Remedial Investigation Report

Airport Kwik Stop Site
Ione, Washington

for
Washington State Department of Ecology

January 29, 2013

GeoEngineers
Earth Science + Technology

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File No. 0504-058-02

January 29, 2013

Prepared for:

Washington State Department of Ecology
Toxics Cleanup Program
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ACRONYMS

AS - Air Sparge
ASTs - above ground storage tanks
ASTM – ASTM International
Avgas - aviation gasoline
bgs - below ground surface
BTEX - benzene, toluene, ethylbenzene and xylenes
BV - bioventing
cfm - cubic feet per minute
COC – chain-of-custody
COPCS - contaminant of potential concern
CSM - Conceptual Site Model
DCAP – Draft Cleanup Action Plan

ACRONYMS (CONTINUED)

DO – dissolved oxygen
DRPH - diesel-range petroleum hydrocarbon
Ecology - Washington State Department of Ecology
EDB - 1,2-dibromoethane
EDC - 1,2-dichloroethane
EMIMD - electromagnetic induction meter detection
EPA – Environmental Protection Agency
fpm - feet per minute
FS - Feasibility Study
gpm - gallons per minute
GPR - Ground Penetrating Radar
GRPH - gasoline-range petroleum hydrocarbons
iow - inches of water
IDW - investigation derived waste
kg – kilogram
LCS – laboratory control sample
LCS/LCSD – laboratory control sample/laboratory control sample duplicate
LNAPL - light non-aqueous phase liquid
mg/kg - milligrams per kilogram
MA - million years
mg – milligram
MS – matrix spike
MSD – matrix spike duplicate
MS/MSD – matrix spike/matrix spike duplicate
MTBE – Methyl-tertiary butyl ether
MTCA - Model Toxics Control Act
mV = millivolts
NAPL – non-aqueous phase liquid
NAVD - North American Vertical Datum
NOAA – National Oceanic and Atmospheric Administration
ORP – oxidation-reduction potential
ORPH - oil-range petroleum hydrocarbon
pcf – pounds per cubic foot
ppm – parts per million
ppmv - parts per million by volume
PID - photo-ionization detector
PQL - practical quantitation limit
psi - pounds per square inch
PVC - polyvinyl chloride
QC – quality control
QC/QA – quality control/quality assurance
RCW – Revised Code of Washington
RI - remedial investigation
RI/FS –remedial investigation/feasibility study
SAP - Sampling and Analysis Plan

ACRONYMS (CONTINUED)

Site – Airport Kwik Stop Site
SVE – soil vapor extraction
TEE - terrestrial ecological evaluation
TPH - total petroleum hydrocarbon
μg/L - micrograms per liter
μg/m^3 - micrograms per cubic meter
USEPA – US Environmental Protection Agency
USGS - United States Geological Survey
UST – underground storage tank
WAC - Washington Administrative Code
WSDOT - Washington State Department of Transportation
VOCs - volatile organic compounds

EXECUTIVE SUMMARY

INTRODUCTION

This remedial investigation (RI) report describes investigations conducted by GeoEngineers, Inc. (GeoEngineers) between November 2011 and August 2012 at the Airport Kwik Stop Site (Site), located near the intersection of Greenhouse Road and State Highway 31, near Ione, Washington. This report also summarizes our assessment activities conducted at the Site in 2010 and 2011. The general location of the Site is shown with respect to surrounding physical features in the Vicinity Map, Figure 1.

The purpose of this RI was to collect, develop and evaluate sufficient soil and groundwater data to determine what cleanup actions at the Site are necessary pursuant to the Model Toxics Control Act (MTCA), Revised Code of Washington (RCW) 70.105D. This RI was prepared in general accordance with the approved remedial instigation/feasibility study (RI/FS) Work Plan dated November 22, 2011.

In addition to the November 2011 through August 2012 investigations, the results of previous site characterization and groundwater monitoring activities conducted between April 2010 and August 2011 provide a comprehensive summary of Site conditions. Results of these previous site characterization activities indicated that vadose zone soil at the Airport Kwik Stop near the fuel dispensers was contaminated with petroleum products, specifically gasoline-range petroleum hydrocarbons (GRPH) and benzene, toluene, ethylbenzene and xylenes (BTEX) compounds, and that a plume of petroleum-contaminated groundwater was present within a shallow unconfined aquifer underlying the Site. The plume extended from the Airport Kwik Stop towards the southeast, and had impacted the domestic water well located on the nearby Cabin Grill property. Results of previous site characterization activities also indicated that contaminated soil and groundwater was not present at the adjacent Ione Airport property.

Additionally, subsequent to completion of RI activities, an interim remedial action was designed for the Airport Kwik Stop to remove vadose zone petroleum contamination. The interim remedial action consists of a soil vapor extraction (SVE)/bioventing (BV) system. The intent of the system is to initially operate as an SVE system by applying a vacuum to wells screened within the contaminated vadose zone, thereby volatilizing and extracting petroleum contaminants from the soil, removing them as a source for additional groundwater contamination. Future operations likely will include pumping air into the vadose zone soil (BV), thereby stimulating biodegradation of remaining petroleum contamination in the vadose zone.

SITE DESCRIPTION

The Site is a former gas station and convenience store, bounded on the east by State Highway 31, on the south by Greenhouse Road, and on the west and north by residential and undeveloped property. Additionally, the Site encompasses surrounding property, including the Ione Airport, the Cabin Grill property, Vacant Property located east and south of the Airport Kwik Stop, and several private residences, also located east and south of the Airport Kwik Stop. While it is shown on the

Site Plan, Figure 2, and was initially investigated as a possible source of groundwater contamination at the Cabin Grill and other downgradient properties, results of subsurface exploration and analytical testing indicate that the Ione Airport is not a source of contamination at the Site. Therefore, the Ione Airport is no longer considered part of the Site. However, because of the presence of an existing crossgradient well on the property and the available date, discussions of the Ione Airport are presented in this report. General site features and property boundaries and the approximate limits of the groundwater contamination as of May 2012 are presented in the Site Plan, Figure 2.

RI SCOPE

The scope of work for the RI at the Site is described in detail in the RI/FS Work Plan and included the following:

- Obtaining water samples from downgradient privately-owned domestic water wells, and submitting samples to a qualified analytical laboratory for analysis of the concentrations of GRPH and volatile organic compounds (VOCs).
- Completing a geophysical survey of portions of the Airport Kwik Stop and Cabin Grill properties to evaluate the properties for the possible presence of underground storage tanks (USTs) as alternative sources of petroleum contamination. This was performed by a subconsultant under contract to GeoEngineers.
- Further delineating the extent of vadose zone contamination near the Airport Kwik Stop fuel dispensers and the downgradient extent of the plume of petroleum-contaminated groundwater by completing 15 direct-push borings.
- Drilling hollow-stem auger borings and installing groundwater monitoring wells and pilot test wells. A total of 11 hollow-stem auger borings were drilled. Four new groundwater monitoring wells were installed, two monitoring points were installed, two SVE pilot test wells were installed, and one air sparge (AS) pilot test well was installed. Two of the borings were backfilled in accordance with applicable regulations. Select soil and groundwater samples obtained from the borings were submitted for laboratory analyses intended to identify petroleum contamination.
- Completing AS and SVE pilot testing at the Airport Kwik Stop. A pumping test was originally part of the RI work plan. However, due to the expansion of the contaminated plume and related concerns regarding the safety and costs of pumping, handling and disposing of contaminated water, this item was not completed. In lieu of pumping tests, slug tests were completed in selected Site monitoring wells in order to estimate hydraulic properties of the shallow aquifer underlying the Site.
- Completing groundwater monitoring activities during four quarterly events between November 2011 and August 2012, including measuring groundwater elevations and collecting and submitting groundwater samples to an analytical laboratory for analyses intended to identify petroleum contamination. An additional monitoring event was completed in December 2011 to sample select wells after analytical results from the November 2011 monitoring event indicated a change in the extent of the plume of contaminated groundwater.

