

Flint Hills Resources Alaska, LLC

**Site Characterization Report – 2012
Addendum**

North Pole Refinery
North Pole, Alaska

January 25, 2013



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2012 Addendum**

North Pole Refinery
North Pole, Alaska

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Acronyms and Abbreviations

AAC	Alaska Administrative Code
ACL	Alternative Cleanup Level
ADEC	Alaska Department of Environmental Conservation
ARCADIS	ARCADIS U.S., Inc.
Barr	Barr Engineering Company
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and total xylenes
btoc	below top of casing
CCV	continuing calibration verification
city	North Pole, Alaska
COC	constituent of concern
CSM	conceptual site model
Draft Final Onsite FS	Draft Final Onsite Feasibility Study
DRO	diesel range organics
ESI	Environmental Standards, Inc.
EU	Extraction Unit
FHRA	Flint Hills Resources Alaska, LLC
GAC	granular activated carbon
GCL	groundwater cleanup level
GPS	global positioning system
GRO	gasoline range organics
GVEA	Golden Valley Electric Association
IB	instrument blank
IRAP	Interim Removal Action Plan
LCS	laboratory control sample

LCSD	laboratory control sample duplicate
LIF	laser-induced fluorescence
LNAPL	light nonaqueous phase liquid
LOD	limit of detection
LOQ	limit of quantification
MB	method blank
mg/kg	milligram per kilogram
MS	matrix spike
MSD	matrix spike duplicate
MTG	migration to groundwater
NPR	North Pole Refinery
PAH	polynuclear aromatic hydrocarbon
PID	photoionization detector
power plant	electrical generating facility
ppm	parts per million
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
RE	reference emitter
report	2012 Site Characterization Report
Revised Draft Final HHRA	Revised Draft Final Human Health Risk Assessment
RPD	relative percent difference
RRO	residual range organics
SAP	Sampling and Analysis Plan
SCL	soil cleanup level
SCR – 2011	Site Characterization Report Through 2011



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SGS	SGS Laboratories in Anchorage, Alaska
site	FHRA North Pole Refinery, an active petroleum refinery located on H and H Lane in North Pole, Alaska
SWI	Shannon and Wilson, Inc.
TPT	Technical Project Team
USEPA	United States Environmental Protection Agency
UVOST	ultraviolet optical screening tool
VOC	volatile organic compound
VPT	vertical profile transect
work plan	2012 Site Characterization Work Plan
WWTP	wastewater treatment plant
µg/L	micrograms per liter

1. Introduction

On behalf of Flint Hills Resources Alaska, LLC (FHRA), ARCADIS U.S., Inc. (ARCADIS) prepared this Site Characterization Report – 2012 Addendum (report) for the FHRA North Pole Refinery (NPR), an active petroleum refinery located on H and H Lane in North Pole, Alaska (site). The site location and layout are shown on Figures 1 and 2.

Additional site characterization activities were proposed in the 2012 Site Characterization Work Plan (work plan; ARCADIS 2012a). The proposed field activities were developed based on recommendations presented in the Site Characterization Report – Through 2011 (SCR – 2011; Barr Engineering Company [Barr] 2012) and the Alaska Department of Environmental Conservation's (ADEC's) requests for additional site assessment, as expressed at Technical Project Team (TPT) meetings and in general communications between the ADEC and FHRA.

ARCADIS and Shannon and Wilson, Inc. (SWI) conducted the proposed field activities during the second and third quarters of 2012. Field activities were completed by qualified persons as defined by 18 Alaska Administrative Code (AAC) 75.990. Many of the proposed field activities are ongoing.

1.1 Site Priorities

In a letter to FHRA dated August 18, 2011 (ADEC 2011a), the ADEC listed priorities for the site per 18 AAC 75. The priorities are listed below, along with some of the specific measures implemented toward addressing these priorities:

1. *Eliminate the current exposure to sulfolane.* FHRA has sampled 726 private wells within and near the plume area. Sulfolane has been detected in approximately 334 wells and all properties with detectable sulfolane have been offered a permanent alternative water supply solution or bottled water as an interim measure. Additionally, FHRA established a buffer zone around the known sulfolane plume where private wells have been sampled (but no sulfolane detected) and bottled water is being provided as a precautionary measure to prevent potential exposure to sulfolane, while longer-term approaches that incorporate the 14 micrograms per liter ($\mu\text{g/L}$) Alternative Cleanup Level (ACL) for sulfolane referenced by the ADEC in its July 19, 2012 letter (ADEC 2012) are considered. Permanent alternative water supply solutions have been offered to all impacted properties including point of entry treatment systems, bulk water tanks, and ongoing bottled water service. City water is being provided to some properties and those outside the city service area have had the opportunity to choose among the three alternative water supply options.
2. *Pursue aggressive onsite remediation.* The verbally approved Interim Removal Action Plan (IRAP; Barr 2010a) is currently being implemented. Upgrades were

completed in 2011 and 2012 to both the groundwater recovery system and to the groundwater treatment system, including the addition of sand filters and granular activated carbon (GAC) vessels and other measures to increase the capacity and reliability of the treatment system. Comprehensive soil and groundwater investigations have been conducted and the data collected from those investigations have guided both the implementation of upgrades to the onsite remediation system and the planning for future remediation activities. Ongoing sampling activities will continue to be evaluated to assess any additional remediation measures that may be necessary, either as part of the permanent remedy through the feasibility study process or as additional interim remedial actions, as appropriate.

During 2012, FHRA began installing four additional recovery wells to replace R-21, R-39, and R-40, and to augment capture in the R-21 area. The ADEC has directed FHRA to prepare and implement an IRAP Addendum. The IRAP Addendum was submitted on January 18, 2013 (ARCADIS 2013).

3. *Establish a monitoring network that adequately measures the success of the remediation at eliminating offsite contaminant migration and removing the contamination onsite.* Field work was completed including the installation and sampling of 67 monitoring wells in 2012, for a total of more than 270 onsite and offsite monitoring wells, approximately 50 observation wells, and 20 recovery wells. The current well networks have provided data to characterize the nature and extent of contamination, and may become part of the long-term monitoring network, which will incorporate the 14 µg/L ACL referenced by the ADEC for the site. The vertical profiling transect (VPT), installed in 2011, provides a detailed profile of the onsite plume. Other topics, such as the nature of sulfolane contamination subpermafrost in the plume area are less understood at present. A work plan describing the use of private wells to evaluate deep impacts has been submitted to the ADEC (ARCADIS 2012b) and is being executed.
4. *Achieve and maintain source control.* Measures to eliminate releases of all contaminants have included ongoing inspection and testing, and where necessary, repair of refinery sump systems to increase integrity and reliability, plant-wide focus on spill prevention and control, and strong preventive maintenance programs for plant piping, tanks, and equipment systems.
5. *Determine the extent of the contamination downgradient and the potential for movement of the plume in order to develop a remedial strategy that will control exposure for the duration of time it takes to achieve final cleanup levels via engineered and/or natural mechanisms.* Extensive groundwater sampling efforts have focused on determining the extent and nature of the downgradient plume, including installation of 45 offsite monitoring wells in 2012 for a total of approximately 120 offsite

monitoring wells (and well nests) to determine plume and permafrost extent, plume movement, and groundwater horizontal and vertical gradients. Ongoing studies to support the site characterization process include groundwater sampling for geochemistry parameters, isotopic studies, subsurface microbiological characterization, and air sparge pilot testing. This work will lead to improved confidence in the selection of final cleanup goals.

6. *Complete an evaluation of risk that accounts for all exposure pathways and cumulative risk.* The Revised Draft Final Human Health Risk Assessment (Revised Draft Final HHRA; ARCADIS 2012c) submitted to the ADEC on May 23, 2012 assessed exposure pathways and cumulative risks, completing this requested step. As part of the assessment, multiple reference doses were evaluated. The Revised Draft Final HHRA (ARCADIS 2012c) presents a range of risk-based cleanup levels for sulfolane in groundwater. As explained in connection with the ARCADIS Scenario of the HHRA, FHRA concludes that the entire presented range would be adequately health protective. For this report, however, FHRA uses the 14 µg/L ACL referenced by the ADEC in its July 19, 2012 letter (ADEC 2012). This report is submitted subject to the positions and reservations expressed by FHRA in its August 20, 2012 letter (FHRA 2012).

FHRA has focused its work to address the ADEC's priorities and significant work has been completed toward achieving them. This report continues the process to address these priorities.

1.2 Purpose

This report outlines results from field activities conducted in 2012, including the technical background and rationale for each activity proposed in the work plan (ARCADIS 2012a). The scope for this report is focused on data presentation. In some instances, data collection and evaluation are ongoing; in these cases this report indicates where the data analysis and recommendations will be presented. Field activities that were completed in 2012 have been documented during TPT, Site Characterization Subgroup, and Working Group meetings. This report summarizes the following characterization activities that were completed during 2012:

- Installed proposed Phase 7 monitoring wells in onsite and offsite areas.
- Further delineated the upper surface of permafrost and of the suprapermafrost sulfolane plume, both onsite and offsite.
- Deployed additional pressure transducers to further characterize groundwater flow conditions in the suprapermafrost aquifer, as well as horizontal and vertical groundwater gradients and their seasonal fluctuations.

- Performed soil characterization activities onsite to delineate soil impacts in “hot spot” areas based on 2011 soil investigation findings, as reported in the SCR – 2011 (Barr 2012). Additional soil characterization activities were conducted to delineate contamination and evaluate remedial alternatives in these areas.
- Conducted a discreet interval groundwater sampling investigation to evaluate sulfolane and BTEX concentrations in groundwater in onsite areas.
- Characterized concentrations of sulfolane and BTEX in soil beneath the liner of Lagoon B.
- Conducted a laser-induced fluorescence (LIF)/ultraviolet optical screening tool (UVOST) investigation to determine the vertical and lateral extent of light nonaqueous phase liquid (LNAPL) near observation well O-27.
- Sampled site production wells for contamination.
- Complete additional investigations and analysis to evaluate whether degradation of sulfolane in groundwater is ongoing at the site and whether any such process is likely to present a risk to human health or the environment. The additional investigation measures include subsurface microbiological characterization, compound-specific isotope monitoring, toxicological evaluation and a comprehensive analysis informed by available literature and experience with sulfolane and other compounds. The analysis of these data is still ongoing, and will be presented under separate cover by March 1, 2013..

In addition, an Air Sparge pilot test was initiated in 2012 to evaluate the effectiveness of this technology to remediate sulfolane in groundwater. This test is ongoing, and recent results were reported in the IRAP Addendum (ARCADIS 2013).

The data collected during the 2012 site characterization activities were used to further refine the conceptual site model (CSM). The additional data collected further defines the nature and extent of contamination at the site. In addition, the data collected help confirm the sources of sulfolane contamination as identified in the Source Summary Report (Appendix A). This report identifies the primary sources of sulfolane contamination at the site as Lagoon B, Sump 02/04-02, Sump 908, Crude Unit #1 Wash Area (the first former Extraction Unit [EU] wash area), the Southwest Area (former EU wash area), and the South Gravel Pit Area.

The data collected also supplement the historical datasets and will be used to develop the final Onsite Feasibility Study and final Onsite Cleanup Plan.

2. Site Setting

2.1 Property 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 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. Currently, only one of the processing units is currently operating. 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. Previously, a truck-loading rack was located between the railcar-loading rack and the tank farms, near the intersection of Distribution Street and West Diesel. 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) or other fuels produced at the site. The property south of the site and the GVEA power plant is occupied by the Petro Star, Inc. Refinery.

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 residential properties. An undeveloped parcel, owned by the Alaska Department of Natural Resources, 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. Site features are presented on Figure 2. Onsite and offsite site plans are presented on Figures 3 and 4, respectively.

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 soils are 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 soils. 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 unit, impeding and redirecting the flow direction 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 Slough 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 site groundwater recovery system, groundwater flow directions are controlled by discharge from the Tanana River to the aquifer and from the aquifer to 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 varies up to 19 degrees 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).

2.3 Nature and Extent of Contamination

The most current site conditions are summarized in the SCR – 2011 (Barr 2012) and Third Quarter 2012 Groundwater Monitoring Report (ARCADIS 2012e). The methods used to delineate the impacts and interpretations of the resulting data are described in the Site Characterization Work Plan (Barr 2010b), the work plan (ARCADIS 2012a), and the SCR – 2011 (Barr 2012). Site conditions are defined by analysis of constituents of concern (COCs) for human health that were identified in the Revised Draft Final HHRA (ARCADIS 2012c).

