

Flint Hills Resources Alaska, LLC

**First Quarter 2013 Groundwater
Monitoring Report**

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

May 31, 2013



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Report**

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Acronyms and Abbreviations

2013 Offsite SCWP	2013 Offsite Site Characterization Work Plan
2013 Onsite SCWP	2013 Onsite Site Characterization Work Plan
AAC	Alaska Administrative Code
ACL	alternative cleanup level
ADEC	Alaska Department of Environmental Conservation
API	American Petroleum Institute
ARCADIS	ARCADIS U.S., Inc.
AS	air sparge
ASTM	ASTM International
Barr	Barr Engineering Company
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and total xylenes
CCV	continuing calibration verification
city	North Pole, Alaska
COC	chain of custody
COPC	constituent of potential concern
DL	detection limit
DNR	Alaska Department of Natural Resources
DO	dissolved oxygen
EDD	electronic data deliverable
ESI	Environmental Standards, Inc.
FHRA	Flint Hills Resources Alaska, LLC
ft ² /day	square feet per day
ft/ft	foot per foot



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g/day	grams per day
GAC	granular activated carbon
GC/MS	gas chromatography/mass spectrometry
gpm	gallons per minute
GVEA	Golden Valley Electric Association
IRAP	Interim Removal Action Plan
IRAP Addendum	Interim Remedial Action Plan Addendum
ITRC	Interstate Technology & Regulatory Council
lb/day	pound per day
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LNAPL	light nonaqueous phase liquid
LOQ	limit of quantitation
MB	method blank
MS	matrix spike
MSD	matrix spike duplicate
NPR	North Pole Refinery
O&M	operation and maintenance
Pace	Pace Analytical Services, Inc.
POE	point-of-entry
power plant	electrical generating facility
QA	quality assurance
QC	quality control
report	First Quarter 2013 Groundwater Monitoring Report
reporting period	first quarter 2013
RPD	relative percent difference



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RSCR	Revised Site Characterization Report
SAP	Sampling and Analysis Plan
SCR – 2011	Site Characterization Report Through 2011
SCR – 2012	Site Characterization Report – 2012 Addendum
SGS	SGS Laboratories
site	Flint Hills Resources Alaska, LLC North Pole Refinery, located on H and H Lane in North Pole, Alaska
SOP	Standard Operating Procedure
SWI	Shannon & Wilson, Inc.
TOC	total organic carbon
Toolkit	Mass Flux Toolkit
TPT	Technical Project Team
TWUP	temporary water use permit
UAF	University of Alaska Fairbanks
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound
VPT	vertical profiling transect
WO	work order
WWTP	wastewater treatment plant
µg/L	micrograms per liter
°C	degrees Celsius



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North Pole, Alaska

1. Introduction

On behalf of Flint Hills Resources Alaska, LLC (FHRA), ARCADIS U.S., Inc. (ARCADIS) prepared this First Quarter 2013 Groundwater Monitoring Report (report) for the FHRA North Pole Refinery (NPR), an active petroleum refinery located on H and H Lane in North Pole, Alaska (site). This report summarizes field activities completed during the first quarter 2013 (reporting period). Field activities completed during the reporting period include onsite and offsite groundwater and light nonaqueous phase liquid (LNAPL) monitoring; baildown testing; deep benzene, toluene, ethylbenzene, and total xylenes (BTEX) monitoring; well installation; private well monitoring including point-of-entry (POE) treatment system monitoring; deep residential well monitoring; onsite remediation system operation and maintenance (O&M) monitoring; and pilot testing. Table 1-1 summarizes the field activities completed during the reporting period.

Field activities were completed by qualified persons, as defined by 18 Alaska Administrative Code (AAC) 75.990. Shannon & Wilson, Inc. (SWI) of Fairbanks, Alaska completed groundwater monitoring, baildown testing, private well monitoring, remediation system monitoring, and well installation. FHRA field staff, under Barr Engineering Company's (Barr's) direction, completed remediation system O&M activities. Barr and SWI completed pilot testing activities. Arctic Home Living completed POE treatment system monitoring under the direction of FHRA.



2. Site Setting

This section describes the site and the site's physical setting, and summarizes the current groundwater monitoring program at the site.

2.1 Site Description

The site is located on 240 acres inside the city limits of North Pole, Alaska (the city). The city is located approximately 13 miles southeast of Fairbanks, Alaska, within Fairbanks North Star Borough (Figure 2-1). NPR is an active petroleum refinery that receives crude oil feedstock from the Trans-Alaska Pipeline. The site was developed in the mid-1970s and operations began in 1977.

Three crude oil processing units are located in the southern portion of the site, making up the process area. Tank farms are located in the central portion of the site. Truck-loading racks are located immediately north of the tank farms and a railcar-loading rack is located west of the tank farms. Wastewater treatment lagoons, storage areas, and two flooded gravel pits (the North and South Gravel pits) are located in the western portion of the site. Rail lines and access roads are located in the northernmost portion of the site.

Along the southern site boundary, partially surrounded by the NPR, is an electrical generating facility (power plant) operated by Golden Valley Electric Association (GVEA). FHRA representatives indicated that the power plant burns heavy aromatic gas oil (diesel 4) and other fuels produced at the FHRA site. The property south of the site and the GVEA power plant is occupied by the Petro Star, Inc. Refinery. Figure 2-2 illustrates the main features on or near the site. An Onsite Site Plan is presented on Figure 2-3 and an Offsite Site Plan is presented on Figure 2-4.

Immediately north of the site are residential properties and the city's wastewater treatment plant (WWTP). The North Pole High School is located immediately north and west of the WWTP and the residential properties. An undeveloped parcel of property, owned by the Alaska Department of Natural Resources (DNR), lies between the site and the WWTP. The Tanana River is located to the south and west, flowing in a northwesterly direction toward Fairbanks. East of the site is property that is residential or undeveloped, the Old Richardson Highway, and the Alaska Railroad right-of-way.

2.2 Physical Setting

The site and the surrounding North Pole area are located on a relatively flat-lying alluvial plain that is situated between the Tanana River and Chena Slough (locally known as Badger Slough). The site is located on the Tanana River Floodplain. Up to 2 feet of organic soil is typically found in the undeveloped portions of the site. A discontinuous silt and silty

sand layer that varies in thickness from 0 to 10 feet typically occurs beneath the organic soil. Alluvial sand and gravel associated with the Tanana River are present below the organic soil and silty layers. Depth to bedrock has been estimated at 400 to 600 feet below ground surface (bgs).

The city is located within an area of Alaska characterized by discontinuous permafrost (Ferrians 1965). Permafrost tends to act as a confining layer, limiting the flow of groundwater (Glass et al. 1996). Based on regional information (Williams 1970, Miller et al. 1999), permafrost is assumed to be absent beneath the Tanana River.

The aquifer beneath the alluvial plain between the Tanana River and Chena River generally consists of highly transmissive sands and gravels under water table conditions (Cederstrom 1963, Glass et al. 1996). The Tanana River has a drainage area of approximately 20,000 square miles upstream of Fairbanks (Glass et al. 1996). Near the site, this aquifer is reportedly greater than 600 feet thick (at least 616 feet thick near Moose Creek Dam) (Glass et al. 1996). Beyond the zones of influence of the NPR groundwater recovery system, groundwater flow directions are controlled by discharge from the Tanana River to the aquifer and from the aquifer to the Chena River, as described by Glass et al. (1996). Variations in river stage through time are believed to be the primary cause of variations in flow direction through the aquifer between the rivers (Lilly et al. 1996, Nakanishi and Lilly 1998). Based on data from U.S. Geological Survey water table wells, the flow direction generally varies from a north-northwesterly direction to a few degrees east of north. The flow direction trends to the north-northwest in spring and more northerly in the summer and fall (Glass et al. 1996).

3. Current Groundwater Monitoring Program and Methods

The current onsite and offsite groundwater monitoring program was originally proposed in the Site Characterization and First Quarter 2011 Groundwater Monitoring Report (Barr 2011) and was subsequently revised in the Site Characterization Work Plan Addendum (ARCADIS 2011), the Site Characterization Report – Through 2011 (SCR – 2011; Barr 2012) and the Site Characterization Report – 2012 Addendum (SCR – 2012; ARCADIS 2013a). Table 3-1 summarizes well construction details. Tables 3-2, 3-3, 3-4, 3-5, 3-6a, and 3-6b summarize the groundwater elevation monitoring well network, LNAPL thickness monitoring well network, LNAPL migration monitoring well network, BTEX monitoring well network, and sulfolane monitoring well network (including both onsite and offsite wells), respectively. Well locations are shown on Figures 2-3 and 2-4.

Routine quarterly groundwater monitoring and sampling was performed as part of the ongoing operations to characterize onsite LNAPL, dissolved-phase BTEX, and onsite and offsite dissolved-phase sulfolane impacts. Methods used for non-routine analyses are described or referenced in corresponding sections.

Groundwater monitoring was completed according to the procedures summarized in the Sampling and Analysis Plan (SAP) initially presented in Appendix M of the Site Characterization Work Plan (Barr 2010a). The SAP is updated on a continuous basis and submitted periodically; updates are tracked in Appendix A of the SAP. The updated SAP is referred to in this report as the project SAP. Revisions and updates have been incorporated into the project SAP (Version 5), which was included as Appendix A of the Fourth Quarter 2012 Groundwater Monitoring Report (ARCADIS 2013d). Table 1-1 summarizes the field activities completed during the reporting period.

Groundwater monitoring data are used to assess changes and any trends that may be present at the site and to characterize the effectiveness of the onsite groundwater recovery system. A statistical analysis of BTEX and sulfolane concentration trends was originally presented in the SCR – 2011 (Barr 2012) and updated in the Fourth Quarter 2012 Groundwater Monitoring Report (ARCADIS 2013d). The statistical analyses will be updated annually in the fourth quarter groundwater monitoring reports.

3.1 Groundwater Elevation and Light Nonaqueous Phase Liquid Monitoring

Depth to groundwater was measured on January 24 and 25, 2013 from an extensive network of onsite and offsite wells. As described in the SCR – 2011 (Barr 2012), the LNAPL monitoring network was expanded and measurements were collected to determine the LNAPL thickness and potential migration to confirm the stability of the LNAPL plume. During this reporting period, LNAPL thickness and migration measurements were collected

monthly from monitoring wells on January 23 and 24, February 26, and March 28 and 29, 2013.

Depth to water and LNAPL thickness measurements were completed according to the project SAP (ARCADIS 2013d). Measurements were collected from site monitoring wells with an oil/water interface probe. If present, LNAPL thickness was calculated based on depth to groundwater and LNAPL measurements. Groundwater elevation was calculated using the previously surveyed top of casing elevation and the depth to water. Groundwater elevation where LNAPL was present was corrected for the thickness of LNAPL using the appropriate LNAPL-specific gravity value presented in the SCR – 2011 (Barr 2012). Onsite and offsite wells were resurveyed in November 2012 to account for frost-jacking and settling of monitoring well casings due to regional weather patterns.

In addition to manual water-level measurements, automated measurements were collected from several wells using vented Global WL-16 automated water-level loggers, vented In-Situ Level Troll 500 loggers, or unvented In-Situ Rugged Troll 100 loggers. Each WL-16 is a combined pressure transducer and data logger with automatic barometric pressure and temperature compensation. One Barotroll[®] logs the barometric pressure for the In-Situ Troll loggers. Each logger provides an elevation reading below top of casing and is programmed to measure water levels on an hourly basis. A total of 71 transducers are currently deployed in 25 onsite wells and 46 offsite wells to observe hydrogeological conditions between wells screened at various depths within the suprapermafrost aquifer, as reported in the SCR – 2012 (ARCADIS 2013a).

FHRA prepared a standard operating procedure (SOP) for groundwater elevation monitoring and submitted the SOP to the Alaska Department of Environmental Conservation (ADEC) for approval. Once approved, groundwater elevation measurements downloaded from the deployed transducer will be evaluated to estimate vertical hydraulic gradients within well nests and horizontal hydraulic gradients and groundwater flow directions between groups of wells, as discussed in the Fourth Quarter 2012 Groundwater Monitoring Report (ARCADIS 2013d).

3.2 Baildown Testing

LNAPL baildown testing is conducted to characterize LNAPL transmissivity at the site. The LNAPL transmissivity results are used to quantify relative LNAPL recoverability to focus LNAPL recovery efforts in areas that have higher recovery potential and to establish practical limits of recovery.

The annual implementation of baildown testing was completed in March 2013 in accordance with the revised schedule proposed in the 2013 On-site Site Characterization Work Plan (SCWP; ARCADIS 2013b). The revised schedule targets the local hydrogeologic

cycle minima instead of a calendar-based schedule. Targeting the groundwater “low” will provide LNAPL baildown testing results that are more representative of the maxima of the transmissivity range. LNAPL baildown testing was conducted according to procedures outlined in the project SAP (ARCADIS 2013d).

