hydrocarbon analytical parameters. Benzene was detected in 33 of the 47 wells screened across the water table at concentrations ranging from 1.88 µg/L (O-5) to 1,180 µg/L (MW-135-20). Among the wells screened from 10 to 55 feet bwt, benzene was detected in seven of the 17 wells sampled, ranging from an estimated 0.210 µg/L (R-47) to 201 µg/L (MW-130-25).

In general, toluene, ethylbenzene, total xylenes, GRO, and DRO were not detected in samples where benzene was below the detection limit, except at O-4 where ethylbenzene and total xylenes were detected at concentrations of 1.19 µg/L and estimated as 2.48J µg/L, respectively. These results support the use of benzene as an indicator of petroleum impacts (ARCADIS 2014a). Detected petroleum hydrocarbons within water table wells are described below:

- Toluene was detected in 20 water table wells, at concentrations ranging from an estimated 0.910J µg/L (R-35R) to 6,000 µg/L (MW-135-20).
- Ethylbenzene was detected in 27 water table wells, at concentrations ranging from an estimated 0.680J µg/L (MW-137-20) to 1,100 µg/L (MW-135-20).
- Total xylenes were detected in 26 water table wells, at concentrations ranging from an estimated 2.48J µg/L (O-4) to 5,590 µg/L (MW-135-20).
- GRO was detected in 12 water table wells, at concentrations ranging from an estimated 0.0440J µg/L (O-5) to 23.2 µg/L (MW-135-20).
- DRO was detected in 20 water table wells, at concentrations ranging from an estimated 0.188J µg/L (MW-371-15) to 2.22 µg/L (S-43).

The estimated horizontal extent of the benzene plume at the water table is identified on Figure 4-14 as isopleths based on benzene concentrations from current and prior quarters.

4.4.2 Sulfolane

Sulfolane was not detected in samples collected during the first quarter from 11 onsite wells screened across the water table, 17 wells screened from 10 to 55 feet bwt, 11 wells screened from 55 to 90 feet bwt, and three wells screened from 90 to 160 feet bwt. Sulfolane was not detected in samples collected during the second quarter from 9 onsite wells screened across the water table, 15 wells screened from 10 to 55 feet bwt, seven wells screened from 55 to 90 feet bwt, and three wells screened from 90 to 160 feet bwt.

Sulfolane was detected in groundwater samples from the remaining onsite wells as follows:

- In wells screened across the water table (59 wells during the first quarter and 51 wells during the second quarter), at concentrations ranging from an estimated 3.45J µg/L (O-31) to 1,870 µg/L (MW-176A-15) and from an estimated 5.03J µg/L (MW-302-CMT-20) to 2,300 µg/L (MW-176A-15), respectively.

- In wells screened from 10 to 55 feet bwt (38 wells during the first quarter and 27 wells during the second quarter), at concentrations ranging from an estimated 3.17J µg/L (MW-302-CMT-50) to 862 µg/L (MW-354-35 duplicate) and from an estimated 3.91J µg/L (MW-344-55) to 1,010 µg/L (MW-354-35), respectively.

- In wells screened from 55 to 90 feet bwt (11 wells during the first quarter and six wells during the second quarter) at concentrations ranging from an estimated 3.94J µg/L (MW-302-80) to 14.9 µg/L (MW-154B-95) and an estimated 3.80J µg/L (MW-371-75) to 17.9 µg/L (MW-154B-95), respectively.

Sulfolane concentrations were flagged as estimated for groundwater samples collected from 44 wells during the first quarter and 26 during the second quarter (Table 4-9). Estimated sulfolane concentrations are discussed in Section 7. Sulfolane concentration isopleths at the water table, 10 to 55 feet bwt, 55 to 90 feet bwt, and 90 to 160 feet bwt are presented on Figures 4-15 through 4-22.

4.4.3 Vertical Profiling Transect

Groundwater samples were collected from the VPT wells to evaluate the vertical distribution of sulfolane concentrations and for mass flux estimation (Section 4.4.4). Sulfolane results for the VPT wells are summarized in Table 4-10 and shown on Figures 4-23 and 4-24. Additionally, Figures 4-15 through 4-22 show sulfolane concentrations for the VPT cluster locations at depths appropriate for each figure; and Appendix I, Figures 2A through 2D illustrate evaluations of the temporal sulfolane trends in the VPT wells.

At the MW-301 well cluster, sulfolane was not detected in the samples collected from 50 feet below ground surface (bgs) during the first quarter. Estimated concentrations of sulfolane during first quarter in groundwater were detected in samples collected from the 60- and 70-foot bgs depth intervals (MW-301-60 [5.27J µg/L] and MW-301-70 [4.55J µg/L]), respectively. Estimated concentrations of sulfolane during second quarter in groundwater were detected in samples collected from the 60- and 70-foot bgs depth intervals (MW-301-60 [5.29 µg/L] and MW-301-70 [4.61 µg/L]), respectively. The 70-foot bgs interval represents the deepest well installed at this location because permafrost was encountered at 70 feet bgs.

At the MW-302 well cluster, sulfolane was detected in groundwater samples collected from the 10-foot bgs depth interval at maximum concentrations of 17.3 µg/L during the first quarter and 11.4 µg/L during the second quarter. From this depth interval, sulfolane concentrations decreased with depth to below the detection limit in the sample collected at 40 feet bgs. There were three additional estimated sulfolane detections from samples collected during the first quarter below this depth interval at 50-, 70-, and 80-foot bgs depths (MW-302-50 [3.17J µg/L], MW-302-70 [7.15J µg/L], and MW-302-80 [3.94 µg/L]); however, sulfolane was not detected below this depth during the second quarter. Sulfolane was not sampled at 95 or 110 feet bgs during this reporting period. The well installed at 110 feet bgs is the deepest well installed at this location because permafrost was encountered at this depth.

At the MW-303 well cluster, sulfolane was not detected during this reporting period in the groundwater samples collected at 9 feet bgs. Sulfolane was detected in the groundwater samples collected at 19 feet bgs, at concentrations of 19.7 µg/L during the first quarter and 18.8 µg/L during the second quarter. Sulfolane concentrations decrease with depth, to an estimated detection of 3.36J µg/L in the sample collected at 49 feet bgs during the first quarter and an estimated detection of 4.76J µg/L in the sample collected at 39 feet bgs during the second quarter. Sulfolane was not detected in samples collected at 59, 70, and 80 feet bgs during the first quarter; and 49 feet bgs during the second quarter. Samples from 95 and 130 feet bgs were not collected for sulfolane analysis during the first quarter, or from 59, 70, 80, and 130 feet bgs during the second quarter. The well installed at 130 feet bgs was not sampled during this reporting period and is the deepest well installed at this location because permafrost was encountered at this depth.

At the MW-304 cluster, the maximum sulfolane detections in groundwater were 113 µg/L in the sample collected at 15 feet bgs during the first quarter and 104 µg/L in the sample collected at 20 feet bgs during the second quarter. Additionally, during the second quarter, sulfolane was detected at 15 feet bgs at a concentration of 74.3 µg/L. Sulfolane concentrations decrease with depth to an estimated 3.74J µg/L in the sample collected from 40 feet bgs during the first quarter and to an estimated 5.84J µg/L in the sample collected from 30 feet bgs during the second quarter. Sulfolane concentrations were not detected in the groundwater samples collected at 50, 60, 70, 80, and 96 feet bgs during first quarter; and 40 and 50 feet bgs during the second quarter. The well installed at 150 feet bgs was not sampled during the first quarter and at 60, 70, 80, 96, and 150 feet bgs during the second quarter. The well at 150 feet bgs is the deepest well installed at this location.