SUMMARY OF INVESTIGATION ACTIVITIES

A total of 71 subsurface explorations have been completed at the Site as part of previous site characterization and recent RI activities. Twenty-nine explorations have been completed at the Airport Kwik Stop property (including 17 as part of RI activities). Fourteen explorations have been completed at the Ione Airport (none as part of RI activities). Twelve explorations have been completed at the Cabin Grill property (one as part of RI activities). Sixteen explorations have been completed on the Vacant Property located south and east of the Airport Kwik Stop (eight as part of RI activities). Eight quarterly groundwater monitoring events have been completed (including three as part of RI activities). Water samples also have been collected from private domestic water wells located downgradient of the Airport Kwik Stop. A geophysical survey has been completed to evaluate the possible presence of USTs located at other areas of the Site. Pilot SVE and air sparge testing has been completed at the Airport Kwik Stop. Slug tests were performed in select Site monitoring wells to estimate hydraulic parameters of the shallow unconfined aquifer.

RESULTS

Results of RI and previous site characterization activities indicate that soil and groundwater at the Airport Kwik Stop is contaminated with GRPH and VOCs, particularly BTEX compounds, at concentrations greater than MTCA Method A cleanup levels for unrestricted land use. GRPH has been detected in soil samples at concentrations ranging from below laboratory detection limits to 17,200 milligrams per kilogram (mg/kg). Results further indicate that the source of contamination is near the Airport Kwik Stop fuel dispensers, and extends from a depth of less than 2 feet below ground surface (bgs), down to the groundwater table (about 35 to 40 feet bgs). Vadose zone soil contamination also extends radially about 30 to 60 feet from the premium fuel dispenser, in a roughly conical shape. A zone of heavily contaminated soil is present underlying the premium fuel dispenser. Contaminated groundwater also is present underlying the Airport Kwik Stop.

Results of groundwater monitoring indicate that the groundwater flow direction under the Site is generally east-southeast, which means that properties located east-southeast of the Airport Kwik Stop (which included the Cabin Grill, Vacant Property and several residential properties), as well as the Pend Oreille River, are located downgradient of the source of petroleum contamination. Results of groundwater monitoring also indicate that groundwater elevations have risen, on average, about 3 feet between the first monitoring event in August 2010 and the latest groundwater monitoring event in August 2012. The groundwater flow regime downgradient of the Airport Kwik Stop also began to shift sometime around August 2011, from a southeasterly direction, to a more east to east-southeasterly direction.

Results of analytical testing of groundwater samples obtained from Site monitoring wells during the groundwater monitoring events, and from downgradient domestic water wells, indicates that the plume of petroleum-contaminated groundwater extends from the Airport Kwik Stop, towards the east and southeast approximately 1,400 lineal feet. At least three domestic water wells are now impacted by the plume.

Results of soil and groundwater sampling at the Ione Airport did not detect GRPH or BTEX compounds, indicating the Ione Airport is not a source of contamination at the Cabin Grill and other downgradient properties. Therefore, the Ione Airport is not considered part of the Site. Shallow vadose zone soil contamination was not detected in Site subsurface explorations other than those located near the fuel dispensers at the Airport Kwik Stop. GRPH and/or BTEX compounds were detected in several soil samples collected near the groundwater interface within several explorations at the Cabin Grill and Vacant properties. Those detections were attributed to the smear zone caused by fluctuations of the groundwater table and the presence of petroleum-contaminated groundwater observed in monitoring wells on these properties.

1.0 INTRODUCTION

This report presents the objectives and results of remedial investigation (RI) activities conducted by GeoEngineers, Inc. (GeoEngineers) between November 2011 and August 2012 at the Airport Kwik Stop Site (Site), located near Ione, Washington. In addition to the RI activities, this report also includes and summarizes the results of previous site characterization activities, completed between April 2010 and August 2011. The approximate site location is shown in the Vicinity Map, Figure 1.

GeoEngineers is performing this RI on behalf of the Washington State Department of Ecology (Ecology). The Site is listed on the Ecology Site Database as Facility Site ID 32584416. The Site also includes several other surrounding properties.

Investigation activities have included: (1) several rounds of subsurface exploration and laboratory analytical testing of soil samples obtained from the explorations; (2) installation of monitoring wells on the Site; (3) quarterly groundwater sampling of Site monitoring wells; (4) periodic sampling and testing of water from nearby domestic water wells; (5) completing a geophysical survey of selected areas of the Site; (6) conducting pilot soil vapor extraction (SVE) and air sparge (AS) testing; and (7) conducting in-situ slug tests to evaluate hydraulic properties of the shallow unconfined aquifer underlying the Site. Details regarding assessment and monitoring activities at the Site and nearby properties are presented in previous reports for this project, which are listed in the "References" section of this report. The Site and areas of interest are shown in in the Site Plan, Figure 2.

The Site is located approximately 1½ miles south of Ione, Washington, and about ¼ mile west of the Pend Oreille River. Results of RI and previous investigation activities document soil at the Airport Kwik Stop is contaminated with gasoline-range petroleum hydrocarbons (GRPH) and volatile organic compounds (VOCs), particularly benzene, toluene, ethylbenzene and total xylenes (BTEX) compounds. Results of groundwater monitoring and analytical testing confirm a plume of petroleum-contaminated groundwater extends from the Airport Kwik Stop, towards the east and southeast, and has impacted at least three downgradient domestic water wells.

This RI report was prepared in general accordance with the requirements defined by the Model Toxics Control Act (MTCA) Regulation (Washington Administrative Code [WAC] 173-340-350) for submittal to Ecology. Appendices to this RI include Appendix A – Remedial Investigation Drilling and Groundwater Sampling Field Methods; Appendix B – Soil Physical Laboratory Testing Results; Appendix C - Soil and Groundwater Analytical Results Tables; Appendix D – Slug Test Results; Appendix E – SVE and AS Pilot Test Results; Appendix F – Laboratory Analytical Data Quality Assessment Summary; Appendix G – Geophysical Survey Report and Appendix H - Laboratory Analytical Reports for RI-Phase Soil and Groundwater Sampling.

1.1. RI Objective

The objective of this RI was to collect, develop and evaluate sufficient information to augment previous site characterization activities, and to determine what areas at the Site require cleanup and should be analyzed in the feasibility study (FS). This RI report also references summaries of the previous investigations conducted at the Site.

1.2. Report Organization

Section 2.0 of this report describes Site history, environmental setting, current land uses, basis of concern and regulatory framework. **Section 3.0** describes cleanup standards development. A summary of Site investigation activities associated with the RI and previous site characterization activities are presented in **Section 4.0**. **Section 5.0** describes soil investigation and analytical test results. **Section 6.0** explains groundwater investigations and presents the results of these investigations. **Section 7.0** presents estimates of the mass of petroleum products in site media. **Section 8.0** describes SVE and air sparge pilot test results. **Section 9.0** presents a conceptual site model based on existing data. **Section 10.0** describes the locations and media that should be evaluated in the FS, based on the results of the RI. **Section 11.0** presents report references and acronyms.

2.0 SITE DESCRIPTIONS, HISTORY, AND REGULATORY FRAMEWORK

This section describes the Site, including properties adjacent to and formerly part of the Site (Ione Airport). This section also provides location, history and current uses, and describes the existing regulatory framework.

2.1. Property Descriptions

2.1.1. General

The Site is located about 1½ miles south of the Town of Ione, Washington, and about ¼ mile west of the Pend Oreille River, near the intersections of State Route 31 and Greenhouse/Dewitt Roads. For the purposes of this report, the Site refers to the Airport Kwik Stop property and several nearby properties that have been investigated as part of site assessment activities. To be consistent with descriptions in previous site characterization reports, these nearby properties include: (1) the Cabin Grill property; (2) the Ione Airport property; and (3) currently vacant properties located east and south of the Airport Kwik Stop and Cabin Grill (Vacant Properties). In addition to these properties, which have been the subject of previous site characterization activities, water samples have recently been collected and sampled from nearby domestic water wells associated with private residences located downgradient and surrounding the Airport Kwik Stop. Additionally, portions of the Site also are located within rights-of-way administered by the Washington State Department of Transportation (WSDOT). The approximate locations of the subject properties and the estimated extent of contaminated groundwater are presented in Figure 2.