3.2.1 Background

The recoverability of LNAPL at an environmental site is influenced by many factors, including LNAPL saturation in the impacted soil, soil permeability, and physical properties of the LNAPL. The saturation and permeability directly influence the relative permeability of LNAPL. Due to the interactions of groundwater, air, and LNAPL within petroleum-impacted soil, the relative permeability of LNAPL is less than the overall soil permeability. Moreover, the physical properties of the LNAPL influence the rate that LNAPL can flow within the formation. An empirical method to assess LNAPL recoverability at the field scale is to test LNAPL transmissivity, which integrates all of the relevant factors influencing LNAPL recoverability. LNAPL transmissivity is commonly characterized using short-term duration LNAPL stress testing, also called LNAPL baildown testing.

An LNAPL baildown test is initiated by quickly removing LNAPL accumulated in a well. The rate of LNAPL flow into the well is a function of soil and LNAPL properties discussed above and the magnitude of the initial hydraulic gradient toward the well developed during LNAPL removal. The relative observed recovery data resulting from LNAPL baildown tests can be inspected to provide a qualitative sense of the recoverability of LNAPL. A short period for the LNAPL to recover to approximately the thickness measured prior to the test indicates favorable recoverability, whereas an extended period for LNAPL recovery points to poor recoverability. The baildown tests were performed and analyzed in a manner consistent with ASTM E2856 – 11, Standard Guide for Estimation of LNAPL Transmissivity. The ASTM guidance states that the target LNAPL transmissivity accuracy for the data collection and analysis methods presented in the guidance is a factor of two. That level of accuracy is validated by LNAPL baildown tests that were repeated within a few days in several wells at the NPR in 2011 and 2012. The variability in calculated transmissivity for most paired tests was less than a factor of 2; the maximum variability was a factor of 2.7.

LNAPL baildown tests that have sufficient LNAPL discharge into the well (recovery) can be quantitatively analyzed to determine LNAPL transmissivity under the test conditions. The calculated LNAPL transmissivity can be used to quantitatively characterize the LNAPL bulk transport conditions onsite and comparatively assess LNAPL recoverability. LNAPL recovery using hydraulic methods (e.g., dual-phase extraction, skimmer pumping, vacuum truck operations) is typically not effective for areas where LNAPL transmissivity is less than 0.1 to 0.8 square feet per day (ft²/day; Interstate Technology & Regulatory Council [ITRC] 2009).

3.2.2 Methods

Pre-test depths to air/LNAPL and LNAPL/groundwater interfaces are recorded using an oil/water interface probe prior to starting a baildown test. The baildown tests are initiated by evacuating LNAPL from a well using a peristaltic pump or bailer. The fluids removed from the well are collected in a graduated cylinder and the total volume of LNAPL and groundwater are documented. After LNAPL has been purged from the well to the extent practical, routine fluid level measurements are taken using the oil/water interface probe. At sites where rapid recharge is expected, the manual fluid level measurement approach may be augmented using a potentiometric surface data logger. Fluid level data are initially collected in short intervals, typically on the order of every minute, at test initiation and adjusted thereafter based on the test-specific rate of LNAPL recovery. This process is continued as long as it is viable or necessary based on field logistics and data quality objectives, respectively.

One LNAPL baildown test per well was completed at 10 monitoring wells in March 2013: MW-176A, MW-334-15, O-10, O-11, O-27, R-14A, S-22, S-44, S-50, and S-51.

Hydrographs of wells with analyzed baildown tests, showing depth to product, depth to water, and corrected water table elevation during the baildown tests are included with the American Petroleum Institute (API) tool output in Appendix A. Other relevant information such as geologic data from soil boring logs, lithologic cross-sections (where available), and well screen intervals are also included on the hydrographs to show how fluid level elevations relate to the well screen and to changes in lithology outside the borehole. Depth measurements on the hydrographs are plotted in units of feet below ground surface.

Baildown tests were analyzed using the Bouwer and Rice (1976) modified slug test method per ASTM International (ASTM) standards (ASTM, 2012). The Bouwer and Rice method is presented in the API tool.

3.3 Groundwater Sampling Priorities

In response to several quarterly sampling events when inclement weather reduced the opportunity to collect samples from all wells within each monitoring well network, well networks were evaluated and each well was assigned a priority (one through four). Sampling is conducted in order of priority to assure that the most valuable data are collected during each sampling event. Tables 3-5, 3-6a, and 3-6b summarize the priority levels assigned to each well in the BTEX and sulfolane monitoring networks, respectively. Priority levels for each monitoring well network were also updated in the project SAP (ARCADIS 2013d).

During the reporting period, weather cooperated and all proposed samples were collected from the BTEX and sulfolane monitoring networks. Seven wells in the BTEX monitoring

network were not sampled because the wells were frozen. Twenty-nine wells in the sulfolane monitoring network were not sampled because the wells were frozen or dry. Non-sampled wells are indicated in the BTEX and sulfolane result tables (Tables 4-6 and 4-7).

Additionally, the ADEC requested an increase in the sampling frequency for sulfolane in 28 wells to establish and understand sulfolane trends at those wells. The selected wells were given sampling priority in January and one additional sample was collected from each well in March. However, five of the ADEC priority wells were not sampled because the wells were frozen. ADEC priority wells are summarized in Tables 3-6a and 3-6b. Results including non-sampled wells are summarized under non-routine activities.

3.4 Groundwater Sampling Methods

Groundwater samples collected during the reporting period were sampled in accordance with the project SAP (ARCADIS 2013d). Groundwater was purged from each sampled well using dedicated or portable pumps. Purging was conducted until geochemical parameters stabilized or three well volumes of groundwater were pumped from the well. A YSI ProPlus multiprobe or equivalent was used to monitor geochemical parameters, including temperature, conductivity, dissolved oxygen (DO), pH, and oxidation-reduction potential.

3.5 Groundwater Monitoring Analytical Methods

Upon collection, groundwater samples were stored in iced coolers and submitted to SGS Laboratories (SGS) of Anchorage, Alaska under proper chain of custody (COC) procedures. Groundwater analytical samples were submitted for the following quarterly analyses:

- BTEX by United States Environmental Protection Agency (USEPA) Method 8260B
- Sulfolane by modified USEPA Method 1625B with isotope dilution gas chromatography/mass spectrometry (GC/MS)

SGS developed an SOP for modified USEPA Method 1625B/8270D with isotope dilution GC/MS, in accordance with a Key Elements document prepared by the Chemistry Subgroup of the Technical Project Team (TPT). The SOP was approved by the ADEC via email on May 18, 2011.

3.6 Geochemical Parameter Monitoring

As proposed in the SCR – 2011 (Barr 2012), geochemical parameter monitoring is performed semiannually during the second and fourth quarters to characterize the potential

for natural attenuation of sulfolane at the site. Geochemical parameter monitoring will resume during the next reporting period.

3.7 Private Well Sampling

A door-to-door survey was previously conducted downgradient from the site to identify private water-supply wells in Search Areas 1 through 9 (Figure 3-1). Site characterization activities began offsite in 2009. Since that time, permanent buildings within the search areas were visited and residents were surveyed to determine the presence of wells on the properties. If a well was identified, information regarding well construction details and water usage was requested. If a drinking-water well was present on a property, permission to collect a groundwater sample for sulfolane analysis was requested. The overall search area was expanded until private well water sample results were non-detect for sulfolane.

One location with a newly constructed home in Search Area 3 was visited during the reporting period; however, the location did not have a private well.

Six additional samples were collected from wells outside the search areas in response to call-in requests submitted to FHRA. The six sampling locations are shown on Figure 3-1. Initial samples were not collected from within the search areas during the reporting period.

As of March 31, 2013, FHRA has not started the 2013 resampling of wells that previously did not contain detectable concentrations of sulfolane during the previous sampling events from areas near the edge of the plume; resampling efforts will begin during the second quarter of 2013. To-date (between November 11, 2009 and March 31, 2013), FHRA has sampled 581 wells within the search areas. In addition, 151 private well samples were collected from outside the search areas at locations near the defined search areas (e.g., sharing a driveway) or where FHRA was contacted (by a landowner, resident, or a real estate agent) with requests for testing. A four-digit private well identification number was assigned to each well location where a water sample was collected and are shown on Figure 3-2. In cases where a property contains several wells that were sampled, each sampled well on the property was assigned a separate identification number. In addition, wells discovered during review of the ADEC septic records were assigned an identification number. Identification numbers were assigned to protect the privacy of the private-well owners.

In addition to historical initial samples and resamples collected within and outside of search areas, FHRA migrated more than 500 historical POE system maintenance sampling results for raw water samples into the sulfolane database to support additional site characterization. Trained Arctic Home Living personnel are completing sample collection under the direction of FHRA. POE system maintenance samples are submitted to Pace Analytical Services, Inc. (Pace). Pace developed an SOP for modified USEPA Method

8270C Capillary Column Technique with isotope dilution by GC/MS, in accordance with a Key Elements document prepared by the Chemistry Subgroup of the Technical Project Team (TPT). The SOP was approved by the ADEC via email on May 18, 2011.

Sampling results presented on Figure 3-1 are designated with a different symbol from well samples that do not have a POE treatment system. A SAP is currently being prepared for future sampling and validation of data collected during maintenance of the POE systems.

3.8 Deep Residential Monitoring

A deep residential monitoring plan was submitted to the ADEC on June 20, 2012 (ARCADIS 2012b). Subsequently, an updated monitoring plan was resubmitted in the 2013 Offsite Site Characterization Work Plan (2013 Offsite SCWP; ARCADIS 2013c). The objectives of the monitoring plan are to:

- Establish a groundwater monitoring network of deep private wells with intake intervals reported to be in the subpermafrost zone.
- Establish a baseline dataset of sulfolane concentrations and geochemical conditions at the deep private well groundwater monitoring network.
- Monitor sulfolane concentrations and geochemical conditions quarterly at deep private wells, for two years.

The monitoring plan proposed a two-phase implementation approach. The objective of Phase I was to select at least one candidate well at each proposed monitoring location, and obtain access agreements for sampling the selected wells. Phase II of the monitoring plan (quarterly sampling) was initiated during the reporting period. Quarterly sampling is also planned for early June, late September, and early December 2013. FHRA contacted residents at 17 homes with private wells reported to have been installed through permafrost, and collected water samples from each of the private wells. FHRA has agreements in place with the private well owners to collect water samples on a quarterly basis. Samples were collected from March 11 through April 19, 2013. Sampling location numbers presented in the 2013 Offsite SCWP (ARCADIS 2013c) were reassigned a four-digit code and are included in Figure 3-2, and are identified on Figure 4-20.

In a continuing effort to evaluate the connectivity of, and vertical gradients between, suprapermafrost and subpermafrost water-bearing zones, a third phase of deep well monitoring was proposed. During the proposed Phase III activities, a down-hole camera inspection was conducted on a property (location number 1230 at 64.757977372, -147.371598729 [WGS 84]) on April 5, 2013 to verify the construction and information obtained from a boring log discovered in the ADEC septic-record files. Due to the

uncertainty surrounding the well and sulfolane results from a water sample collected on March 11, 2013 (558 µg/L), it was necessary to verify that the boring log was properly assigned. The address and parcel numbers noted on the boring log have changed since the well installation date (October 6, 1982); however, based on visual inspection and interviews with the owner, the well noted on the boring log existed at 64.757977372, -147.371598729. The boring log indicates that the well that was constructed in 1982 and is cased to 231 feet bgs; permafrost was encountered from 33 to 205 feet bgs at the time of installation and the pump was set to 210 feet bgs. The well is the closest known private well installed through permafrost to the NPR.

Following pump removal, a submersible video camera was used to observe the inside casing. Due to build up on the walls and poor water clarity, a majority of the well casing was not viewable. However, in areas where welded seams were visible, they appeared to be intact and in good condition. Ice was observed along the sides of the wall; the first viewable ice was noted at approximately 74 feet bgs. In addition, large pieces of ice that had been attached to the inside wall were pulled out of the well when the camera was removed. Due to an obstruction, the camera could not be lowered deeper than approximately 225 feet bgs. A perforated screen was not observed at the obstruction. It was concluded that the observed well is the well noted on the boring log and was installed through permafrost.

The well was restored to the original condition for future deep residential sampling events and is secured to prevent use by the tenants of the property. The well is being sampled quarterly as part of the expanded deep residential monitoring plan presented in the 2013 Offsite SCWP (ARCADIS 2013c).