At the MW-305 cluster, sulfolane was not detected in the two samples collected during the first quarter (MW-305-CMT-18 and MW-305-CMT-28) or in the sample collected during the second quarter (MW-305-CMT-18). Well MW-305-100 was not sampled during the reporting period and is the deepest well installed at this location, because permafrost was encountered at 110 feet bgs.

Well cluster MW-306 was not sampled during the reporting period. Sulfolane has historically not been detected in samples collected at the MW-306 well cluster (92 samples) with the exception of six samples which had results flagged due to quality control procedure failures.

4.4.4 Sulfolane Mass Flux

Quarterly analysis of mass flux using analytical data collected across the VPT well cluster transect was recommended in the Fourth Quarter 2012 Groundwater Monitoring Report (ARCADIS 2013b). Methods to calculate mass flux and site-specific geologic input data are included as Appendix H. The Mass Flux Toolkit (toolkit) developed by GSI Environmental for the Department of Defense Environmental Security Technology Certification Program (Farhat et al. 2006) was used to calculate sulfolane mass flux across the VPT.

Sulfolane mass flux across the VPT was first calculated with this method from data collected in November 2011 and was estimated at approximately 86 grams per day (g/day; or 0.19 pound per day [lb/day]). A sulfolane mass flux of approximately 16 g/day (0.04 lb/day) was calculated for the first quarter 2015 and 13 g/day (0.03 lb/day) for the second quarter 2015, less than one-fourth of the initial flux calculated in samples collected in November 2011. Mass flux rates across the VPT continue to decrease and are presented on Figure 4-27. The zones exhibiting the majority of mass flux are summarized in Table 4-11.

During the first quarter, 62 percent of the total sulfolane mass flux was discharged across the VPT near MW-302 (water table to approximately 30 feet bgs), MW-303 (approximately 18 to 42 feet bgs), and MW-304 (water table to approximately 22 feet bgs zone; Figure 4-25). In addition, during the first quarter, sample concentrations within the 60- and 70-foot bgs depth intervals at MW-301; 20-, 30-, 50-, 70-, and 80-foot bgs depth intervals at MW-302; 29-, 39-, and 49-foot bgs depth intervals at MW-303; and 30- and 40-foot bgs depth intervals at MW-304 were flagged as estimated by the laboratory (J-flags).

During the second quarter, 58 percent of the total sulfolane mass flux was discharged across the VPT near MW-302 (water table to approximately 30 feet bgs), MW-303 (approximately 18 to 42 feet bgs), and MW-304 (water table to approximately 27 feet bgs zone; Figure 4-26). In addition, during the second quarter, sample concentrations within the 60- and 70-foot bgs depth intervals at MW-301, 20- and 30-foot bgs depth intervals at MW-302, 29- and 39-foot bgs depth intervals at MW-303, and 30-foot bgs depth interval at MW-304 were flagged as estimated by the laboratory (J-flags).

The estimated values during this reporting period may skew the mass discharge distribution, reducing the relative magnitude of the total contribution to flux of the zones of the transect, where sulfolane was actually detected with greater analytical certainty.

During the reporting period, a low rate of mass discharge is indicated across the alternative point of compliance. There is likely no significant mass flux of sulfolane at the lateral edges of the plume at these locations. The toolkit (Farhat et al. 2006) assumes a concentration boundary of zero at each end of the transect. Because no detections were reported in the deep intervals from well clusters MW-303, MW-304, and MW-305, these sampling points act as a boundary and were assigned values equal to zero rather than one-half of the detection limit.

4.5 Statistical Analysis of Benzene and Sulfolane Data

The Mann-Kendall Trend Analysis is a nonparametric statistical method for determining trends for concentrations of a given constituent at a given monitoring well. The protocol described in the Monitoring and Remediation Optimization System (MAROS) is used to complete the Mann-Kendall Trend analysis for benzene and sulfolane in select groundwater monitoring wells. MAROS is a decision support tool developed by the Air Force Center for Engineering and the Environment in order to use statistical methods based on site-specific data. The use of MAROS for Mann-Kendall analysis was applied to groundwater monitoring data collected since 2006 from monitoring and observation wells. Wells having a historical presence of LNAPL were excluded from the evaluation of the benzene statistical trend. The analysis trends are expressed as probably increasing, increasing, probably decreasing, decreasing, stable, or no trend. A detailed evaluation of trends is included in Appendix I.

A statistical and graphical evaluation of benzene and sulfolane concentration trends is conducted semiannually during first and third quarters at monitoring and observation wells. Results through the first quarter of 2015 are summarized in the table below. The data are used to evaluate plume migration and stability and remedial action effectiveness, and to identify relationships between dissolved-phase concentrations, groundwater elevations, and flow directions. Section 6.2 describes an additional evaluation of the sulfolane and BTEX concentration trends for data collected from the performance monitoring network associated with the GRTS since 2011.

Parameter Trend	First Quarter	
	Benzene	Sulfolane
No. of wells	126	293
All results nondetect[1]	74	116
Insufficient data points[1]	12	16
Probably decreasing	2	17
Decreasing	11	78
Probably increasing	2	3
Increasing	1	5
Stable	4	38
No trend	20	20

[1]Wells with insufficient data points for the statistical analysis (less than four points), but with all results below detection limits, are listed under "all results nondetect."

Using data from 2006 through the first quarter 2015 benzene concentrations in groundwater from 13 monitoring wells and sulfolane concentrations in groundwater from 81 monitoring wells were found to have decreasing or probably decreasing trends.

Using data from 2006 through the first quarter 2015 benzene concentrations in groundwater from three monitoring wells (out of 126 sampled) and sulfolane concentrations in groundwater from eight monitoring wells (out of 293 sampled) were found to have increasing or probably increasing trends. These results are discussed in the following paragraphs.

4.5.1 Benzene Statistical Evaluation

The Mann-Kendall statistical analysis resulted in an increasing benzene concentration trend at R-46 and probably increasing concentration trends at R-47 and MW-127-25. These trends are consistent with trends calculated for these wells during the fourth quarter 2014. Recovery wells R-46 and R-47 are currently actively being pumped by the recovery system likely influencing dissolved benzene concentrations at these locations.

Less than 50 percent of all sampling events resulted in detections at MW-127-25 (16.1 percent) and R-47 (46.2 percent). Benzene concentrations at MW-127-25 ranged from a non-detectable concentration (February 2015)) to 54.6 µg/L (October 2013), while concentrations at R-47 ranged from a non-detectable concentration (February 2015) to an estimated 0.350J µg/L (November 2014).

Benzene concentrations in R-46 ranged from 28.8 µg/L (April 2014) to 140 µg/L (October 2014). Benzene time series plots included as Attachment 1 in Appendix I show that concentrations at this location appear to be increasing. This location is within the detectable benzene plume at the site near the plume's leading edge. During the first quarter 2015, the benzene concentration at R-46 was 74.5 µg/L.