2.1.2. Airport Kwik Stop

The Airport Kwik Stop (Property ID No. 6477, Geographic ID 433707449008 based on Pend Oreille County Assessor records) is a former convenience store, retail fuel sales operation facility located northwest of the intersection of State Highway 31 and Greenhouse Road. The property is bounded on the east by State Highway 31, on the south by Greenhouse Road, and on the west and north by residential and undeveloped property. The ground surface is relatively level. The Kwik Stop building is located near the southeast portion of the property, fronting State Highway 31 and Greenhouse Road. The fuel dispensers are located about 50 to 75 feet northwest of the intersection. Three former USTs were located on the property, presumably on the north side of the building about 100 to 200 feet from the intersection. Currently, above ground storage tanks (ASTs) are located behind (west) of the building, about 200 feet from the intersection.

2.1.3. Cabin Grill

The Cabin Grill (Property ID No. 6714, Geographic ID 433718519001 based on Pend Oreille County Assessor records) property is located southeast of the intersection of State Highway 31 and Dewitt Road. The property is bounded on the north by Dewitt Road, on the west by State Highway 31, and on the east and south by undeveloped property. The property generally is level, with a slight topographic high point east of the Cabin Grill restaurant. Most of the ground surface is covered with field grass and stands of pine trees. A gravel parking area surrounds the Cabin Grill restaurant. A single family residence also is located on the property south of the Cabin Grill restaurant. A domestic water well is located near the south side of the Cabin Grill restaurant, about 375 feet southeast of the Airport Kwik Stop fuel dispensers. The existing domestic well provides water to both the Cabin Grill restaurant and the single family residence.

2.1.4. Vacant Properties

The Vacant Properties are located northeast of the intersection of State Highway 31 and Dewitt Road, and south and east of the Cabin Grill property. The northern portion of the Vacant Properties (Property ID No. 6475 and 6422, Geographic ID 433707449006 and 433707040004 based on Pend Oreille County Assessor records) extends about 850 feet north of Dewitt Road and about 530 feet east of State Route 31. The southern portion of the Vacant Properties (Property ID No. 6611, Geographic ID 433717529009) is roughly triangular shaped, and measures about 75 feet east-west near the north property boundary, about 1,000 feet east-west near the south property boundary, and about 1,200 feet north-south. The southern portion of the Vacant Properties is bounded on the east by Stillwater Road, on the north by Dewitt Road, and on the west and south by sparsely populated residential and undeveloped property. The property is undeveloped and most of the ground surface is covered with field grass. A hand dug well is located about 100 feet north of Dewitt Road and 60 feet east of State Highway 31. The hand-dug well is about 8 feet in diameter and constructed of concrete. An approximate 3-foot-diameter concrete hatch provides access to the well. At the time of field work, concrete blocks had been stacked on top of the access hatch and wire fencing had been erected around the well. The northern portion of the Vacant Properties is relatively level, with a gradual slope down towards the east. The southern portion of the Vacant Properties slopes gently down approximately 25 to 30 vertical feet from the northwest towards the southeast.

2.1.5. Private Residences

2.1.5.1. PROPERTY ID NO. 6610

Property 6610 (Geographic ID 433717529008 based on Pend Oreille County Assessor records) is located east the intersection of Dewitt Road and Stillwater Road. The property is bounded on the north by the Vacant Property, on the east by the Pend Oreille River, on the south by residential property and on the west by Stillwater Road. The ground surface slopes down from west to east towards the river, with an elevation difference in the range of about 50 to 60 feet. The property includes a single family residence located in the eastern portion of the property. Two domestic wells are located on the property. A drilled well is located near the south property boundary. A hand-dug well is located near the northeast portion of the property. The current property owner also installed two new wells on the property in the summer of 2012. Well construction records were not available. The property is covered by a mixture of field grass and trees.

2.1.5.2. PROPERTY ID NO. 6608 AND 6609

Property 6608 and 6609 (Geographic ID 433717529006 and 433717529007 based on Pend Oreille County Assessor records) are located south of Property ID 6610. These properties are bounded on the north and south by residential properties, on the east by the Pend Oreille River, and on the west by Stillwater Road. The ground surface slopes down from west to east towards the river, with an elevation difference in the range of about 50 to 60 feet. The properties are occupied by a single family residence located in the eastern portion of Property 6609. A domestic water well is located in the northeastern portion of Property 6608. The properties are predominantly covered with field grass, with a stand of trees located along the river bank.

2.1.5.3. PROPERTY ID NO. 6607

Property 6607 (Geographic ID 433717529005 based on Pend Oreille County Assessor records) is located south of Property 6608. This property is bounded on the north and south by residential properties, on the east by the Pend Oreille River, and on the west by Stillwater Road. The ground surface slopes down from west to east towards the river, with an elevation difference in the range of about 50 to 60 feet. The property is occupied by a single family residence, which is located in the eastern portion of the property. A domestic water well is located near the northwestern portion of the property. The property is predominantly covered with field grass, and a stand of trees located along the river bank. Analytical results of water samples obtained from the domestic well in April and May 2012 indicated that groundwater at the well was contaminated with GRPH and benzene at concentrations greater than MTCA Method A cleanup levels. A carbon filtration system was installed to treat groundwater from the well during June or July 2012.

2.1.5.4. PROPERTY ID NO. 6606

Property 6606 (Geographic ID 433717529004 based on Pend Oreille County Assessor records) is located south of Property 6607. This property is bounded on the north by residential property, on the south by residential and undeveloped property, on the west by Stillwater Road and on the east by the Pend Oreille River. Most of the property is relatively level. Near the eastern edge of the property the ground surface slopes down from west to east towards the river, with an elevation difference in the range of about 50 to 60 feet. The property is occupied by a single family residence located on the east portion of the property. A domestic water well is located near the northwestern corner of the property. The property is predominantly covered with field grass, and a stand of trees located along the river bank.

2.1.5.5. PROPERTY ID NO. 6628

Property 6628 (Geographic ID 433717530018 based on Pend Oreille County Assessor records) is located south of the south portions of the Vacant Property. It contains a single family residence serviced by a domestic water well.

2.1.6. Ione Airport

The Ione Airport (Property ID No. 6698, Geographic ID 433718000001 based on Pend Oreille County Assessor records) property is located southwest of the intersection of State Highway 31 and Greenhouse Road. The property is bounded by State Highway 31 on the east, Greenhouse Road on the north, and on the west and south by sparsely populated residential and undeveloped property. The airport extends approximately 4,000 feet to the south. The area of previous interest at the airport is located north of the runway in the area of two former USTs, which were removed in 2008. The ground surface near the former tank locations generally is level. Additional site improvements at the airport include a paved runway and several pre-fabricated metal airplane hangars.

2.2. Historical Operations and Site Uses

2.2.1. Airport Kwik Stop

The Airport Kwik Stop was formerly known as Crandall's Airport Grocery and Bob & Cindy's Airport Grocery. Ecology records from 1987 indicate that three underground storage tanks (USTs) were on the property at that time. The Airport Kwik Stop historically sold regular and premium gasoline. Ecology records indicate that two tanks were approximately 2,000 gallons, and a third had a capacity of less than 500 gallons. The small UST reportedly last stored gasoline in 1984, and was reportedly emptied in 1984. The two larger USTs were reportedly closed in 1989. The 1989 tank closure notice indicates that the two larger USTs were had been in-place for 6 years and 9 years, respectively, at the time of closure. The Airport Kwik Stop continued to dispense gasoline and added diesel using ASTs, which are located behind (west) of the Airport Kwik Stop. In May 2008, a flex pipe beneath the premium (north) fuel dispenser was observed to be spraying gasoline inside the dispenser. Fuel was observed within the sump under the dispenser up to the elevation of the pipe boot, indicating that fuel was leaking out of the sump into the surrounding soil. The flex pipe was repaired and subsequently, after passing a tightness test, returned to service. Records are not available to indicate the length of time the flex pipe was leaking, or estimates of the volume of gasoline which was released. The Airport Kwik Stop has not sold petroleum since the fall of 2008, when it terminated operations. The Airport Kwik Stop reopened as a convenience store during the spring/ summer 2011, but closed again in the fall/winter of 2011/2012. At the time of this report, the property is owned by Mrs. Cheryl Winther. Based on County records, the property was previously owned by Robert and Cynthia Foy, and was sold in 2002.