4. Groundwater Monitoring Results

Groundwater impacts have been, and continue to be, characterized through the analysis of gauging data and groundwater samples collected from onsite and offsite monitoring wells. This section presents results of gauging data and groundwater analyses of onsite well samples (analyzed for BTEX and/or sulfolane), offsite well samples (analyzed for sulfolane), private well samples (analyzed for sulfolane), and non-routine samples collected during the reporting period. Groundwater field parameters, groundwater elevation and LNAPL thickness measurements, LNAPL migration measurements, LNAPL baildown testing results, BTEX analytical results, sulfolane analytical results, sulfolane mass flux results, residential well analytical results, deep residential well analytical results and the March resampling event results are presented in Tables 4-1 through 4-12. Constituent of potential concern (COPC) sampling, which includes iron, GRO, and DRO, is currently scheduled to be conducted on an annual basis during the second quarter (Barr 2012). Iron was inadvertently sampled at three wells during the reporting period; results are provided in Table 4-13. Historical groundwater elevation and LNAPL thickness measurements, BTEX analytical results, sulfolane analytical results, geochemical analytical results, and private well analytical results are included as Appendix B. Laboratory analytical reports and ADEC review checklists are included as Appendices C and D, respectively. Field data sheets are included as Appendix E.

4.1 Groundwater Elevation

Depth to water measurements were collected from monitoring wells on January 24 and 25, 2013. 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. Depth to water measurements and groundwater elevation data are summarized in Table 4-2. Potentiometric maps are included for each monitoring zone: water table, 10 to 55 feet below the water table, 55 to 90 feet below the water table, and 90 to 160 feet below the water table (Figures 4-1 through 4-6). An onsite magnitude of the horizontal hydraulic gradient of approximately 0.001 foot per foot (ft/ft) was calculated at the water table and at 10 to 55 feet below the water table during the reporting period. Offsite, the magnitude of the horizontal hydraulic gradients at the water table and at 10 to 55 feet below the water table were calculated at 0.00075 and 0.0009 ft/ft, respectively. The magnitude of the horizontal hydraulic gradients at 55 to 90 feet below the water table and 90 to 160 feet below the water table were calculated at 0.0011 ft/ft.

In addition to manual water-level measurements, automated measurements were collected with transducers from 53 wells including 20 well nests. Transducer data were downloaded on March 18 through 21, 2013. 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 draft SOP using the most recent survey data preceding data downloads. The technical memorandum prescribing the error calculation method is not yet approved; upon approval future hydrographs will contain error bars. The following observations were made from data collected during the reporting period and are based on draft hydrographs presented in Appendix F:

- An upward vertical gradient is evident on hydrographs from 10 well nests.
- A downward vertical gradient was evident on hydrographs from three well nests.
- No vertical gradient was evident during the reporting period for four well nests.
- Vertical gradients were not available for three well nests during the reporting period because one or more of the pressure transducers were frozen in the well and could not be accessed as described further below.

Several pressure transducer data logs are incomplete between December 26, 2012 and March 21, 2013. The pressure transducers installed in monitoring wells MW-151C, MW-172B, MW-179A, MW-179B, MW-179C, MW-179D, MW-304-15, and MW-320-130 have incomplete data logs for the reasons outlined in the table below.

Monitoring Well	Reason for Data Loss	Dates Affected
MW-151C	Pressure transducer is frozen in the well. Cannot communicate with pressure transducer.	12/26/2013 to 3/20/2013 Note: data will be downloaded once the logger can be accessed.
MW-172B	Pressure transducer is frozen in the well. Cannot communicate with pressure transducer.	12/26/2013 to 3/19/2013 Note: data will be downloaded once the logger can be accessed.
MW-179A	Pressure transducer is frozen in the well. Cannot communicate with pressure transducer— batteries are likely expired.	1/4/2013 to 3/21/2013 Note: a partial log may still be recovered once the well has thawed and communication with the device can be established.
MW-179B	Pressure transducer is frozen in the well. Cannot communicate with pressure transducer— batteries are	1/4/2013 to 3/21/2013 Note: a partial log may still be recovered once the well has thawed and communication with the device can



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	likely expired.	be established.
MW-179C	Pressure transducer is frozen in the well. Cannot communicate with pressure transducer— batteries are likely expired.	1/4/2013 to 3/21/2013 Note: a partial log may still be recovered once the well has thawed and communication with the device can be established.
MW-179D	Pressure transducer is frozen in the well. Cannot communicate with pressure transducer— batteries are likely expired.	1/4/2013 to 3/21/2013 Note: a partial log may still be recovered once the well has thawed and communication with the device can be established.
MW-186A	The procedure for adjusting data to account for LNAPL in the well hasn't been addressed.	No data has been imported into the database.
MW-304-15	Pressure transducer is frozen in the well. Cannot communicate with pressure transducer.	12/26/2013 to 3/20/2013 Note: data will be downloaded once the logger can be accessed.
MW-320-130	Pressure transducer is frozen in the well. Cannot communicate with pressure transducer.	12/26/2013 to 3/19/2013 Note: data will be downloaded once the logger can be accessed.
MW-334-15	The procedure for adjusting data to account for LNAPL in the well hasn't been addressed.	No data has been imported into the database.

A detailed evaluation of transducer data and hydraulic gradients will be submitted under separate cover, as discussed in the Fourth Quarter 2012 Groundwater Monitoring Report (ARCADIS 2013d).

4.2 Surface-Water Elevation

Measurements were recorded from gauging points located at the North and South Gravel pits on January 24, 2013. The North Gravel Pit measurement was taken from a surveyed mark on an I-beam above a grate in the fire pump house that sits over the water on the southeast end of the gravel pit (Figure 4-1). The South Gravel Pit measurement was taken from a 12-foot staff gauge in the pond (Figure 4-1). The North and South Gravel pits were measured during the reporting period at elevations of 484.52 and 490.07 feet above mean sea level, respectively. Data are summarized in Table 4-2 and presented on Figure 4-1. Historical gauging data are summarized in Appendix B.

4.3 Light Nonaqueous Phase Liquid Monitoring Results

As described in the SCR – 2011 (Barr 2012), new observation wells (O-5 through O-30) were installed to better define LNAPL occurrence at the site. LNAPL thickness measurements were collected on January 23 and 24, February 26, and March 28 and 29, 2013 from a network of monitoring, observation, and recovery wells screened across the water table. An apparent LNAPL thickness was measured in 26 wells during January 2013, in 23 wells during February 2013, and in 25 wells during March 2013. A visible sheen or trace (not measureable in the field) was recorded in four wells during January 2013, in seven wells during February 2013, and in five wells during March 2013. On February 26, 2013, a maximum LNAPL thickness of 4.07 feet was measured in monitoring well MW-176A (Figure 4-7).

4.3.1 Light Nonaqueous Phase Liquid Extent

LNAPL migration measurements were collected from wells along the perimeter of the LNAPL plume on January 23 and 24, February 26, and March 28 and 29, 2013. LNAPL was not measured in any of the LNAPL migration monitoring wells during the reporting period.

4.3.2 Light Nonaqueous Phase Liquid Thickness

LNAPL thicknesses and the LNAPL footprint observed during the reporting period are similar to historical footprints. LNAPL thickness and migration data are summarized in Tables 4-3 and 4-4, respectively, and maximum thickness data from the reporting period are presented on Figure 4-7.

4.4 Bardown Testing Results

Qualitative assessment of the LNAPL bardown test results suggests low to moderate LNAPL transmissivity in most of the wells tested. Results for the bardown tests are included in Table 4-5.

Tests at wells MW-176A, O-10, O-11, O-27, R-14A, S-22, S-44, S-50, and S-51 were analyzed using the API tool. LNAPL transmissivity values for these wells are presented in Table 4-5. Output from the API tool is included for each test in Appendix A.

Quantitative estimates of LNAPL transmissivity could not be made at one of the wells planned for bardown testing for the following reason:

- The bardown test completed at well MW-334-15 could not be analyzed due to the high LNAPL transmissivity of the well. LNAPL cannot be removed fast enough to collect enough data for a proper analysis.

LNAPL transmissivity results are depicted on Figure 4-8. Figure 4-8 shows that transmissivity values determined from the March 2013 bardown testing data generally indicate a decreasing trend since the 2011 and 2012 events. This can be attributed to the following:

1. Decreased LNAPL thicknesses in wells due to ongoing LNAPL mass recovery.
2. Change in methodology in analyzing data beginning with the October 2012 bardown testing event. Transmissivity estimates for earlier events were based on geometric mean values obtained using three slug testing methods: Bouwer and Rice (1976), Cooper et al. (1967)/Jacob and Lohman (1952), and Bredehoeft and Papadopoulos (1967). In October 2012, transmissivity values were obtained using only the Bouwer and Rice (1976) and Cooper et al. (1967)/Jacob and Lohman (1952) methods. Transmissivity estimates for the reporting period were obtained using only the Bouwer and Rice (1976) method due to the simplistic direct relationship between LNAPL discharge to LNAPL drawdown, and the inclusion of a test specific ratio of change in LNAPL drawdown to change in LNAPL thickness, the JRATIO (API 2012). This ratio allows for fluctuation between either a non-constant potentiometric surface or LNAPL/water interface, assumed boundary conditions based on bardown testing theory, effectively making the Bouwer and Rice (1976) method applicable to a wider range of bardown tests.

LNAPL transmissivity estimates at wells MW-176A, O-11, R-14A, S-22, S-44, and S-51 are within or below the range of 0.1 to 0.8 ft²/day suggested by the ITRC as the lower limit of practicable recoverability (ITRC 2009). This indicates that LNAPL is minimally recoverable

surrounding these test locations. Transmissivity calculations for wells O-10, O-27, and S-50 were above the ITRC criterion of 0.1 to 0.8 ft²/day, indicating potential for beneficial reduction of the LNAPL mass in areas surrounding these wells via ongoing recovery operations. Based on the higher transmissivity measured and potential for increased LNAPL recovery, increased manual product recovery activities are planned for wells O-10 and O-27. Additionally, a pneumatic skimmer system has been installed in well S-50.

4.5 Onsite Monitoring Well Sampling Results

The majority of BTEX data are collected semiannually during the second and fourth quarters; however, eight wells are sampled quarterly for BTEX. BTEX results for the reporting period, summarized in Table 4-6 and plotted on Figure 4-9; show the inferred extent of the dissolved-phase BTEX plume at the water table. Deeper BTEX sampling from groundwater zones beneath the water table were recommended in the SCR – 2011 (Barr 2012) and the 2013 Onsite SCWP (ARCADIS 2013b). BTEX sampling results for wells screened at 10 to 55, 55 to 90, and 90 to 160 feet bgs below the water table are presented on Figures 4-10, 4-11, and 4-12, respectively.

Sulfolane data were collected from wells that are on a quarterly schedule. Groundwater samples collected from 126 onsite wells during the reporting period were submitted for sulfolane analysis using the isotope dilution method. These data are presented in Tables 4-7 and 4-8. Sulfolane data collected from monitoring wells are plotted on Figures 4-13 through 4-16 to show the estimated extent of the dissolved-phase sulfolane plumes at the following depth intervals: water table, 10 to 55 feet below the water table, 55 to 90 feet below the water table, and 90 to 160 feet below the water table.

Fifty-six of the 126 sampling locations were from the vertical profiling transect (VPT); each groundwater sample was analyzed for sulfolane and results are described in Section 4.5.2.5. Data are summarized in Table 4-8 and presented on Figure 4-17. Sulfolane concentrations for VPT wells in each groundwater zone are also presented on Figures 4-13 through 4-16.

For this report, FHRA uses the 14 micrograms per liter (µg/L) alternative cleanup level (ACL) referenced by the ADEC in a letter dated July 19, 2012 (ADEC 2012). This report is submitted subject to the positions and reservations expressed by FHRA in a letter dated August 20, 2012 (FHRA 2012). The ACL of 14 µg/L was used to evaluate sulfolane groundwater data collected during the reporting period. Historical sulfolane analytical results are included as Appendix B.

4.5.1 Benzene, Toluene, Ethylbenzene, and Total Xylenes

During the reporting period, benzene was detected above the ADEC groundwater cleanup level of 5 µg/L in the sample collected from well MW-334-15 at a concentration of 2,430 µg/L (duplicate sample). Toluene (4,420 µg/L), ethylbenzene (610 µg/L), and total xylenes (3,480 µg/L; duplicate sample) were also detected in the sample collected from MW-334-15. Benzene concentrations detected in the sample collected from well MW-137 were flagged as estimated, as described in Section 6. Figure 4-9 depicts an isopleth map at the water table to show the inferred extent of the BTEX plume. BTEX results are summarized in Table 4-6. Historical BTEX analytical results are included as Appendix B.

