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Flint Hills Resources Alaska, LLC

2013 Offsite Site Characterization Work Plan

North Pole Refinery
North Pole, Alaska

March 12, 2013

ARCADIS

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Appendices

AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
ARCADIS	ARCADIS U.S., Inc.
ASTM	ASTM International
Barr	Barr Engineering Company
bgs	below ground surface
city	North Pole, Alaska
COPC	constituent of potential concern
CSIA	compound specific isotope analysis
CSM	conceptual site model
FHRA	Flint Hills Resources Alaska, LLC
GAC	granular activated carbon
GVEA	Golden Valley Electric Association
IRAP	Interim Removal Action Plan
LNAPL	light nonaqueous phase liquid
monitoring plan	North Pole Refinery – Deep Private Well Groundwater Monitoring Plan
NPR	North Pole Refinery
POE	point of entry
power plant	electrical generating facility
Revised Draft Final HHRA	Revised Draft Final Human Health Risk Assessment
SAP	Sampling and Analysis Plan
SCR – 2011	Site Characterization Report – Through 2011
SCR – 2012	Site Characterization Report – 2012 Addendum
site	FHRA North Pole Refinery, an active petroleum refinery located on H and H Lane in North Pole, Alaska

SOP	Standard Operating Procedure
TPT	Technical Project Team
UAF	University of Alaska – Fairbanks
work plan	2013 Offsite 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 2013 Offsite Site Characterization Work Plan (work plan) 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 site features are shown on Figures 1-1 and 1-2.

This work plan addresses recommendations presented in the Site Characterization Report – Through 2011 (SCR – 2011; Barr Engineering Company [Barr] 2012a), the Site Characterization Report – 2012 Addendum (SCR – 2012; ARCADIS 2013a) 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 other communications between the ADEC and FHRA.

It is acknowledged that in 18 Alaska Administrative Code (AAC) 75.990(115), the ADEC defines the term "site" as an "area that is impacted, including areas impacted by the migration of hazardous substances from a source area, regardless of property ownership." For this work plan, the term "onsite" is the area that is located within the property boundary of the FHRA NPR, and the term "offsite" is the area located outside the property boundary in the downgradient north-northwest direction, based on the approximate extent of the dissolved-phase sulfolane plume detected at concentrations above the laboratory limit of detection (approximately 3 micrograms per liter [µg/L]).

Site conditions were previously evaluated in the Site Characterization and First Quarter 2011 Groundwater Monitoring Report (Barr 2011), Site Characterization Work Plan Addendum (ARCADIS 2011), SCR – 2011 (Barr 2012a), and SCR – 2012 (ARCADIS 2013a). The Revised Draft Final Human Health Risk Assessment (Revised Draft Final HHRA; ARCADIS 2012a) evaluates whether concentrations of site-related constituents in groundwater pose a risk to onsite and offsite receptors.

ARCADIS and Shannon and Wilson, Inc. will complete the scope of work presented in this work plan including well installation, additional groundwater monitoring, and additional field activities at deep residential wells. These field activities will be completed by qualified persons as defined by 18 AAC 75.990.

1.1 Site Priorities

In a letter to FHRA dated August 18, 2011 (ADEC 2011), ADEC listed priorities for the site per 18 AAC 75. The additional characterization activities proposed below are intended to continue to address the ADEC's site priorities through proposed enhancements to the monitoring network and collection of additional data to support development of an aggressive cleanup plan.

1.2 Purpose

This work plan outlines proposed field activities and includes the scope, technical background, and rationale for each proposed activity. The progress of the proposed field activities will be discussed during meetings of the Site Characterization Subgroup. The proposed field activities include:

- Installation of additional Phase 8 monitoring wells and well nests for further characterization and delineation.
- Collection of groundwater samples from deep residential wells.
- Additional field work at one to two deep residential wells, including down-hole camera examinations, pressure transducer deployment, and installation of adjacent shallow piezometers for groundwater-level monitoring purposes.

Additional data collected during the proposed activities will be used to validate the human health conceptual site model (CSM) to support the groundwater model presented in the North Pole Refinery Groundwater Model Report (Geomega Inc. 2013) and to support refinement of the hydrogeological CSM. The additional data will enhance the project team’s understanding of the fate and transport of sulfolane at the site. The data will also be used to help develop the final Cleanup Plan for the site. Appendix A of this work plan presents the updated offsite human health CSM.