4.5.2 Sulfolane Statistical Evaluation

Using statistical approaches to evaluate groundwater monitoring data collected since 2006, increasing or probably increasing trends were observed at only eight onsite monitoring wells (MW-179B-50, MW-304-96, MW-321-65, MW-355-15, O-27-65, O-5-65, S-43, and R-45). However, it's notable that wells MW-321-65 and MW-304-96 are outside the detectable sulfolane plume and have not exhibited detections since third quarter 2012 and third quarter 2013, respectively. Remaining wells with increasing sulfolane concentrations are located within the detectable sulfolane plume. Furthermore, wells MW-179B-50, MW-355-15, O-5-65, S-43 and R-45 are located upgradient or adjacent to the GTRS and are therefore influenced by the groundwater remediation effort. Additionally, wells MW-304-96, MW-355-15, and O-27-65 had no trend as of fourth quarter 2014.

Groundwater monitoring data collected since 2006 resulted in decreasing or probably decreasing trends at 81 onsite wells. Onsite wells will continue to be monitored as per the LTM plan (2014b).

4.6 Nonroutine Activities

There were no nonroutine sampling activities completed during the reporting period.

5. Groundwater Remediation and Treatment System Results and Evaluation

This section discusses the operating results for the existing GRTS for the reporting period. Ongoing remediation efforts at the site include groundwater recovery and treatment and LNAPL recovery and recycling, as described in Sections 5.2 and 5.3, respectively. The GRTS layout is shown on Figure 5-1 and process flow diagrams for the systems are shown on Figures 5-2a and 5-2b.

5.1 Associated Permits

Treated groundwater from the original treatment system (GAC East) and the expanded groundwater recovery system (GAC West) recovery well R-42 are discharged at the SGP in accordance with wastewater disposal permit 2005-DB0012 issued by ADEC, temporary water use permit (TWUP) A2011-48 issued by ADEC and DNR water use permit LAS24907.

Treated groundwater from GAC West recovery wells R-47 and R-48) is discharged at the NGP in accordance with an Interim Approval to Operate and Temporary Water Use Authorization (TWUA) A2014-13, both issued by ADEC.

5.2 Groundwater Recovery and Treatment

The objective of the GRTS is to capture and remediate sulfolane- and BTEX-impacted groundwater, provide hydraulic control of the dissolved-phase sulfolane and BTEX plumes, and enhance LNAPL recovery.

5.2.1 Reporting Period

The average groundwater recovery rate for the GRTS was 564 gallons per minute (gpm) during the reporting period. This rate was calculated from the combined GAC East and GAC West outlet flowrates. For comparison, during 2014, the groundwater recovery rate for the GRTS averaged 454 gpm.

Pumping rates for the individual recovery wells are measured continuously by the facility process control system, with the exception of recovery well R-40. R-40 was not used as an active recovery well from May 2013 through December 2014; however, it was restarted in December 2014 and continued operating through the reporting period to maintain hydraulic capture in the R-45 area as described below. It is not connected to the process control system; therefore, flow readings are recorded manually. Additionally, the facility process control system underwent maintenance in late March and early April, and flowrates were recorded manually at each location during this time period.

The average flow rates (when pumping) and total and percent runtimes for the reporting period are shown in the table below, along with the target flow rate for each well.

Location	First and Second Quarter 2015 Average Flow Rate	Target Flow Range	First and Second Quarter 2015 Runtime	Percent Runtime
R-21	47.4 gpm	40 to 50 gpm	4,294 hours	98.9
R-35R	52.2 gpm	50 to 65 gpm	4,295 hours	98.9
R-40	25.7 gpm	Not applicable	4,303 hours	99.1
R-42	97.9 gpm	60 to 85 gpm	4,233 hours	97.5
R-43	53.0 gpm	60 to 85 gpm	4,127 hours	95.0
R-44	55.5 gpm	60 to 90 gpm	4,159 hours	95.8
R-45	34.9 gpm	50 to 65 gpm	3,970 hours	91.4
R-46	25.5 gpm	30 to 40 gpm	4,161 hours	95.8
R-47	79.9 gpm	Maximum 80 gpm	4,207 hours	96.9
R-48	118.2 gpm	Maximum 120 gpm	4,223 hours	97.2

Each of the recovery wells maintained a high runtime during the reporting period. Any downtime for each recovery well is further discussed in Section 5.6, with the most significant event being planned downtime at recovery wells R-43, R-44, R-45, and R-46 for completion of chemical well rehabilitation to restore the specific capacity of each well. Results of the chemical well rehabilitation are discussed in Section 5.6. Following the completion of the well rehabilitation, all of the recovery wells are capable of pumping within the target flow range, with the exception of R-45. As noted above, R-40, which is located near R-45, was operated during the reporting period to further ensure capture and to allow LNAPL recovery due to the packer system installed in R-45. Although the recovery rates at several individual wells periodically exhibited some variability during portions of the operating period in comparison to target flow rates, the design of groundwater recovery was sufficient to demonstrate hydraulic capture was maintained in aggregate during the reporting period as described in Section 6.1.

The majority of reporting period downtime for recovery wells connected to GAC West (R-42, R-47, and R-48) was planned to accommodate recharge of the green sand filter through the addition of potassium permanganate.

5.2.2 Cumulative Groundwater Recovery

Table 5-1 summarizes the volume and rate of groundwater recovered monthly from 2009 through the end of the reporting period. Annual groundwater recovery totals, as measured at the final effluent of the treatment systems, are summarized below:

- 2009: 69,200,000 gallons
- 2010: 107,100,000 gallons
- 2011: 136,900,000 gallons
- 2012: 188,300,000 gallons
- 2013: 200,815,291 gallons
- 2014: 237,348,487 gallons
- 2015: 147,100,000 gallons (through second quarter)

5.2.3 Groundwater Treatment Performance Evaluation

5.2.3.1 GAC East

In accordance with the wastewater disposal permit for GAC East, FHRA conducted monthly monitoring of the GAC East effluent during the reporting period; results are summarized in Tables 5-2a through 5-2d. FHRA also conducted multiple additional monitoring events to evaluate performance of the treatment system, which are included in the tables.

The sulfolane concentration measured in the GAC East final effluent was below 15 µg/L during each monitoring event in the reporting period (Table 5-2a). Additionally, the sulfolane concentration was below detection limits in the GAC East final effluent during each monitoring event, with the exception of a low-level detection (3.89 J µg/L) on February 25, 2015.

BTEX and polyaromatic hydrocarbon concentrations measured at the GAC East final effluent were below the discharge limits for the system during each monitoring event (Table 5-2b and c). Additionally, the results of the GAC East effluent were below detection limits, with the exception of a low-level detection of naphthalene (0.378 J µg/L) on February 11, 2015. This detection was flagged and is considered estimated and biased high due to a method blank detection. Total organic carbon, total suspended solids, iron, and manganese monitoring were also performed to evaluate system operation; results are included in Table 5-2d. Analytical laboratory reports are provided in Appendix B.

The GAC media were changed out of the A and B vessels in February 2015.

5.2.3.2 GAC West

During the reporting period, GAC West was sampled at an increased frequency (in addition to the required monthly sampling) to evaluate system performance. Results for monitoring completed at GAC West are included in Tables 5-3a, 5-3b, and 5-3c.

As shown in Table 5-3a, GAC West removed sulfolane and the GAC East final effluent was below detection limits for sulfolane during each monitoring event. Periodic BTEX monitoring was also conducted and the results are shown in Table 5-3b. All results at the GAC West vessel outlets were below detection limits for BTEX. Additional sampling was completed in January due to discovery of a sheen on the inlet section of the gallery pond. It was determined that the oil reservoir for the R-42 pump motor had leaked, causing the sheen. The motor and oil reservoir were replaced and returned to service. The GAC within the treatment system has the capability to remove trace hydrocarbon residual prior to final effluent discharge. Iron and manganese monitoring were also performed to evaluate system operation and the results are included in Table 5-3c.