Benzene was not detected above the ADEC groundwater cleanup level of 5 µg/L in wells screened below the water table zone. Benzene concentrations detected in the sample collected from well MW-154B were flagged by the laboratory as estimated as described in Section 6. Figures 4-10, 4-11, and 4-12 depict analytical results for BTEX at 10 to 55, 55 to 90, and 90 to 160 feet below the water table, respectively.

A statistical analysis of benzene trends was originally presented in the SCR – 2011 (Barr 2012) and a revised analysis was presented in the Fourth Quarter 2012 Groundwater Monitoring Report (ARCADIS 2013d). The statistical analysis will be updated annually in the fourth quarter submittal each year.

4.5.2 Sulfolane

4.5.2.1 Water Table

Sulfolane was detected above the ACL of 14 µg/L in samples collected from 28 onsite monitoring and observation wells screened across the water table, with results ranging from 21.1 µg/L (MW-131) to 6,520 JL µg/L (O-1). Sulfolane concentrations detected in groundwater samples collected from wells MW-138, MW-176A, MW-303-CMT-9, O-1, and O-3 were flagged as estimated, as described in Section 6. The maximum sulfolane concentration of 6,520 JL µg/L was detected in the groundwater sample collected from well O-1, which exhibited a maximum concentration of 10,400 µg/L in November 2011. The estimated extent of the sulfolane plume is identified as an isopleth based on the ACL and is presented on Figure 4-13.

4.5.2.2 10 to 55 Feet Below the Water Table

Sulfolane was detected at or above the ACL of 14 µg/L in groundwater samples collected from 14 onsite wells at 10 to 55 feet below the water table, with results ranging from 14 µg/L (MW-305-CMT-28) to 81.9 µg/L (MW-304-CMT-30). Sulfolane concentrations detected in the groundwater samples collected from wells MW-301-CMT-50, MW-301-60, MW-304-

CMT-20, MW-304-CMT-60, MW-305-CMT-18, and MW-334-65 were flagged by the laboratory as estimated, as described in Section 6. The estimated extent of the sulfolane plume from 10 to 55 feet below the water table is identified as an isopleth based on the ACL and is presented on Figure 4-14.

4.5.2.3 55 to 90 Feet Below the Water Table

Sulfolane was detected above the ACL of 14 µg/L in five groundwater samples collected from onsite wells screened at 55 to 90 feet below the water table, with concentrations ranging from 15.3 µg/L (MW-154A) to 79.3 µg/L (MW-154B). Sulfolane concentrations detected in groundwater samples collected from wells MW-301-70, MW-303-70, MW-304-70, MW-304-80, and MW-304-96 were flagged as estimated, as described in Section 6. The estimated extent of the sulfolane plume at 55 to 90 feet below the water table is identified as an isopleth based on the ACL and is shown on Figure 4-15.

4.5.2.4 90 to 160 Feet Below the Water Table

Sulfolane was not detected above the ACL of 14 µg/L in groundwater samples collected from any onsite monitoring wells screened at 90 to 160 feet below the water table. Sulfolane analytical results at this depth are presented on Figure 4-16.

Sulfolane results are summarized in Table 4-7. Historical sulfolane analytical results are included as Appendix B. A statistical analysis of sulfolane trends was originally presented in the SCR – 2011 (Barr 2012). This analysis was updated with 2012 data and is presented in Section 4.7.

4.5.2.5 Vertical Profiling Transect

Groundwater sampling was conducted at the VPT wells to evaluate vertical distribution of sulfolane concentrations. Sulfolane results for the VPT wells are summarized in Table 4-8 and shown on Figure 4-17. Additionally, Figures 4-13 through 4-16 show sulfolane concentrations for the VPT cluster locations at depths appropriate for each figure.

In samples collected from the MW-301 cluster, sulfolane in groundwater was detected at estimated concentrations of 3.89 J micrograms per liter (µg/L) at 50 feet bgs, 4.64 J µg/L at 60 feet bgs, and 4.31 JL µg/L at 70 feet bgs, which was the deepest interval installed at this location due to permafrost. Sulfolane concentrations were not detected in samples collected from the 10-, 20-, 30-, and 40-foot depth intervals.

At the MW-302 well cluster, sulfolane in groundwater was detected at a maximum concentration of 61 µg/L in the sample collected from the 20-foot bgs depth interval. The sulfolane concentration decreased with depth from 52.3 µg/L in the sample collected at 30

feet bgs, to 18 µg/L in the sample collected at 80 feet bgs. Sulfolane concentrations were not detected in the samples collected from 95 and 110 feet bgs, which is the deepest well installed at this location due to permafrost.

In samples collected from the MW-303 well cluster, sulfolane in groundwater was detected at a maximum concentration of 69.39 µg/L at 19 feet bgs. Sulfolane concentrations decreased with depth from 37.6 µg/L at 29 feet bgs to 6.64 µg/L in the sample collected at 70 feet bgs. Sulfolane concentrations were not detected at 80, 95, or 130 feet bgs, which is the deepest well installed at this location due to permafrost.

At the MW-304 cluster, sulfolane in groundwater was detected at a maximum concentration of 337 µg/L in the sample collected at 15 feet bgs. Sulfolane concentrations decreased with depth from 81.9 µg/L at 30 feet bgs to 5.05 µg/L at 96 feet bgs. A sulfolane concentration of 3.45 µg/L was detected in the groundwater sample collected from the 20-foot depth, which is inconsistent with historical data at this location. MW-304-CMT-10 was frozen/obstructed and was not sampled. Sulfolane concentrations were not detected at 125 or 150 feet bgs, which is the total depth explored in MW-304.

At the MW-305 cluster, sulfolane was detected at 8.98 µg/L and 14 µg/L at the 18- and 28-foot depth intervals, respectively. Sulfolane concentrations were not detected in the samples collected from 38 to 100 feet bgs, which is the deepest well installed at this location due to permafrost. A sample was not collected from the 8-foot depth interval because the sample port was obstructed and likely frozen.

At the MW-306 cluster, sulfolane was not detected in any of the groundwater samples collected to the total depth explored of 150 feet bgs.

4.5.3 Sulfolane Mass Flux

A quarterly analysis of mass flux using analytical data collected across the VPT well cluster transect each quarter was recommended in the Fourth Quarter 2012 Groundwater Monitoring Report (ARCADIS 2013d). Methods to calculate mass flux and site-specific geologic input data are included as Appendix G. 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 from data collected in November 2011 (Barr 2012) and was estimated at approximately 86 grams per day (g/day; or 0.19 pound per day [lb/day]). An update was provided in the Fourth Quarter 2012 Groundwater Monitoring Report (ARCADIS 2013d). Mass flux was estimated at approximately 62 g/day (0.14 lb/day), 83 g/day (0.18 lb/day), and 73 g/day (0.16 lb/day) across the VPT plane

during the first, second, and third quarters 2012, respectively. Because cold weather prevented sampling of parts of the VPT, mass flux for the fourth quarter 2012 reporting period was not evaluated. A sulfolane mass flux of approximately 43 g/day (0.09 lb/day) was calculated for the reporting period. Mass flux rates across the VPT are presented on Figure 4-18. The zones targeting the majority of mass flux are summarized in Table 4-9.

During the reporting period, 83 percent of the total sulfolane mass flux was discharged across the VPT near MW-302 (water table to approximately 90 feet bgs), MW-303 (approximately 18 to 42 feet bgs), and MW-304 (water table to approximately 42 feet bgs zone; Figure 4-18). Because a sample was not collected from the 10-foot intervals at MW-304 during the first quarter and a large increase in concentration is routinely detected in the 15-foot interval, previously collected third quarter 2012 non-detect data were applied to the 10-foot interval in the Toolkit. Additionally, a sample was not collected from the 8-foot interval at MW-305. The Toolkit interpolated sulfolane concentrations at this location, which may skew mass flux in these zones and the overall mass flux during the first quarter 2013. In addition, sample concentrations within the 50-, 60- and 70-foot intervals at MW-301 were flagged as estimated by the laboratory. This estimation 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, sample intervals for VPT well clusters MW-301 and MW-306 indicated low mass discharge and no mass discharge, respectively. There is likely no significant mass flux of sulfolane at the lateral edges of the plume at these locations. The Toolkit assumes a concentration boundary of zero at each end of the transect. Since no detections were reported in MW-306, the well cluster acts as a boundary and therefore was assigned values equal to zero rather than half of the detection limit. Nondetectable sulfolane concentrations in the 10-, 20-, 30-, and 40-foot intervals at MW-301 are considered half of the detection limit because estimated “J”-flagged concentrations are observed at deeper depth intervals.

4.6 Offsite Monitoring Well Sampling Results

During this reporting period, groundwater samples were collected from 89 offsite monitoring wells and submitted for sulfolane analysis. These data are presented in Table 4-7. Sulfolane data are plotted on Figures 4-13 through 4-16 to show the estimated extent of the dissolved-phase sulfolane plumes at the following depth intervals: water table, 10 to 55 feet below the water table, 55 to 90 feet below the water table, and 90 to 160 feet below the water table. Historical sulfolane analytical results are included as Appendix B.

4.6.1.1 Water Table

Sulfolane was detected above the ACL of 14 µg/L in groundwater samples collected from 15 monitoring wells screened at the water table, ranging from 15.8 µg/L (duplicate sample, MW-194A) to 224 µg/L (duplicate sample, MW-161A). Sulfolane concentrations detected in groundwater samples collected from the following wells were flagged by the laboratory as estimated, as described in Section 6: MW-167A, MW-185A, MW-187, MW-193A, MW-308-15, and MW-316-15. The estimated extent of the sulfolane plume is identified as an isopleth based on the ACL and is presented on Figure 4-13.

4.6.1.2 10 to 55 Feet Below the Water Table

Sulfolane was detected above the ACL of 14 µg/L in groundwater samples collected from 22 wells screened at 10 to 55 feet below the water table, with results ranging from 14.8 µg/L (MW-168B) to 276 µg/L (MW-161B). The sulfolane concentrations detected in the groundwater samples collected from wells MW-169C and MW-185B were flagged by the laboratory as estimated, as described in Section 6. The estimated extent of the sulfolane plume is identified as an isopleth based on the ACL and is presented on Figure 4-14.

4.6.1.3 55 to 90 Feet Below the Water Table

Sulfolane was detected above the ACL of 14 µg/L in the groundwater samples collected from two wells screened at 55 to 90 feet below the water table, with results of 70.6 µg/L (duplicate sample, MW-159C) and 82 µg/L (MW-160B). Sulfolane was not detected in the sample collected from well MW-170B. The estimated extent of the sulfolane plume is identified as an isopleth based on the ACL and is presented on Figure 4-15.

4.6.1.4 90 to 160 Feet Below the Water Table

Samples collected from 10 offsite monitoring wells screened at 90 to 160 feet below the water table were analyzed for sulfolane during the reporting period. Sulfolane was detected above the ACL of 14 µg/L in the groundwater sample collected from one well near Horseshoe Way (MW-332-150), at a concentration of 208 µg/L. Results are presented on Figure 4-16.

4.7 Private Well Sampling Results

As stated in Section 3.7, sampling of residential wells was conducted from November 11, 2009 through March 31, 2013. Since November 2009, groundwater samples have been collected from 581 private wells located within the search areas and analyzed for sulfolane. Samples collected through May 11, 2011 were analyzed for sulfolane using USEPA Method 8270D. Subsequent samples were analyzed using USEPA Method 1625 with isotope

dilution. Residential locations sampled for the first time during this reporting period were analyzed for sulfolane using USEPA Method 1625B with isotope dilution and are presented in Table 4-10.

The initial results from six private wells outside of search areas collected during the reporting period exhibited no detectable concentrations of sulfolane (Figure 3-1). The most recent data for each residential data point are shown on Figure 3-1 with color-gradation to indicate the concentration. In addition, more than 500 historical POE system maintenance data were merged into the residential sulfolane database to further develop the hydrogeologic conceptual site model and evaluate analytical trends. Historical POE data are included in the dataset shown on Figure 3-1. Additionally, location IDs are shown on Figure 3-2 for each private well including wells with POE treatment systems. Private well results are also included on appropriate sulfolane data figures as described below.

Of the private wells in search areas that were sampled for sulfolane, depth information was obtained for approximately 100 locations as reported in the SCR – 2011 (Barr 2012). Screen intervals for private wells were assumed to be relatively discrete and consistent with groundwater zones. Data from these wells are plotted on the appropriate monitoring zone maps with first quarter 2013 sulfolane data from the monitoring wells, as shown on Figures 4-14, 4-15, 4-16, and 4-19. Private well data shown on the figure were analyzed within the past year from April 1, 2012 to April 19, 2013, in order to include the full deep residential monitoring network in addition to data from POE treatment systems.