1.3 Alaska Department of Environmental Conservation Requests

On January 28, 2013, the ADEC issued a letter to FHRA detailing offsite data gaps identified by the ADEC team. The requested activities, FHRA’s response to the issues identified as data gaps, and proposed efforts to address them are summarized below:

1. *Prioritize monitoring locations and establish their optimal monitoring frequencies. Optimize groundwater monitoring offsite to understand and quantify concentration trends for all contaminants of concern.*

   A sampling prioritization schedule is provided in the revised Sampling and Analysis Plan (SAP), included as Appendix A of the Fourth Quarter 2012 Groundwater Monitoring Report (ARCADIS 2013c). FHRA will continue to work with the ADEC during Site Characterization Subgroup meetings to refine this prioritization on a quarterly basis, as well as to determine a reduced sampling frequency for select wells.

2. *Complete Hydrogeological CSM. The fate and transport of sulfolane must be understood both onsite and offsite in order to ensure protectiveness and determine appropriate*

cleanup alternatives. DEC disagrees with the current conceptual model and requires additional data collection to either correct or support it.

FHRA will continue to work with ADEC to refine the hydrogeological CSM, and to address critical data gaps necessary to assess risk and evaluate remediation. For example, data will be collected from deep residential wells, from newly installed offsite monitoring wells, and from the existing monitoring well network as described in Sections 4 through 6. These additional data will be used to expand and refine the current understanding of the fate and transport of sulfolane, to revise and strengthen the current hydrogeological CSM, and to inform decision making with regard to the potential utility of future investigation approaches.

3. *A) Additional multilevel well transects downgradient of the refinery and offsite. Understanding vertical and horizontal sulfolane flow pathways (including permafrost effects).*

Proposed additional offsite well locations were discussed with the ADEC during Site Characterization Subgroup meetings, and are summarized in Section 6 of this work plan. Cross sections showing offsite updated transects previously presented in the SCR – 2011 (Barr 2012a) with proposed additional well locations are included in Appendix B. These cross sections also indicate where private property access for additional wells is limited or not yet possible.

B) Transects must be coupled with CSIA (compound specific isotope analysis), microbial fingerprinting or sequencing to determine sulfolane degradation rates along suspected flow pathways.

Additional CSIA sampling and microbial fingerprinting or sequencing is not proposed at this time. As discussed with the ADEC during Site Characterization Subgroup meetings, FHRA intends to review the University of Alaska – Fairbanks' (UAF) progress with their current studies to evaluate the potential continued use of these characterization tools with regard to potential sulfolane degradation within the plume.

4. *Additional wells in areas with currently poor resolution. Understanding sulfolane flow pathways, including how sulfolane has migrated to aquifer depth of 300 feet.*

On April 26, 2012, the ADEC issued comments to FHRA for the Revised Site Characterization Report submitted March 2012 (Barr 2012b). FHRA included responses to ADEC comments in the SCR – 2011 (Barr 2012a), including a response to comment #4 above, which included discussing with the ADEC a potential scope of work regarding tracer testing at subpermafrost private well locations to determine if leaks exist around existing drinking water well locations were likely sources of sulfolane detections in deep private wells. FHRA's previous response to comment #4 was:

Tracer testing was suggested as an approach for understanding the potential connectivity of suprapermafrost and subpermafrost water bearing zones at deep well monitoring locations due to leakage of groundwater along the outside or/and inside of well casings. Specifically, the suggested approach has included: introduction of a tracer into the suprapermafrost zone at a location adjacent to a deep well, and monitoring of the deep well for evidence of tracer break-through during a pumping test of the deep well. In this approach, a detection of the tracer in the deep well would provide evidence that, under the influence of pumping at the deep well, there is potential connectivity between the suprapermafrost and subpermafrost zones.

However after further evaluation of all site data collected to date, at this time, FHRA does not believe that the results from this type of tracer test at single well locations will allow for robust conclusions with regard to the principal and relevant mechanisms by which sulfolane may be entering the subpermafrost water bearing zone. The primary issues limiting the applicability of this type of tracer test are:

- Results of tracer tests at individual locations cannot be extrapolated to the offsite area as a whole.
- Evidence of connectivity at individual well locations does not preclude other mechanisms whereby sulfolane may enter the sub-permafrost zone.
- It is not possible to quantify the potential contribution of sulfolane to the subpermafrost zone by this approach.
- This approach does little to elucidate the potential distribution of sulfolane within the subpermafrost zone.
- Absence of evidence is not evidence of absence. A lack of tracer detection in the subpermafrost zone cannot be considered evidence that there is no connectivity between the suprapermafrost and subpermafrost zones.
- Results from tracer testing at single wells would not alter the overall approach to risk assessment or remediation.