The GAC media were changed out of each vessel during the reporting period (A and B vessels were changed out in March 2015, and C and D vessels were changed out in June 2015).

5.3 Light Nonaqueous Phase Liquid Recovery and Recycling

5.3.1 Volumetric Recovery Rates

During the reporting period, FHRA performed LNAPL recovery via a skimmer system when adequate LNAPL was consistently present in wells MW-334-15, R-20R, and R-21 (Figure 5-1). Manual LNAPL recovery was conducted using a vacuum truck or portable LNAPL pump at wells MW-176A-15, MW-138-20, MW-334-15, O-11, O-19, O-21, O-31, O-33, O-34, O-38, R-32, R-32R, R-40, S-22, S-39, S-44, S-50, and S-51. Recovered LNAPL from the skimmer systems and manual recovery activities is stored onsite until it is recycled.

LNAPL recovery for the reporting period is summarized in Table 5-4, and historical LNAPL recovery at the site since 1986 is summarized in Table 5-5. During the reporting period, 477 gallons of LNAPL were recovered, the majority of which was removed from wells MW-334-15, R-21, and R-40. From 1986 to present, approximately 397,000 gallons of LNAPL have been recovered. LNAPL gauging data collected as part of the operations and maintenance of the LNAPL recovery efforts are included as Appendix L.

Based on the results of LNAPL transmissivity testing described in Sections 4.3.3 and 4.3.4, FHRA installed a well house and heating system at MW-334-15 to allow year-round LNAPL recovery with a skimmer system.

5.3.2 Transmissivity

As noted in Section 3.2, baildown testing was conducted in March 2015 and results are summarized in Section 4.3.3. FHRA is planning to continue LNAPL recovery with a skimmer system at MW-334-15, and routine recovery with a portable LNAPL pump at MW-176A-15 and O-21 when LNAPL thickness is greater than 0.5 feet. As per the OMM plan, if LNAPL thicknesses decrease to less than 0.5 feet, manual recovery will be suspended (Barr 2014).

5.4 Benzene, Toluene, Ethylbenzene, and Total Xylenes Mass Capture

FHRA monitored the BTEX concentrations in recovered groundwater on a monthly (first quarter) and quarterly (second quarter) basis to calculate mass removal rates (Table 5-6).

The rates for GAC East were calculated from BTEX concentrations measured at the combined influent during the first quarter. In the second quarter, the BTEX mass capture was calculated based on the concentration and flowrate at each individual recovery well. Based on the monitoring results, BTEX mass removal averaged 0.78 lb/day and totaled approximately 210 pounds during the reporting period. For comparison, the GRTS (or GAC East) removed approximately 293 pounds of BTEX in 2014 and 403 pounds during 2013 (ARCADIS 2015b).

The BTEX concentrations detected in GAC West (Table 5-3b) are minimal and not included in the mass removal calculations shown in Table 5-6. However, the April and May samples collected from R-47 and R-48 were inadvertently not analyzed for BTEX. The results were below detection limits for BTEX in R-48 during the remaining monitoring events in the reporting period, and R-47 only had estimated detections of benzene (maximum of 0.3J µg/L).

5.5 Sulfolane Mass Capture

5.5.1 Per Well

FHRA monitored the sulfolane concentration in recovered groundwater at each active recovery well; mass recovery rates for each well are summarized in Tables 5-7a and 5-7b, for GAC East and GAC West, respectively. During the reporting period, the highest average mass recovery rate was measured at well R-21 (0.13 lb/day; Table 5-7a). Well R-46 had no measurable recovery of sulfolane and is considered to be outside the sulfolane plume (Table 5-7a); however, groundwater recovery continues at well R-46 to maintain capture of the BTEX plume in this area.

5.5.2 Cumulative

Table 5-8 summarizes the combined sulfolane mass removal rates for GAC East and GAC West. The rates were calculated from sulfolane concentrations measured monthly in the GRTS influent or individual recovery wells. Approximately 147,100,000 gallons of recovered groundwater were remediated during the reporting period. Sulfolane mass removal averaged 0.33 lb/day and, based on the systems runtime, totaled approximately 59 pounds during the reporting period. For comparison, in 2014 the GRTS removed approximately 120 pounds of sulfolane (ARCADIS 2015b).

5.6 Summary of Routine and Nonroutine Repairs, Changes, and Maintenance

The GRTS maintained a high runtime as demonstrated at the individual recovery wells (Section 5.2.1). As further discussed in Section 5.6.1, four recovery wells (R-43, R-44, R-44, and R-46) had downtime for well rehabilitation but still maintained a high overall runtime for the reporting period. The majority of downtime events were associated with changeout of the coalescer filters (GAC East), with a typical duration of 1 to 2 hours. Additional downtime for maintenance events and changes at the individual recovery wells or treatment systems during the reporting period are summarized in Table 5-9. As further described in Section 6, results of the hydraulic capture events and concentration trends in the portions of the sulfolane and BTEX plumes north of the GRTS capture zone, which continue to show an overall decline, indicate the effectiveness of the GRTS as operated during the first and second quarters of 2015 and preceding quarters. Thus, operation of the GRTS is meeting its performance goals and limited downtime events in the reporting period fell within design expectations.

During the reporting period, well rehabilitation was completed at recovery wells R-43, R-44, R-45, and R-46. The rehabilitation was conducted to improve the specific capacity of the recovery wells. The work was completed in accordance with information provided to ADEC and a Letter of Non-Objection (ADEC Division of Water 2015). Following completion of the well rehabilitation at R-45, a technical memorandum summarizing the results was submitted to ADEC on April 20, 2015 (Barr 2015). The rehabilitation at R-45 included installation of a well packer to isolate the well screen and thereby reduce the rate of fouling in this location. FHRA will continue to monitor water levels in R-45 and the other recovery wells to evaluate if the well packer is successful in reducing the rate of fouling. Additionally, LNAPL recovery has continued in this area at nearby recovery well R-40 and monitoring well MW-334-15 as described in Sections 4.3.3 and 5.3.1.

Qualitative constant rate drawdown testing was performed prior to and during the well rehabilitation at R-45 to monitor progress. Step-drawdown testing was performed pre- and post-rehabilitation at recovery wells R-43, R-44, and R-46. The results of the step-drawdown testing at R-43, R-44, and R-46 are provided in Appendix J. In each case, the well rehabilitation was successful at improving the specific capacity of the well. As a result of the well rehabilitation, all of the recovery wells are capable of operating within target flow ranges noted in the OCP ((ARCADIS 2014a) with the exception of R-45. As a result, FHRA will continue to operate nearby recovery well R-40 to further ensure groundwater and LNAPL capture in the R-45 area.

5.7 Summary

During the reporting period, FHRA maintained a high runtime for the recovery wells and treatment systems. FHRA continued to meet goals associated with maintaining hydraulic capture, which is further discussed in Section 6, and treatment of recovered groundwater. FHR completed significant tasks to maintain the recovery wells and treatments systems, including well rehabilitation at four recovery wells.

6. Groundwater Remediation and Treatment System Performance Monitoring

This section discusses performance monitoring results for the GRTS, as defined in the OCP (ARCADIS 2014a). A groundwater flow model-based capture zone evaluation for summer, fall, and winter conditions is presented as Attachment A to Appendix M of the 4Q 2014 Onsite GWMR (ARCADIS 2015b) and a comprehensive capture zone evaluation of the GRTS based on multiple lines of evidence is presented in Appendix M of the 4Q 2014 Onsite GWMR (ARCADIS 2015b). These documents were prepared in accordance with the Expanded Groundwater Recovery System Aquifer Testing and Capture Zone Evaluation Technical Memorandum presented as Appendix F to the OCP (ARCADIS 2014a).