Sulfolane is the only COC in the offsite groundwater plume. Although BTEX and other volatile organic compounds (VOCs) are considered site COCs, those impacts are contained onsite. Also, LNAPL impacts are present and limited to onsite areas. A number of onsite monitoring, observation, and extraction wells contain measurable thicknesses of LNAPL.

Onsite and offsite groundwater quality and sulfolane concentrations are assessed through collection and analysis of groundwater samples from monitoring wells. The extent of onsite and offsite sulfolane impacts in groundwater are based upon the results of third quarter 2012 (ARCADIS 2012e) and previous groundwater monitoring, as described in the SCR – 2011 (Barr 2012).

2.4 Current Remedial Operations

FHRA is currently in the final stages of implementing the interim corrective actions described in the IRAP (Barr 2010a) to optimize the existing groundwater pump and treat remediation

system to address LNAPL and impacted groundwater onsite. Operation of the remediation system currently involves groundwater recovery from five recovery wells (R-21, R-35R, R-39, R-40, and R-42). Recovered groundwater is treated through a prefilter for solids removal, a coalescer for LNAPL removal, and four air strippers for removal of 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 GAC system for sulfolane removal. Installation and startup of the sand filters and GAC treatment system was completed during the second quarter 2011 and active operation was initiated on June 9, 2011.

A fifth recovery well (R-42) was installed as part of the IRAP (Barr 2010a) implementation and pumping from well R-42 was initiated on July 26, 2011. Also, in accordance with the IRAP (Barr 2010a), nested monitoring wells MW-186 A/B/C were installed and a capture zone test was conducted in late August and early September 2011. Performance monitoring was conducted to evaluate the horizontal and vertical capture of the groundwater pump and treat remediation system. Results of the performance monitoring are discussed in the SCR – 2011 (Barr 2012).

Pneumatic LNAPL recovery systems are continuously operated at MW-138, R-20R, R-21, R-35R and R-40. Additional pneumatic LNAPL recovery systems are operated seasonally at R-32, R-33 and S-50. The LNAPL recovery system currently utilized at S-50 was previously installed at O-2, but was moved due to low LNAPL recovery. FHRA also uses a hand-held product recovery pump at other locations (e.g., R-39) if LNAPL is present and recovery is possible. Recent LNAPL recovery data are included in the third quarter groundwater monitoring report (ARCADIS 2012e). An expanded LNAPL recovery network was proposed in the IRAP Addendum (ARCADIS 2013).

Recovered LNAPL is recycled within the refinery process unit. In addition, LNAPL recovered from the groundwater stream by the groundwater recovery pumps is collected for recycling in a coalescer installed ahead of the air stripper. FHRA installed replacement recovery for R-21, R-39, and R-40 during the fourth quarter 2012. Development and operation of these new wells will be completed in second quarter 2013 to increase the system's ability to capture groundwater and LNAPL (Barr 2012).



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3. Current Conceptual Site Model

The onsite and offsite CSMs were most recently updated in connection with the Revised Draft Final HHRA (ARCADIS 2012c) and were presented in the Draft Final Onsite Feasibility Study (Draft Final Onsite FS; ARCADIS 2012f) and Draft Offsite Feasibility Study (ARCADIS 2012g), respectively and are included in Appendix B of this report. The CSMs will be refined as needed to account for additional data collected in the future.

4. Phase 7 Well Installation

Based on groundwater monitoring data, the 2012 Site Characterization Work Plan (ARCADIS 2012a) recommended a seventh phase of monitoring well installation to further characterize the extent of the sulfolane plume both onsite and offsite.

Groundwater monitoring data collected during the third quarter 2012 were generally consistent with data collected during previous reporting periods. Benzene concentrations were sampled for and detected during the second and third quarters of 2012 and are limited to onsite areas. Sulfolane concentrations continue to be detected in both onsite groundwater observation and monitoring wells and in offsite groundwater monitoring wells. Also, depth to LNAPL measurements continue to be regularly collected from a network of onsite monitoring, observation, and recovery wells onsite as part of the FHRA's on-going source removal remediation activities. Sulfolane and BTEX concentrations and LNAPL thickness measurements from the third quarter 2012 are summarized in the Third Quarter 2012 Groundwater Monitoring Report (ARCADIS 2012e).

The majority of proposed Phase 7 monitoring wells were screened across the water table to characterize sulfolane impacts at the water table. Additionally, select wells were installed in offsite areas to further delineate the depth to permafrost throughout the study area. Prior to the installation of Phase 7 monitoring wells, permafrost was typically encountered within 55 feet of the water table as the offsite monitoring well network was expanded; therefore, wells were installed at the top of the permafrost (Barr 2012). The installation of offsite Phase 7 monitoring wells either further delineated permafrost, or confirmed that permafrost was not present at a given offsite location to a maximum depth of 150 feet below the water table.

In addition to delineating permafrost, deeper Phase 7 monitoring wells (maximum 150 feet below the water table, as described below) are being used to obtain vertical sulfolane delineation in groundwater. The maximum depth proposed for deep borings was the maximum operational depth of the drill rig. Routine monitoring of the sulfolane plume using Phase 7 and existing monitoring wells is ongoing as part of quarterly monitoring activities approved by ADEC and as defined in the SAP (ARCADIS 2012a).

Furthermore, additional monitoring wells are used to further monitor BTEX concentrations in onsite areas. Historical well construction data are presented in Table 1. The locations of Phase 7 wells are shown on Figures 3 and 4. Tables 2 and 3 summarize the construction details for each Phase 7 monitoring well in onsite and offsite areas, respectively. Boring logs for the Phase 7 wells are presented as Appendix C. The results of routine (quarterly) groundwater monitoring of the new Phase 7 wells will be included in the quarterly groundwater monitoring reports. Dissolved-phase trend analyses for site monitoring wells will be presented in the fourth quarter 2012 groundwater monitoring report, to be submitted to ADEC by March 1, 2013.

4.1 Phase 7 Delineation Wells – Onsite

Between April 17 and August 21, 2012, FHRA installed 24 onsite monitoring wells at variable depths, including:

- Seven monitoring wells and one observation well were screened across the water table (MW-304-15, MW-306-15, MW-309-15, MW-310-15, MW-321-15, MW-330-20, MW-334-15, and O-30).
- Six monitoring wells were screened at depths ranging from 10 to 55 feet below the water table (MW-197A, MW-309-65, MW-310-65, MW-321-65, MW-330-65, and MW-334-65).
- Four monitoring wells were screened at depths ranging from 56 to 90 feet below the water table (MW-186E, MW-302-95, MW-303-95, and MW-304-96).
- Five monitoring wells were screened at depths ranging from 91 to 150 feet below the water table (MW-309-150, MW-310-110, MW-321-151, MW-330-150, and MW-331-150).

Several of the newly installed monitoring wells (MW-302-95, MW-303-95, MW-304-15, MW-304-96, and MW-306-15) were additions to preexisting VPT well nests. The new wells were installed within the VPT nests to further refine the vertical profile of dissolved sulfolane impacts at each location and to allow for the installation of pressure transducers and collection of vertical gradient measurements along the VPT.

As stated above, 24 of the Phase 7 wells proposed in the work plan (ARCADIS 2012a) were installed in onsite locations between April 17 and August 21, 2012. However, one of the proposed onsite wells (7-AP) was not installed at the water table. Proposed well nest 7-AP consisted of two wells: one at the water table and one at the depth of permafrost. Of these, MW-331-150 was installed at 150 feet bgs because permafrost was not encountered. A monitoring well may be installed and screened across the water table in the future, based on the need for characterization of dissolved sulfolane at this depth. Similarly, three wells were proposed for well nest 7-J: one screened across the water table and two screened at depths between 10 and 55 feet below the water table. Of these, two wells (MW-334-15 and MW-334-65) were installed. Installation of the third proposed well was temporarily postponed based on evaluation of monitoring results from the other two wells. The third well is proposed for installation in the forthcoming 2013 Site Characterization Work Plan (ARCADIS, in press).

4.1.1 Soil Classification and Permafrost Delineation

Onsite monitoring wells were generally installed in western, northwestern, and northern areas of the site (Figure 3). Soils encountered during well installation activities generally comprised sandy gravel to gravelly sand with varying amounts of silt. Silty sand, sand, and sandy silt were encountered at depths between 0 and 7 feet bgs. These soils are typically underlain by

gravelly sand to sandy gravel to the maximum depth explored (150 feet bgs). These soil conditions are generally consistent with historical soil classification data at the site, representing highly heterogeneous lithology predominantly comprising gravelly sands and sandy gravel.

Permafrost was generally not encountered in onsite areas during the installation of Phase 7 monitoring wells, except at the proposed location for MW-149C along the north property boundary. Historically, permafrost was not encountered onsite, except in the northern portions of the site (MW-102 and MW-104) and along the VPT transect, including at VPT nests MW-301, MW-302, MW-303, and MW-305 at depths of 70, 110, 130, and 110 feet bgs, respectively. These nests are located in the northern and northwestern portions of the site, and permafrost generally becomes shallower as it extends offsite to the northwest.

The proposed location for MW-149C is approximately 800 feet north of VPT nest MW-305 near the site boundary. Permafrost was encountered at a depth of 23 feet bgs during the advancement of the boring for MW-149C. Permafrost was previously reported during the installation of a monitoring well at this well nest location, and MW-149C was installed to confirm the depth to permafrost in this onsite area. The boring was decommissioned in accordance with the Sampling and Analysis Plan (SAP) included as part of the work plan (ARCADIS 2012a) and a well was not installed at this location. The other borings for Phase 7 monitoring wells were advanced to depths ranging from 91 to 150 feet below ground surface and were located to the southeast and south of the extent of onsite permafrost. The extent of permafrost in onsite areas was further delineated; with the exception of MW-179D (permafrost observed at 140.5 feet) permafrost does not appear to extend southeast or south of the VPT wells at depths of 150 feet or less. This trend is consistent with regional information (Williams 1970, Miller et al. 1999), which assumes that permafrost is absent beneath the Tanana River. This trend is also consistent with previous efforts to delineate the top of permafrost near the site, as described in the SCR – 2011 (Barr 2012). Figure 5 provides a graphical representation of the depth to permafrost in site monitoring wells.

4.1.2 Well Construction Methodology

Onsite monitoring wells were generally designed, constructed, and installed in accordance with the ADEC's Monitoring Well Guidance (ADEC 2011b). Monitoring wells were constructed of 2-inch-diameter Schedule 40 polyvinyl chloride (PVC) casing with 0.010-inch slot screen from the ground surface to the screened interval. A 10-foot-long section of machine-slotted, threaded well screen was placed to span the top of the water table for wells screened across the water table. For deeper wells, a 5-foot-long section of well screen was placed at the desired depth.

Drilling, soil sampling, permafrost and soil classification, soil screening, and monitoring well installation and development were completed in accordance with the procedures described in the SAP (ARCADIS 2012a).

4.1.3 Soil Screening and Sampling Methodology

Split spoon soils were screened using a photoionization detector (PID); soils with readings exceeding 20 parts per million (ppm) were sampled and submitted to SGS Laboratories in Anchorage, Alaska (SGS). The submitted samples were analyzed for the following:

- BTEX by United States Environmental Protection Agency (USEPA) Method 8021
- Gasoline range organics (GRO) by AK Method 101
- Diesel range organics (DRO) by AK Method 102
- Sulfolane by USEPA modified Method 8270D with isotope dilution

4.1.4 Soil Sample Analytical Results

Soil samples were collected at 5-foot intervals for soil screening and logging. Select soil samples were collected and submitted for laboratory analyses based on procedures outlined in the SAP (ARCADIS 2012a). Soil samples were collected from boring MW-197A at a depth of 10 feet bgs (S-197A-10), boring MW-334-15 at depths of 1 and 8 feet bgs (S-334-15-1 and S-334-15-8, respectively), and boring O-30 at a depth of 15 feet bgs (S-O-30-15). The sample collected from boring O-30 was collected as a confirmation sample, because there were no PID readings greater than 0.0 parts per million by volume from this soil.

Sulfolane was not detected in any of the soil samples collected from onsite Phase 7 well installations. Benzene and toluene were detected at concentrations exceeding ADEC soil cleanup levels (SCLs) (0.025 and 6.5 milligrams per kilogram [mg/kg], respectively) for soil sample S-197A-10 (0.9 and 11.8 mg/kg, respectively). BTEX was detected at concentrations exceeding ADEC SCLs (0.025, 6.5, 6.9, and 63 mg/kg, respectively) for soil sample S-334-15-8 (140, 688, 162, and 865 mg/kg, respectively). BTEX was not detected in samples S-334-15-1 or S-O-30-15. GRO was detected at concentrations exceeding the ADEC SCL (1,400 mg/kg) in soil sample S-334-15-8 (4,380 mg/kg). GRO and DRO were not detected above SCLs in samples S-334-15-1 or S-O-30-15. Data validation for these samples is discussed in Section 10 of this report. Phase 7 well boring soil analytical results are summarized in Table 4. Laboratory analytical reports for soil samples are presented as Appendix D.