Rather, to characterize areas identified as having poor resolution and to further understand sulfolane flow pathways, FHRA proposes additional offsite well locations discussed in Section 6 of this work plan.

5. *Additional pressure transducers. Understanding sulfolane flow pathways and vertical flow.*

Installation of additional pressure transducers has been deferred pending finalization of a Standard Operating Procedure (SOP) for evaluation of the pressure transducer data and application of marginal error. Once this SOP has been finalized, data collected during fourth quarter 2012 and previous quarters will be evaluated and a plan for additional pressure transducers, if necessary, will be proposed. This will continue to be discussed in the Site Characterization Subgroup as data are evaluated.

6. *Stable isotope analysis for subpermafrost and suprapermafrost groundwater. Understanding sulfolane flow pathways, including how sulfolane has migrated to aquifer depths of 300 feet.*

   Additional stable isotope analysis efforts will be led by the UAF. The FHRA team will continue to provide support and collect samples, as determined during Site Characterization Subgroup meetings.

7. *A) Sampling for sulfolane intermediates. Are the carbon filters (GAC) in point of entry systems causing secondary contamination that could be harmful to humans?*

   B) Sampling of point of entry systems GAC. Evaluation formation of intermediates in GAC filters.

   During the February 1, 2013 Site Characterization Subgroup meeting, it was determined that additional discussion is warranted before a plan for granular activated carbon (GAC) sampling of intermediates is developed. FHRA will continue to participate in the Site Characterization and Degradation Subgroup discussions on this issue.

8. *Subpermafrost well sampling (both private wells and monitoring wells). Understanding subpermafrost sulfolane transport pathways. Why is there an increasing sulfolane concentration in a drinking water well that is over 150 feet deep? We cannot ensure protectiveness of the drinking water supply if we do not understand this dynamic.*

   In June 2012, FHRA proposed the North Pole Refinery – Deep Private Well Groundwater Monitoring Plan (monitoring plan; Appendix C). The monitoring plan (Appendix C) incorporates quarterly monitoring of private wells with reported well intakes located in the subpermafrost. FHRA has been actively pursuing access to select private wells, and implementation of the monitoring plan (Appendix C) is expected to begin in mid-March 2013. Additional investigative activities for deep private wells are proposed in Section 5 of this work plan.

   During the February 1, 2013 Site Characterization Subgroup meeting, installation of subpermafrost monitoring wells was deferred pending an evaluation of data obtained from the deep private well sampling program, as well as further discussion with the ADEC regarding the objectives and expected outcome of subpermafrost data collection.

As discussed above in response #2, FHRA will refine the hydrogeological CSM as applicable based on the results of additional data collection.

9. *Periodic sampling of selected private wells. Track trends in private wells.*

   As noted above in response #8, quarterly sampling of select private wells is expected to begin in approximately mid-March 2013. In addition, FHRA is in the process of migrating point of entry (POE) system maintenance sampling results into the sulfolane database and data will be provided to the ADEC. A SAP is currently being prepared for future sampling and validation of data collected during maintenance of the POE systems. These data will be used to further refine the site hydrogeologic CSM.

10. *Down-hole camera assessment. Determine depths of selected private wells to use as deep (subpermafrost) monitoring wells.*

    A down-hole camera assessment of select deep private wells is proposed in Section 5 of this work plan.

11. *Surface water sampling. Complete evaluation of the surface water exposure pathway.*

    A plan for surface water sampling will be proposed at a later date pending further discussion with the ADEC.

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 1-1). 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. 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 are occupied by the Petro Star, Inc. Refinery. Site features are presented on Figure 1-2.

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. Current site features are presented on Figure 1-2. Onsite and offsite site plans are presented on Figures 1-3 and 1-4, 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 River. 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 River generally consists of highly transmissive sands and gravels under water table conditions (Cederstrom 1963, Glass et al. 1996). The Tanana River has a drainage area of approximately 20,000 square miles upstream of Fairbanks (Glass et al. 1996). Near the site, this aquifer is reportedly greater than 600 feet thick (at least 616 feet thick near Moose Creek Dam) (Glass et al. 1996). Beyond the zones of influence of the site groundwater recovery system, groundwater flow directions are controlled by discharge from the Tanana River to the aquifer and from the aquifer to the Chena River, as described by Glass et al. (1996). Variations in river stage through time are believed to be the primary cause of variations in flow direction through the aquifer between the rivers (Lilly et al. 1996, Nakanishi and Lilly 1998). Based on data from U.S. Geological Survey water table wells, the flow direction generally varies from a north-northwesterly direction to a few degrees east of north. The flow direction trends to the north-northwest in spring and more northerly in the summer and fall (Glass et al. 1996).