Figure 4-14 shows results for private and monitoring wells installed at 10 to 55 feet below the water table. The 14 µg/L isopleth extends north of the intersection of Badger Road and Peridot Street around a few wells with concentrations less than 14 µg/L, to capture a group of private wells with concentrations that exceed 14 µg/L.

Results for private and monitoring wells installed at 55 to 90 feet below the water table are shown on Figure 4-15. The sulfolane plume extends offsite at this depth. Sulfolane was reported in several private wells at this depth; most of these wells are located along Badger Road, north of Richardson Highway.

Results from wells installed at 90 to 160 feet below the water table are shown on Figure 4-16. Based on reported construction information, the private well samples with detectable sulfolane appear to be installed below permafrost.

Figure 4-19 shows the results for private wells installed at depths greater than 160 feet below the water table. The 14 µg/L isopleth extends north to the intersection of Badger Road and Peridot Street to capture private well sulfolane concentrations that exceed 14 µg/L. Based on reported construction information, wells installed at depths greater than 160 feet appear to be installed in the subpermafrost aquifer.

Historical private well data including historical POE treatment system data for raw water samples are presented in Appendix B. Copies of laboratory reports were provided to the well owners. Laboratory reports and ADEC data review checklists for residential samples collected during the reporting period are included in Appendices C and D, respectively. Laboratory reports and ADEC data review checklists for POE data through 2011 are provided in the SCR – 2011 (Barr 2012). Selected historical laboratory reports post- 2011 were reviewed for data quality and are described in Section 7. Selected historical POE laboratory reports and associated ADEC data review checklists are presented in Appendices C and D, respectively. Data were evaluated for potential sulfolane concentration trends and results are included in Appendix H. A limited number of split samples will be collected from deep residential monitoring well locations during the second quarter 2013 to confirm data comparability between Pace and SGS.

4.8 Deep Residential Monitoring Results

As stated in Section 3.8, groundwater samples were collected between March 11 and April 19, 2013 from 17 residential wells that were reported to have been installed below permafrost. Deep residential monitoring results are summarized in Table 4-11 and shown on Figure 4-20. Results are also included on Figure 3-1 and on appropriate sulfolane data figures described above. In addition to the residential water supply well at Location 0296, one garden well (Location 0297) installed to a depth of 24 feet bgs was sampled. Sulfolane was detected above the ACL of 14 µg/L in groundwater samples collected from 11 deep residential wells ranging from 23.1 µg/L (Location 0466) to 558 µg/L (Location 1230). Because the sulfolane concentration detected in the groundwater sample from Location 1230 was the maximum off-site concentration to date, a second sample (517 µg/L) and duplicate sample (497 µg/L) were collected to verify the result.

Sulfolane concentrations detected in groundwater samples collected from Locations 1296 and 0297 were flagged by the laboratory as estimated as described in Section 6. The sample collected from the well at Location 0332 was flagged as potentially biased because the sample location may have been collected downstream of the water softener at this sentinel well location outside the plume area. The sample results will be verified during the second quarter sampling event and the validation flag finalized, if applicable. These data will be included in the annual evaluation of sulfolane trends during the fourth quarter. Historical data are included in Appendix B. Laboratory reports and checklists are included in Appendices C and D, respectively.

4.9 Geochemical Parameters

As proposed in the RSCR (Barr 2012), geochemical parameter monitoring is performed semiannually during the second and fourth quarters to characterize the potential for natural

attenuation of sulfolane at the site. Geochemical parameter monitoring will resume during the next reporting period. Historical geochemical data are summarized in Appendix B.

4.10 Non-Routine Activities

Non-routine sample collection, including the March second sampling event, COPCs, air sparge (AS) pilot test monitoring, and site characterization activities are discussed in Sections 4.10.1 through 4.10.5.

4.10.1 First Quarter Second Sampling Event

As previously mentioned, FHRA conducted a second round of sampling during first quarter 2013 in selected wells from the water table, 10 to 55 feet below water table and 90 to 160 feet below water table monitoring zones, as requested by the ADEC. This sampling was requested to enhance the data set to facilitate trend analyses. Concentrations were generally consistent with samples collected during the first round of sampling. A side-by-side comparison of data from each round of sampling is summarized in Table 4-12 and presented on Figures 4-21 through 4-23. Data will be included in the annual evaluation for sulfolane trend during the fourth quarter. Laboratory reports and checklists are included in Appendices C and D, respectively.

4.10.2 Constituent of Potential Concern Analysis

COPC analysis was initiated during the third quarter 2011 reporting period and COPCs were evaluated in the SCR – 2011 (Barr 2012), which recommended discontinuation of the sampling for additional COPCs other than sulfolane and BTEX. However, per ADEC email correspondence dated July 20, 2012, continued analysis of iron was required. The SCR – 2011 (Barr 2012) recommended continued annual sampling of gasoline range organics, diesel range organics, and iron, to be conducted during the second quarter of the year. However, iron was inadvertently collected from three wells (MW-148A, MW-149A, and MW-153A) during the reporting period; data are summarized in Table 4-13. Concentrations of total iron were not detected above the USEPA Regional Screening Level of 11 milligrams per liter. Historical COPC data are summarized in Appendix B. Laboratory analytical reports are included in Appendix C.

4.10.3 Air Sparging Pilot Test

Based on peer-reviewed literature, monitoring results at the Gallery Pond, and bench-scale testing which indicated sulfolane removal associated with aeration, FHRA commenced an AS pilot test to evaluate if aeration will create conditions for sulfolane removal in-situ. A technical memorandum describing the pilot test startup, monitoring results and data evaluation was provided as an appendix to the Interim Remedial Action Plan Addendum

(IRAP Addendum; ARCADIS 2013e). A review of the data generated by the AS pilot test suggests that AS is an effective remediation strategy to enhance in-situ degradation of sulfolane in the impacted groundwater at the site.

Operation of the pilot test system was continued into the first quarter 2013, with two injection points (AS-5 and AS-7) along the south line (Figure 4-24) operating to evaluate the potential minimum air flow rate or DO concentration that is necessary to promote sulfolane removal. Only one monitoring event was completed during the reporting period and the results (Table 4-14) indicated that DO concentrations remained elevated and sulfolane degradation is still occurring with only two active injection points. Sulfolane concentrations were below detection limits at all of the monitoring locations, except for upgradient well AS-MW-8. Following the first quarter groundwater monitoring event, FHRA continued the pilot test with all injection points on the southern line operational. Operation of the AS pilot system will continue to facilitate sampling and analysis for potential degradation intermediates as requested by the sulfolane degradation sub-group and the University of Alaska Fairbanks (UAF). Upon completion of this sampling, the pilot system will be shut down and additional monitoring will be completed to measure potential rebound of sulfolane concentrations in the AS treatment zone. Results of this monitoring will be presented in future quarterly groundwater monitoring reports.

4.10.4 2013 Onsite Site Characterization Activities

Additional onsite site characterization activities were proposed in the 2013 Onsite SCWP (ARCADIS 2013b) and the IRAP Addendum (ARCADIS 2013e). The majority of proposed field activities are scheduled to be completed during the second and third quarters of 2013. Table 1-1 summarizes field activities conducted during this reporting period. The following field activities were conducted during the reporting period as part of the 2013 onsite site characterization activities:

- Installation of monitoring well MW-174-15 to replace decommissioned well MW-111 (Figure 2-3).
- Baildown testing on select wells during March to target local hydrogeologic cycle minima instead of a calendar-based schedule as described in Section 3.2.
- Additional LNAPL samples were collected for compositional analysis to improve the spatial understanding of the BTEX and sulfolane fractions of the LNAPL. Results are pending and will be reported under separate cover.
- Additional BTEX characterization in groundwater zones below the water table as described in Section 4.5.1.



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Additional data collected during the onsite site characterization activities will further refine the hydrogeological conceptual site model.

4.10.5 2013 Offsite Site Characterization Activities

Additional offsite site characterization activities were proposed in the 2013 Offsite SCWP (ARCADIS 2013c). The majority of proposed field activities are scheduled to be completed during the second and third quarters of 2013. Table 1-1 summarizes field activities conducted during this reporting period. Field activities that were conducted during the reporting period as part of the 2013 offsite site characterization activities include deep residential monitoring and the down-hole camera assessment described in Sections 3.8 and 4.8.

5. Remediation System Results and Evaluation

This section summarizes and evaluates the operating results for the existing onsite remediation system for the reporting period. This section also provides an update on implementation of the interim corrective actions described in the Interim Remedial Action Plan (IRAP; Barr 2010b) and the SCR – 2011 (Barr 2012). FHRA has also provided the ADEC with routine updates on IRAP implementation progress during the TPT and subgroup meetings.

Ongoing remediation efforts at the site include groundwater recovery and treatment and LNAPL recovery and recycling, as described in Sections 5.1, 5.2, and 5.3. The components of the remediation systems during the reporting period are described below:

- Groundwater recovery from five recovery wells (R-21, R-35R, R-39, R-40, and R-42) (Figure 5-1).
- Recovered groundwater is treated through a prefilter for solids removal, a coalescer for LNAPL removal, and four air strippers for removal of volatile organic compounds (VOCs) before accumulating in the Gallery Pond. The groundwater from the Gallery Pond is then pumped through sand filters for solids removal and a four-vessel granular activated carbon (GAC) system for sulfolane removal. The layout of the groundwater recovery and treatment system is shown on Figure 5-1 and a process flow diagram of the system is shown on Figure 5-2.
- Pneumatic LNAPL recovery systems are operated continuously when recoverable LNAPL is present at MW-138, R-20R, R-21, R-35R, R-40, and S-50. Additional pneumatic LNAPL recovery systems are operated seasonally at R-32 and R-33. The LNAPL recovery system installed at O-2 was removed due to low LNAPL recovery and was installed at S-50 during the reporting period. FHRA also uses a hand-held product recovery pump or vacuum truck at other locations (e.g., R-39) if LNAPL is present and recovery is possible.

5.1 Groundwater Recovery

The objective of the recovery well system operation is to provide capture of the shallow dissolved-phase plume, and enhance LNAPL recovery. Implementation of the corrective actions described in the IRAP (Barr 2010b) included installation of one additional recovery well (R-42). Operation of the groundwater pump and treat system currently involves groundwater recovery from five recovery wells (R-21, R-35R, R-39, R-40, and R-42), as shown on Figure 5-1. Recovery well R-42 began operation on July 26, 2011 upon issuance of an amended temporary water use permit (TWUP [A2011-48]) from the DNR. An additional amendment to TWUP A2011-48 was received on October 3, 2012, which allows



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increased groundwater withdrawal volume plus withdrawal from proposed additional recovery wells.

Recovered groundwater is treated onsite prior to discharge at the South Gravel Pit in accordance with wastewater disposal permit 2005-DB0012 issued by the ADEC. The treatment system operation and performance is further discussed in Section 5.1.2.

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

- 2009: 69,200,000 gallons
- 2010: 107,100,000 gallons
- 2011: 136,900,000 gallons
- 2012: 188,300,000 gallons
- 2013: 44,441,828 gallons (through the first quarter)

The groundwater recovery total measured at the final effluent is slightly less than the sum of the total recovery measured at the individual recovery wells, which is likely the result of evaporation across the air strippers and Gallery Pond.

As shown in the groundwater recovery totals above and in Table 5-1, FHRA has continued to optimize the existing remediation system to increase capture of the shallow dissolved-phase plume onsite. An evaluation of system modifications to increase the capacity of the groundwater recovery and treatment systems is included in the Draft Final Onsite Feasibility Study (ARCADIS 2012a), and the installation of additional recovery wells is described in the IRAP Addendum (ARCADIS 2013e) and in Section 5.2.

Pumping rates for the individual recovery wells are measured weekly. The average for the reporting period for each well are shown in the tables below. These tables also present the total and percent run times for the reporting period. As shown below, each recovery well maintained high run times during the reporting period.

Location	First Quarter 2013 Average Flow Rate	First Quarter 2013 Runtime	Percent Runtime
R-21	50 gpm	2,116 hours	98.0%
R-35R	84 gpm	2,104.5 hours	97.4%
R-39	86 gpm	2,075 hours	96.1%
R-40	50 gpm	2,075 hours	96.1%
R-42	114 gpm	2,090.5 hours	96.8%

Note:

gpm = gallons per minute

As discussed in the SCR – 2011 (Barr 2012), if the LNAPL recovery system is not operating efficiently, some LNAPL may be inadvertently entrained into the groundwater recovery system and removed by a coalescer prior to flow through the air strippers. During periods of excessive LNAPL entrainment in 2011, an increase in the dissolved-phase hydrocarbon concentrations was measured in the air stripper effluent. As a result, FHRA continued operation of the recovery system at a reduced pumping rate at R-21 and R-40 during the reporting period to reduce the amount of LNAPL entrained into the groundwater recovery system.