4.2 Phase 7 Delineation Wells – Offsite

Between April 10 and June 12, 2012, FHRA installed 45 monitoring wells in offsite locations, at variable depths, including:

- Twenty-two monitoring wells were screened across the water table (MW-188A, MW-308-15, MW-311-15, MW-312-15, MW-313-15, MW-314-15, MW-315-15, MW-316-15, MW-317-15, MW-318-20, MW-319-15, MW-320-20, MW-322-15, MW-323-15, MW-324-15,

MW-325-18, MW-326-20, MW-327-15, MW-328-15, MW-329-15, MW-332-15, and MW-333-16).

- Nine monitoring wells were screened at depths ranging from 10 to 55 feet below the water table (MW-150C, MW-308-30, MW-311-46, MW-312-50, MW-316-56, MW-319-45, MW-323-61, MW-329-66, and MW-335-41).
- One monitoring well was screened at a depth ranging from 55 to 90 feet below the water table (MW-317-71).
- Thirteen monitoring wells were screened at depths ranging from 90 to 160 feet below the water table (MW-313-150, MW-314-150, MW-315-150, MW-318-135, MW-320-130, MW-322-150, MW-324-151, MW-325-150, MW-326-150, MW-327-150, MW-328-151, MW-332-150, and MW-333-150).

As stated above, 45 of the Phase 7 monitoring wells proposed in the work plan (ARCADIS 2012a) were installed at offsite locations between April 10 and June 12, 2012. Also, proposed well nests 7-M and 7-AJ were not installed because permafrost was encountered at a depth that made well installation unfeasible (ground surface and 1.5 feet bgs, respectively). Therefore, the borings were backfilled and named PF-3 and PF-4, respectively.

4.2.1 Soil Classification and Permafrost Delineation

Offsite monitoring wells were generally installed in areas north and northwest of the site. The furthest offsite well is located approximately 8 miles northwest of the northern site boundary. Silty sand, sand, and sandy silt were encountered in the vadose zone at depths between 0 and 10 feet bgs. These soils are typically underlain by gravelly sand to sandy gravel in the saturated zone, to the maximum depth explored (150 feet bgs). These soil conditions are generally consistent with historical soil classification data at the site, representing heterogeneous lithology predominantly comprising gravelly sands and sandy gravel.

Permafrost has historically been present in offsite areas northwest of the site at depths ranging from 33.5 to 151.5 feet bgs. Depths to the top of permafrost typically become shallower in areas further downgradient from the site, relative to the area immediately near the site. Permafrost was encountered at depths of ground surface and 1.5 feet bgs in soil borings PF-3 and PF-4, respectively, and proposed monitoring wells could not be installed in these borings. Depths to permafrost encountered during Phase 7 installations ranged from the ground surface to 67 feet bgs.

Permafrost delineation was improved through installation of Phase 7 offsite monitoring wells. In areas further northwest from the site, the top of permafrost is typically detected at depths between 40 and 50 feet bgs, but was as shallow as the ground surface. The furthest northwest well where permafrost was encountered (MW-319-45) was located approximately

6.5 miles from the northern site boundary (Figure 4). The top of permafrost at this boring was encountered at 45.5 feet bgs. Figure 5 provides a graphical representation of the depth to permafrost in site monitoring wells.

4.2.2 Well Construction Methodology

Offsite monitoring wells were generally designed, constructed, and installed in accordance with the ADEC's Monitoring Well Guidance (ADEC 2011b). Monitoring wells were constructed of 2-inch-diameter Schedule 40 PVC casing with 0.010-inch slot screen from the ground surface to the screened interval. A 10-foot-long section of machine-slotted, threaded well screen was placed to span the top of the water table for wells screened across the water table. For wells screened below the water table, a 5-foot-long section of well screen was placed at the desired depth.

4.2.3 Soil Screening Methodology

Drilling, soil sampling, permafrost and soil classification, soil screening, and monitoring well installation and development were completed in accordance with the procedures described in the SAP (ARCADIS 2012a). Soil samples were not collected for laboratory analyses at offsite locations, because there were no PID detections exceeding 20 ppm in any of the screened soil.

5. Pressure Transducer Monitoring Well Network Revisions

As proposed in the work plan (ARCADIS 2012a), FHRA expanded the current pressure transducer monitoring well network onsite and downgradient of the site to further characterize groundwater hydrogeologic conditions in the suprapermafrost aquifer and any observed seasonal fluctuations. The existing pressure transducer network prior to submission of the work plan (ARCADIS 2012a) is summarized in the SCR – 2011 (Barr 2012).

Data from the pressure transducers is exported and reviewed quarterly, in conjunction with groundwater sampling activities. The gradient direction variation and vertical gradient for data collected through the end of the second quarter 2012 are summarized in Appendix E. An evaluation of pressure transducer data will be included in the fourth quarter 2012 groundwater monitoring report, to be submitted to ADEC on March 1, 2013. The expanded pressure transducer network locations are presented on Figure 6 and summarized in Table 5.

6. Monitoring of North Pole Refinery Production Wells

The work plan (ARCADIS 2012a) proposed sampling the fire suppression production wells (29241 and 29237) to determine if sulfolane or BTEX are present in these wells. Water from these production wells is mixed with water from the North Gravel Pit and is fed into the onsite fire hydrant system. The depth of the production wells is approximately 60 feet below top of casing (btoc). Production well 29241 is screened from 55 to 60 feet btoc and production well 29237 is screened 50 to 60 feet btoc. No survey data are available for these wells. The wells are housed within a building north of the GVEA power plant (Figure 2).

These production wells were sampled during the second quarter 2012; results were reported in the Second Quarter 2012 Groundwater Monitoring Report (ARCADIS 2012d). Results indicated that samples collected from the fire suppression production wells exhibited no detectable concentrations of BTEX or sulfolane.

7. Hydropunch™ Investigation

As proposed in the work plan (ARCADIS 2012a), discrete interval groundwater soil borings were advanced at various locations throughout the site to characterize dissolved-phase sulfolane and dissolved-phase BTEX concentrations for select borings at the site. Groundwater samples were obtained from discrete intervals to obtain a vertical profile of sulfolane and BTEX impacts. The placement of these borings in strategic locations allows for a lateral profile of sulfolane and BTEX impacts.

Specific investigation areas include:

- Asphalt truck-loading rack
- Areas east and west of the railcar-loading rack and south of the current truck-loading rack
- Area downgradient from the sulfolane extraction unit
- Exchanger wash skid
- Area southeast of the North Gravel Pit
- Area near the intersection of Tank Farm Road and Naphtha Avenue
- Area along Distribution Street

Initially, the work plan (ARCADIS 2012a) proposed advancing 11 Hydropunch™ borings throughout the site. As field activities commenced, additional borings were advanced to further characterize the site. By August 10, 2012, a total of 54 Hydropunch borings had been advanced at various locations throughout the site using direct-push technology methods and a Hydropunch rig. Hydropunch boring locations are shown on Figure 7. Hydropunch boring sample field parameters and analytical results are included in Tables 6 and 7, respectively.

7.1 Hydropunch Sampling Methodology

After hand auguring borings to approximately 5 feet bgs, the Hydropunch probe was advanced to between 13 and 17 feet bgs. This depth range was generally where the first groundwater sample could be collected. When it was determined that the probe was in sufficient groundwater, the screen was extended between 6 inches to 3 feet. Once the screen was extended, a depth to water measurement was recorded and dedicated tubing was placed through the direct-push rod to the approximate middle of the screen. Groundwater was then purged through a flow-through cell using a peristaltic pump. Water quality parameters were recorded using a Yellow Springs Instrument 556 meter until the conductivity stabilized. After conductivity stabilized, one groundwater sample was collected from each boring. Once sampling was completed, the boring was advanced approximately 10 feet deeper from the first total depth and the process was repeated using new dedicated tubing. Borings were advanced until refusal, and most borings terminated at approximately 55 feet bgs. Boring HP-18 met with refusal in the first 10 feet of the boring; therefore, no groundwater samples could be collected from HP-18. The boring was not relocated due to the successful advancement of borings nearby.

Following groundwater sample collection at the final boring depth, the borings were backfilled with bentonite chips to ground surface and hydrated with potable water. The horizontal coordinates of each boring were collected using a hand-held global positioning system (GPS) unit. Soil cuttings were staged in a labeled 55-gallon drum pending results of waste classification sampling.

Water samples submitted for analysis included sulfolane by USEPA modified Method 1625 with isotope dilution. Select water samples were also submitted for analysis to determine BTEX using USEPA Method 8021. Groundwater field parameters and sampling results are summarized in Tables 6 and 7, respectively. Data validation for these samples is discussed in Section 10 of this report. Laboratory analytical reports for these samples are included as Appendix F. Due to the nature of the sampling process, soil samples were not collected during this event for sampling or for lithological classification.

Advancement of Hydropunch borings, groundwater sampling, and decommissioning of borings were completed in accordance with the procedures described in the SAP (ARCADIS 2012a).

7.2 Hydropunch Sampling Analytical Results

A total of 54 soil borings were advanced and 250 Hydropunch groundwater samples were collected and analyzed for sulfolane to further characterize the vertical and lateral extent of sulfolane impacts onsite. Of these, 137 Hydropunch groundwater samples were also analyzed for BTEX to further characterize areas where BTEX impacts were detected in monitoring wells. Hydropunch groundwater sample analytical results for sulfolane are presented at variable depths on Figures 8 through 13. Select boring locations analyzed for BTEX are indicated on Figure 14. Hydropunch groundwater sample analytical results for benzene are presented at variable depths on Figures 15 through 19. Cross section locations for sulfolane data are shown on Figure 20. Cross section locations for soil borings where benzene data was collected are shown on Figure 21. Monitoring well data from the second quarter 2012 are included on the Hydropunch data figures (Figures 8 through 13). While Hydropunch borings are temporary, monitoring wells are permanent and the data are collected via different methodologies; however, the two datasets are complementary.

7.2.1 Area Near the Truck-Loading Rack

Eleven borings (HP-10, HP-11, HP-12, HP-13, HP-22, HP-23, HP-24, HP-25, HP-26, HP-27, and HP-28) were advanced near the truck-loading rack area; HP-11 was the most eastern boring and HP-28 was the most western boring (Figure 7). These borings were advanced along a transect (excluding HP-12 and HP-13) generally running northeast to southwest. Hydropunch groundwater samples were collected at 10-foot intervals at variable depths typically between 13 and 54 feet bgs. Borings HP-11 and HP-22 were advanced to terminal

depths of 44 and 43 feet bgs, respectively. With the exception of HP-12, groundwater samples collected from these borings were also analyzed for BTEX.

Sulfolane concentrations ranged from below limits of detection for several samples to 515J* $\mu\text{g/L}$ at HP-25 at 14 feet bgs. Generally, sulfolane concentrations were elevated in samples closest to the top of the water table and decreased with depth. Vertical delineation of sulfolane impacts below the ADEC ACL of 14 $\mu\text{g/L}$ was achieved at each boring, except HP-12 (21.9 $\mu\text{g/L}$ at 54 feet bgs), HP-27 (19 $\mu\text{g/L}$ at 51 feet bgs), and HP-28 (25.1 $\mu\text{g/L}$ at 55 feet bgs). Borings advanced in the northeastern portion of the transect typically achieved vertical delineation at shallower depths than borings in the southwestern portion of the transect. Borings HP-10, HP-11, and HP-22 achieved vertical delineation at the interval between 20 and 30 feet bgs. Borings HP-13, HP-23, HP-24, HP-25, and HP-26 achieved vertical delineation at the interval between 40 and 50 feet bgs. Figures 8 through 13 depict sulfolane analytical results for discreet interval groundwater samples at variable depths. Except for borings HP-12 and HP-13, Cross Section A-A' (Figure 22) depicts sulfolane concentrations in discreet interval groundwater samples collected in the investigation area.