2.3 Geology

Using information from monitoring wells installed through 2011 and private well logs obtained through 2011 cross sections were prepared for the SCR – 2011 (Barr 2012a) to show the stratigraphy in the upper alluvial deposits. The cross sections have been updated with data from monitoring wells installed in 2012 and private well logs obtained in 2012. The eight cross sections were located as shown on the cross section location map included in Appendix B; Cross Sections I-I’ through VIII-VIII’ are also included in Appendix B. The cross sections show the major stratigraphic units, depth to permafrost, zone of water table fluctuation, and dissolved-phase sulfolane data (fourth quarter 2012 for monitoring wells, historic high for private wells). Proposed Phase 8 offsite monitoring wells are described in Section 6 of this work plan and are located near existing cross sections included as proposed locations on the appropriate cross section. The cross sections will be updated with Phase 8 monitoring well data once available.

As described above, up to 2 feet of organic soils can be found at the surface of undeveloped portions of the site and surrounding area. As properties are developed, the surficial organic soils are often removed during construction and replaced with sand and gravel fill derived from local sources. As shown on the cross sections (Appendix B), fill is present at a few onsite and offsite locations at depths of up to 6 feet bgs.

Interbedded discontinuous layers of silt, fine sandy silt, and silty fine sand, with occasional peat lenses predominate the upper 10 to 15 feet of the unconsolidated soils. These soils are believed to have been deposited in sloughs and meander-cutoff channels, and as overbank flood deposits. Historical topographic maps and aerial photographs predating NPR construction show a slough and a meander loop near the current truck-loading area and silty deposits were encountered during construction of the current truck-loading rack. Peat was encountered at the MW-170 well nest from approximately 8 to 12 feet bgs and 20 to 21 feet bgs, and in several 2011 soil borings (SB-108, SB-111, SB-125, and SB-141) at depths ranging from 2.1 to 10.5 feet bgs (Barr 2012a). As is the case with the organic soils, the silty layers were often excavated and replaced with sand and gravel fill during site development.

As shown on cross sections, coarse-grained alluvial sands and gravels are present below the surficial silt/sand deposits (Appendix B). These deposits are predominantly sandy gravels and gravelly sands, with occasional discontinuous lenses of sand, silt, and rare thin lenses of peat. The gravel is fine to coarse and the sands are typically fine- to medium-grained with a relatively low fraction of coarse sand. The upper surface of these coarse-grained alluvial deposits is typically encountered within 10 to 15 feet of the ground surface. The deposits likely extend to the upper bedrock surface. Denser zones within the coarse-grained alluvial deposits have been encountered at depths of about 130 to 140 feet bgs during the installation of several deep wells, including the new city water supply wells, wells along the VPT transect, and deeper wells onsite (Barr 2012a). The dense zones slowed auger advancement during drilling. At the city well site, the dense zones did not yield water.

Permafrost has been observed in the subsurface in both onsite and offsite areas and was encountered during the installation of several site monitoring wells. Top of permafrost depths ranged from near the ground surface to approximately 151.5 feet bgs (27 to 143 feet below the water table) in monitoring well borings. Monitoring wells and/or borings installed since October 2009 were not advanced through the permafrost.

Top of permafrost depths have also been noted in the logs of residential wells installed within the last 35 years. Private well logs from unverified sources have reported that the top of permafrost encountered ranged from 1 foot to 65 feet bgs. The bottom of permafrost was reported from 14 to 245 feet bgs. The thickness of the permafrost layer was reported to range from 5 to 242 feet. The upper surface of permafrost appears to be irregular and its thickness is not well defined. Groundwater flow pathways between the suprapermafrost and subpermafrost aquifers have not been identified.

Well logs indicate that permafrost was encountered in wells at shallower depths in areas farther northwest of the refinery, especially in the area along Peridot Street between Richardson Highway and Badger Road. The upper surface of the permafrost appears to be deepest onsite and at wells installed near Badger Slough. A possible linear depression in the upper surface of the permafrost appears to extend northwest from the site.

The approximate top of permafrost is also shown on the cross sections (Appendix B). The cross sections illustrate the irregular nature of the upper permafrost, particularly onsite near the boundary between the developed and undeveloped areas west of the railroad tracks and north of the gravel pits (Cross Section IV-IV', Appendix B). Cross Section II-II' (Appendix B) shows the apparent linear depression in the upper permafrost surface that was encountered at well MW-170 and appears to trend in a northwesterly direction.