6.1 Groundwater Capture Evaluation

Performance monitoring for the GRTS includes monthly hydraulic capture monitoring and quarterly and semiannual water quality assessment. Performance monitoring is conducted to confirm the continued effectiveness of the GRTS. Hydraulic capture of the sulfolane and BTEX plumes was assessed during the reporting period using groundwater elevation and groundwater quality data as described below. Beginning in third quarter 2015, hydraulic capture monitoring will be performed quarterly.

During this reporting period, the GRTS was demonstrated to maintain hydraulic control at the water table from east of well MW-137-20 westward to the NGP in each of six monthly events described in Section 6.1.1. This capture zone encompassed the entire width and depth of the BTEX plume and the width of the sulfolane plume east of the NGP. The estimated capture zone extends vertically to depths up to 80 feet bgs, below the known extent of sulfolane concentrations greater than 15 µg/L.

6.1.1 Manual Groundwater Elevation Measurements

Manual groundwater-level measurements were completed concurrently with a top of well casing survey in a subset of site monitoring and observation wells defined in the OCP (Table 5-1 of ARCADIS 2014a). No significant deviations were made during the reporting period relative to the monitoring network included in Table 5-1 of the OCP (ARCADIS 2014a). Minor deviations are described in Section 2 of Appendix K.

The hydraulic capture measurements (water-level measurements with concurrent top of casing surveys) were taken to provide the most accurate groundwater elevation data for delineation of the capture zone of the GRTS. These measurements were recorded on the dates noted below, including combined pumping rates, as read from the individual recovery well flow meters at the time of the hydraulic capture field measurements:

- January 21, 2015: combined pumping rate of 596 gpm.

- February 25, 2015: combined pumping rate of 621 gpm.
- March 18, 2015: combined pumping rate of 571 gpm. The water table monitoring well near recovery well R-43 was frozen (MW-345-15). It was later determined that the ice plug in this well could be pushed downward into the well screen, allowing a measurement to be taken. Therefore, an estimate of the capture zone of the GRTS was not made based on data from March 18, 2015; this event was superseded by the March 26, 2015 event.
- March 26, 2015: combined pumping rate of 588 gpm.
- April 16, 2015: combined pumping rate of 555 gpm.
- May 21, 2015: combined pumping rate of 593 gpm.
- June 10, 2015: combined pumping rate of 615 gpm.

Measured depths to water, calculated hydraulic heads, and capture zone estimates based on these measurements are presented in Appendix K. Capture zone estimates are made for each event at the water table and in four cross sections.

The first and second quarter 2015 capture zone evaluations included measurement of the NGP surface water elevation. A series of control points along the shoreline of the NGP were used with the estimated elevations shown on Figures 1, 6, 11, 16, 21, and 26 in Appendix K. This approach is based on the observation that surface water in the NGP is hydraulically connected to groundwater, which is consistent with the CSM (ARCADIS 2013a). Methods for improving the reliability of the field measurements are described in Section 6.1.1 of the 4Q 2014 Onsite GWMR (ARCADIS 2015b). Details regarding the methods used to estimate the extent of the capture zone at the water table and in cross section are presented in Appendix M of 4Q 2014 Onsite GWMR (ARCADIS 2015b).

Field measurements made in each of the hydraulic capture measurement events during the reporting period were determined to acceptable for use with the minor exceptions described in Section 1 of Appendix K.

6.1.2 Capture Zone Summary

With implementation of the Interim Removal Action Plan (Barr 2010) improvements in January 2010, FHRA began to increase the overall groundwater recovery rate. Groundwater recovery rates further increased in July 2011 following the installation of R-42 and again in June 2013 following implementation of the Revised Interim Removal Action Plan Addendum (ARCADIS 2013c) and installation of wells R-43, R-44, R-45, and R-46.

The effects of these improvements and additions were demonstrated in the hydraulic capture zone analysis (Barr 2013), and, along with the monthly measurement events conducted since August 2013, indicate that the GRTS maintained hydraulic control at the water table from east of well MW-137-20 westward to at least the MW-309 nest. With the addition of recovery wells R-47 and R-48, the capture zone of the GRTS consistently extends to the NGP (Figures 1, 6, 11, 16, 21, and 26 in Appendix K).

During the reporting period, the capture zone at the water table encompassed the entire width and depth of the BTEX plume as well as the width of the sulfolane plume east of the NGP, as demonstrated in each monthly hydraulic capture measurement event. Sulfolane that flows into in the NGP is reduced to concentrations below the limit of quantitation of the analytical method. In addition, the estimated capture zone during each monthly hydraulic capture measurement event extended vertically to depths up to 80 feet bgs, below the known extent of sulfolane concentrations greater than 15 µg/L.

6.2 Concentration Trend Evaluation

FHRA monitors sulfolane concentrations quarterly and BTEX semiannually to determine trends and evaluate the performance of the GRTS. As discussed in Section 4.5, Mann-Kendall concentration trends are calculated using the protocol described in Appendix I and are based on analysis of the dataset since 2006 or since well installation, whichever is more recent, through the first quarter 2015. While an excellent tool for evaluating concentration trends, Mann-Kendall analysis has limitations. For example, within a long-term dataset, it may not recognize more recent trends that are influenced by recently implemented remediation measures.

6.2.1 Sulfolane

Table 6-1 summarizes FHRA's interpretation of the current sulfolane concentration trends at individual GRTS performance monitoring wells. The analyses summarized in Table 6-1 focus on the trends in more recent monitoring data and identify the effects of enhanced groundwater remediation implemented since 2011. The performance monitoring wells identified in Table 6-1 are categorized based on location relative to the treatment zone; each area is summarized below:

- *Upgradient.* Sulfolane concentration trends in wells upgradient from the GRTS treatment zone are decreasing or stable, except at well MW-130-25 where they appear to be fluctuating. It is likely that the locations with decreasing or stable trends are minimally influenced by operation of the GRTS; these trends are believed to primarily be the result of a decreasing upgradient source mass.

- *Within the treatment zone.* Sulfolane concentration trends from monitoring wells within the treatment zone are decreasing or stable except at well O-5-65, where the sulfolane concentrations have fluctuated between nondetect and 12 µg/L in 2014 and 2015, and well O-2, where concentrations have increased slightly since the second quarter 2014. The variation noted at O-5-65 may be the result of increased capture with operation of the GAC West recovery wells, which is altering the flow paths in this area prior to capture. The increased sulfolane concentration noted in second quarter 2015 at O-2 may be the result of changes in the groundwater recovery rate at nearby R-44, because the second quarter 2015 samples were collected during a period of reduced groundwater recovery at R-44 prior to well rehabilitation.

- *Downgradient.* Sulfolane concentration trends from monitoring wells downgradient from the treatment zone are decreasing or stable.

In addition to the trends presented in Table 6-1, a low concentration zone has developed immediately north (downgradient) of the recovery wells. For example, sulfolane was reported as nondetect or low (less than 15 µg/L) concentrations in water table wells MW-371-15, O-4, O-12, and O-31 (Figures 4-15 and 4-19), and deeper wells MW-351-55, MW-371-55, O-12-65, O-26-65 (Figures 4-16 and 4-20) and MW-351-75 and MW-371-75 (Figures 4-17 and 4-21). In addition, overall downward trends in concentration and mass flux at the VPT are likely the result of source controls and operation of the GRTS (Sections 4.4.3 and 4.4.4).