Benzene concentrations ranged from below limits of detection for several samples to 157 $\mu\text{g/L}$ at HP-22 at 24 feet bgs. Toluene, ethylbenzene, and total xylenes detections were generally co-located with benzene detections along the vertical profile of each boring. This is consistent with historical data collected at the site. Generally, benzene concentrations were elevated in samples collected closest to the water table and decreased with depth. Vertical delineation of benzene impacts below the ADEC Groundwater Cleanup Level (GCL) of 5 $\mu\text{g/L}$ was achieved at each boring; no exceedances of the GCL were noted in borings HP-11, HP-13, HP-24, HP-25, and HP-26. Typically, borings with exceedances of the GCL achieved vertical delineation between 15 and 25 feet bgs. Groundwater samples exceeding the GCL at HP-10, HP-22, and HP-23 were laterally delineated to the east by HP-11 and to the west by HP-24. Groundwater samples exceeding the GCL at HP-27 and HP-28 were laterally delineated to the east by HP-26, but were not delineated to the west. Figures 15 through 19 depict benzene analytical results for discreet interval groundwater samples at variable depths. Cross Section A-A' (Figure 23) depicts benzene concentrations in groundwater samples collected in the investigation area.

7.2.2 Area East and West of Railcar-Loading Rack and South of Current Truck-Loading Rack

Eight borings (HP-14, HP-15, HP-16, HP-17, HP-19, HP-20, HP-21, and HP-29) were advanced in this investigation area; HP-17 was the most eastern boring and HP-29 was the most western boring (Figure 7). Hydropunch groundwater samples were collected at 10-foot intervals at variable depths typically between 14 and 62 feet bgs. Boring HP-21 was advanced to a terminal depth of 31 feet bgs; boring HP-18 was not advanced due to refusal above the water table. With the exception of HP-19, HP-20, and HP-29, groundwater samples collected from these borings were also analyzed for BTEX.

Sulfolane concentrations ranged from below limits of detection for several samples to 1,380 µg/L at HP-17 at 14 feet bgs. Generally, sulfolane concentrations were elevated in samples collected closest to the water table and decreased with depth. Vertical delineation of sulfolane impacts below the ADEC ACL of 14 µg/L was generally not achieved at each boring. Borings with concentrations exceeding the ACL in the deepest groundwater sample include HP-15 (26.8 µg/L at 54 feet bgs), HP-16 (64.7 µg/L at 25 feet bgs), HP-17 (62.9 µg/L at 54 feet bgs), HP-19 (21.8J* µg/L at 54 feet bgs), HP-21 (152 µg/L at 31 feet bgs), and HP-29 (20.3 µg/L at 54 feet bgs). Samples from HP-16 between 35 and 62 feet bgs could not be quantified for sulfolane due to hydrocarbon interference; therefore, these data were rejected. Boring HP-14 achieved vertical delineation at a depth between 24 and 34 feet bgs. Boring HP-20 achieved vertical delineation at a depth between 34 and 44 feet bgs. Figures 8 through 13 depict sulfolane analytical results for discrete interval groundwater samples at variable depths. Cross section B-B' (Figure 24) depicts sulfolane concentrations in discrete interval groundwater samples collected in the investigation area. Boring HP-30 is shown on Figure 23 at the intersection of Cross Section E-E' (Figure 28) and is included in the area upgradient from the North Gravel Pit described in Section 7.2.5.

Benzene concentrations ranged from below limits of detection for several samples to 2,710 µg/L at HP-16 at 53 feet bgs. Toluene, ethylbenzene, and total xylenes detections were generally co-located with benzene detections along the vertical profile of each boring. This is consistent with historical data collected at the site. Generally, benzene concentrations were elevated in samples collected closest to the water table and decreased with depth. Vertical delineation of benzene impacts below the ADEC GCL of 5 µg/L was achieved at boring HP-17 between 14 and 24 feet bgs. No exceedances of the GCL were noted in borings HP-15 and HP-21. Borings exceeding the GCL at the deepest groundwater sample include HP-14 (87.8 µg/L at 54 feet bgs) and HP-16 (1,780 µg/L at 62 feet bgs). BTEX concentrations at HP-14 and HP-16 generally increased with depth. Figures 15 through 19 depict benzene analytical results for discrete interval groundwater samples at variable depths. A plan for further evaluation of BTEX at depth will be proposed in the 2013 On-Site Site Characterization Work Plan.

7.2.3 Area Downgradient from Sulfolane Extraction Unit

Five borings (HP-42, HP-43, HP-44, HP-45, and HP-46) were advanced in this investigation area; HP-46 was the most eastern boring and HP-42 was the most western boring (Figure 7). Hydropunch groundwater samples were collected at 10-foot intervals at variable depths typically between 14 and 55 feet bgs. Borings in this investigation area had terminal depths ranging from 54 to 55 feet bgs. Groundwater samples collected from these borings were also analyzed for BTEX.

Sulfolane concentrations ranged from below limits of detection for several samples to 15,900JL* µg/L at HP-45 at 14 feet bgs. Sulfolane was not detected at HP-42. Generally, sulfolane concentrations were elevated in samples collected closest to the water table and

decreased with depth. Vertical delineation of sulfolane impacts below the ADEC ACL of 14 µg/L was generally achieved at each boring, except for HP-45 (278 µg/L at 29 feet bgs).

Borings advanced in the western portion of the investigation area typically achieved vertical delineation at shallower depths than in the eastern portion of the investigation area. Boring HP-43 achieved vertical delineation at a depth between 15 and 25 feet bgs. Boring HP-44 achieved vertical delineation at a depth between 24 and 34 feet bgs. Boring HP-46 achieved vertical delineation at a depth between 14 and 34 feet bgs.

Samples collected from HP-45 between 44 and 54 feet bgs and HP-46 at 24 feet bgs could not be quantified for sulfolane due to hydrocarbon interference; therefore, these data were rejected. Groundwater samples from HP-45 at variable depths are orders of magnitude greater than groundwater samples at similar depths from HP-44 to the west or from HP-46 to the east. Sulfolane concentrations were also delineated west of HP-45. Figures 8 through 13 depict sulfolane analytical results for discrete interval groundwater samples at variable depths. Cross section C-C' (Figure 25) depicts sulfolane concentrations in discrete interval groundwater samples collected in the investigation area.

Benzene concentrations ranged from below limits of detection for several samples to 11,300 µg/L at HP-45 at 14 feet bgs. Toluene, ethylbenzene, and total xylenes detections were generally co-located with benzene detections along the vertical profile of each boring. This is consistent with historical data collected at the site. Generally, benzene concentrations were elevated in samples collected closest to the water table and decreased with depth. Vertical delineation of benzene impacts below the ADEC GCL of 5 µg/L was achieved at boring HP-42 between 24 and 34 feet bgs. Borings with concentrations exceeding the GCL in the deepest groundwater sample include HP-43 (8.64 µg/L at 55 feet bgs), HP-45 (270 µg/L at 54 feet bgs), and HP-46 (310 µg/L at 54 feet bgs). Concentrations at HP-46 generally increased with depth. Figures 15 through 19 depict benzene analytical results for discrete interval groundwater samples at variable depths. Cross Section C-C' (Figure 26) depicts benzene concentrations in discrete interval groundwater samples collected in the investigation area.

7.2.4 The Southwest Area (Former EU Wash Area)

Nine borings (HP-05, HP-07, HP-08, HP-09, HP-47, HP-48, HP-49, HP-50, and HP-51) were advanced in this investigation area, with HP-47 being the most eastern boring and HP-07 being the most western boring (Figure 7). Hydropunch groundwater samples were collected at 10-foot intervals at variable depths typically between 14 and 56 feet bgs. Borings HP-05 and HP-07 were advanced to terminal depths of 40 and 45 feet bgs, respectively, while the other borings were advanced to terminal depths from 54 to 56 feet bgs. Groundwater samples collected from these borings were not analyzed for BTEX.

Sulfolane concentrations ranged from below limits of detection for several samples to 1,110 µg/L at HP-08 at 15 feet bgs. Sulfolane was not detected at HP-07. Generally, sulfolane

concentrations were elevated in samples collected closest to the water table and decreased with depth. Vertical delineation of sulfolane impacts below the ADEC ACL of 14 µg/L was achieved at each boring. Borings advanced in the eastern portion of the investigation area typically achieved vertical delineation at shallower depths than in the western portion of the investigation area. Boring HP-47 achieved vertical delineation at a depth between 14 and 24 feet bgs. Borings HP-05 and HP-08 achieved vertical delineation at a depth between 25 and 35 feet bgs. Borings HP-09, HP-48, and HP-51 achieved vertical delineation at depths between 34 and 45 feet bgs. Borings HP-49 and HP-50 achieved vertical delineation at a depth between 44 and 54 feet bgs. Figures 8 through 13 depict sulfolane analytical results for discrete interval groundwater samples at variable depths. Cross section D-D' (Figure 27) depicts sulfolane concentrations in discrete interval groundwater samples collected in the investigation area.

7.2.5 Area Upgradient from North Gravel Pit

Ten borings (HP-01, HP-02, HP-03, HP-04, HP-06, HP-30, HP-31, HP-52, HP-53, and HP-54) were advanced in this investigation area, with HP-30 being the most northeastern boring and HP-06 being the most southwestern boring (Figure 7). Hydropunch groundwater samples were collected at 10-foot intervals at variable depths typically between 14 and 60 feet bgs. Borings HP-02, HP-04, and HP-06 were advanced to terminal depths of 35, 40, and 48 feet bgs, respectively, while the other borings were advanced to terminal depths from 54 to 60 feet bgs. Groundwater samples collected from these borings were not analyzed for BTEX.

Sulfolane concentrations ranged from below limits of detection for several samples to 395 µg/L at HP-53 at 15 feet bgs. Generally, sulfolane concentrations were elevated in samples collected closest to the water table and decreased with depth. Vertical delineation of sulfolane impacts below the ADEC ACL of 14 µg/L was achieved at boring HP-03 at depths between 40 and 50 feet bgs, at boring HP-06 at depths between 30 and 40 feet bgs, at boring HP-52 at depths between 44 and 54 feet bgs, and at boring HP-53 at depths between 45 and 55 feet bgs. Borings with concentrations exceeding the ACL in the deepest groundwater sample include HP-01 (49.1 µg/L at 54 feet bgs), HP-02 (121 µg/L at 35 feet bgs), HP-04 (27.2JL* µg/L at 40 feet bgs), HP-30 (52.3 µg/L at 54 feet bgs), HP-31 (94.8 µg/L at 44 feet bgs), and HP-54 (190 µg/L at 54 feet bgs). Figures 8 through 13 depict sulfolane analytical results for discrete interval groundwater samples at variable depths. Cross Section E-E' (Figure 28) depicts a subset of sulfolane concentrations in discrete interval groundwater samples collected in the investigation area.

7.2.6 Area Near Intersection of Tank Farm Road and Naphtha Avenue

Eight borings (HP-32, HP-33, HP-34, HP-35, HP-36, HP-37, HP-38, and HP-39) were advanced in this investigation area, with HP-35 being the most eastern boring and HP-32 being the most western boring (Figure 7). Hydropunch groundwater samples collected in this area were intended to characterize sulfolane concentrations at the groundwater table only;

therefore, samples were collected at 5-foot intervals at variable depths, typically between 14 and 25 feet bgs. Groundwater samples collected from these borings were also analyzed for BTEX.

Sulfolane concentrations ranged from below limits of detection at HP-37 at 15 feet bgs to 2,040JN[^] µg/L at HP-36 at 25 feet bgs. Generally, sulfolane concentrations in this area were elevated at multiple depths below the water table and did not decrease with depth. Vertical delineation of sulfolane impacts below the ADEC ACL of 14 µg/L was not achieved in these borings; the terminal depths at these borings ranged from 24 to 25 feet bgs. Borings with concentrations exceeding the ACL in the deepest groundwater sample include HP-32 (1,310 µg/L at 24 feet bgs), HP-33 (937 µg/L at 24 feet bgs), HP-34 (850 µg/L at 25 feet bgs), HP-35 (104 µg/L at 25 feet bgs), HP-36 (2,040JN[^] µg/L at 25 feet bgs), HP-37 (261 µg/L at 25 feet bgs), HP-38 (1,460 µg/L at 25 feet bgs), and HP-39 (512 µg/L at 25 feet bgs). The data flag “^” indicates that the data flags applied to this sample are based on a Level IV data assurance review. Generally, dissolved sulfolane concentrations were higher in groundwater samples collected from the western borings compared to groundwater samples collected from the eastern borings. Figures 8 through 13 depict sulfolane analytical results for discrete interval groundwater samples at variable depths.