2.4 Current Offsite Groundwater Impacts

Offsite groundwater monitoring data collected during the most recent annual reporting period (fourth quarter 2012) are generally consistent with data collected during previous reporting periods. Sulfolane concentrations continue to be detected at offsite groundwater monitoring wells at concentrations up to approximately 297 µg/L (MW-161B). Fourth quarter 2012 data are presented in the Fourth Quarter 2012 Groundwater Monitoring Report (ARCADIS 2013c).

2.5 Current Remedial Operations

FHRA is currently in the final stages of implementing interim corrective actions described in the Interim Remedial Action Plan (IRAP; Barr 2010). These interim corrective actions include optimizing the existing groundwater pump and treat remediation system to address light nonaqueous phase liquid (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 volatile organic compounds before accumulating in the Gallery Pond. 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 were completed during 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 2010) implementation and groundwater pumping at well R-42 was initiated on July 26, 2011. Also, in accordance with the IRAP (Barr 2010), 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 2012a).

FHRA is in the process of installing four additional recovery wells designated as R-43, R-44, R-45, and R-46 to replace existing wells R-39 and R-40, and to augment groundwater capture in the R-21 area. Well development and piping installation were suspended due to extreme winter conditions during fourth quarter 2012. FHRA anticipates completing this project in April 2013 as winter conditions subside. The new recovery wells have a greater total depth and diameter than the existing recovery wells, which will allow a higher groundwater recovery rate and larger capture zone while maintaining LNAPL-only recovery with a skimmer system. The goal of the upgrades is to optimize groundwater capture using the full capacity of the treatment system.

Pneumatic LNAPL recovery systems are operated continuously when recoverable LNAPL is present at wells MW-138, R-20R, R-21, R-35R, and R-40. Additional pneumatic LNAPL recovery systems are operated seasonally at wells R-32, R-33, and O-2. The LNAPL recovery system installed at O-2 was removed due to low LNAPL recovery at that location and was moved to well S-50 in early 2013. 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 fourth quarter groundwater monitoring report (ARCADIS 2013c). An expanded LNAPL recovery network was proposed in the Interim Remedial Action Plan Addendum (ARCADIS 2013b).

Recovered LNAPL is recycled within the NPR 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.

3. Human Health Conceptual Site Model

An ADEC Human Health Conceptual Site Graphic Form prepared for the offsite area was most recently updated in connection with the Revised Draft Final HHRA (ARCADIS 2012a), was presented in the Draft Final Onsite Feasibility Study (ARCADIS 2012b), and is included in Appendix A of this work plan. This Graphic Form was prepared in accordance with ADEC Policy Guidance on Developing Conceptual Site Models (ADEC 2010), and was refined based on input from the ADEC and its consultants. A human health CSM evaluates potential exposure pathways, potential receptors, and general potential routes of exposure (for example, through direct contact with soil or groundwater).

The only known current offsite constituent of potential concern (COPC) is dissolved-phase sulfolane. Sulfolane is not volatile and is not readily absorbed by dermal contact, so the only exposure pathway deemed complete or potentially complete for dissolved-phase sulfolane is ingestion of groundwater, surface water, and wild or farmed foods that may be irrigated with sulfolane-impacted groundwater. Inhalation of wind-blown dust containing COPCs from onsite is also a potential exposure pathway for offsite receptors. The offsite human health CSM will continue to be refined as needed to incorporate additional data collected in the future.

4. Hydrogeological Conceptual Site Model Updates

In a letter dated January 28, 2013, the ADEC requested preparation of a robust hydrogeological CSM, to include a conceptual, graphical, and text representation of the contaminant sources/releases, groundwater flow, and contaminant flow paths, onsite and offsite, to represent the current best understanding of contaminant fate and transport at the site.

A preliminary hydrogeological CSM was presented in the North Pole Refinery Groundwater Model Report (Geomega Inc. 2013). This hydrogeological CSM will be refined and updated with information regarding assumed or understood transport mechanisms and flow pathways. Specifically, the hydrogeological CSM will be updated with data from the following:

- Quarterly monitoring of deep residential wells as described in the monitoring plan (Appendix C); an updated plan is described in Section 5 of this work plan.

- Installation and sampling of additional offsite monitoring wells as described in Section 6 of this work plan. Data from these new wells will expand the knowledge of permafrost distribution, groundwater flow patterns, aquifer material types, and sulfolane distribution.