2.2.2. Cabin Grill

The Cabin Grill property was developed in 1985 as a realty office. Subsequent site uses included a cabinet maker, a pottery business, Pend Oreille North Realty, and currently, the Cabin Grill restaurant. Records indicate the domestic water well at the Cabin Grill property was installed in 1986. Petroleum compounds have been detected in groundwater samples collected from the domestic well on at least two separate occasions prior to the 2010-2012 site characterization and remedial investigation activities. Ecology conducted an initial investigation in 1993 following notification by Pend Oreille North Realty of a strong petroleum odor emanating from the drinking water tap. A water sample was collected and submitted to North Creek Analytical in Spokane, Washington for analysis of GRPH and VOCs. Results indicated that the water sample was contaminated with GRPH and benzene at concentrations greater than MTCA Method A cleanup levels. Ecology was notified in April 2008 by the Cabin Grill owners of a strong petroleum odor emanating from the drinking water tap. A water sample was collected and submitted to TestAmerica (formerly North Creek Analytical) in Spokane, Washington for analysis of VOCs. Results indicated that the water sample was contaminated with benzene, toluene and total xylenes at concentrations greater than applicable MTCA Method A cleanup levels.

In May 2008, the Department of Health issued a Health Advisory for the Cabin Grill. Following the Health Advisory, the Cabin Grill began using bottled water. The Cabin Grill was destroyed by fire in July 2008, and was subsequently rebuilt and reopened in March 2009. A carbon filtration system was installed during reconstruction of the restaurant. The filtration system consists of two carbon canisters and associated plumbing, located within a shed situated between the well and the Cabin Grill restaurant.

2.2.3. Vacant Properties

No records are available for the Vacant Properties. A search of the Ecology on-line water well database did not result in a well log for the hand-dug well located on the north portion of the property northeast of the intersection of State Route 31 and Dewitt Road.

2.2.4. Private Residences

No records were available for the single family residences to indicate uses other than for residential purposes.

2.2.5. Ione Airport

Based on information provided by Ecology, two USTs were installed at the Airport in about 1974/1975. Initially, the tanks stored aviation gasoline (Avgas). During the mid- to late-1980s, airplanes utilizing the airport were retrofitted to use unleaded gasoline. The tanks were removed and disposed in 2008. Soil contamination was discovered during removal of the westernmost tank, which showed signs of structural failure. Analytical results from soil samples collected from the western tank excavation indicated that portions of the soil adjacent to the tanks were contaminated with GRPH and BTEX compounds, and methyl-tertiary butyl ether (MTBE) at concentrations greater than MTCA Method A cleanup levels for unrestricted land use. Contaminated soil adjacent to the tank excavation was not removed. Laboratory analytical results of soil samples collected from the eastern side of the tank excavation did not detect the presence of petroleum contamination. The excavations were backfilled with clean imported fill material and the site was restored to grade. Subsequent investigation in 2010 in the area of the western most tank found no further evidence of soil contamination.

2.3. Environmental Setting

This section describes the geology and hydrogeology of the area. The description is based on information obtained during previous investigations.

2.3.1. Geologic Conditions

The Town of Ione is situated within the Pend Oreille River Valley in Pend Oreille County, Washington. Localized topography slopes gently downward to the north along the main axis of the river valley, and the valley is bounded by upland areas to the east and west.

Basement rocks near the subject site generally consist of a complex assemblage of variously metamorphosed and folded sedimentary and volcanic rocks. These include Pre-Cambrian-age (greater than about 570 million years old [MA]) metasedimentary and metavolcanics, Cambrian-age (about 570 to 510 MA) phyllite, and Ordovician-age (about 510 to 440 MA) metacarbonate rocks. These rocks were later intruded by Cretaceous granite, which outcrops in abundance on both sides of the river valley to the south of Ione.

During the Quaternary (as recently as 15,000 years ago), glacial ice flowed through the ancestral Pend Oreille River Valley and is thought to have extended as far south as Newport. Subsequently as the climate warmed, the ice melted in-place and deposited large quantities of poorly-sorted glacial till on the surrounding mountains. The voluminous melt waters reworked some of the till into outwash plains and carried abundant silt and clay to quiescent marginal lakes. These marginal lakes were ideal depositional sites for thick laminated silts and clays, which are found in abundance within the Pend Oreille River Valley. Near Ione, glacial deposits are widely distributed and generally are mapped as glacial drift (found within upland areas and primarily consisting of till and outwash) and glaciolacustrine deposits (found on the valley floor and primarily consisting of silt and clay). Alluvial deposits associated with the Pend Oreille River and its tributaries occur in close proximity to surface water and floodplain areas.

Review of water well reports from near the project area indicates that subsurface conditions consist of an upper zone of silt, sand and gravel, which extends to depths in the range of about 40 to 60 feet. The upper silt, sand and gravel unit appears to be underlain by clay. The water well report for the domestic water well at the Cabin Grill indicates that sand and gravel extends to a depth of about 50 feet below the site. Reports for several water wells in the area indicate that the clay layer extends to depths of at least several hundred feet.

Results of explorations at the Site completed during site characterization and RI activities in 2010 through 2012 generally confirm the published geologic conditions. Subsurface conditions encountered in the borings and monitoring wells at the Site generally consisted of an upper layer of sand with variable silt content, which extended to depths in the range of about 17 to 50 feet bgs, underlain by low-permeability silt and clay.

2.3.2. Hydrogeologic Conditions

The complex distribution and geometry of bedrock and unconsolidated formations within the Pend Oreille River valley has resulted in numerous locally-important aquifers of limited areal extent and storage capacity. Aquifer systems within the valley occur within basement rocks and unconsolidated glacial and alluvial deposits.

A hydrogeologic evaluation performed by Golder Associates (2002) for the Town of Ione identified three primary hydrogeologic units including: (1) an unconfined aquifer of relatively high permeability consisting of outwash and alluvial sand and gravel; (2) an aquitard consisting of glacial till and glaciolacustrine silt and clay; and (3) a confined aquifer of moderate permeability within Ordovician-age carbonate rocks. Over 60 percent of the area wells inventoried by Golder Associates were completed within the unconfined aquifer. The maximum specific capacity (well discharge per foot of drawdown) in wells completed in the unconfined aquifer was reported at about 80 gallons per minute per foot (gpm/foot), whereas maximum specific capacity was reported at less than 2 gpm/foot for wells completed within the confined aquifer.

Results of site explorations and groundwater monitoring activities indicate that depth to the shallow unconfined aquifer underlying the site is in the range of about 20 to 50 feet bgs. The saturated thickness of the aquifer above the underlying silt and clay aquitard generally is in the range of about 5 to 10 feet. Groundwater flow is generally east-southeast, away from upland recharge areas, and towards the Pend Oreille River. Variations in groundwater flow direction and gradient have been measured both areally and over time. Detailed descriptions of groundwater conditions are presented in Section 6. Water level information for the Pend Oreille River was obtained from the United States Geological Survey (USGS) for the period between October 2005 and November 2011 for the Ione Station located near the Site, upstream from Box Canyon Dam. The measured elevation of the Pend Oreille River at the gaging station based on the available data ranged from about Elevation 2,031 to about Elevation 2,038 (NAVD 88 datum), which is about 30 feet to 40 feet lower than the groundwater elevations measured in downgradient Site monitoring wells. Based on this information, and anecdotal information provided by local residents, it is likely that the shallow unconfined aquifer underlying the Site daylights within seeps and springs along the banks of the Pend Oreille River. The remnants of a pond and the presence of cattails located near and north of property ID 6610 also document the day-lighting of the shallow unconfined aquifer.

2.4. Current and Likely Future Land Use

2.4.1. Airport Kwik Stop

The Airport Kwik Stop has not sold gasoline since the fall of 2008. It currently does not operate as fuel station or convenience store. Its future as a convenience store or fuel station is unknown.

2.4.2. Ione Airport

The Ione Airport continues to operate as a small municipal airport. It is anticipated that operations will continue in the future.

2.4.3. Cabin Grill

The Cabin Grill continues to operate, at least seasonally, as a restaurant. The property likely will continue to be used for commercial/residential purposes.

2.4.4. Vacant Properties

Vacant properties currently are undeveloped, and the properties occasionally are used for agricultural purposes (hay). Future use of the property is unknown.

2.4.5. Private Residences

Current and likely future uses for the properties located east of Stillwater Road will be for single family residences. A number of those residences currently are used as seasonal (summer) residences.

2.5. Exposure Pathways and Receptors

A conceptual site model (CSM) was developed as part of the RI Work Plan to help direct the RI exploration program. The CSM consists of three components: (1) the sources of contaminants of potential concern (COPCs) at the Site; (2) the subsequent potential migration of those hazardous substances in environmental media; and (3) complete exposure pathways.