Benzene concentrations ranged from 0.280J at HP-38 at 15 feet bgs to 55.4 µg/L at HP-34 at 20 feet bgs. Toluene, ethylbenzene, and total xylenes detections were generally co-located with benzene detections along the vertical profile of each boring. This is consistent with historical data collected at the site. Generally, benzene concentrations were elevated in samples collected closest to the water table and decreased with depth. Vertical delineation of benzene impacts below the ADEC GCL of 5 µg/L was achieved at boring HP-32 between 19 and 24 feet bgs, at boring HP-34 between 20 and 25 feet bgs, and at boring HP-39 between 15 and 20 feet bgs. Groundwater samples collected from borings HP-37 and HP-38 did not exceed the GCL. Borings with concentrations exceeding the GCL in the deepest groundwater sample include HP-33 (5.4 µg/L at 24 feet bgs), HP-35 (10.3 µg/L at 25 feet bgs), and HP-36 (34.3 µg/L at 25 feet bgs). Generally, dissolved benzene concentrations were higher in groundwater samples collected from the borings located near HP-34. Figures 15 through 19 depict benzene analytical results for discrete interval groundwater samples at variable depths.

7.2.7 Area Along Distribution Street

Two borings (HP-40 and HP-41) were advanced in this investigation area, with HP-40 being the most northern boring and HP-41 being the most southern boring (Figure 7). Hydropunch groundwater samples were collected at 10-foot intervals at variable depths between 14 and 54 feet bgs. Borings HP-40 and HP-41 both had terminal depths of 54 feet bgs. Groundwater samples collected from these borings were also analyzed for BTEX.

Sulfolane concentrations ranged from below limits of detection at HP-41 at 54 feet bgs to 53.7 µg/L at HP-41 at 14 feet bgs. Generally, sulfolane concentrations were elevated in samples collected closest to the water table and decreased with depth. Vertical delineation of sulfolane impacts below the ADEC ACL of 14 µg/L was achieved at each boring at depths between 34 and 44 feet bgs. Generally, dissolved sulfolane concentrations at variable depths were similar in both borings. Figures 8 through 13 depict sulfolane analytical results for discrete interval groundwater samples at variable depths.

Benzene concentrations ranged from below limits of detection for several samples to 149 µg/L at HP-41 at 14 feet bgs. Toluene, ethylbenzene, and total xylenes detections were generally co-located with benzene detections along the vertical profile of each boring. This is consistent with historical data collected at the site. Generally, benzene concentrations were elevated in samples collected closest to the water table and decreased with depth. Vertical delineation of sulfolane impacts below the ADEC GCL of 5 µg/L was achieved at boring HP-41 between 14 and 24 feet bgs. Groundwater samples collected from HP-40 did not exceed the GCL. Figures 15 through 19 depict benzene analytical results for discrete interval groundwater samples at variable depths.

8. Soil Characterization

Historical soil investigations at the site are described in the SCR – 2011 (Barr 2012; Figure 29). Recommendations were outlined in 2012 Site Characterization Work Plan (ARCADIS 2012a) for further soil characterization investigations at the following locations:

- Area around boring SB-143, The Southwest Area (Former EU Wash Area)
- The Southwest Area (Former EU Wash Area)
- Area around boring O-6, west of the railcar-loading rack in the historical storage yard
- Area around boring O-27, west of the current truck-loading rack

In addition to the locations outlined in the SCR – 2011, three other locations were proposed in the work plan (ARCADIS 2012a) to delineate soil impacts. These areas were chosen based on further evaluation of 2011 soil and groundwater data and first quarter 2012 groundwater data in order to address soil characterization data gaps in these areas. These locations include:

- Area north of the asphalt-truck loading rack and O-25
- Lagoon B
- Area northwest of Lagoon B

From May 22 to August 16, 2012, FHRA collected 146 soil samples for sulfolane and BTEX analysis from the areas proposed in the work plan (ARCADIS 2012a).

8.1 Soil Characterization Methodology

8.1.1 Direct-Push Soil Borings

The soil borings located in the target areas discussed above were advanced using direct-push technology. Soil samples were typically collected from immediately above the air-groundwater interface (smear zone) and the bottom of the boring. An additional soil sample was collected based on field observations and elevated PID measurements.

Boring advancement, soil sampling, soil classification, soil screening, and field quality control measures were completed in accordance with the procedures described in the SAP (ARCADIS 2012a). Boring logs were prepared for each boring or surface soil location and are included in Appendix C. Data validation for these samples is discussed in Section 10 of this report. Soil analytical laboratory reports are included as Appendix D.

Soil samples collected from the soil borings were submitted to SGS for the following analysis:

- Samples throughout the site were analyzed for sulfolane by USEPA modified Method 8270D with isotope dilution.

- Samples collected in Lagoon B, northwest of Lagoon B, the area west of the current truck-loading rack, The Southwest Area (Former EU Wash Area), and the area north of the asphalt truck-loading rack and O-25 were analyzed for BTEX using USEPA Method 8021.

8.1.2 Hand Auger Soil Borings

Soil borings were advanced in Lagoon B to characterize dissolved-phase sulfolane and BTEX concentrations underlying the lagoon. Thirty-two soil borings were advanced using hand auger methods as shown on Figure 30.

A liner system is present at Lagoon B, consisting of a top primary liner and bottom secondary liner with PVC spacers in between the two liners. Prior to hand auguring, standing water present between the primary and secondary liner was pumped out of the lagoon. The primary and secondary liners were then cut to expose the underlying soil at the proposed boring locations, and sandbags were laid out along the exposed soil. The hand auger was then advanced at each location until immediately above the water table or until refusal. All proposed borings were able to be completed following dewatering of the standing water between the primary and secondary liners at each proposed location. Total boring depths ranged from approximately 3 to 5 feet bgs. Whenever possible, each boring was advanced below the top of water table to delineate the thickness of an observed silty sand layer.

Starting at 1 foot bgs, soil samples were collected at continuous intervals for soil classification and soil screening purposes. Soil screening included PID measurements and visual observations of staining and odors. In addition, one soil sample was collected for laboratory analysis in each boring immediately above the water table or at the deepest interval achieved. Lab analyses included sulfolane by USEPA modified Method 8270D with isotope dilution and BTEX using USEPA Method 8021. Soil boring logs are presented in Appendix C.

Following hand auger advancement and sample collection, the borings were backfilled with bentonite chips to ground surface and hydrated with potable water. The horizontal coordinates of each boring were collected using a hand-held GPS unit. Excavated soil was staged in a labeled 55-gallon drum pending results of waste classification sampling.

8.2 Soil Analytical Results

The 2012 soil characterization boring locations and sulfolane concentrations detected in each boring are shown on Figures 30 through 34 and described in the following sections. Soil boring analytical results are presented in Table 8.

8.2.1 The Southwest Area (Former EU Wash Area)

The area surrounding SB-143 was proposed for additional investigation based on the findings presented in the SCR – 2011 (Barr 2012), where sulfolane was detected at a concentration of 18.4 mg/kg in a soil sample collected from 3 to 5 feet bgs (SB-143). Soil samples were collected in the Southwest Area (Former EU Wash Area) near SB-143 from the vadose zone in the top 2 feet bgs and smear zone immediately above the air-groundwater interface. Samples were collected at locations SB-188 through SB-197 and SB-235 through SB-251 as depicted on Figures 31 and 32. Samples were analyzed for sulfolane and BTEX.

An interim-estimated screening level for sulfolane of 0.043 mg/kg was derived by ADEC, and was based on the EPA PPRTV oral, chronic reference dose of 0.001 mg/kg-d (and a target groundwater concentration of 16 µg/L) and ADEC's soil migration to groundwater cleanup level equation. This screening level was referenced in the July 9, 2012 comments to the 2012 Site Characterization Work Plan. Sulfolane was detected above the ADEC-derived interim estimated screening level of 0.043 mg/kg at locations SB-190, SB-191, SB-193 through SB-196, SB-236 through SB-244, and SB-246 through SB-251. Detections in the vadose zone ranged from 0.00543J mg/kg (SB-197) to 72.0J* mg/kg (SB-191). Detections in the smear zone ranged from 0.00819J mg/kg (SD-197) to 724 mg/kg (SB-238).

Concentrations of BTEX did not exceed the ADEC SCLs in any of the soil samples collected from the Southwest Area (Former EU Wash Area), and in many of the samples BTEX concentrations did not exceed detection limits. BTEX was detected in the vadose zone sample collected from SB-190 at concentrations less than SCLs (benzene at 0.0233 mg/kg, toluene at 0.0938 mg/kg, ethylbenzene at 0.845 mg/kg, p&m-xylene at 1.04 mg/kg, and o-xylene at 0.574 mg/kg). In addition, toluene (0.0284J mg/kg) and o-xylene (0.0122J mg/kg) were detected in the vadose zone samples from SB-191 and SB-241, respectively. Toluene was also detected in three smear zone samples at concentrations ranging from 0.0102J mg/kg (SB-251) to 0.162 mg/kg (SB-250). Other samples collected from the Southwest Area (Former EU Wash Area) were below detection limits for BTEX compounds.

Sulfolane impacts present in the vadose zone were generally located in the areas immediately surrounding SB-143. The maximum concentration of sulfolane in the vadose zone was located at SB-191 (72.0J* mg/kg), southwest of SB-143. Generally, sulfolane concentrations in the vadose zone were most elevated at borings located south of and near SB-143. Sulfolane impacts present in the smear zone were generally most elevated at soil borings located to the south of SB-143. The maximum concentration of sulfolane in the smear zone was located at SB-238 (724 mg/kg), south of SB-143. The water table was encountered at the bottom of this sample and boring, at 6.8 feet bgs. Samples from borings located north of SB-143 generally have lower concentrations than samples from borings located to the south of SB-143. A plan for additional delineation of sulfolane impacts to soil in this area will be proposed in the 2013 On-Site Site Characterization Work Plan.

8.2.2 Exchanger Wash Skid

Soil investigation was proposed for the area between the wash skid and pore water sample location PORE-1, located near the southeastern bank of the North Gravel Pit, to evaluate potential soil impacts related to the operation of the exchanger wash skid drain lines and sumps (Barr 2012). Samples were collected from the vadose zone and smear zone at four locations east and northeast of the exchanger wash skid (SB-184 through SB-187) as depicted on Figures 31 and 32. Samples collected were analyzed for sulfolane and BTEX.

Sulfolane was not detected in the vadose zone samples. Sulfolane was detected in two samples collected from the smear zone at 0.0331 mg/kg (SB-186) and 0.514 mg/kg (SB-187). The smear zone sample from SB-187 (0.514 mg/kg) exceeded the ADEC estimated sulfolane screening level of 0.043 mg/kg. The water table was encountered at the bottom of this sample and boring, at 11 feet bgs. BTEX was not detected in the vadose zone or smear zone samples collected from the exchanger wash skid area.

Soil samples from borings collected from areas between the skid and pore-water sample PORE-1 did not exhibit concentrations of sulfolane or BTEX above detection limits. Impacts appear to be limited to the smear zone at the southeast corner of the exchanger wash skid (SB-187). Sump inlets or sumps are not located in this area; however, a 3-inch-diameter high-density polyethylene underground pipe is located in this area at 4 feet bgs. Sump S-05116 is located near SB-186, which exhibited a sulfolane detection in the smear zone below the ADEC estimated sulfolane screening level as described above.

8.2.3 Area West of Railcar-Loading Rack in the Historical Storage Yard

The SCR – 2011 (Barr 2012) recommended further delineation of the area west of the railcar-loading rack in the historical storage yard, due to the sulfolane detection in recovery well O-6. Sulfolane was detected at a concentration of 1.79 mg/kg in a soil sample collected from 4 to 6 feet bgs in O-6. Soil investigation in the area of O-6 was conducted by collecting samples from eight locations, both upgradient and downgradient of O-6 (SB-198 through SB-205), as shown on Figures 33 and 34. Samples were collected from the vadose zone and smear zone from each location and analyzed for sulfolane and BTEX.

Sulfolane was detected above the interim estimated screening level of 0.043 mg/kg at one location in the smear zone at 0.182 mg/kg (SB-200 [5.0-6.9]). The other samples were either below detection levels or below the ADEC interim estimated soil screening level. Sulfolane detections ranged from 0.0107JL mg/kg (SB-205 [2 to 4]) to 0.182 mg/kg (SB-200 [5.0-6.9]). Smear zone samples were more than one order of magnitude below the sulfolane detection at O-6.

Benzene concentrations were below detection limits in the soil samples collected from SB-198 through SB-205. Toluene was detected in one sample (SB-199 [1.5-2.5]) and one

duplicate sample (SD-200 [0.0-2.0]), while ethylbenzene, p&m-xylene, and o-xylene were detected in four samples (SB-199 [1.5-2.5], SB-200 [0.0-2.0], SB-204 [0.0-2.0] and SB-204 [2.0-4.0]) and one duplicate sample (SD-200 [0.0-2.0]). All detections were below their respective SCLs.