- Ongoing monitoring of the existing offsite monitoring well network according to the revised project SAP (ARCADIS 2013c). These data will expand our knowledge of sulfolane concentration trends and plume stability offsite.

- Monitoring of stable isotopes in water as briefly discussed in Section 1.3. This monitoring may help explain the origin of supra- and sub-permafrost groundwaters at the site. FHRA will work with UAF to collect samples and UAF will complete the analysis. If results of the isotope analyses being performed by UAF are conclusive, the implications of the results will be incorporated in the hydrogeological CSM.

The hydrogeological CSM will be developed in conjunction with Modeling Subgroup discussions. Findings from the above activities will be discussed within the Modeling Subgroup, and will be used to support ongoing modeling efforts as part of the development of the hydrogeological CSM. A pictorial representation of the offsite hydrogeological CSM will be developed to facilitate communication regarding the potential for sensitive receptor exposure to dissolved-phase sulfolane in groundwater. Ongoing hydrogeological CSM development and refinement based on available data and the new offsite data listed above will continue to be informed by the guidance provided in the ASTM International (ASTM) Standard Guide for Developing Conceptual Site Models for Contaminated Sites (ASTM 2008), and by the ADEC Policy Guidance on Developing Conceptual Site Models (ADEC 2010).

5. Deep Private Well Groundwater Monitoring Plan

FHRA submitted a monitoring plan to the ADEC on June 20, 2012 (Appendix C). The objectives of this monitoring plan (Appendix C) were to:

- Establish a groundwater monitoring network of deep private wells with intake intervals reported to be in the subpermafrost zone.

- Establish a baseline dataset of sulfolane concentrations and geochemical conditions at the deep private well groundwater monitoring network.

- Monitor sulfolane concentrations and geochemical conditions quarterly at deep private wells in areas where sulfolane has previously been detected, for a 2-year period.

Seventeen monitoring locations were identified in the monitoring plan (Appendix C), with six locations outside of the zone where sulfolane was detected in groundwater (also known as perimeter monitoring locations), and 11 locations within the zone where sulfolane was detected (Figure 1 in Appendix C). Between one and seven deep private wells with intake intervals reported to be in the subpermafrost zone were identified at each of the proposed monitoring locations (Figure 1 and Table 1 in Appendix C).

The monitoring plan (Appendix C) proposed a two-phase implementation approach. The objective of Phase I was to select at least one candidate well at each proposed monitoring location, and obtain access agreements for sampling the selected wells. Phase I progress to date is summarized below:

- Selected candidate private wells at each of the 17 proposed locations.

- Determined that access to private wells at two of the proposed monitoring locations within the zone where sulfolane was detected (locations 11 and 17) was not feasible.

- Initiated access agreements with 18 well owners at the remaining 15 proposed locations. Multiple candidate wells were selected at location 12 (three wells) and location 15 (two wells) (Figure 5-1).

- Identified one newly installed well (location 18) within the zone where sulfolane was previously detected, and this well was added to the proposed monitoring network.

- Obtained written access agreements from well owners at 15 of the 19 currently proposed monitoring locations (Figure 5-1).

- Obtained verbal access agreements from an additional two well owners (Figure 5-1).

- Pursuing access from well owners at locations 3 and 4 (Figure 5-1).

Available details from well installation logs for wells currently included in the proposed monitoring network are summarized in Table 5-1.

Phase II of the monitoring plan (quarterly sampling; Appendix C) will be initiated during first quarter 2013. Sampling schedules are currently being finalized, with the initial sampling event expected to be conducted during the last two weeks of March 2013. Quarterly sampling is also planned for early June, late September, and early December 2013.

The connectivity of, and vertical gradients between, suprapermafrost and subpermafrost water-bearing zones remain under investigation offsite. In a continuing effort to address this question, a third phase of deep well monitoring is proposed. During the proposed Phase III activities, between one and four private wells will be selected from the deep private well monitoring network for further investigation. The additional proposed work at the selected Phase III locations includes:

- Down-hole camera inspection.
- Installation of a suprapermafrost piezometer adjacent to the deep well.
- Installation of automated pressure transducers in both the suprapermafrost piezometer and the adjacent deep well.

The purpose of the proposed down-hole camera inspections are:

- Verify the well depths reported in well installation logs.
- Examine the integrity of the inside of the well casing and screen prior to initiating any additional work.