Contaminant sources include the vadose zone soil contamination at the Airport Kwik Stop property and the contaminated groundwater plume (both in liquid and dissolved phase) underlying the Site. While the area of known shallow vadose zone contamination currently is mostly covered by pavement, direct contact exposure with petroleum-contaminated soil is possible if any underground construction or utility work were to occur on the Airport Kwik Stop property. Based on groundwater analytical results, contaminants have been leached and transported downward to the water table and have been detected in at least three downgradient drinking water wells. Contaminated groundwater could potentially impact additional downgradient domestic water wells, surface water, and associated ecological receptors.

A complete exposure pathway consists of: (1) an identified contaminant source; (2) a transport pathway to locations (exposure points) where potential receptors might come in contact with COPCs; and (3) an exposure route (e.g., soil ingestion) through which potential receptors might be exposed to COPCs.

Potential exposure pathways and receptors include:

- Ecological
  - Direct contact with contaminated soil– small mammals, birds, soil biota, plants.
  - Ingestion of contaminated soil – small mammals and birds.
  - Ingestion of plants or fauna that have ingested or absorbed contaminants from the Site – predatory small mammals and birds.
  - Possible ingestion of contaminated surface water (Pend Oreille River) or groundwater (seeps along the banks of the Pend Oreille River) – aquatic and terrestrial food chain.
- Human
  - Ingestion of contaminated groundwater from on-site domestic water wells – residents and patrons of the Cabin Grill and residents of other impacted downgradient domestic water wells.
  - Dermal contact with contaminated groundwater removed from on-site wells – residents and restaurant patrons of the Cabin Grill and residents of other impacted downgradient domestic water wells.
  - Inhalation of contaminated vapors – residents and patrons of the Cabin Grill, residents of other impacted downgradient domestic wells and on-site workers during sampling and remediation activities.
  - Dermal contact with contaminated soil during excavation work – on-site workers and trespassers.
  - Dermal contact with contaminated groundwater removed from on-site wells or from seeps – on-site workers.
  - Possible dermal contact and ingestion of contaminated surface water (Pend Oreille River).

2.6. Regulatory Framework

Ecology is conducting RI/FS activities and an interim action cleanup under MTCA regulations.

3.0 DEVELOPMENT OF CLEANUP STANDARDS

Cleanup standards consist of: (1) cleanup levels that are protective of human health and the environment; and (2) the point of compliance at which the cleanup levels must be met. Preliminary cleanup standards are developed in this RI. Proposed cleanup standards for remedial alternative evaluation are presented in the FS, and serve as the basis for developing media-specific objectives for the cleanup action. Final cleanup standards for the Site will be established in the Draft Cleanup Action Plan (DCAP) to be prepared by Ecology following completion of the FS. The DCAP will be subject to public comment before it is finalized.

3.1. Cleanup Levels

In accordance with MTCA, development of preliminary cleanup levels includes identifying potential exposure pathways for human and environmental impacts based on planned land use. None of the properties within the Site is currently zoned industrial, and future zoning is not anticipated to change. As discussed previously, the Site consists of residential, commercial and undeveloped properties.

3.1.1. Soil

Access to the Airport Kwik Stop property is currently unrestricted. Based on current and likely future zoning and Site use, preliminary soil cleanup levels will be based on MTCA Method A cleanup levels for unrestricted land use. During the FS, cleanup levels based on protection of groundwater and/or risk-based remediation levels for specific land uses and associated institutional controls might be considered a component of cleanup alternative development and evaluation. Preliminary soil cleanup levels are based on MTCA Method A cleanup levels for unrestricted land use, WAC 173-340-740 and Chapter 173-340 WAC Table 740-1. Preliminary cleanup levels are presented in Table 1.

TABLE 1. PRELIMINARY SOIL CLEANUP LEVELS

Analytes	Units	MTCA Method A Cleanup Level, Unrestricted Land Use	Analytical Laboratory Criteria[1]		Preliminary Soil Cleanup Level
			Reporting Limits	Analytical Method	
GRPH	mg/kg	100	5	NWTPH-Gx	100
Benzene	mg/kg	0.03	0.0125	Environmental Protection Agency (EPA) 8260B	0.03
Toluene	mg/kg	7	0.0125	EPA 8260B	7
Ethylbenzene	mg/kg	6	0.0125	EPA 8260B	6
Xylenes	mg/kg	9	0.0250	EPA 8260B	9
MTBE	mg/kg	0.1	0.0125	EPA 8260B	0.1

Analytes	Units	MTCA Method A Cleanup Level, Unrestricted Land Use	Analytical Laboratory Criteria[1]		Preliminary Soil Cleanup Level
			Reporting Limits	Analytical Method	
1,2-dibromoethane (EDB)	mg/kg	0.005	0.005	EPA 8260B	0.005
1,2-dichloroethane (EDC)	mg/kg	-	0.0125	EPA 8260B	-
Naphthalene	mg/kg	5	0.0125	EPA 8260B	5

Note:
[1] Reporting limits and methods provided by Anatek Laboratories

3.1.2. Groundwater

Preliminary groundwater cleanup levels were selected from MTCA Method A Cleanup Levels for Groundwater, WAC 173-340-720(3) and Chapter 173-340 WAC Table 720-1.

Preliminary cleanup levels for groundwater are shown in Table 2.

TABLE 2. PRELIMINARY GROUNDWATER CLEANUP LEVELS

Analytes	Units	MTCA Method A Cleanup Level	Analytical Laboratory Criteria[1]		Preliminary Groundwater Cleanup Level
			Reporting Limits	Analytical Method	
GRPH	µg/L	800	100	NWTPH-Gx	100
Benzene	µg/L	5	0.5	EPA 8260B	5
Toluene	µg/L	1,000	0.5	EPA 8260B	1,000
Ethylbenzene	µg/L	700	0.5	EPA 8260B	700
Xylenes	µg/L	1,000	1.0	EPA 8260B	1,000
MTBE	µg/L	20	0.5	EPA 8260B	20
EDB	µg/L	0.001	0.001	EPA 8260C-SIM	0.001
EDC	µg/L	5	0.5	EPA 8260B	5
Naphthalene	µg/L	160	0.5	EPA 8260B	160

Note:
[1] Reporting limits and methods provided by Anatek Laboratories

3.1.3. Terrestrial Ecological Evaluation

Because the only location where soil contamination was encountered at depths shallower than 15 feet was at the Airport Kwik Stop, terrestrial ecological evaluation was limited to the Airport Kwik Stop property. Based on the developed nature of the area surrounding known soil contamination at the Airport Kwik Stop, and the lack of habitat, it is unlikely that the COPCs detected in soil will pose an unacceptable risk to terrestrial ecological receptors. Based on WAC 173-340-7491, the site does not meet the criteria for a terrestrial ecological evaluation (TEE) exclusion. A review was performed of the TEE forms [Terrestrial Ecological Evaluation Process – Primary Exclusions Documentation Form and Terrestrial Ecological Evaluation Process-Simplified

Evaluation Documentation Form (Ecology, 2008)]. Based on that review, a simplified TEE was completed for the Airport Kwik Stop property consistent with the criteria in WAC 173-340-7492(2)(a)(ii): land use at the Site and surrounding area makes substantial wildlife exposure unlikely based on completion of Table 749-1. The following values were used in Table 749-1 to complete the simplified TEE:

1. Box 1 (Area Size): 5 points for 0.50 acres or less of undeveloped land – The Airport Kwik Stop property surrounding the fuel dispensers is either paved or surfaced with gravel.
2. Box 2 (Site Use): 3 points for commercial property.
3. Box 3 (Habitat Quality): 2 points for intermediate habitat quality – There is minimal plant life immediately surrounding the dispensers, but grass and trees within about 50 to 100 feet. There are undeveloped habitat areas surrounding the Site.
4. Box 4 (Wildlife Attraction): 1 point for potential for undeveloped portions of the property to attract wildlife.
5. Box 5 (Contaminants Present): 4 points, Contaminants included in Table 749-1 include: chlorinated dibenzo-p-dioxins/dibenzofurans, PCB mixtures, DDT, DDE, DDD, aldrin, chlordane, dieldrin, endoslfan, endrin, heptachlor, benzene, hexacloride, toxaphene, hexachlorobenzene, pentachlorphenol and pentachlorobenzene. Most of these compounds were previously used as pesticides or fungicides, and therefore are most commonly present in agricultural or wood treatment settings, or places where these chemicals were manufactured or stored. PCB mixtures are most commonly found in electrical transformer and capacitor manufacturing and repair facilities, facilities containing hydraulic lifts and hoists, and facilities containing waste oil storage tanks. Dioxins and furans are the by-products of industrial processes involving manufacture of chlorinated compounds such as pesticides, PVC and pulp and paper bleaching processes. Based on review of the site history, the site was not used for the purposes generally associated with the listed contaminants.
6. Box 6 Summary of above scores in Boxes 2 through 5: 10 points – If the Box 6 total is greater than the Box 1 value, the simplified TEE is complete.