The vertical and lateral extents of sulfolane concentrations in the investigation area were characterized and sulfolane impacts were identified at the smear zone for boring SB-200, located southeast of O-6. Other soil samples did not contain concentrations of sulfolane exceeding the detection level. Many of the soil samples in the investigation area were collected at 5 to 5.5 feet bgs. Therefore, sulfolane impacts in soil identified at 4 to 6 feet bgs at O-6 were further delineated and soil impacts are present to the southeast of this boring.

8.2.4 Area West of the Current Truck-Loading Rack

Based on LNAPL characterization completed in 2011, benzene is present in the LNAPL and may be an ongoing source to the benzene in soil and groundwater in the area west of the current truck-loading rack (Barr 2012). Benzene was detected in observation well O-27 at concentrations of 0.445 and 0.0277 mg/kg in soil samples collected from 9 to 9.5 and 10.3 to 11 feet bgs, respectively. Furthermore, LNAPL was detected in O-27 during the first quarter 2012 (ARCADIS 2012h). Therefore, further delineation of soil impacts near O-27, west of the current truck-loading rack, was recommended in the work plan (ARCADIS 2012a).

Soil samples were collected from three locations in the area west of the current truck-loading rack (SB-226 through SB-228) as depicted on Figures 33 and 34. Samples were collected from the vadose, smear, and saturated zones at these locations and analyzed for sulfolane and BTEX.

Sulfolane was not detected in the three vadose zone soil samples. The smear zone samples could not be quantified for sulfolane due to hydrocarbon interference from the three samples in this area. Sulfolane detections in the saturated zone were below the screening level of 0.043 mg/kg and ranged from 0.00506JL* mg/kg (SB-227) to 0.0158JL* mg/kg (SB-226 and SB-228).

BTEX was not detected at concentrations exceeding SCLs in samples collected from the vadose and saturated zone samples in the area west of the truck-loading rack. BTEX was detected in all samples collected from the smear zone. Benzene exceeded the SCL of 0.025 mg/kg at all three locations, with concentrations ranging from 0.306JL* mg/kg (SB-226 [7.0-9.0]) to 0.486 mg/kg (SB-227 [7.0-8.9]).

Ethylbenzene exceeded its SCL of 6.9 mg/kg in all three smear zone sample locations, with concentrations ranging from 9.22JL* (SB-226 [7.0-9.0]) to 22.8JL* (SB-228 [6.0-7.5]). Total xylenes exceeded its SCL of 63 mg/kg in smear zone samples collected from all three locations. Concentrations for p&m-xylenes and o-xylenes ranged from 37.0JL* mg/kg to

95.3JL* mg/kg and 16.0JL* to 43.7JL* mg/kg at SB-226 and SB-228, respectively. Toluene did not exceed its migration to groundwater (MTG) SCL of 6.5 mg/kg in any sample collected. Toluene detections in the smear zone ranged from 0.683JL* (SB-226) to 3.97JL* (SB-228). The saturated zone samples did not exceed the SCL for BTEX.

Sulfolane was not detected in the soil samples from the vadose zone and was less than the ADEC interim estimated soil screening level of 0.043 mg/kg in soil samples from the saturated zone. However, sulfolane could not be quantified for the majority of the soil samples collected from the smear zone due to hydrocarbon interference. BTEX impacts in soil were vertically delineated in all three borings. Concentrations of BTEX exceed SCLs in soil samples in the smear zone, but did not exceed SCLs in soil samples in the vadose or saturated zone. BTEX impacts in soil were not laterally delineated, because soil samples from the three borings contained concentrations of BTEX exceeding SCLs.

8.2.5 Lagoon B

Investigation was proposed in the area underlying Lagoon B to characterize sulfolane and BTEX concentrations in soil. During the fourth quarter 2011, sulfolane was detected in the groundwater sample from monitoring well MW-110 at a concentration of 1,150 µg/L. This monitoring well is located downgradient from Lagoon B. Also, soil samples collected downgradient from Lagoon B contained concentrations of sulfolane exceeding laboratory detection limits. Therefore, the work plan (ARCADIS 2012a) proposed collecting soil samples from the lagoon to determine if sulfolane impacts are present in Lagoon B soils.

Thirty-two soil boring locations (SB-206 through SB-225 and SB-252 to SB-263) were advanced within the lagoon. All samples were collected from the bottom of the lagoon through the liner, rather than from lagoon berms or slopes. The locations of these borings are shown on Figure 30.

Borings were advanced to the top of the water table below the lagoon bed, and soil samples were collected at depths ranging from 2 to 4 feet bgs. Sulfolane was detected at concentrations ranging from 0.0151JL* mg/kg (SB-224) to 5.95 mg/kg (SB-216). Sulfolane was detected above the screening level of 0.043 mg/kg in soil samples collected from borings SB- 211, SB -212, SB- 215, SB-216, SB-217, SB -219, SB -220, and SB-252 through SB-263.

Benzene was the only BTEX compound detected above its SCL of 0.025 mg/kg. Benzene was detected in sample SB-213 (3-3.2) at a concentration of 0.484J*. BTEX constituents either did not exceed SCLs or did not exceed detection limits in the other soil samples collected from Lagoon B.

Generally, sulfolane concentrations in soil samples from Lagoon B were the most elevated in borings located within the center of the lagoon. Soil samples collected along the peripheral

sides of the lagoon floor generally contained sulfolane concentrations less than detection limits or the ADEC interim estimated soil screening level. BTEX impacts were laterally delineated within Lagoon B, because benzene was only detected at a concentration exceeding the SCL in one sample from SB-213 (3-3.2). Borings were advanced to the top of the water table and soil samples were collected at these depths. Therefore, the vertical extents of sulfolane and BTEX impacts in unsaturated soils underlying Lagoon B were delineated.

8.2.6 Area Northwest of Lagoon B

Soil borings were proposed to the northwest of Lagoon B to delineate sulfolane and BTEX impacts from documented historical spills that have occurred near Lagoon B. The SCR – 2011 (Barr 2012) presents information pertaining to these spills. Four soil borings (SB-229, SB-230, SB-231, and SB-232) were advanced in the downgradient area northwest from Lagoon B. Samples were collected from the vadose and smear zones in these borings, except for SB-230, where samples were collected from the vadose and saturated zones at 10 to 11 feet bgs. Water was encountered in boring SB-230 at 8.6 feet bgs. The location of these borings is shown on Figure 30.

Sulfolane was not detected in the vadose zone, but was detected in the smear zone at concentrations ranging from 0.0143 mg/kg (SB-229 [5.0-6.0]) to 0.134 mg/kg (SB-232 [3.0-3.8]). Sulfolane was detected in the saturated soil sample SB-230 (10.0-11.0) at a concentration of 1.8 mg/kg. Benzene was the only BTEX compound that was detected in the area northwest of Lagoon B soil samples at a concentration of 0.0153J (SB-230 [10.0-11.0]), below its SCL of 0.025 mg/kg.

Sulfolane was not detected in the soil samples from the vadose zone, but exceeds the ADEC interim estimated soil screening level in the soil samples from the smear and saturated zones of borings SB-230, SB-231, and SB-232. Sulfolane concentrations from boring SB-229 did not exceed the ADEC interim estimated soil screening level. The lateral extent of sulfolane impacts extends northwest from Lagoon B and is relatively isolated as shown on Figure 30.

8.2.7 Area North of Asphalt Truck-Loading Rack and O-25

Soil boring locations north of the asphalt truck-loading rack area were proposed based on the detection of dissolved-phase sulfolane and benzene concentrations in observation well O-25 samples, which were collected during the first quarter 2012 (ARCADIS 2012h). This well was sampled for the first and only time during the first quarter 2012. Due to these findings, the work plan (ARCADIS 2012a) proposed advancing soil borings near O-25. Two soil boring locations (SB-233 and SB-234) were advanced adjacent to Hydropunch groundwater sampling locations HP-10 and HP-11, which identified sulfolane (55.3 and 10.8 JL $\mu\text{g/L}$, respectively) and BTEX (5.65 $\mu\text{g/L}$ in HP-10) concentrations at 13 feet bgs. Soil boring locations and concentrations are shown on Figures 33 and 34.



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Sulfolane and BTEX were not detected in soil samples analyzed from this area. This suggests that the impacts are limited to groundwater in this area. Laboratory analytical reports for soil samples collected during the advancement of these soil borings are presented in Appendix D.

9. Laser-Induced Fluorescence Investigation

During the second quarter 2012, LNAPL was observed in observation well O-27 (ARCADIS 2012d). In response to this observation, FHRA conducted an LIF investigation to delineate the vertical and horizontal extents of LNAPL near well O-27. The investigation was extended to the truck-loading rack and the northwestern corner of the tank farm.

9.1 Technical Background

LIF investigations are conducted by advancing a UVOST probe in areas of known or suspected LNAPL impact. The UVOST probe emits an ultraviolet excitation light through optical fibers that are strung through direct-push steel rods and captures returning fluorescence. The light reflects off a small parabolic mirror within the probe and exits through a window on the probe's face. The incident light excites PAH compounds that are present in most petroleum hydrocarbon mixtures, which respond by releasing photons (light) of a longer wavelength. As the probe is advanced downward, the fluorescence data form a vertical profile of LNAPL impacts at a soil boring location. The fluorescence observed is quantified by comparison to the response of a standard reference solution known as the reference emitter (RE); the results are expressed as a percentage of RE response. Some instrument response is expected in areas with no LNAPL impacts due to the fluorescent properties of native soil materials. However, background fluorescence is typically weak compared to LNAPL fluorescence and does not greatly diminish instrument sensitivity.

The UVOST probe detects four distinct fluorescent light wavelengths; the relative response magnitude of each of the four wavelengths at a given depth is collectively referred to as a waveform. Differences in waveform patterns may indicate differences in LNAPL composition or potentially the subsurface environment. Waveform changes are indicated by color shifts in the LIF boring log; snapshots of waveforms at selected depths are presented as callouts on each log.

The return (fluorescent) light signal is analyzed in real time by onsite equipment. As the probe is advanced downward, the fluorescence data form a vertical profile of LNAPL impact at a soil boring location. Results were reviewed during and after completing each LIF boring and were considered when selecting subsequent locations.

LNAPL samples were collected from observation wells O-11 and O-13 using bailers and were sent to Dakota Technologies in May 2012 to ensure that the UVOST probe would respond to the LNAPL. Dakota Technologies tested these LNAPL samples for response and a strong waveform was observed from each LNAPL sample. The UVOST log depicting the UVOST response for each LNAPL type is presented in Appendix G.

LNAPL was found to be fluorescent in bench testing and LIF was determined to be an appropriate technology for investigation. A predominant LIF waveform signature was observed in LNAPL samples that is typical of weathered jet fuel (kerosene based) as seen in

the Dakota Technologies LIF training module slide in Appendix G. The waveform displayed gradually declining peaks and is represented with a blue coloration on the LIF logs. This waveform is consistent with the interpretation of a fingerprint analysis of LNAPL collected from O-13 that is presented in Section 3.9.2 of the SCR – 2011 (Barr 2012). The green waveform observed in O-11 is potentially due to weathering and was observed in FHR-L36. FHR-L36 also depicts a strong blue peak and indicates a jet fuel signature.

9.2 Laser-Induced Fluorescence Investigation Methodology

The following methods/practices were employed during the investigation:

- The LIF/UVOST investigation consisted of hand auguring each location to a depth of 5 feet bgs and advancing a UVOST probe via direct-push technology.
- The UVOST probe was advanced using a track-mounted direct-push rig.
- Based on a correlation of the observed fluorescence with expected LNAPL distribution, it was determined that LIF readings of less than 3 percent RE were attributable to background fluorescence of aquifer materials.
- No soil samples were collected during the investigation and minimal cuttings were generated during hand auguring for utility clearance. Soil cuttings were staged in a labeled 55-gallon drum pending results of waste classification sampling.
- Boreholes were abandoned with bentonite chips after completion and hydrated with potable water.
- The same LIF equipment and LIF calibration standard were used throughout the investigation, which allows for cohesive LIF data analysis.
- The horizontal coordinates of each boring were collected using a Trimble™ GPS unit.
-

Between July 12 and 27, 2012, UVOST soil borings were advanced west of Track 4 on approximate 50-foot centers around O-27, in the truck-loading rack, and in the northwestern corner of the tank farm. The purpose of the investigation was to characterize the vertical and lateral extents of LNAPL impacts. Borings were advanced to below the observed LNAPL smear zone (determined by field inspection of the real-time LIF data) to determine the vertical extent of impact. Fifty-three borings were advanced using hand auger and direct-push technology methods in these areas; boring locations and UVOST detections are depicted on Figure 35. Borings L-48 and L-50 were not completed during this investigation due to their proximity to utilities. No soil samples were collected during the investigation.