As proposed in the IRAP Addendum (ARCADIS 2013e), FHRA installed four additional recovery wells (R-43, R-44, R-45, and R-46) to replace R-39 and R-40, and to augment recovery in the R-21 area. Installation of the wellhouses, electrical supply, and discharge piping was ongoing during the reporting period. FHRA anticipates completion of the project in May 2013; startup information will be provided in the second quarter groundwater monitoring report. Two of the new recovery wells have a greater total depth and all four of the new recovery wells have greater diameters than the existing recovery wells, which will allow a higher groundwater recovery rate while conducting LNAPL-only recovery with a skimmer system. The goal of the upgrades is to optimize groundwater capture using the full capacity of the treatment system. The locations of the new recovery wells are shown on Figure 5-1.

5.1.1 Groundwater Capture Evaluation

As proposed in the IRAP Addendum (ARCADIS 2013e), performance monitoring was conducted to confirm the continued effectiveness of the groundwater extraction system. Hydraulic and contaminant capture of the sulfolane and BTEX plumes were assessed using fluid level and groundwater quality data.

5.1.1.1 Hydraulic Capture

As discussed in the SCR – 2011 (Barr 2012), a recovery well pumping test was performed to evaluate the horizontal and vertical capture of the groundwater recovery system and to provide information for updating the groundwater flow model. Using the pumping test information, FHRA completed capture zone modeling of the groundwater recovery system; results are presented in the SCR – 2011 (Barr 2012) and the North Pole Refinery Groundwater Model Report (Geomega, 2013).

A site-wide groundwater elevation monitoring event is completed quarterly to evaluate the groundwater elevation. For this report, groundwater elevations were plotted and contoured, with an apparent depression in the potentiometric surface indicated in the area of the groundwater recovery wells (Figure 4-1). The total flow from the groundwater recovery system averaged 412 gpm during this event (full capacity is estimated at approximately 460

to 480 gpm for the current system). Groundwater recovery rates during 2013 were maintained below full capacity to prevent excessive LNAPL capture by the groundwater recovery system and to minimize LNAPL loading to the air strippers; however, groundwater recovery at full capacity of the treatment system is anticipated following startup and testing of the new recovery wells.

As previously noted, FHRA is proceeding with installation and start-up of four new recovery wells. FHRA will start operation of the wells during the second quarter, with an initial shake-down period to verify that all recovery wells are producing sand-free water and that the treatment system is working properly at the increased flow rate. Upon completion of the initial shake-down, FHRA will complete an aquifer test. A work plan for the aquifer test was provided to ADEC on April 19, 2013 (Barr 2013). The ADEC issued comments to the work plan on May 22, 2013. FHRA provided partial comment responses via e-mail on May 24 and May 29, 2013 to facilitate coordination and execution of the testing which was initiated on May 28, 2013.

Upon completion of the aquifer test, a technical memorandum will be submitted that describes any updates to the groundwater model (if necessary), compares model inputs and predicted and actual water levels and drawdowns prior to and after any updates to the model, and presents the hydraulic capture zone evaluation for the modified recovery system. Recommendations for O&M of the recovery system will be provided based on evaluation of data collected during the shake-down period and start-up aquifer testing.

5.1.1.2 Contaminant Capture

A statistical trend analysis of groundwater analytical data to evaluate plume migration and stability was included in the Fourth Quarter 2012 Groundwater Monitoring Report (ARCADIS 2013d). Trend analysis of the groundwater data is another line of evidence used to evaluate the effectiveness of the groundwater recovery system. With implementation of the IRAP (Barr 2010b) improvements in January 2010, FHRA began to increase the overall groundwater recovery rate (Table 5-1). Groundwater recovery rates further increased in July 2011, following the installation of R-42.

As described in the IRAP Addendum (ARCADIS 2013e), FHRA is continuing to monitor trends in sulfolane and BTEX concentrations to evaluate performance of the groundwater extraction system. To evaluate the results, select monitoring locations have been categorized as upgradient (O-6, O-19, MW-130, S-43), within the treatment zone (O-2, MW-113, MW-125, MW-186 A/B/E, MW-334-15/65), and downgradient (MW-127, MW-129, MW-139, MW-142, MW-154A/B, MW-309-15/66, O-3, O-4, O-12, O-24, O-26). All monitoring wells selected for evaluation are located upgradient from the VPT; monitoring results for the VPT are discussed in Section 4.5.2.5. Results are summarized below for each designated location.

5.1.1.2.1 Upgradient from the Treatment Zone

As shown in Appendix I, sulfolane and BTEX concentrations detected in samples collected from wells upgradient from the groundwater extraction system treatment zone (O-6, O-19, MW-130, S-43) are generally declining. These results are likely minimally influenced by operation of the groundwater extraction system, but rather are more likely the result of decreased upgradient source material.

Sulfolane results for upgradient wells are discussed below:

- Wells S-43 and O-19 (both screened across the water table) were recently added to the monitoring program and only one sampling event has been completed; thus, trends at these locations will be discussed after collection of sufficient data in future reports.
- The results at well O-6 (screened across the water table) have indicated a declining trend since the initial monitoring event in the fourth quarter 2011.
- The results at well MW-130 (screened 19 to 23 feet bgs) have fluctuated since the initial monitoring event in 2011.

BTEX results for upgradient wells are discussed below

- Well O-6 is outside the BTEX plume and exhibits no detectable concentrations.
- Well MW-130 has historically exhibited elevated BTEX concentrations; however, data show a steady decrease since installation with only low-level detections during the most recent monitoring event.
- Wells O-19 and S-43 have been added to the semi-annual BTEX monitoring program and future results will be evaluated as data are received.

5.1.1.2.2 Within the Treatment Zone

As shown in Appendix I, sulfolane and BTEX concentrations detected in samples collected from wells within the treatment zone (O-2, MW-113, MW-125, MW-186 A/B/E, MW-334-15/65) have exhibited a general declining trend. One exception occurred at well MW-113 which may be due to initiating extraction from well R-42, which increased the transport of contaminants to the R-42 area for capture.

Sulfolane results for wells within the treatment zone are discussed below:

- Well O-2 (screened across the water table) was recently added to the sulfolane monitoring program and only one sampling event has been completed; thus, trends will be discussed in future reports.
- At well MW-113 (screened 11.5 to 15 feet bgs), an increasing trend was observed in 2012. These results may be due to operation of extraction well R-42, which increased the transport of contaminants to the R-42 area for capture. Following the initial increase observed with operation of well R-42, a decrease in the sulfolane concentration was measured during the fourth quarter 2012 and this reporting period.
- The results at well MW-125 (screened 19.5 to 24 feet bgs) indicate a declining trend, with the results below detection limits since the first quarter 2012.
- A declining trend has been observed at well MW-186A (screened across the water table) since installation. The results at well MW-186B (screened 50 to 60 feet bgs) and well MW-186E (screened 70 to 75 feet bgs) have been generally stable since installation.
- A declining trend has been observed at well MW-334-15 (screened across the water table) since the initial monitoring event in the third quarter 2012. The results at well MW-334-65 (screened 60 to 65 feet bgs) have indicated estimated “J”-flagged detections below the LOQ since the initial monitoring event in the third quarter 2012.

BTEX results for wells within the treatment zone are discussed below:

- Wells MW-113, MW-186B, and MW-334-65 currently exhibit no detectable BTEX concentrations, which indicate that the wells are located outside of the BTEX plume.
- Well MW-125 has exhibited elevated BTEX concentrations historically, but these concentrations have decreased steadily over time.
- Well MW-334-15 is within the BTEX plume. This well has been sampled twice and future monitoring results will be used to evaluate trends.
- Wells O-2 and MW-186A have been added to the semi-annual BTEX monitoring program and future results will be evaluated as data are received.

5.1.1.2.3 Downgradient from the Treatment Zone

As shown in Appendix I, sulfolane and BTEX concentrations detected in samples collected from monitoring wells downgradient of the treatment zone (MW-127, MW-129, MW-139, MW-142, MW-154A/B, MW-309-15/66, O-3, O-4, O-12, O-24, O-26) generally exhibit a declining trend. Except for new monitoring wells in which trends have not been established, decreasing trends are also observed in wells exhibiting detectable BTEX concentrations.

Sulfolane results for wells downgradient from the treatment zone are discussed below:

- Consistent declining trends have been observed at well MW-127 (screened 20 to 25 feet bgs), well MW-139 (screened across the water table), well MW-142 (screened across the water table), well O-12 (screened across the water table), and well O-26 (screened across the water table). Although seasonal fluctuations have been observed at some locations, measured peak concentrations have decreased each year.
- Concentrations in samples collected from well MW-129 (screened 37 to 41.5 feet bgs) have been below detection limits during each monitoring event. This well is located outside the sulfolane plume area.
- A declining trend has been observed at wells MW-154A (screened 71 to 75 feet bgs) and MW-309-66 (screened 59 to 64 feet bgs).
- The sulfolane concentrations measured at well MW-309-15 (screened across the water table) have been stable. Well MW-309-15 has been monitored four times; future monitoring results will be used to further evaluate trends.
- The sulfolane concentrations measured at wells O-3 and O-24 (both screened across the water table) have exhibited concentrations near or below the limit of quantitation (LOQ).
- Concentrations increased in samples collected from well MW-154B (screened 90 to 95 feet bgs) during the first three monitoring events of 2012, then decreased during the last two events (fourth quarter 2012 and first quarter 2013). This monitoring well nest is located directly downgradient from new recovery well R-43, thus future monitoring results will be used to further evaluate trends and the effect of well R-43.
- Concentrations increased in samples collected from well O-4 (screened across the water table) during each of its three sampling events (fourth quarter 2011, fourth quarter 2012, and first quarter 2013). This monitoring well is near the location of new recovery well R-43, thus future monitoring results will be used to further evaluate trends and the effect of R-43.

BTEX results for wells downgradient from the treatment zone are discussed below:

- BTEX concentrations were below detection limits in samples collected from wells MW-127, MW-129, MW-142, MW-154A, MW-154B, O-4, O-12, and O-24.
- BTEX concentrations have historically been detected in the sample collected from well MW-139. BTEX concentrations have decreased over the past four monitoring events. This well is the furthest downgradient monitoring location with detectable BTEX concentrations. MW-142 is approximately 175 feet downgradient from this location and has non-detectable BTEX concentrations.
- Wells O-3 and O-26 have only been sampled once and exhibited detectable concentrations of BTEX constituents. Future monitoring results will be used to evaluate trends.

To further evaluate the effectiveness of the groundwater recovery system, Figures 5-3, 5-4, 5-5, and 5-6 provide concentration trends for monitoring wells in longitudinal transects (as shown on Figure 5-3) parallel with the groundwater flow path. Transects A and B (Figures 5-4 and 5-5) show shallow wells and Transect C (Figure 5-6) shows deeper wells. Monitoring wells are noted on the figures based on the location relative to the groundwater recovery system (upgradient, within the treatment zone, or downgradient). Also shown are the pumping rates of the groundwater extraction system to demonstrate the effects of increased groundwater recovery in 2010 and 2011.

Based on Figures 5-4 and 5-5, the decreasing concentration trends in the downgradient wells and the relatively low concentrations compared to upgradient results, indicate the ongoing groundwater extraction is successfully recovering a substantial volume of sulfolane impacted groundwater and is reducing concentrations in downgradient wells. The results at the deeper wells (Figure 5-6) suggest that the current recovery system is not influencing the deeper zone as effectively as the shallow zone; however, sulfolane concentrations in the deeper zone near the recovery system are substantially less than the shallower groundwater, and the proposed deeper recovery wells will result in increased capture of the lower sulfolane concentrations found at depth. Future analytical data will be evaluated to monitor the effects of the new recovery wells.

5.1.2 Mass Recovery

Table 5-2 summarizes the sulfolane mass recovery during sampling events conducted during 2012 and the reporting period. The sampling results include routine monthly sampling plus additional sampling completed as part of the IRAP (Barr 2010b) performance monitoring. This additional performance monitoring continued through the second quarter 2012; during the third quarter 2012, a monthly monitoring schedule resumed in accordance

with the wastewater disposal permit and continued through the reporting period. During the reporting period, the sulfolane mass recovery averaged 0.37 lb/day. However, the mass recovery was lower during the March sampling event due to a brief downtime period at R-21 (which has the highest sulfolane concentration of the recovery wells) that coincided with the sampling event.