Based on the results of the simplified TEE, there are no expected impacts to wildlife at the Airport Kwik Stop property. Future TEEs might be necessary in the event contaminated groundwater emerges within seeps and springs along the banks of the Pend Oreille River.

3.2. Points of Compliance

Under MTCA, the point of compliance is the point or location on a site where the cleanup levels must be attained. The points of compliance for affected media will be approved by Ecology and presented in the site-wide DCAP. However, it is necessary to identify proposed points of compliance to develop and evaluate the effectiveness of cleanup action alternatives in the FS. This section describes the proposed points of compliance for soil and groundwater.

3.2.1. Soil

The standard point of compliance for preliminary soil cleanup levels based on protection of humans from direct contact shown in Table 2 will be throughout the soil column from the ground surface to 15 feet, in accordance with WAC 173-340-740(6)(d) and WAC 173-340-7490(4)(b). The standard point of compliance for preliminary soil cleanup levels based on protection of groundwater shown in Table 1 will be throughout the soil column [WAC 173-340-740(6)(b)].

3.2.2. Groundwater

The standard point of compliance for preliminary groundwater cleanup levels shown in Table 2 will be all groundwater at the Site located within the shallow unconfined aquifer from the top of the saturated zone to the lowest depth which could be affected (top of the silt and clay aquitard) {WAC173-340-720(8)(b)}.

4.0 SITE INVESTIGATIONS

4.1. General

Site investigation activities were conducted between April 2010 and August 2012 as part of previous site characterization activities and as part of the RI to address data gaps described in the RI/FS Work Plan. The subsurface investigation consisted of a series of drilled and direct-push borings and the installation of groundwater monitoring wells and SVE and AS pilot test and observation wells. Water samples were collected from domestic water wells near the Site. A geophysical survey also was completed at the Site by a subconsultant to evaluate select locations for the possible presence of USTs. Slug tests were completed in selected monitoring wells to evaluate hydrogeologic parameters of the shallow unconfined aquifer underlying the Site.

The following subsurface explorations (71 total) have been completed to date as part of previous Site characterization and recent RI activities:

- Forty-one direct-push explorations (DP-1, DP-2, DP-2A, DP-3, DP-4, DP-4A, DP-5 through DP-19, DP-21 through DP-40); note that there is no boring designated as DP-20.
- Nineteen groundwater monitoring wells (MW-1 through MW-19).
- Six hollow-stem auger borings (B-1 and B-3 through B-7); note that there is no boring designated as B-2.
- Two pilot SVE test wells (SVE-1 and SVE-2).
- Two pilot SVE monitoring points/wells (MP-1 and MP-2).
- One pilot air sparge test well (AS-1).

Soil samples obtained from the explorations were field-screened for headspace vapors and for petroleum-related sheens. Refer to Appendix A for descriptions of field screening methods conducted as part of RI investigation activities. Sample screening and collection were completed in accordance with the Sampling and Analyses Plan (SAP), Appendix B, of the applicable Work Plans. Select soil and groundwater samples obtained from the explorations were subsequently submitted for chemical analyses. Grain-size analyses also were completed on several soil samples obtained from the explorations. Results of grain-size analyses are presented in Appendix B.

Direct push borings DP-1 through DP-25 were completed in April 2010. Hollow-stem auger borings B-1, B-3 and B-4 and monitoring wells MW-1 through MW-8 were completed in July 2010. Details regarding field activities related to these explorations are contained in the Site Characterization

Report (October 14, 2010). Hollow-stem auger boring B-5 and monitoring wells MW-9 through MW-12 were completed in November 2010. Details regarding field activities related to these explorations are presented in the Supplemental Site Characterization Report (January 3, 2011). Monitoring wells MW-13 through MW-15 were completed in July 2011. Details regarding field activities related to these explorations are presented in the Second Supplemental Site Characterization Report (August 31, 2011).

Direct-push borings DP-26 through DP-40 were completed in November and December 2011 as part of RI activities. Hollow-stem auger borings B-6 and B-7, monitoring wells MW-16 through MW-19, SVE pilot test wells SVE-1 and SVE-2, air sparge pilot test well AS-1, and monitoring points MP-1 and MP-2 were completed in April and May 2012 as part of RI activities. Detailed descriptions of the field activities related to subsurface explorations completed as part of RI activities, and logs of all the explorations completed as part of site characterization and RI activities between 2010 and 2012 are presented in Appendix A.

The locations of the explorations completed as part of RI and previous site characterization activities are shown in Site Exploration Locations, Figure 3. A detailed map of explorations completed at the Airport Kwik Stop is shown in Airport Kwik Stop Detail Exploration Locations, Figure 4. A detailed map of explorations completed at the Ione Airport is shown in Ione Airport Detail Exploration Locations, Figure 5.

The geophysical survey consisted of completing a visual reconnaissance, and using analog real time electromagnetic induction metal detection (EMIMD), magnetic location and ground penetrating radar (GPR) techniques to evaluate selected locations for unknown USTs. The areas evaluated included: (1) areas surrounding the Airport Kwik Stop building; (2) areas surrounding the Cabin Grill restaurant; and (3) the area within the Vacant Property located northeast of the intersection of State Highway 31 and Dewitt Road.

4.2. Airport Kwik Stop

Direct-push borings DP-11 through DP-19 and DP-30 through DP-40 were completed at the Airport Kwik Stop property. The objective of borings DP-11 through DP-15 was to characterize the vertical and lateral extent of GRPH and VOC soil contamination near the existing ASTs and product lines. The objective of direct-push borings DP-16 through DP-19 and DP-30 through DP-40 was to characterize vertical and lateral extent of petroleum contamination in soil near the fuel dispensers. Boring B-7 was initially intended to serve as air sparge test well AS-1. However, because of difficulties during installation of the well screen, casing and sand pack, the driller abandoned the well, which was then designated as boring B-7. Monitoring wells MW-1, MW-7 and MW-8 are located on the Airport Kwik Stop property. Wells MW-1 and MW-7 serve as upgradient wells. MW-8 is located near (and downgradient of) the fuel dispensers. SVE test wells SVE-1, SVE-2, monitoring points MP-1, MP-2 and air sparge test well AS-1 also are located on the Airport Kwik Stop property near the fuel dispensers, and were utilized for SVE and air sparge pilot testing.

The geophysical survey evaluated the Airport Kwik Stop property from the west side of the Kwik Stop building to the highway.

4.3. Cabin Grill

Direct-push borings DP-21 through DP-25, hollow-stem auger boring B-3 and monitoring wells MW-4, MW-5, MW-6, MW-12, MW-13 and MW-19 were completed at the Cabin Grill property. The objective of the direct-push borings was to evaluate the presence and extent of soil and groundwater contamination on the property. The objective of the monitoring wells was to evaluate the extent, magnitude and distribution of groundwater contamination on the property. Boring B-3 was initially intended as a downgradient or crossgradient well outside of the contaminated groundwater plume, but was abandoned after field screening indicated the presence of petroleum hydrocarbons at that location at a depth of about 40 feet bgs (near the groundwater interface).

The geophysical survey evaluated the Cabin Grill property from the southeast corner of the intersection of Greenhouse Road, east to the driveway to the private residence on the property, and encompassed areas which appeared to have been previously disturbed based on the appearance of vegetation.