6.2.2 Benzene, Toluene, Ethylbenzene, and Total Xylenes

Performance monitoring for BTEX occurred during the first quarter 2015, with the exceptions noted in Section 3.3. Table 6-2 summarizes FHRA's interpretation of the current BTEX concentration trends at individual performance monitoring wells. Many of the wells were recently added to the performance monitoring network; therefore, insufficient data have been generated to evaluate trends at these wells. The concentration trend analyses for BTEX summarized in Table 6-2 focus on trends in more recent monitoring data and identify the effects of the GRTS implementation since 2011. The performance monitoring wells identified in Table 6-2 are categorized based on location relative to the treatment zone; each area is summarized below:

- *Upgradient*. Of the seven monitoring locations upgradient of the GRTS, two were not sampled due to the presence of LNAPL. Three wells have consistently low or nondetect concentrations of BTEX. Concentrations appear to be increasing at one location (MW-130-25). One location (S-43) lacks sufficient data to analyze the trend.

- *Within the treatment zone*. Nine of the 13 treatment zone monitoring wells have decreasing or stable concentrations. Three of the 13 monitoring locations were not sampled due to the presence of LNAPL, and concentrations are fluctuating at low concentrations at one location (O-5).

- *Downgradient*. Eight of the 12 downgradient locations have stable or decreasing concentrations. Fluctuating concentrations of one or more BTEX compounds were noted at three locations. The low concentrations measured in samples collected from well O-4 had been increasing until they decreased during the reporting period.

6.3 Transect Trend Evaluation

To further evaluate the effectiveness of the GRTS, sulfolane concentration trends were evaluated along three longitudinal transects parallel to the groundwater flow path (Figure 6-1). Transects A and B (Figures 6-2 and 6-3) comprise shallow wells (water table and 10 to 55 feet bwt); Transect C (Figure 6-4) comprises deeper wells (55 to 90 feet bwt). Monitoring wells are noted on the figures based on their location relative to the GRTS (upgradient, within the treatment zone, or downgradient). Also shown are the pumping rates of the GRTS to demonstrate the effects of increased groundwater recovery on sulfolane concentrations in these wells since 2010.

The data presented on Figures 6-2 and 6-3 demonstrate that shallow sulfolane concentrations downgradient from the treatment zone are lower than concentrations upgradient from the treatment zone. In addition, these figures show that decreasing downgradient sulfolane concentrations correlate with increased pumping from the GRTS starting in 2010. This indicates that ongoing groundwater remediation is successfully recovering sulfolane-impacted groundwater and is eliminating the migration of sulfolane-impacted groundwater past the GRTS. Additionally, concentrations measured in deeper wells MW-154B-95 and MW-186E-75 are decreasing or stable (Figure 6-4). One deeper well was installed adjacent to well O-19 (O-19-90) and sulfolane has not been detected at this location.

Sulfolane concentrations in deeper portions of the aquifer near the GRTS are lower than concentrations reported in the shallow groundwater, as demonstrated at the well nests in MW-186A-15, MW-334-15, MW-344-15, and MW-345-15 (Figures 4-16 and 4-20).

6.4 Remediation Performance Monitoring Summary

Monthly hydraulic capture zone monitoring demonstrates that the GRTS capture zone at the water table encompasses the entire width and depth of the BTEX plume. With the addition of GAC West, the GRTS capture zone at the water table also encompasses the width of the sulfolane plume east of the NGP. The estimated capture zone extends vertically to depths up to 80 feet bgs, encompassing the depth of the sulfolane plume in the upgradient and treatment zone areas with concentrations greater than 15 µg/L.

Concentrations of sulfolane and BTEX in the downgradient portion of the plume adjacent to the capture zone continue to show an overall decline, thus indicating the effectiveness of the GRTS as operated during the first and second quarters 2015 and preceding quarters.

7. Analytical Quality Assurance and Quality Control

QA/QC procedures assist in producing data of acceptable quality and reliability. Analytical results for laboratory QC samples were reviewed and a QA assessment of the data was conducted as the data were generated. The QA review procedures provided documentation of the accuracy and precision of the analytical data and confirmed that the analyses were sufficiently sensitive to detect analytes at levels below suggested action levels or regulatory standards, where such standards exist. The laboratory reports for each of the samples for this report, including case narratives describing laboratory QA results, and completed ADEC data review checklists are included in Appendices B and C. SWI conducted QA/QC reviews of the data for this reporting period. Data quality flags applied to the analytical results are summarized in Table 7-1.

Level IV data packages and third-party review are requested if an interference is noted in the groundwater samples from a new well or is identified in an existing well where no interference was previously identified. In addition, when laboratory sample mislabelings or systematic analytical failures are noted, Level IV reports may be requested. In the absence of any of these issues mentioned, periodic Level IV reports will be requested to perform an in-depth review of the laboratory performance. Environmental Standards, Inc. (Environmental Standards) conducts Level IV data validation for this project. Level IV laboratory reports are included in Appendix B for packets associated with the first and second quarter 2015 results. The Level IV validation reports prepared by Environmental Standards are included in Appendix M.

7.1 Water Sample Data Quality

This section summarizes the results of the QA/QC review of data for this reporting period. Samples were submitted to SGS Laboratories (SGS) for analysis of sulfolane, and/or BTEX, GRO, and DRO for select monitoring wells. ADEC data review checklists are included in Appendix C.

The SGS work orders (WOs) reviewed during the reporting period for results associated with the groundwater monitoring wells are listed in the table below.

Q1 Groundwater Monitoring WO List					
1157528	1157593	1157599	1157611	1157612	1157614
1157617	1157618	1157620	1157621	1157624	1157633

Q2 Groundwater Monitoring WO List							
1157746	1157752	1157782	1157797	1157803	1157804	1157807	1157814

Q2 Groundwater Monitoring WO List							
1157818	1157828	1157830	1157831	1157844	1157846	1157958	

Q1 GAC East WO List							
1157503	1157505	1157506	1157514	1157523	1157534	1157535	1157538
1157543	1157547	1157553	1157554	1157562	1157579	1157580	1157587
1157600	1157601	1157626	1157627	1157637	1157638	1157645	1157665
1157678	1157703						

Q2 GAC East WO List							
1157738	1157744	1157806	1157934	1158010	1158063	1158137	

Q1 GAC West WO List							
1157519	1157525	1157544	1157582	1157623	1157646	1157668	1157702

Q2 GAC West WO List							
1157743	1157745	1157812	1157915	1157935	1158011	1158078	1158079
1158136							

Results of the QA/QC review are discussed below. Only those issues that affected data quality (i.e., resulted in applying data qualifiers) are summarized; for additional details regarding QA/QC for each WO, refer to the data review checklists (Appendix C).

7.2 Sample Handling

Monitoring well samples collected by SWI were generally hand delivered to the SGS receiving office in Fairbanks, Alaska and then shipped overnight via Lynden Transport or Alaska Airlines Goldstreak to the SGS laboratory in Anchorage, Alaska to perform the requested analyses, using the methods specified in the chain of custody records.