After hand auguring borings to approximately 5 feet bgs to clear utilities, the UVOST borings were backfilled with sand to create a background reading for the probe. During drilling, field observations indicated that UVOST elevated response ended at approximately 12 feet bgs. Based on that finding, it was determined that the probe would advance an additional 4 feet; therefore, each boring was advanced to 16 feet bgs. UVOST sampling logs and a copy of the driller's UVOST report are presented in Appendix G.

9.3 Background Fluorescence

Visual inspection of the LIF logs was used to establish a site-specific “background” fluorescence response. LIF responses greater than this “background” level were considered indicative of LNAPL impact.

Based on the review of the LIF logs, a fluorescence response greater than 3 percent was used as an indication of LNAPL depending on the depth and waveform observed. Each waveform was inspected to determine if it was indicative of site LNAPL.

9.4 Areal and Vertical Distribution of Impacts

Elevated impacts were observed toward the center of the investigation area in the sand and gravel alluvium on both sides of the railroad tracks (e.g., L-6, L-37, L-40, and L-46). Results indicate that areal delineation of LNAPL onsite is complete in the truck-loading rack area to the north, which is the direction of groundwater flow, and to the southwest. No anomalies were observed for the known horizontal extent. LIF locations near monitoring wells without historical or recent LNAPL (i.e., MW-113 and O-12) thicknesses confirm the absence of LNAPL in these areas and vice versa. These data confirm and improve the current understanding of the horizontal extent of LNAPL in the areas investigated.

LNAPL was observed from 4 to 13 feet bgs along the water table across the investigation area. All LIF borings were advanced to 16 feet bgs. Background reflectance was observed at that depth at each location, indicating that the borings were advanced deep enough to provide complete vertical delineation. The data from several LIF locations were compared to soil boring logs to verify that LNAPL impacts were being observed at the same depth interval. The LIF log form FHR-L49 was compared to the soil boring log SB-123 and indicated impacts across the same depth interval of 5 to 10 feet bgs as logged by PID measurements during advancement of the boring. FHR-L41 and FHR-L42 logs were compared to the soil boring log S-109 and, consistent with the previous comparison, indicated impacts across the same depth interval of 7 to 11 feet bgs. The LIF data indicate that the vertical extent of LNAPL does not extend past 13 feet bgs. This is consistent with soil boring logs and the CSM and indicates that LNAPL resides near the water table in the sand and gravel alluvium, with an LNAPL smear zone related to seasonal groundwater table fluctuation.



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The maximum fluorescence range observed at each boring location is presented on Figure 35 and in Table 9. LIF boring logs that present the output generated by the LIF equipment are included as Appendix G.

A plan for additional characterization of LNAPL impacts at the site will be included in the 2013 On-Site Site Characterization Work Plan.

10. 2012 Site Characterization Data Quality

The samples collected for site characterization during the 2012 field season included soil obtained from monitoring wells installed under Phase 7 sulfolane delineation activities (at three well locations), soil from borings advanced to characterize soil at the site (112 soil borings), Lagoon B soil borings (34 samples), and water samples from Hydropunch characterization borings (53 locations with 250 samples collected). The SGS work orders reviewed for this section are identified below.

10.1 Phase 7 Wells

The Phase 7 well soil samples (SGS work orders 1128071, 1128383, and 1128399) were analyzed for GRO by Alaska Method AK101, BTEX by USEPA Method 8260B, and sulfolane by USEPA Method 8270D M with isotope dilution; select samples were also analyzed for DRO by Alaska Method AK102.

10.2 Hydropunch Characterization

SGS work order numbers are listed in the table below.

1127996	1128006	1128022	1128038	1128052	1128054
1128062	1128070	1128082	1128093	1128099	1128100
1128108	1128120	1128082	1128093	1128099	1128100
1128154	1128184	1128141	1128257	1128266	1128286
1128294	1128272	1128280	1128293	1128303	1128308
1128318	1128321	1128326	1128330	1128344	1128352
1128364					

Each of the Hydropunch characterization samples were analyzed for sulfolane by the method noted in Section 10.1; select samples were also analyzed for BTEX by USEPA Method 8021B.

10.3 Soil Borings and Lagoon B Soil Samples

Soil boring work order numbers are listed in the table below.

1127898	1127899	1127904	1127917	1127930	1127947
1127965	1128159	1128169	1128227	1128234	1128236

Lagoon B soil boring work order numbers are listed in the table below.

1128023	1128037	1128155	1128388
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The soil boring and Lagoon B soil samples were analyzed for sulfolane and BTEX by the methods noted above.

Data validation flags associated with this review are provided in Table 10; the data review checklists for the soil samples are provided in Appendix D.

At times, one sample may have multiple quality control (QC) issues that prompt multiple data flags. When this occurs, professional judgment is used to apply the most conservative flag to the data. QC issues are discussed in the respective work order's data review checklist; additional information regarding instances of multiple flags are also provided in the checklists. This section presents information relevant to the most conservative flags applied, if applicable.

Review of soil data and select water sample work orders (where hydrocarbon interference is identified) is followed by a review of the Level IV data packages by Environmental Standards, Inc. (ESI) to validate the data and to check that the "key elements" of the sulfolane analysis are met.

10.4 Sample Handling

Samples were generally collected and handled in accordance with the SAP (ARCADIS 2012a), as appropriate for each sampling project. Samples were maintained at the proper temperatures prior to analysis, with a few exceptions. All samples in the following work orders were received at the laboratory above the acceptable upper temperature limit (6 degrees Celsius): Hydropunch work orders 1128006, 1128093, and 1128099 (samples HP-4 20', HP-4 30', HP-4 40', HP-22 13', HP-22 24', HP-22 34', HP-22 43', HP-23 14', HP-23 24', HP-23 32', HP-23 42', HP-23 53', HP-10 13', HP-10 23', HP-10 33', HP-10 44', HP-10 54', HP-11 13', HP-11 23', HP-11 34', and HP-11 44'); and Lagoon B work order 1128023 (samples SB-206 [2.8-3.0], SB-222 [3.0-3.2], SB-223 [3.0-3.2], SB-224 [3.6-3.8], SB-225 [3.6-3.8], SB-209 [3.0-3.2], SB-213 [3.0-3.2], SB-208 [3.0-3.2], SB-207 [3.2-3.4], and SB-217 [3.2-3.4]). The affected analyses associated with these samples were BTEX and sulfolane. Results (including non-detections) from these work orders are considered biased low and appropriately flagged. If the analyte was not detected, results are flagged "UJ" at the limit of detection (LOD) to indicate that the analyte may not have been detected due to the low bias from high temperatures. Detected results are flagged "JL" to indicate that the analyte is estimated and biased low. These validation flags are shown in Table 10.

Several samples were extracted outside the acceptable holding time for various reasons. Water samples HP-46 34 and HP-44 14 were extracted outside the 7-day holding time for sulfolane analysis. Sulfolane results for these samples are considered biased low and flagged JL (sulfolane was detected in both samples). The following soil samples were extracted outside the 14-day holding time for sulfolane analysis, but within two-times the holding time (28 days): SB-203 (0.0-1.3), SB-203 (5.0-5.4), SB-204 (0.0-2.0), SB-204 (2.0-

4.0), SB-205 (0.0-2.0), SB-205 (2.0-4.0), SB-226 (0.0-2.0), SB-226 (16.0-17.7), SB-227 (0.0-2.0), SB-227 (16.0-17.3), SB-228 (0.0-2.0), SB-228 (11.5-13.0), SD-205 (0.0-2.0), SB-206 (2.8-3.0), SB-207 (3.2-3.4), SB-208 (3.0-3.2), SB-209 (3.0-3.2), SB-213 (3.0-3.2), SB-217 (3.2-3.4), SB-222 (3.0-3.2), SB-223 (3.0-3.2), SB-224 (3.6-3.8), SB-225 (3.6-3.8), and S-334-15-8. Sulfolane results for these samples are considered biased low; detected results are flagged JL and LODs are flagged UJ where sulfolane was not detected. The following soil samples were extracted outside two-times the holding time for sulfolane analysis using the water cleanup method: SB-199 (1.5-2.5), SB-200 (0.0-2.0), SD-200 (0.0-2.0), SB-226 (7.0-9.0), SB-227 (7.0-8.9), SB-228 (6.0-7.5), and SD-226 (7.0-9.0). Samples were rejected where sulfolane was not detected (flagged R) and consider the detected results biased low (flagged JL).

Other sample handling anomalies that may have affected data quality occurred in four work orders:

- In soil boring work order 1127965, the methanol field extractant leaked from the sample jars during transit. This affected two soil samples analyzed for BTEX (samples SB-228 [6.0-7.5] and SB-228 [0.0-2.0]). The BTEX results for these samples are considered to be biased low. Analytes not detected in these samples are flagged “UJ” at the LOD to indicate that the analytes may not have been detected due to the discrepancy. Analytes that were detected are flagged “JL” at the reported concentration to indicate a potential low bias. In this same work order, the methanol field extractant in sample SD-226 (7.0-9.0) was missing when the samples were received at the SGS Fairbanks receiving office. Upon receipt by SGS, methanol was added to the sample; however, all BTEX results for this sample are still considered estimated biased low and are flagged “UJ” for non-detections and “JL” for detections.
- In Hydropunch work order 1128028, all BTEX vials for sample HP-21 31 arrived at SGS containing bubbles (i.e., headspace). These results are considered estimated biased low and all BTEX results for this sample are flagged either “UJ” for non-detections or “JL” for detections.
- In the soil boring work order 1127904, the BTEX sample SB-193 (0.0-2.0) was not properly preserved and is considered estimated. However, BTEX was not detected in this sample; therefore, the results are flagged “UJ” to indicate that the analytes may not have been detected due to the discrepancy.
- The last sample handling anomaly occurred in Hydropunch work order 1128257. All BTEX bottles for sample HP-40 15 were received by SGS in a broken condition due to possibly being frozen. Because of this discrepancy, BTEX could not be analyzed for this sample and is not reported.

Review of laboratory sample receipt documents did not reveal other sample handling problems that would affect the quality or usability of the data and chains of custody were not breached. The validation flags associated with this evaluation are shown in Table 10.

10.5 Sensitivity

The analytical sample results were compared to the ADEC soil MTG cleanup levels, ADEC groundwater cleanup levels, or the ADEC sulfolane ACL to determine whether the analyses were sufficiently sensitive to detect the analytes of interest at the required levels. Each of the soil boring and Lagoon B samples, Hydropunch water samples, and Phase 7 well soil samples collected had limits of detection that were below the required cleanup levels or ACL.

Analytical method blanks (MBs) and instrument blanks (IBs) were analyzed in association with field samples to check that no laboratory-based contamination might be affecting the sample results. There were no analytes detected in MBs or IBs that had an effect on sample results.

Trip blanks were kept with the volatile analyte samples (i.e., BTEX) during sampling and shipment to the laboratory to determine if cross-contamination or contamination from an outside source may have occurred during shipment or storage. One trip blank issue occurred in Lagoon B work order 1128388. A trip blank was not included with the samples that were sent to the SGS Fairbanks receiving office. SGS added a trip blank prior to sending the samples to Anchorage for analysis. Samples in this work order contained low levels of BTEX analytes. All except two detections were flagged “J” and the others were 10 to 1,000 times below cleanup levels.

The discrepancies noted above did not affect data quality and the soil and water analyses appear to have been sufficiently sensitive for the purposes of these investigations.

10.6 Accuracy

The laboratory assessed the accuracy of their analytical methods through a variety of quality assurance (QA) procedures. Analytical accuracy for soil and water samples was assessed through analysis of laboratory control samples (LCSs) and LCS duplicates (LCSDs), which evaluate the laboratory’s ability to recover analytes added to a clean matrix. It was also assessed through analysis of matrix spikes (MSs) and MS duplicates (MSDs), which evaluate analyte recovery from matrices from the field. In addition, SGS evaluated analytical accuracy for each sample by assessing the recovery of analyte surrogates added to individual project samples. Continuing calibration verification (CCV), a standard practice to verify the calibration of the instrument, also allowed the laboratory to check for analytical accuracy.