Specifically, the inside of the well casings and screens will be examined using the down-hole camera for evidence of cracking or other discontinuities such as broken well materials, corrosion, or encrustations. If the inside of the well casings or well screens are found to be damaged, deteriorated, or plugged with solid precipitates, this could be an indication that the integrity of the well seal has been compromised and the project and/or technical manager will be contacted prior to proceeding with additional work.

The purpose of installing shallow piezometers adjacent to the selected deep private wells is to provide water level-monitoring data that may be used to evaluate the direction and magnitude of vertical hydraulic gradients if present and measurable. The purpose of installing pressure transducers is to collect automated groundwater level monitoring data that would allow an assessment of the absence or presence of transient groundwater level fluctuations in the water bearing zone where deep wells are completed and the suprapermafrost zone, with the aim of better understanding the connectivity of water bearing zones.

During the preliminary quarterly monitoring event, the suitability of private wells for the proposed Phase III activities will be evaluated. Suitability for this work will be based on:

- Access to the wellhead.
- Availability of an alternate water source for the well owner.
- Agreement by the well owner regarding the installation of a suprapermafrost piezometer on their property.

The well at location 7 (Figure 5-1) was identified as the first candidate for a down-hole inspection because this residence is connected to the municipal water supply; scheduling of this inspection is underway. FHRA is working to identify other private wells where down-hole inspections may be feasible and desirable. Finally, during Phase I implementation, two private well locations with both shallow and deep wells were identified (location 15a and location 18; Figure 5-1). These wells may potentially be used for further investigation of the connectivity of water-bearing zones without the installation of a suprapermafrost piezometer. Groundwater samples will be collected from both wells at each of these locations during the preliminary quarterly sampling event, and the suitability of these locations for down-hole inspection and subsequent transducer deployment will be evaluated based on ease of access to both wellheads, availability of an alternate water source for the well owner, and agreement by the well owner regarding the installation of pressure transducers in their wells.

Private wells will be decontaminated following deployment of down-hole instruments, and as necessary, in accordance with appropriate regulations. Purge water generated during sampling and decontamination procedures will be disposed of according to the SAP (ARCADIS 2013c).

6. Offsite Phase 8 Groundwater Monitoring Well Installation

Phase 7 monitoring well installation was completed in August 2012 (ARCADIS 2013a) to provide additional site characterization offsite. Horizontal and vertical delineation of the sulfolane plume has progressed; however, to further enhance the understanding of the nature and extent of sulfolane impacts, FHRA proposes to install additional offsite Phase 8 monitoring wells and well nests. Proposed wells and well nests described in this section are summarized in Table 6-1 and presented on Figure 6-1.

Cross sections originally presented in the SCR – 2011 (Barr 2012a) were updated with Phase 7 wells installed in 2012 and proposed offsite Phase 8 monitoring wells and are included in Appendix C.

6.1 Proposed Additional Monitoring Wells at Existing Well Nests

To further enhance the understanding of the nature and extent of sulfolane impacts and permafrost depths at select monitoring wells, FHRA proposes to install additional offsite monitoring wells at five existing monitoring well nest locations (8-O, 8-P, 8-X, 8-Z, and 8-AE). Proposed well nests described below are summarized in Table 6-1 and are presented on Figure 6-1.

One new monitoring well designated as 8-O is proposed to replace damaged well MW-160A. The replacement well will be screened across the water table to evaluate sulfolane concentrations in groundwater within the plume interior. This well cluster is located at the intersection of Cross Sections II-II' and VI-VI' (Appendix B). Data collected during installation of this proposed well will confirm the data presented on each cross section.

One additional deeper monitoring well designated as 8-P will be installed at well nest MW-317 to further characterize the depth to the top of permafrost at this location. This well cluster is located on Cross Section V-V' (Appendix B). Data collected during installation of this proposed well will further refine the depth to the top of permafrost data presented on this cross section.

Three additional monitoring wells at the location designated as 8-X will be installed at existing well nest MW-332 to further evaluate the vertical distribution of sulfolane concentrations in this area. Existing monitoring wells at nest MW-332 in this area extend to depths of 15 and 150 feet bgs. Permafrost was not encountered at this location. The proposed monitoring wells will be installed to depths of 40, 70, and 110 feet bgs.

One replacement and one additional monitoring well designated as 8-Z are proposed for installation at existing well nest MW-190. During first quarter 2013 monitoring activities, well MW-190B was confirmed as damaged. Monitoring well MW-190B will therefore be replaced to a total depth of 60 feet bgs. One additional monitoring well will be installed to determine the depth to the top of permafrost at this location.