4.4. Vacant Properties

Direct-push borings DP-26 through DP-29, hollow-stem auger borings B-1, B-5 and B-6, and monitoring wells MW-9, MW-10, MW-11, and MW-14 through MW-18 were completed on the Vacant Properties. Boring B-6 was initially intended as a downgradient monitoring well, but was abandoned after field screening indicated the presence of petroleum hydrocarbons at that location at a depth of about 25 feet bgs (near the groundwater interface). The objective of the explorations was to delineate the downgradient and crossgradient extent of the contaminated groundwater plume, and to evaluate the magnitude and variation (areally and with time) of the contaminants within the plume.

The geophysical survey evaluated the Vacant Property located northeast of the intersection of State Highway 31 and Dewitt Road, near the location of the hand-dug well.

4.5. Ione Airport

Direct-push borings DP-1 through DP-10, hollow-stem auger boring B-4 and monitoring well MW-2 were previously completed at the Ione Airport property. Direct-push borings DP-1 through DP-6 were completed within the approximate footprint of the former USTs in order to characterize lateral and vertical extent of soil contamination near the former USTs. Direct-push borings DP-8 through

DP-10, boring B-4 and monitoring well MW-2 were completed to the east and southeast (downgradient) of the location of the former USTs in order to characterize groundwater conditions and soil conditions near the groundwater table downgradient of the former USTs.

5.0 SOIL INVESTIGATION RESULTS

5.1. Physical Characterization of Site Subsurface Conditions

Variable subsurface conditions were encountered to the depths explored in site explorations. For the purposes of this report, soil underlying the site was characterized in two general units: (1) sand; and (2) silt and clay.

Loose to medium dense sand with variable silt and gravel content was encountered in all soil borings. Where explorations penetrated through the upper sand layer, the sand unit extended from the ground surface to depths in the range of about 21 to 50 feet bgs. The sand unit encountered in the explorations was consistent with geologic descriptions for the outwash- and alluvially deposited unconfined aquifer of sand and gravel with increasing depth. In general, the silt content decreased with increasing depth across the site. Within the saturated zone, the sand unit also generally graded with more coarse sand and gravel. Based on visual observation, the sand unit contained a higher percentage of silt within the western portions of the Site near the Airport Kwik Stop and Ione Airport, compared to the percentage of silt in the sand unit within the eastern portions of the Site.

Below the sand unit, soft to stiff silt and clay was encountered. Where encountered, the top of the silt and clay unit was located at depths in the range of about 21 to 50 feet bgs, and extended to the depths explored. The silt and clay unit is consistent with the geologic descriptions for the glaciolacustrine-deposited aquitard of silt and clay.

Three cross sections depicting subsurface conditions were developed based on results of the explorations and are presented in Cross Section A-A', Figure 6; Cross Section B-B', Figure 7; and Cross Section C-C', Figure 8. The locations of the cross sections are shown in Figure 3.

5.2. Airport Kwik Stop Analytical Testing Results

Select samples obtained from the 2010 explorations (direct-push borings DP-11 through DP-19 and monitoring well MW-7) were submitted for chemical analysis of GRPH, diesel-range petroleum hydrocarbons (DRPH), oil-range petroleum hydrocarbons (ORPH), BTEX compounds, methyl tert-butyl ether (MTBE), naphthalene and lead. Select samples obtained from explorations completed as part of RI activities (direct-push borings DP-30 through DP-40, SVE test wells SVE-1 and SVE-2, monitoring points MP-1 and MP-2, and air sparge test well AS-1) were submitted for chemical analysis of GRPH and BTEX compounds. A summary of soil testing analytical results from the 2011/2012 RI explorations is presented in Summary Soil Chemical Analytical Results-RI Phase Explorations, Table C-1, in Appendix C.

Chemical data for soil samples obtained within the Airport Kwik Stop property were compared to preliminary soil cleanup levels to assess the nature and extent of soil contamination. Field screening and analytical results of select soil samples did not detect contamination in direct-push borings DP-11 through DP-15 located near the ASTs and near the product lines. Field screening and analytical results indicate that GRPH and VOCs, particularly BTEX compounds, are present in soil near the fuel dispensers at concentrations greater than MTCA Method A cleanup levels for unrestricted land use. Results of field screening and laboratory chemical analytical testing indicate that the zone of petroleum contaminated soil near the fuel dispensers extends from less than 2 feet bgs, to groundwater (about 35 feet bgs). Concentrations of GRPH and BTEX compounds in samples which exceeded preliminary cleanup levels are shown in Table 3.

TABLE 3. SOIL ANALYTICAL EXCEEDANCE SUMMARY – AIRPORT KWIK STOP

Location ID	Sample ID	Sample Date	Sample Depth (feet)	GRPH mg/kg	Benzene mg/kg	Toluene mg/kg	Ethylbenzene mg/kg	Total Xylenes mg/kg
MTCA Method A Unrestricted Land Use Cleanup Level				**100/30**	**0.03**	**7**	**6**	**9**
DP-18	IKSDP18-18-19	04/28/10	18-19	**11,500**	**12.8**	**612**	**219**	**970**
DP-18	IKSDP18-21-22	04/28/10	21-22	**11,400**	**1.10**	**369**	**189**	**1,331**
DP-18	IKSDP18-36.5-37.5	04/28/10	36.5-37.5	23.2	**0.132**	0.823	0.242	1.748
DP-32	DP-32 (36-40)	11/30/11	36-40	29.7	**0.117**	1.26	0.293	2.02
DP-34	DP-34 (7-8)	11/30/11	7-8	**10,600**	**16.9**	**267**	**99.2**	**779**
DP-37	DP-37(27-28)	11/30/11	27-28	7.78	**0.0835**	0.368	0.0504	0.381
DP-38	DP-38 (7-8)	12/1/11	7-8	24.0	**0.224**	0.951	0.214	1.60
DP-38	DP-38(15-16)	12/1/11	15-16	11.8	**0.0374**	0.378	0.0903	0.658
DP-39	DP-39(10-12)	12/1/11	10-12	**9,140**	**4.14**	**215**	**106**	**658**
DP-40	DP-40(7-8)	12/1/11	7-8	**17,200**	**34.2**	**466**	**88.7**	**1,870**
SVE-1	SVE-1(5)	4/12/12	5	**595**	**1.13**	**14.80**	**4.73**	**33.80**
SVE-1	SVE-1(10)	4/12/12	10	**13,500**	**54**	**752**	**224**	**1,347**
SVE-1	SVE-1(20)	4/12/12	20	**15,600**	**106**	**147**	**431**	**2,403**
SVE-2	SVE-2(15)	4/12/12	15	**46.0**	**0.0423**	0.815	0.305	2.444
SVE-2	SVE-2(25)	4/12/12	25	**948**	**0.396**	**12.9**	**6.200**	**44.8**
SVE-2	SVE-2(35)	4/12/12	35	**124**	**0.473**	2.41	0.888	5.350
MP-1	MP-1(25)	4/13/12	25	**742**	**0.272**	**9.6**	5.760	**41.0**
MP-1	MP-1(35)	4/13/12	35	**38.4**	**0.206**	0.562	0.137	0.752
AS-1	AS-1(10)	4/16/12	10	**129**	**0.0527**	1.11	0.605	4.46
AS-1	AS-1(15)	4/16/12	15	24.2	**0.0904**	0.453	0.136	1.045
AS-1	AS-1(25)	4/16/12	25	**37.5**	**0.370**	1.88	0.408	2.702
AS-1	AS-1(35)	4/16/12	35	**38.1**	**0.820**	3.99	0.534	3.068

Notes

mg/kg=milligram per kilogram

GRPH preliminary cleanup level is 30 mg/kg when benzene is present; 100 mg/kg when benzene is not detected

Bolding and shading indicates contaminant detected at concentration exceeding MTCA Method A unrestricted land use cleanup level

The estimated areal extent of petroleum-contaminated soil at the Airport Kwik Stop is presented in Airport Kwik Stop Vadose Zone Contamination, Figure 9. A cross section through the contaminated vadose zone is presented in Cross Section D-D', Figure 10. The estimated GRPH concentration ranges depicted on Figure 10 were based on the results of analytical testing of soil samples and field screening using a photo-ionization detector (PID). In some instances, results of PID measurements and laboratory analytical results are in conflict (i.e., PID headspace reading of 2,650 parts per million (ppm) and analytical testing results indicating a GRPH concentration less than MTCA Method A cleanup level). The estimated zone of GRPH present at concentrations greater than 10,000 mg/kg was based on the results of laboratory analytical testing. The estimated zone of GRPH present at concentrations greater than 100 mg/kg was based on both results of field screening and laboratory analytical testing. The zone was estimated by including soil samples with laboratory analytical results indicating GRPH concentrations greater than 100 mg/kg, or PID headspace readings greater than 750 ppm. The zone of GRPH present at concentrations less than 100 mg/kg was estimated based on detections from analytical laboratory testing, or PID readings greater than 100 ppm from screening.