FHRA also measured the sulfolane concentration in the recovered groundwater at each active recovery well on a monthly basis; mass recovery rates are shown in Tables 5-3a through 5-3e. During the reporting period, the highest mass recovery rate was measured at R-21 (0.19 lb/day), while R-39 had no measured recovery of sulfolane. As previously mentioned, FHRA is in the processing of installing additional recovery wells near R-21 to allow increased groundwater recovery in the area with the highest measured sulfolane concentration. Although R-39 is outside the sulfolane plume, operation is ongoing to maintain capture of the BTEX plume in this area.

5.2 Light Nonaqueous Phase Liquid Recovery

During the reporting period, FHRA performed LNAPL recovery using skimmer systems at MW-138, R-20R, R-21, R-35R, and R-40 (Figure 5-1). Additional systems are operated seasonally at R-32 and R-33 and were not operated during the reporting period. The LNAPL recovery system previously installed at O-2 was removed due to low LNAPL recovery and was installed at S-50 during the reporting period. However, the LNAPL pump encountered maintenance problems once installed in S-50 and limited LNAPL recovery was achieved at this location in the reporting period. Manual product recovery was completed during the reporting period with a vacuum truck, portable product pump, or during baildown testing at MW-176A, MW-334-15, O-10, O-11, O-27, R-14A, R-18, R-32, S-22, S-44, S-50 and S-51. The recovered LNAPL from the skimmer systems and manual recovery activities is recycled within a refinery process unit.

LNAPL recovery during the reporting period is summarized in Table 5-4. During this period, 102 gallons of LNAPL were recovered. The majority of the LNAPL recovered during the reporting period was from recovery wells R-21, R-32, and R-40. It is anticipated that the installation of the four proposed additional recovery wells will increase the potential for LNAPL capture. As mentioned in Section 4.4, based on the higher transmissivity measured and potential for increased LNAPL recovery, increased manual product recovery activities are planned for wells O-10 and O-27.

Table 5-5 summarizes LNAPL recovery at the site since 1986. From 1986 to present, approximately 393,980 gallons of LNAPL have been recovered.

5.3 Groundwater Treatment Evaluation

As noted in Section 5.1, FHRA operates groundwater recovery wells to provide capture of shallow dissolved-phase contaminants. The recovered groundwater is pumped to an onsite groundwater treatment system, which is operated to remove LNAPL and dissolved-phase contaminants. The recovered groundwater passes through a prefilter for solids removal, a coalescer for LNAPL removal, and a series of air strippers for removal of VOCs before accumulating in the Gallery Pond. The groundwater from the Gallery Pond is then pumped through sand filters and a four-vessel GAC system, which were added as part of the IRAP implementation. The sand filters were added to remove suspended solids and GAC vessels were added to remove organic compounds, including sulfolane. The treated groundwater is discharged to the South Gravel Pit in accordance with wastewater disposal permit 2005-DB0012, issued by the ADEC. A process flow diagram of the groundwater recovery and treatment system, including the sand filter and GAC vessels, is provided on Figure 5-2.

Since operation of the sand filters and the GAC filter system began on June 9, 2011, additional monitoring has been conducted to evaluate the effectiveness of the sand filters and the GAC filter system following startup. The ADEC approved a -four-month monitoring period (expired September 30, 2011) to evaluate performance of the GAC filter system prior to establishing a discharge limit for sulfolane. At the conclusion of this period, FHRA requested an extension of the monitoring period to continue evaluation of GAC filter system performance. The ADEC extended the monitoring period until the new permit is issued (Smyth 2011).

In accordance with the wastewater disposal permit, FHRA conducted monthly monitoring during the reporting period; results for the reporting period are summarized in Table 5-6. Analytical laboratory reports are provided in Appendix C.

Low-level concentrations of BTEX constituents were detected in samples collected at the air stripper effluent (prior to discharge to the Gallery Pond) during the reporting period. However, the final system effluent analytical results for each monitoring event indicated that residual contaminants were removed by the GAC vessels to below the discharge limits (Table 5-6). During the February monitoring event, concentrations below the LOQ were reported at the final effluent for benzene, ethylbenzene, and total xylenes. Because the Vessel A results were below detection limits for all analytes, it is unclear why the low-level concentrations were detected at the final effluent. As confirmed by the March sampling results, there are no other indications of breakthrough for the GAC system. Additionally, the results were well below the wastewater discharge permit limit of 10 µg/L for total aromatic hydrocarbons.

As shown in Table 5-6, the sulfolane concentration in the final effluent has been below the LOD during every monitoring event, showing effective removal of sulfolane from the

recovered groundwater. During the reporting period, Vessel A was the lead vessel followed by Vessel B in series, which was followed by Vessels C and D in parallel.

5.4 Summary of Non-Routine Repairs, Changes, and Maintenance

The overall groundwater recovery system maintained a runtime of 99.3 percent during the reporting period, with downtime for replacement of a valve within the treatment system. Minimal downtime occurred at the individual recovery wells during the reporting period as described below:

- *January 3, 2013.* All recovery wells were down for 14.5 hours for a valve replacement.
- *February 7, 2013.* Recovery well R-42 was down for 1.75 hours for a flow meter replacement.
- *February 12, 2013.* Recovery well R-42 was down for 24 hours to connect piping for new recovery well R-43.
- *February 24, 2013.* Recovery wells R-21, R-39, R-40, and R-42 were down for 2 hours to address plugging at the sand filter.
- *March 11, 2013.* Recovery wells R-21, R-39, R-40, and R-42 were down for 27.5 hours to perform electrical maintenance.
- *March 27, 2013.* Recovery wells R-35R, R-39, and R-40 were down for 41 hours to connect piping for R-44 and R-45.

6. Analytical Quality Assurance and Quality Control

Quality assurance (QA)/quality control (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 C and D. SWI conducted QA/QC reviews of the data for this reporting period. Data quality flags applied to the analytical results are summarized in Table 6-1.

In email correspondence dated March 20, 2012, the ADEC reduced the requirement for continued submittal of Level IV data packages. Level IV data packages are required for 10 percent of the residential well samples. Level IV data packages and third-party review will continue to be required for monitoring well data if an interference is noted in a groundwater sample from a new well or is identified in an existing well, where no interference was previously identified. One level IV data package for sulfolane was required for monitoring well data (MW-304-CMT-60) during the reporting period; results are summarized in Section 6.5. Level IV laboratory reports are required for 10 percent of residential well data and are included in Appendix C. The level IV validation report prepared by Environmental Standards, Inc. (ESI) for the reporting period is included in Appendix J.

6.1 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 for analysis of sulfolane and BTEX for select monitoring wells.

Residential water well sulfolane samples and deep residential well samples collected during the reporting period were reviewed. Deep residential well sampling extended into April, but is included in this report. ADEC data review checklists are included in Appendix D. The SGS work orders (WOs) reviewed for the reporting period are listed in the table below.

Groundwater Monitoring Sample WO List							
1137505	1137507	1137508	1137513	1137514	1137519	1137522	1137527
1137528	1137534	1137533	1137535_rev2	1137536	1137543	1137550	1137552
1137556	1137557	1137558	1137573	1137572	1137580	1137602	1137596

The SGS WOs reviewed for ADEC-requested first quarter second sampling event in March 2013 for select wells are listed in the table below.

ADEC Second Sample WO List				
1137571	1137575	1137579	7737581	1137628

The SGS WOs reviewed for the initial residential groundwater samples are listed in the table below.

Initial Residential Water Well Sample WO List				
1137537	1137538	1137549	1137569	1137574
1137611				

The SGS WOs reviewed for the deep residential water well samples are listed in the table below.

Initial Residential Water Well Sample WO List				
1137589	1137590	1137601	1137600	1137603
1137608	1137609	1137610	1137621	1137622
1137627	1137618	1137639	1137638	1137657
1137656	1137678	1137683		

Results of the QA/QC analysis are discussed below.

6.2 Sample Handling

Samples were generally hand delivered to the SGS (Fairbanks, Alaska) receiving office 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 COC 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 indicated on the ADEC data review checklist (2 ± 4 degrees Celsius [$^{\circ}\text{C}$]). The ADEC data review checklist (Appendix D) contains details regarding this review. The ADEC considers temperatures received between 0 and 6 $^{\circ}\text{C}$ acceptable in the absence of ice, as specified by USEPA Method SW-846. Therefore, for this report, temperatures between 0 and 6 $^{\circ}\text{C}$ are considered acceptable.

Samples were received within the acceptable temperature range upon arrival at each SGS location during the reporting period. Samples were received properly preserved and in good condition.

For one deep residential sample (deep residential monitoring Location 332), the results indicate that the sample may have been collected downstream of the POE water treatment system (softener). Results were flagged as “J” and are pending further evaluation. The sample location will be examined during the second quarter sampling event and the flag finalized, if applicable.

COC records for each WO were also reviewed to confirm that information was complete, custody was not breached, and samples were analyzed within the acceptable hold time. COC records were complete and correct, with the following exceptions (Table 6-1):

- *WO 1137514.* Samples MW-138 and MW-176A were re-extracted outside of hold time due to sulfolane concentrations above the calibration limits in the first extraction. The results are considered estimated, biased low, and flagged as “JL.”
- *WO 1137519.* Sample MW-301-70 was re-extracted outside of hold time due to a laboratory error. The laboratory spiked the original sample with twice the normal amount of surrogates. Compared to historical data, this result is similar to other results and the re-extracted result was flagged as “JL” (biased low). For sample O-1, the laboratory had to re-extract outside of hold time because sulfolane concentrations were above the calibration limits in the first extraction. The data was flagged as “JL” (biased low) for hold time exceedance.
- *WO 1137533.* Sample MW-166B arrived at the laboratory with no label intact. After using the process of elimination and getting approval from SWI, the laboratory added the sample label. This discrepancy does not affect data quality or usability.
- *WO 1137535_rev2.* Sample MW-434-15 was labeled MW-434-65 upon receipt at the laboratory. After approval from SWI, the laboratory corrected the sample name. This does not affect data quality or usability.
- *WO 1137536.* Sample MW-323-61 was labeled MW-323-50 upon receipt at the laboratory. After approval from SWI, the laboratory corrected the sample name. This does not affect data quality or usability.
- *WO 1137557.* The times for samples MW-170A and MW-170C were listed wrong on the COC. The laboratory corrected the sample times on the COC after approval from SWI.

- *WO 1137603, 1137621, and 1137657 (deep residential)*. Nitrate and nitrite were analyzed outside of hold time. The results for these analytes are considered estimated and flagged “J.” No bias is imparted because nitrate is calculated based on the nitrite result; reduction in one concentration causes an increase in the other.

Sample ID changes for residential samples collected during the reporting period are addressed in the ADEC data review checklists (Appendix D). To maintain privacy, the homeowner names are not disclosed in this report. No other sample handling anomalies were identified during the reporting period that would adversely affect data quality.

6.3 Analytical Sensitivity

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

Laboratory method blanks (MBs) 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 analysis to verify that cross-contamination did not occur during sample handling and transport. Equipment blanks were collected to assess the possibility of cross-contamination from sampling equipment. There were no method blank (MB), trip blank, or equipment blank detections affecting data quality for the reporting period, with the following exceptions (Table 6-1):

- *WO 1137535_rev2*. Toluene was detected in the trip blank at a concentration of 0.380J µg/L. In all project samples in this WO, except for MW-154B, toluene was either not detected or was detected at a concentration of more than five times the amount found in the trip blank. In sample MW-154B, toluene was detected at a concentration within five times the amount found in the trip blank and the detection should be considered attributed to field- or cross-contamination and is flagged “UB” (estimated non-detect) at the LOQ.
- *WOs 1137589, 1137590, 1137608, 1137609, 1137657, 1137627, 1137622, and 1137610*. Either nitrate or nitrite was detected in the MB between the LOQ and detection limit (DL). All samples in these WOs were non-detects; therefore, the results are unaffected.
- *WOs 1137656, 1137657, 1137627, and 1137622*. Total organic carbon (TOC) was detected in the MB between the LOQ and DL. All sample results were greater than five times the amount found in the MB and are not affected.
- *WO 1137603*. Nitrate, nitrite, and total nitrate/nitrite were detected in the MB between the LOQ and DL. Nitrate was within five times the amount found in the MB and is

flagged “UB” at the LOQ. Nitrite was not affected by this detection because sample results were above five times the amount found in the MB, but is flagged “J” for a hold time exceedance, as discussed above.

- *WO 1137621.* Ammonia, TOC, nitrate, and total nitrate/nitrite were detected in the MB between the LOQ and DL. The sample results for ammonia were within five times the amount found in the MB and are flagged “UB” at the LOQ. Sample results for nitrate were also within five times the amount found in the MB and are also flagged “UB” at the LOQ. Sample results for TOC were above five times the amount found in the MB and are not affected.
- *WO 1137622.* Along with TOC and nitrite detection in the MB (which are discussed earlier), ammonia was also detected in the MB. The sample results were within five times the amount found in the MB and are flagged “UB” at the reported concentration.