One additional monitoring well designated as 8-AE is proposed at existing well nest MW-161 to further evaluate the vertical distribution of sulfolane concentrations in this area. Existing monitoring wells extend to depths of 15 and 50 feet bgs at well nest MW-161. Permafrost was encountered at a depth of 54 feet bgs at this location. The proposed monitoring well will be installed to an intermediate depth of approximately 30 feet bgs. This well cluster is located at the intersection of Cross Sections I-I' and VII-VII' (Appendix B). Data collected during installation of the proposed monitoring well will further refine the data presented on each cross section.

6.2 Proposed Additional Monitoring Well Nests

Horizontal and vertical delineation of the sulfolane plume has progressed; however, to further enhance the understanding of the nature and extent of sulfolane impacts and presence of permafrost, FHRA proposes to install 12 additional offsite monitoring well nests (8-Q, 8-R, 8-S, 8-T, 8-U, 8-V, 8-W, 8-Y, 8-AA, 8-AB, 8-AC, and 8-AD). Each well cluster is proposed to include one well screened across the water table, one well installed to the top of permafrost, and one intermediate well. Installation of an intermediate well at these new well nests is contingent on the depth to permafrost. If permafrost is encountered deeper than approximately 50 feet bgs, an intermediate well will be installed. Proposed well nests described below are summarized in Table 6-1 and are presented on Figure 6-1:

- Proposed well clusters 8-Q and 8-R will be installed to characterize increasing sulfolane concentration trends hydraulically upgradient from existing wells MW-161 and MW-187 and in residential areas with elevated sulfolane concentrations. These well clusters are located on Cross Section I-I' (Appendix B). Data collected during installation of these proposed well clusters will further refine the data presented on each cross section.

- Proposed well clusters 8-S and 8-T will be installed to characterize increasing sulfolane concentration trends hydraulically crossgradient from existing well MW-161 and in residential areas with elevated sulfolane concentrations. Well cluster 8-S will be projected onto Cross Section VII-VII' (Appendix B). Data collected during installation of proposed well clusters 8-S will further refine the data presented on the cross section.

- One new well cluster designated as 8-U will be installed to characterize suprapermafrost sulfolane concentrations downgradient from a residential well installed below 160 feet bgs that exhibits an elevated concentration (154 µg/L).

- Proposed well clusters 8-V and 8-AB will be installed to further characterize sulfolane concentrations along Cross Section II-II' (Appendix C). Data collected during installation of these proposed well clusters will further refine the data presented on the cross section.

- One new well cluster designated as 8-W will be installed to characterize sulfolane concentrations near existing well cluster MW-332.

- One new well cluster designated as 8-Y will be installed to characterize sulfolane concentrations on the east side of Badger Slough across from well MW-190.

- Proposed well cluster 8-AA will be installed to further characterize sulfolane concentrations on the west side of Badger Slough.

- Proposed well cluster 8-AC will be installed to further characterize sulfolane concentrations on the south side of Badger Slough, across from well MW-181 and near the intersections of Cross Sections II-II’ and VIII-VIII’. Data collected during installation of the proposed well cluster will further refine the data presented on each cross section.

- Proposed well cluster 8-AD will be installed to further characterize sulfolane concentrations along the plume edge and on the west side of Badger Slough.

Soil samples will be collected during installation of these proposed wells for lithological description and screening in accordance with the SAP (ARCADIS 2013c). The additional proposed wells will be sampled in conjunction with quarterly groundwater monitoring events according to procedures outlined in the SAP (ARCADIS 2013c). Collected groundwater samples will be analyzed for concentrations of sulfolane using modified United States Environmental Protection Agency Method 1625 with isotope dilution.

7. Schedule and Reporting

Data collected during the proposed additional site investigation activities will be validated and posted to the NPR data sharing portal. Also, validated data will be added to the historical site data set. The CSM and groundwater model will be refined as appropriate, based on the findings of these assessments. The data will support the preparation of the Final Offsite FS and Cleanup Plan.

Activities proposed in this work plan are anticipated to be completed during the 2013 field season. Updates on data collection will be presented to the ADEC during TPT meetings, Site Characterization Subgroup meetings, and in quarterly groundwater monitoring reports. Data collected during 2013 will be reported in a 2013 addendum to the site characterization report.

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Appendix **A**

Human Health Conceptual Site Model

Appendix **B**

Updated Cross Sections

ARCADIS

Appendix **C**

North Pole Refinery – Deep Private Well Groundwater Monitoring Plan

Tables

Figures