Several samples had LCS and/or LCSD recoveries above the laboratory control limits. There were no detections of the analyte that was recovered above the laboratory control limits in

any of the associated samples; therefore, the results were unaffected by the recovery failures.

In work orders 1128159, 1128169, 1128234, 1128236, and 1128388, MS and/or MSD recovery of sulfolane was outside the laboratory control limits. For work orders 1128159, 1128234, 1128236, and 1128388, the MS/MSDs were spiked from samples not in the work order's project sample set, or it was a small spike on a high native concentration. In accordance with U.S. Army Corps of Engineers EM200-1-10, MS recovery failures only imply matrix interference if the spiked amount is at least two-times the native concentration. In these cases, the results were not considered affected by matrix interference and associated data were not flagged. However, for the MS/MSD of sample SB-236 (3.1-8.1), analyzed in work order 1128169, the MS recovery was acceptable, the MSD recovery was above laboratory control limits, and the spike amount was greater than the native analyte concentration. While the spike amount was not quite two-times the native analyte concentration, the recovery failure in the MSD (with acceptable MS recovery) may indicate a matrix effect and poor accuracy and/or precision and result in flagging the sulfolane result in the parent sample as estimated (flagged "J").

Surrogate analyte recoveries and internal standard sulfolane-d8 recoveries for sulfolane analyses were checked for each sample subjected to organic analysis. If a surrogate was recovered above or below laboratory control limits, the concentrations of the associated analytes in the sample were considered to be either biased high or low. In the case of a low surrogate recovery where the analyte was not detected in the sample, it was considered not detected at the LOD and was flagged "UJ" to indicate a possible low bias. In the case of a high surrogate recovery where the analyte was not detected, the associated analytical result was not considered to be affected and no data validation flag was applied. If an analyte was detected (either above or below the limit of quantification [LOQ]) and the associated surrogate was recovered above laboratory control limits, the analytical result was flagged "JH" to indicate that the analyte concentration may be biased high.

Several nitrobenzene-d5 surrogate recovery failures occurred for Hydropunch boring water samples and soil boring samples; however, the surrogate nitrobenzene-d5 is used for informational and comparison purposes only and does not affect sulfolane sample results.

Samples with sulfolane results (or limits of detection) associated with internal standard recovery failures were flagged "J" as estimated. A bias was not imparted because the isotope dilution method theoretically corrects the result for the high or low recovery; however, because the method is being extended beyond its usual capabilities, a "J" flag is applied in these cases to indicate the potential lack of accuracy.

Twelve samples in 11 work orders (listed below) were affected by surrogate recoveries outside laboratory control criteria and are appropriately flagged.

SGS Work Order	Sample ID	Analytical Method
1128071	S-197A-10	AK101
1128023	SB-213 (3.0-3.2)	SW8021B
1128038	HP-7 30	Sulfolane-USEPA 1625B w/Iso Dil-
1128052	HP-15 25'	Sulfolane-USEPA 1625B w/Iso Dil-
1128054	HP-19 54	Sulfolane-USEPA 1625B w/Iso Dil-
1128054	HP-20 25	Sulfolane-USEPA 1625B w/Iso Dil-
1128108	HD-01 44	Sulfolane-USEPA 1625B w/Iso Dil-
1128149	HP-25 14	Sulfolane-USEPA 1625B w/Iso Dil-
1128141	HP-26 14	Sulfolane-USEPA 1625B w/Iso Dil-
1128272	HP-46 44	Sulfolane-USEPA 1625B w/Iso Dil-
1128280	HP-44 24	Sulfolane-USEPA 1625B w/Iso Dil-
1128399	S-334-15-8	SW8021B and AK102

The list of affected results and their associated data validation flags are listed in Table 10.

CCV recoveries were within the laboratory control limits for all analyses.

Aside from the LCS/LCSD and surrogate recovery anomalies noted above, the laboratory QA data indicate that the analytical results are accurate.

10.7 Precision

Field duplicate samples were collected at a frequency of 10 percent of total samples to evaluate the precision of analytical measurements and the reproducibility of the sampling technique. The duplicate precision was assessed by evaluating the relative percent difference (RPD; the difference between the sample and its field duplicate result divided by the mean of the two). RPD can be evaluated only if the results of the analyses for both the sample and its duplicate are above LOQs. RPDs greater than 50 percent for soil samples and greater than 30 percent for water samples were considered to indicate imprecise results. Soil field duplicate RPD failures occurred (i.e., RPD greater than 50 percent), affecting the sample results identified in the table below.

SGS Work Order	Sample ID	Analyte Affected
1127947	SB-200 (0.0-2.0)	Toluene
1127947	SB-200 (0.0-2.0)	o-Xylene
1127947	SD-200 (0.0-2.0)	Toluene
1127947	SD-200 (0.0-2.0)	o-Xylene
1127965	SB-226 (7.0-9.0)	Ethylbenzene
1127965	SB-226 (7.0-9.0)	o-Xylene
1127965	SB-226 (7.0-9.0)	p&m-Xylene

Affected results were flagged “J” as estimates where analytes were detected and LODs were flagged “UJ” where analytes were not detected due to sample duplicate imprecision. The affected analytes and their associated data validation flags are listed in Table 10.

Laboratory analytical precision can also be evaluated by RPD calculations. The laboratory MS/MSD or LCS/LCSD RPDs provide information regarding the reproducibility of their procedures and, therefore, a measure of analytical precision. LCS/LCSD and MS/MSD RPDs were within the acceptable limits and data quality and usability were not affected.

Other than the results affected by RPD anomalies noted above, the analytical data collected from the soil and Hydropunch boring water samples for this project are considered precise.

10.8 Sulfolane Analysis Hydrocarbon Interference and Detection Above Calibration Range

Following the analysis of several soil and Hydropunch boring water samples collected for determination of sulfolane, petroleum hydrocarbons were found to be interfering with the sulfolane quantitation. The hydrocarbon interference led to several of the sulfolane results being flagged “R” (Table 10) as rejected, or unusable. In work order 1128191, the lab noted that for five samples the internal standard sulfolane-d8 was quantified using ion m/z 46 instead of m/z 128. After Level IV data validation by ESI, the five sulfolane samples were flagged “JN^.” This indicates that there is presumptive evidence to make a tentative identification of this compound. ESI Level IV data validation reports are included as Appendix H.

Sulfolane was detected in three soil samples (see below) above the laboratory’s upper calibration range. The laboratory identified these results with an “E” flag; however, the results presented in this report are flagged as “J” to indicate they are estimates.

The following table shows the work orders, sample names, flags, and reasons for the flags applied due to hydrocarbon interference or sulfolane above the calibration range.

SGS Work Order	Sample ID	Flag	Reason for Flag
1128052	HP-16 35	R	Result rejected due to fuel interference
1128052	HP-16 53	R	Result rejected due to fuel interference
1128052	HP-16 45	R	Result rejected due to fuel interference
1128052	HP-16 62	R	Result rejected due to fuel interference
1128191	HP-37 20	JN^	Estimated tentative identification
1128191	HP-39 15	JN^	Estimated tentative identification
1128191	HP-37 15	U^	Hydrocarbon interference
1128191	HP-36 25	JN^	Estimated tentative identification
1128191	HP-39 20	JN^	Estimated tentative identification
1128286	HP-43 25	JN^	Estimated tentative identification
1128272	HP-46 24	R	Result rejected due to hydrocarbon

SGS Work Order	Sample ID	Flag	Reason for Flag
			interference
1128280	HP-45 44	R	Result rejected due to hydrocarbon interference
1128280	HP-45 54	R	Result rejected due to hydrocarbon interference
1127899	SB-191 (5.8-7.8)	J	Result estimated; above calibration range
1127899	SB-191 (0.0-2.0)	J	Result estimated; above calibration range
1127904	SB-194 (3.6-5.6)	J	Result estimated; above calibration range

Samples with sulfolane data rejected due to hydrocarbon interference were re-extracted using SGS's aqueous-extraction protocol if sufficient sample mass remained. The samples that were re-extracted using this method did not have data flags and are not included in the table above, but may have been conducted outside the holding time (see Section 10.4).

10.9 Summary

By working in general accordance with the SAP (ARCADIS 2012a), the samples collected are considered to be representative of site conditions at the locations and times they were obtained. Aside from the issues noted above, the quality of the analytical data for these projects does not appear to have been compromised by analytical irregularities.

Table 10 lists affected results and their associated data validation flags. The laboratory reports for all soil boring and Hydropunch boring samples and the ADEC data quality review checklists for these reports are included in Appendices D and F, respectively.

11. Subsurface Microbiological Characterization

FHRA completed Bio-Trap[®] field, desorption, and seeding studies in Phase 1 of the subsurface microbial characterization. Phase 1 results and conclusions are presented in the SCR – 2011 (Barr 2012). Phase 2 of the subsurface microbial characterization was designed based on results and conclusions from Phase 1. Phase 2 has been completed and data evaluation is underway. Results from this investigation will be discussed in periodic TPT and subgroup meetings and reported under a separate cover.

12. Biodegradation Stable Isotope Investigation

FHRA conducted the first phase of a compound-specific stable isotope analysis to assess in-situ biodegradation of sulfolane in groundwater at the site. Phase 1 results and conclusions are presented in the SCR – 2011 (Barr 2012). Stable isotope monitoring augments standard geochemical parameter monitoring and provides direct evidence of biodegradation. A second phase of the biodegradation stable isotope evaluation to further understand sulfolane biodegradation characteristics in groundwater at the site has recently been completed and will be reported under separate cover.

13. Large-Scale Tracer Test Summary

ARCADIS performed a large-scale tracer injection test at the site on March 26, 2012. The tracer test was performed following completion of two potable water injection tests summarized in the Draft Final Onsite FS (ARCADIS 2012f). The large-scale tracer test was proposed in the Scope of Work for Additional Site Characterization Activities (ARCADIS 2011). The tracer study results are presented in Appendix I.

14. Summary

ARCADIS and SWI conducted the activities proposed in the work plan (ARCADIS 2012a) during the second and third quarters of 2012. The proposed activities included well installation, pressure transducer installation, production well groundwater monitoring, Hydropunch boring groundwater sampling, soil boring advancement, LIF/UVOST advancement, subsurface microbiological characterization activities, and stable carbon isotope monitoring. Additionally, ARCADIS performed a large-scale tracer injection test during the first quarter 2012 and Barr performed a hydraulic gradient study during the second quarter 2012. The subsurface microbiological characterization activities and stable carbon isotope monitoring are currently ongoing.

Field activities conducted during the second and third quarters of 2012 included:

- Installation of 23 onsite monitoring wells
- Installation of 45 offsite monitoring wells
- Advancement of 54 Hydropunch borings
- Advancement of 80 soil borings
- Advancement of 53 LIF/UVOST points

The field activities conducted during the second and third quarters of 2012 resulted in the further characterization of onsite and offsite sulfolane and onsite BTEX impacts. Furthermore, the vertical and lateral distribution of LNAPL at the site has been further delineated through LIF/UVOST points and Phase 7 well installations. The vertical and lateral extent of permafrost in onsite and offsite areas has also been further delineated. The extent of onsite permafrost from Phase 7 wells is generally consistent with previous onsite permafrost data. The extent of offsite permafrost from Phase 7 wells allowed for improved permafrost delineation in these areas within and beyond the current sulfolane plume (Figure 5).

An IRAP Addendum was submitted on January 18, 2013, which proposed interim remedial activities based on the current CSM through 2012. Remaining site characterization activities to close data gaps identified in this report will be proposed in a focused 2013 On-Site Site Characterization Work Plan (ARCADIS, In Press).

15. Recommendations

Results from site characterization activities conducted in 2012, as well as in previous years, provide a comprehensive understanding of impacts, both onsite and offsite. Past and present field activities conducted at the site support development and subsequent refinement of the current offsite and onsite CSMs. FHRA concludes that site characterization has been sufficiently addressed through additional data collection to support implementation of ongoing interim remedial actions and those proposed in the Interim Remedial Action Plan Addendum (ARCADIS 2013). Further characterization activities will continue as needed to assist with remedial actions and to further refine the onsite CSM.

16. References

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Appendix A

Source Summary Report



Appendix B

Current Conceptual Site Model



Appendix C

Boring Logs



Appendix D

Soil Samples Laboratory Data
Reports



Appendix E

Hydraulic Gradient Study



Appendix F

Hydropunch Samples Laboratory
Data Reports



Appendix G

LIF/UVOST Sample Analytical
Results and Boring Logs



Appendix H

ESI Level IV Data Validation Reports



Appendix I

Tracer Study Results