6.4 Accuracy

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

The laboratory did not report CCV or initial calibration verification failures for samples obtained during the reporting period. All LCS/LCSD and MS/MSD results were reviewed from preparatory batches associated with project samples. LCS and LCSD recoveries were within laboratory control limits for each preparatory batch. The MS/MSD recoveries were within acceptable limits, with the following exceptions (Table 6-1):

- *WOs 1137609 and 1137610.* MS recovery failures for ammonia occurred in these WOs. The MS samples were not part of FHRA’s project sample set, and therefore do not affect data. LCS and LCSD are used to measure accuracy for this analyte.
- *WOs 1137627, 1137657, 1137656, and 1137637.* MS recovery failures for sulfate occurred in these WOs. The MS samples were not part of FHRA’s project sample set, and therefore do not affect data. LCS and LCSD are used to measure accuracy for this analyte.

Recovery of analyte surrogates and the sulfolane internal standard were within laboratory control limits, with the following exceptions:

- *WO 1137535_rev2*. In sample MW-330-150, nitrobenzene-d5 and internal standard sulfolane-d8 were recovered outside QC criteria. The ADEC chemistry subgroup met on February 18, 2013 and agreed that nitrobenzene-d5 is used for historic-comparison purposes only; recovery failures for this surrogate are not considered to affect sulfolane results. However, the sulfolane-d8 recovery failure affects the data and the results are considered estimated (not detected) were flagged “UJ” at the LOD.
- *WOs 1137552, 1137556, and 1137557*. Internal standard sulfolane-d8 was recovered outside control limits for one or more QC samples (MB, LCS, LCSD) for these WOs. Because internal standard recoveries for the associated project samples were within laboratory control limits, no sample results are considered affected.
- *WO 1137558*. Nitrobenzene-d5 was recovered below laboratory control limits in sample MW-172A. Because this surrogate is used for informational purposes only, it does not affect data quality or usability.

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

The laboratory case narrative noted the following ion ratio errors:

- *WO 1137534*. The laboratory noted that qualifier ions were outside QC criteria for sample MW-304-CMT-60. A Level IV data deliverable was requested and ESI evaluated whether the potential interference affected sulfolane results for these samples. The laboratory flagged the results “J” as estimated because the results were below the LOQ. Therefore ESI concluded that no further qualification of data was required due to this issue, as summarized in the First Quarter 2012 Analysis of Sulfolane in Monitoring Well Samples Validation Report 1, included in Appendix J.

6.5 Precision

Duplicate samples were collected at a frequency of at least 10 percent of the overall number of samples collected 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 can be evaluated only if the results of the analyses for both duplicates are above the LOQ.

During the reporting period, the following duplicate samples were collected:

- Three duplicates for BTEX samples from monitoring wells (15 samples total)
- Twenty-six duplicates for sulfolane samples from monitoring wells (214 samples total)
- One duplicate for residential water well samples (six samples total)
- Three duplicates for deep residential water well samples (19 samples total)

The collection frequency for sulfolane sample duplicates was approximately 12 percent of the total samples collected. Results of RPD calculations for these duplicate samples were within the data quality objective of 30 percent, where calculable, with the following exceptions (Table 6-1):

- *WO 1137535_rev2*. Field duplicate samples MW-137 and MW-237 had an RPD of 38 percent for benzene. Both sample and duplicate are considered estimated and flagged “J.”
- *WO 1137601 (deep residential)*. The field duplicates had an RPD of 152 percent for methane. Both sample and duplicate are considered estimated and flagged “J.”

Laboratory analytical precision can also be evaluated by laboratory QC sample RPD calculations using the LCS/LCSD and MS/MSD, or laboratory duplicate sample results. The results of RPD calculations for LCS/LCSD, MS/MSD, and laboratory duplicate sample pairs were within the laboratory’s acceptable range, as summarized below:

- For all deep residential WOs, there were no laboratory duplicates for metals analysis. Field-duplicate RPDs were used to evaluate overall precision for metals results.
- *WOs 1137589, 1137590, and 1137657*. There were no laboratory duplicates for nitrate/nitrite. Field-duplicate RPDs were used to evaluate overall precision for metals results.

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

6.6 Data Quality Summary

Based on the methods outlined in the project SAP (ARCADIS 2013d), 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



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not appear to have been compromised by analytical irregularities and results affected by QC anomalies are qualified with the appropriate data flags.

7. Point-of-Entry Data Quality Summary

During the reporting period, the analytical database was modified to accept and report data for private well samples analyzed by Pace. Pace provided electronic data deliverable (EDD) files for sulfolane samples collected from homes with POE treatment systems; EDDs were received for 155 POE locations and one replacement POE location.

Sulfolane results for influent or raw water samples collected during the initial pilot testing of the POE treatment systems were imported into the analytical database. In addition, influent water samples for 531 EDDs with sulfolane results from samples collected during installation and routine maintenance events (post-pilot) were added to the database. Pace EDDs will continue to be imported to the database as they are received. As a precaution, samples collected post-pilot through the current reporting period are considered estimated (“J”-flagged) because duplicate samples had not been collected; “J” flags have been imported into the database. A SAP for POE maintenance sampling is in progress. This SAP will detail appropriate QA/QC sampling going forward, so future results will not require the “estimated” flag.

An analytical data review was previously conducted for the laboratory packets issued during the initial pilot testing and for 126 post-pilot EDDs. Data review checklists were reviewed and data flags were imported to the analytical database, where applicable. Laboratory packets and associated data review checklists for the previously reviewed results were presented to the ADEC in the SCR – 2011 (Barr 2012). Section 7.1 describes the procedures used to review the remaining data packages.

7.1 Analytical Quality Assurance and Quality Control

As of April 15, 2013, 512 post-pilot laboratory data packages were received. Of the 512 data packages, 126 were previously reviewed for data quality. The database was used to select laboratory packets for data quality review from the remaining 386 laboratory packets. A database searched targeted data tagged with internal standard (sulfolane-d8), surrogate, LCS, LCSD, MS, and MSD recovery failures and MB detections. Seventy six laboratory packets (approximately 20 percent) had QC failures and were selected for data review.

Data review was conducted for 76 laboratory packets with QC issues noted above. In addition, data review was conducted on 19 laboratory packets received after April 15, 2013. The QA review procedures allow documentation of the accuracy and precision of the analytical data, and check that the analyses were sufficiently sensitive to detect analytes at levels below suggested action levels or regulatory standards.

Pace laboratory packets and associated data review checklists where data review was conducted are presented in Appendices C and D, respectively. Results of QA review are

summarized below. The ADEC data review checklists contain additional details regarding the QA review. Data quality flags applied to the sulfolane results are summarized in Table 7-1.

7.2 Sample Handling

Samples were shipped to the Pace laboratory in Minnesota to perform sulfolane analysis using the ADEC-approved method. Forms documenting the sample conditions upon receipt, case narratives, and COCs were reviewed. Samples were received in good condition and within the acceptable temperature indicated on the ADEC data review checklist (2 ± 4 °C). The ADEC chemist considers samples received at temperatures between 0 and 6 °C acceptable in the absence of ice, as specified in USEPA publication SW-846. Therefore, for the purposes of this review, temperatures between 0 and 6 °C are considered acceptable. Sample handling was not verified for laboratory packets not selected for data review.

Samples were received within the acceptable temperature range upon arrival at the laboratory and were properly preserved and in good condition, with the few exceptions noted in Table 7-1.

COC records were reviewed for each reviewed WO to confirm that information was complete, custody was not breached, and samples were analyzed within the acceptable holding times. It was also confirmed that the laboratory used the correct sample identification for reporting analytical results. COC records were complete and holding times were acceptable.

7.3 Analytical Sensitivity

Reporting limits for non-detect sulfolane samples were below the ACL for reviewed WOs.

Laboratory MBs were analyzed to check for contributions to the analytical results, possibly attributable to laboratory-based contamination. There were no MB detections affecting data.

7.4 Accuracy

Laboratory analytical accuracy may be assessed by evaluating the analyte recoveries from LCS and 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 also spiked project samples as MS and MSD samples to assess their ability to recover analytes from a matrix similar to that of project samples. Accuracy was also assessed by evaluating the recovery of the internal standard, sulfolane-d8.

The LCS/LCSD and MS/MSD results were reviewed for each preparatory batch associated with the project samples. LCS/LCSD and/or MS/MSD recoveries were within laboratory control limits for each preparatory batch, with a few exceptions noted in Table 7-1.

Sulfolane results associated with internal standard recovery failures were flagged “J” as estimated (Table 7-1). A bias was not imparted as the isotope dilution method theoretically corrects the result for the high or low recovery. However, because the low sulfolane-d8 recoveries may indicate matrix interference or extraction inefficiency, a “J”-flag is applied to indicate the potential lack of accuracy.

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

7.5 Precision

Field duplicates were not collected, so the precision of analytical measurements as well as the reproducibility of sampling techniques was not evaluated. However, laboratory analytical precision can also be evaluated by laboratory QC sample RPD calculations using the LCS/LCSD or MS/MSD sample results. The results of RPD calculations for LCS/LCSD and MS/MSD sample pairs associated with project samples were within laboratory control limits, with a few exceptions noted in Table 7-1.

The water sample data collected are considered precise, with the exceptions noted above.

7.6 Data Quality Summary

The reviewed WOs 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 the POE treatment system data 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 and Recommendations

Groundwater monitoring data collected during the reporting period are generally consistent with data collected during recent quarters. As requested by the ADEC, FHRA conducted a second round of sampling for select wells during the reporting period. Data were consistent with first round results; however, the additional results collected during the reporting period will provide additional data during future trend analyses. In addition, deep BTEX monitoring proposed in the 2013 Onsite SCWP (ARCADIS 2013b) was conducted during the reporting period. Monitoring wells screened below the water table exhibited no BTEX concentrations above the LOQ. Additionally, deep residential monitoring proposed in the 2013 Offsite SCWP (ARCADIS 2013c) was conducted during the reporting period.

Deep residential monitoring results were added to the private well data set. In addition, more than 500 historical POE treatment system results were added to the private well data set. Both the deep residential and POE monitoring results will be routinely added to the private well data set moving forward. The maximum offsite sulfolane concentration (558 µg/L) to date was detected in the sample collected from the deep residential well at Location 1230. Although a preliminary sulfolane trend evaluation is included in Appendix H for private well data, sulfolane concentration trends for both the monitoring wells and private wells will be evaluated annually during the fourth quarter.

Operation of the sand filters and GAC vessels began on June 9, 2011 and the system continues to successfully treat sulfolane-impacted groundwater collected from the onsite recovery wells. The onsite treatment system has effectively treated sulfolane-impacted groundwater and recovery, treatment, and monitoring will be continued as outlined in the project SAP (ARCADIS 2013d). Start-up will be completed on four new recovery wells during the next reporting period. AS pilot testing is complete; however, the system will be shut down following anticipated sampling. Wells will continue to be monitored for potential sulfolane rebound, and results will continue to be presented in quarterly reports.

The groundwater monitoring programs proposed in the SCR – 2011 (Barr 2012) and described in the project SAP (ARCADIS 2013d) are underway for the next reporting period (second quarter 2013). Additional activities will include well installation, soil sampling, LNAPL monitoring, deep BTEX monitoring, remediation system O&M, deep residential well sampling, private well resampling, POE treatment system monitoring, and additional private well sampling, as required. Additionally, the ongoing stable isotope sampling will be conducted by SWI on behalf of UAF. Mass flux analysis of the VPT will continue on a quarterly basis pending the availability of a complete data set.

Field activities and performance monitoring proposed in the IRAP Addendum (ARCADIS 2013e), 2013 Onsite SCWP (ARCADIS 2013b), and 2013 Offsite SCWP (ARCADIS 2013c) will continue during the second quarter 2013.

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Tables

Figures



Appendices
(on enclosed CD)



Appendix A

LNAPL Baildown Testing API Outputs



Appendix B

Historical Data Tables for
Groundwater Elevation and LNAPL
Thickness, BTEX, Sulfolane,
Geochemical Parameters, Private
Wells, COPCs, and Culvert Water
Elevations



Appendix C

Analytical Laboratory Reports



Appendix D

ADEC QA/QC Checklists



Appendix E

Field Data Sheets

Appendix F

Hydrographs



Appendix G

Mass Flux Methods



Appendix H

Private Well Sulfolane Mann-Kendall
Trend Analysis Summary



Appendix I

Contaminant Capture Analysis



Appendix J

Level IV Data Validation Reports