Sample receipt forms for each WO for both SGS Alaska locations were reviewed and checked to verify that samples were received in good condition and within the acceptable temperature range. The ADEC data review checklists (Appendix C) contain details regarding this review. ADEC considers samples received at temperatures between 0 and

6 degrees Celsius (°C) acceptable in the absence of ice, as specified by United States Environmental Protection Agency Method SW-846. Therefore, for this report, sample temperatures between 0 and 6°C are considered acceptable.

Samples were received within the acceptable temperature range upon arrival at each location during the reporting period. Minor discrepancies noted during review did not have an effect on data quality or usability (see checklists for details). Samples were received properly preserved and in good condition.

Chain of custody records for each WO were also reviewed to confirm that information was complete, custody was not breached, and samples were analyzed within the acceptable holding time. Chain of custody records were complete and correct, except for several minor discrepancies that did not have an effect on data quality or usability (see checklists for details). Samples were analyzed within holding times, with the following exceptions:

- *2015 Q1 SGS WO 1157617* and *1157618.* Project samples MW-334-65, MW-351-55, MW-371-15, and MW-186A-15 were analyzed outside the recognized hold time for sulfolane analysis. The samples with detectable results are considered estimated, biased low, and are flagged 'JL.' The samples that did not have detections for sulfolane are considered estimated and are flagged 'UJ.'

- *2015 Q2 SGS WO 1157807*. Project sample O-38 was analyzed outside the recognized hold time for sulfolane analysis. Sulfolane was not detected in the sample and the result is considered estimated and is flagged 'UJ.'

No other sample handling anomalies were identified during the reporting period that would adversely affect data quality.

7.3 Analytical Sensitivity and Blanks

Reported limits of detection for regulated analytes were below ADEC cleanup levels or interim action levels during the reporting period.

Laboratory method blanks were analyzed in association with samples collected for this project to check for contributions to the analytical results, possibly attributable to laboratory-based contamination. Trip blanks were submitted with groundwater samples for BTEX and GRO analysis to verify that cross-contamination did not occur during sample handling and transport. Equipment blanks were collected to assess the possibility of sample contamination from sampling equipment. There were no blank detections affecting data quality for the reporting period that had an effect on the data quality or usability with the following exceptions:

- *2015 Q1 SGS WOs 1157580, 1157582, 1157665, 1157678, and 1157857:* Total organic carbon (TOC) was detected in the method blank. Project samples in the same preparatory batch as the method blank detection are considered to be affected if the project sample has detectable results within ten times the method blank detection. Project samples with detectable results less than five times the method blank detection are considered not detected and are flagged 'UB' at the sample result or the LOQ, whichever value is larger. Project samples with detectable results between five and ten times the method blank detection are considered estimated, biased high, and are flagged 'JH.' Refer to the ADEC Data Review Checklist for details.

- *2015 Q1 SGS WO 1157582:* Total suspended solids (TSS) were detected in the method blank. Project samples in the same preparatory batch as the method blank detection are considered to be affected if the project sample has detectable results within ten times the method blank detection. Project samples with detectable results less than five times the method blank detection are considered not detected and are flagged 'UB' at the sample result or the LOQ, whichever value is larger. Project samples with detectable results between five and ten times the method blank detection are considered estimated, biased high, and are flagged 'JH.' Refer to the ADEC Data Review Checklist for details.

- *2015 Q1 SGS WO 1157587:* Naphthalene was detected in the method blank. Project samples in the same preparatory batch as the method blank detection are considered to be affected if the project sample has detectable results within ten times the method blank detection. Project samples *Sand Filter Influent* and *Trmt Sys Effluent* had detectable results between five and ten times the method blank detection are considered estimated, biased high, and are flagged 'JH.'

- *2015 Q2 SGS WO 1157738, 1157745, 1157934, 1157935, 1158063, and 1158079:* TOC was detected in the method blank. Project samples in the same preparatory batch as the method blank detection are considered to be affected if the project sample has detectable results within ten times the method blank detection. Project samples with detectable results less than five times the method blank detection are considered not detected and are flagged 'UB' at the sample result or the LOQ, whichever value is larger. Project samples with detectable results between five and ten times the method blank detection are considered estimated, biased high, and are flagged 'JH.' Refer to the ADEC Data Review Checklist for details.

- *2015 Q1 SGS WO 1157738:* TSS were detected in the method blank. Project samples in the same preparatory batch as the method blank detection are considered to be affected if the project sample has detectable results within ten times the method blank detection. Project samples with detectable results less than five times the method blank detection are considered not detected and are flagged 'UB' at the sample result or the LOQ, whichever value is larger. Project samples with detectable results between five and ten times the method blank detection are considered estimated, biased high, and are flagged 'JH.' Refer to the ADEC Data Review Checklist for details.

7.4 Accuracy

Laboratory analytical accuracy may be assessed by evaluating the analyte recoveries from continuing calibration verification (CCV), laboratory control sample (LCS), and laboratory control sample duplicate (LCSD) analyses. LCS/LCSD samples assess the accuracy of analytical procedures by checking the laboratory's ability to recover analytes added to clean aqueous matrices. In some cases, the laboratory spiked project samples as matrix spike (MS) and matrix spike duplicate (MSD) samples to assess their ability to recover analytes from a matrix similar to that of project samples. Accuracy was also assessed for organic analyses by evaluating the recovery of analyte surrogates added to project samples. For sulfolane results, recovery of the sulfolane internal standard (sulfolane-d8) was evaluated.

There were no CCV or initial calibration verification failures affecting data quality noted in the case narratives for samples collected during the reporting period. Recovery information was reviewed for LCS/LCSDs and MS/MSDs associated with project samples. LCS, LCSD, MS, and MSD recoveries were within laboratory control limits for each preparatory batch.

Recovery of analyte surrogates and sulfolane-d8 were within laboratory control limits, with one exception:

- *2015 Q1 SGS WO 1157617.* The surrogate 4-bromofluorobenzene for GRO analysis was recovered outside laboratory control limits for sample MW-130-25. The GRO result for this sample is considered estimated, biased high, and flagged 'JH.'

- *2015 Q2 SGS WO 1158063:* The internal standard sulfolane-d8 for sulfolane analysis was recovered outside laboratory control limits for sample *C-Outlet*. The sulfolane result for this sample is considered estimated (no direction of bias) and flagged 'J."

Laboratory CCV, LCS/LCSD, MS/MSD, and surrogate recovery information indicate the analytical results were accurate, with the exceptions noted above.

7.5 Precision

Field duplicate samples were collected at a frequency of approximately 10 percent of the overall number of samples collected during the reporting period, to evaluate the precision of analytical measurements, as well as the reproducibility of the sampling technique. The relative percent difference (RPD; difference between the sample and its field duplicate divided by the mean of the two) was calculated to evaluate the precision of the data. An RPD was evaluated only if the results of the analyses for both duplicates were detected.

During the first quarter 2015, the following duplicate samples were collected:

- Fifteen duplicates for monitoring-well samples analyzed for sulfolane (139 primary samples)
- Five duplicates for monitoring-well samples analyzed for BTEX (30 primary samples)
- Nineteen duplicates for the GAC East Treatment System analyzed for sulfolane (177 primary samples)
- Nine duplicates for the GAC East Treatment System analyzed for BTEX (90 primary samples)
- No duplicates for the GAC East Treatment System analyzed for PAH (9 primary samples)
- Nineteen duplicates for the GAC East Treatment System analyzed for TOC (242 primary samples)
- No duplicates for the GAC East Treatment System analyzed for TSS (29 primary samples)
- Three duplicates for the GAC East Treatment System analyzed for metals (44 primary samples)
- Six duplicates for the GAC West Treatment System analyzed for sulfolane (59 primary samples)
- Four duplicates for the GAC West Treatment System analyzed for BTEX (32 primary samples)
- Three duplicates for the GAC West Treatment System analyzed for TOC (26 primary samples)
- Three duplicates for the GAC West Treatment System analyzed for TSS (29 primary samples)

- Three duplicates for the GAC West Treatment System analyzed for metals (29 samples)

During the second quarter 2015, the following duplicate samples were collected:

- Twelve duplicates for monitoring-well samples analyzed for sulfolane (109 primary samples)
- No duplicates for monitoring-well samples analyzed for BTEX (1 primary sample)
- Three duplicates for the GAC East Treatment System analyzed for sulfolane (57 primary samples)
- Four duplicates for the GAC East Treatment System analyzed for BTEX (43 primary samples)
- No duplicates for the GAC East Treatment System analyzed for PAH (5 primary samples)
- Three duplicates for the GAC East Treatment System analyzed for TOC (24 primary samples)
- Three duplicates for the GAC East Treatment System analyzed for TSS (24 primary samples)
- Three duplicates for the GAC East Treatment System analyzed for metals (24 primary samples)
- Three duplicates for the GAC West Treatment System analyzed for sulfolane (50 primary samples)
- No duplicates for the GAC West Treatment System analyzed for BTEX (3 primary samples)
- Three duplicates for the GAC West Treatment System analyzed for TOC (24 primary samples)
- Three duplicates for the GAC West Treatment System analyzed for TSS (24 primary samples)

- Three duplicates for the GAC West Treatment System analyzed for metals (24 primary samples)

The overall project goal for the frequency of sample duplicates of approximately 10 percent was met. Results of RPD calculations for each of these duplicate sample sets met the data quality objective (DQO) of 30 percent, where calculable, with the following exceptions:

- *2015 Q1 SGS WO 1157514*: The field duplicate pair *R-21* and *R-121* had a RPD failures for TSS and o-xylene. The sample results for these analytes are considered estimated and are flagged 'J' to identify the imprecision.

- *2015 Q2 SGS WO 1158063*: The field duplicate pair *B-Outlet* and *E-Outlet* had an RPD failure for TSS. The sample results for TSS are considered estimated and are flagged 'J' to identify the imprecision.

- *2015 Q2 SGS WO 1158079*: The field duplicate pair *Greensand Filter Outlet* and *Yellowsand Filter Outlet* had an RPD failure for TSS and TOC. The samples results for TSS are considered estimated and are flagged 'J' to identify the imprecision. The TOC results are qualified due to a method blank detection. Further qualification of the TOC results is not required.

Laboratory analytical precision can also be evaluated by laboratory RPD calculations using the LCS/LCSD and MS/MSD, or laboratory duplicate sample results. Results of RPD calculations for each of these duplicate samples met the DQO of 30 percent, where calculable, with the following exception:

- *2015 Q1 SGS WO 1157519:* The laboratory duplicate RPD for TSS was outside QC criteria. The project sample *Gallery Pond Inlet* is considered to be affected by the QC failure. The TSS result for the sample is considered estimated and is flagged 'J' to identify the imprecision.

- *2015 Q2 SGS WO 1157934*: The LCS/LCSD RPDs for acenaphthene, acenaphthylene, fluorine, and naphthalene were outside laboratory QC criteria. The project sample Trmt Sys Effluent is considered to be affected by the QC failure. The analytes were not detected in the project sample and the results are considered estimated and are flagged 'UJ' to identify the imprecision.

- *2015 Q2 SGS WO 1157934:* The laboratory duplicate RPD for TSS was outside QC criteria. The project samples *A-Outlet*, *B-Outlet*, *C-Outlet* and *D-Outlet* are considered to be affected by the QC failure. The TSS results are considered estimated and are flagged 'UJ' for non-detect results and 'J' for detected results.

Based on a review of the data, the water results associated with the reporting period are considered precise.

7.6 Hydrocarbon Interference and Level IV Review

In addition to the standard QA review described above, Environmental Standards will conduct an additional review of select WOs, where necessary. There were no hydrocarbon-interference issues for samples collected from on-site monitoring wells that required Level IV review during the reporting period. An additional Level IV data packet will be reviewed for the second quarter, but was requested after the data receipt cutoff, and will be included in the second semiannual 2015 report. The WO and reason for the Level IV review included in this report are described below:

- *2015 Q1 SGS WO 1157611.* A suspected sample switch was confirmed by the laboratory and a Level IV investigation by Environmental Standards. The project sample was logged in incorrectly and the discrepancy was corrected. The project sample results are not considered to be affected after the corrected results were reported.

Level IV laboratory reports are included in Appendix B for packets associated with the first quarter 2015 results. Completed ADEC data review checklists are included in Appendix C. The level IV validation reports prepared by Environmental Standards are included in Appendix M.

7.7 Data Quality Summary

Based on the methods outlined in the Onsite RSAP (ARCADIS 2015a), the samples collected are considered to be representative of site conditions at the locations and times they were obtained. Based on the QA review, no samples were rejected as unusable due to QC failures. In general, the quality of the analytical data for this reporting period does not appear to have been compromised by analytical irregularities, and results affected by QC anomalies are qualified with the appropriate data flags.

8. Conclusions

- Groundwater monitoring data collected during the reporting period are consistent with data collected during recent quarters.
- The statistical analyses included in Appendix I show that sulfolane concentrations at 78 wells and benzene concentrations at 11 wells across the plume are stable or decreasing.
- Sulfolane concentrations and trends continue to decrease in the onsite areas near the site boundary.
- The estimated sulfolane mass flux rate across the alternative point of compliance continues to decrease. BTEX concentrations are consistent with historical detections and the BTEX plume appears to be stable.
- BTEX concentrations continue to be limited to the developed area onsite.
- During the reporting period, the GRTS continued to effectively capture and remediate sulfolane- and BTEX-impacted groundwater, provide hydraulic control of the entire width of the dissolved-phase BTEX plume and the width of the dissolved-phase sulfolane plume east of the NGP, and enhance LNAPL recovery.
- Concentrations of sulfolane and BTEX in the downgradient portion of the plume adjacent to the capture zone continue to show an overall decline, thus indicating the effectiveness of the GRTS.
- The estimated capture zone extends vertically to depths up to 80 feet bgs, encompassing the depth of the BTEX plume and the depth of the sulfolane plume in the upgradient and treatment zone areas with concentrations greater than 15 µg/L.

9. References

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Tables

Figures

ARCADIS

Appendix A

Historical Data Tables for Groundwater Elevation and LNAPL Thickness, BTEX, Sulfolane, Geochemical Parameters, and COCs

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Appendix B

Analytical Laboratory Reports

Provided electronically

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Appendix C

ADEC QA/QC Checklists

Provided electronically

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Appendix D

Field Data Sheets

Provided electronically

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Appendix E

Hydrographs

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Appendix F

Baildown Tests Input and Output

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Appendix G

Groundwater Extraction-Enhanced Recovery Data

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Appendix H

Mass Flux Methods

Appendix I

Mann-Kendall Trend Analysis Summary

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Appendix J

Recovery Well Rehabilitation Step Drawdown Testing Results

Appendix K

Recovery System Capture Zone Analysis, Vertical Head Differences, and Hydraulic Gradients

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Appendix L

Operational LNAPL Gauging Data

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Appendix M

Data Validation Reports