Results of the geophysical survey indicated the possible presence of a backfilled excavation near the northeast corner of the Airport Kwik Stop building. Direct-push boring DP-16 was completed to a depth of about 25 feet bgs in the general area identified in the geophysical report as the possible former UST location. Results of the direct-push boring indicated that petroleum-contaminated soil was not present at that location within the depth explored. Historical photographs obtained as part of the geophysical survey indicated the possible presence of former USTS located near the southeast corner of the Site near the intersection of State Highway 31 and Greenhouse Road. Direct-push borings DP-17, DP-33 and DP-36 were completed in the general area of the possible USTs. Results of direct-push borings indicate soil contamination starting at depths in the range of about 17 to 27 feet bgs at these exploration locations. Results of field screening of soil samples from these explorations did not indicate the presence of shallower petroleum contamination. Based on the results of these subsurface explorations, it did not appear that a tank was present in this area.

5.3. Cabin Grill Analytical Testing Results

Select soil samples obtained from the previous site characterization explorations were submitted for chemical analysis of GRPH, DRPH, ORPH, VOCs and lead. GRPH and/or VOCs were detected at concentrations greater than MTCA Method A cleanup levels for unrestricted land use in five soil samples from direct-push borings and hollow-stem auger borings/monitoring wells. The samples containing petroleum contamination were obtained from near the groundwater interface. Concentrations of GRPH and BTEX compounds in samples, which exceeded preliminary cleanup levels are shown in Table 4.

TABLE 4. SOIL ANALYTICAL EXCEEDANCE SUMMARY – CABIN GRILL

Location ID	Sample ID	Sample Date	Sample Depth	GRPH mg/kg	Benzene mg/kg	Toluene mg/kg	Ethylbenzene mg/kg	Total Xylenes mg/kg
MTCA Method A Unrestricted Land Use Cleanup Level				**100/30**	**0.03**	**7**	**6**	**9**
DP-21	CGDP21-37-38	04/29/10	37-38	**768**	<0.125	1.67	**6.08**	**40.7**
DP-24	CGDP24-37.4-38	04/29/10	37.4-38	**1,060**	<0.125	<0.125	<0.125	1.67
DP-25	CGDP25-37-38	04/29/10	37-38	**1,130**	<0.125	<0.125	0.252	3.99

Location ID	Sample ID	Sample Date	Sample Depth	GRPH mg/kg	Benzene mg/kg	Toluene mg/kg	Ethylbenzene mg/kg	Total Xylenes mg/kg
MTCA Method A Unrestricted Land Use Cleanup Level				**100/30**	**0.03**	**7**	**6**	**9**
MW-5	MW-5-38.5	07/21/10	38.5	**2,670**	**9.32**	**189**	**52.8**	**302**
MW-6	MW-6-43.5	07/22/10	43.5	9.48	**1.42**	2.65	0.275	2.69

Notes

mg/kg=milligram per kilogram

GRPH preliminary cleanup level is 30 mg/kg when benzene is present; 100 mg/kg when benzene is not detected

Bolding and shading indicates contaminant detected at concentration exceeding MTCA Method A cleanup level.

Two soil samples were collected from the boring associated with monitoring well MW-19, completed as part of RI activities. The samples were from depths of about 35 feet and 40 feet bgs (groundwater was measured at a depth of about 35 feet bgs on May 7, 2012). The samples were submitted for analyses of GRPH and BTEX compounds. GRPH and BTEX compounds (except benzene) were detected in both samples at concentrations less than MTCA Method A cleanup levels. A summary of soil analytical testing results from RI activities is presented in Table C-1 in Appendix C. Practical quantitation limits (PQLS) were less than applicable MTCA Method A cleanup levels.

Results of the geophysical survey indicated the possible presence of a backfilled excavation near the southwest corner of the Cabin Grill restaurant. Direct-push boring DP-22 and monitoring well MW-5 were completed within the general area. Results of field-screening and analytical testing results of soil samples indicate that petroleum-contaminated soil is not present at these locations above depths of about 35 to 40 feet bgs (near the groundwater interface).

5.4. Vacant Properties Analytical Testing Results

Select soil samples obtained from the previous site characterization explorations were submitted for chemical analysis of GRPH. Selected samples also were analyzed for DRPH, ORPH, VOCs and/or lead. GRPH and/or VOCs were detected at concentrations greater than MTCA Method A cleanup levels for unrestricted land use in five soil samples from direct-push borings and hollow-stem auger borings/monitoring wells. The samples containing petroleum contamination were obtained from near the groundwater interface.

Select soil samples collected from explorations completed as part of RI activities (direct-push borings DP-26 through DP-29, boring B-6 and monitoring wells MW-16 through MW-18) were submitted for analytical laboratory analyses. Soil samples collected from near the groundwater interface from direct-push borings DP-26 through DP-29 were analyzed for GRPH, EDB and EDC to evaluate for the presence of the leading (downgradient) edge of the contaminated groundwater plume. Analytes were not detected in any of the samples. PQLs were less than MTCA Method A cleanup levels for unrestricted land use.

PQLs refer to the smallest concentrations that analytes can be detected during laboratory testing with a reasonable degree of accuracy. PQLs are established by the analytical laboratory and are based on a number of factors including the testing equipment and the amount samples must be diluted in order to be tested. When conducting laboratory analytical testing, the PQLs for analytes should generally be less than the applicable cleanup levels. Therefore, if analytes are not detected, and the PQL is less than the applicable cleanup level, there is relative confidence that the analytes are not present in the samples, or at least are not present at concentrations greater than the cleanup level.

Soil samples collected from near the groundwater interface in boring B-6 and monitoring well explorations MW-16, MW-17 and MW-18 were submitted to a qualified analytical laboratory for analysis of GRPH and BTEX compounds. Benzene was detected in the sample from boring B-6 (25-foot depth) at a concentration (0.506 mg/kg) greater than the MTCA Method A cleanup level for unrestricted land use. GRPH, toluene, ethylbenzene and xylenes also were detected at concentrations less than the applicable MTCA Method A cleanup levels for unrestricted land use. Toluene, ethylbenzene and xylenes were detected in the soil sample from MW-18 (20-foot depth) at concentrations less than applicable MTCA Method A cleanup levels. GRPH and benzene were not detected in the sample from MW-18. PQLs were less than applicable MTCA Method A cleanup levels for unrestricted land use.

Concentrations of GRPH and BTEX compounds in samples collected during previous site characterization and recent RI activities which exceeded preliminary cleanup levels are shown in Table 5.

TABLE 5. SOIL ANALYTICAL EXCEEDANCE SUMMARY – VACANT PROPERTIES

Location ID	Sample ID	Sample Date	Sample Depth	GRPH mg/kg	Benzene mg/kg	Toluene mg/kg	Ethylbenzene mg/kg	Total Xylenes mg/kg
MTCA Method A Unrestricted Land Use Cleanup Level				**100/30**	**0.03**	**7**	**6**	**9**
B-1	B-1-40.0	07/13/10	40	**198**	**1.31**	13.6	3.78	**20.5**
B-6	B-6 (25)	04/16/12	25	4.29	**0.506**	0.533	0.0685	0.368
MW-3	MW-3-40.0	07/13/10	40	<5.95	**0.401**	0.869	0.300	0.981

Notes:

mg/kg=milligram per kilogram

GRPH preliminary cleanup level is 30 mg/kg when benzene is present; 100 mg/kg when benzene is not detected

Bolding and shading indicates contaminant detected at concentration exceeding Method A unrestricted land use cleanup level.

GRPH and BTEX compounds were not detected in the soil samples from monitoring wells MW-16 and MW-17. PQLs were less than applicable MTCA Method A cleanup levels for unrestricted land use. A summary of analytical testing results from RI activities is presented in Table C-1 in Appendix C.

A portion of the Vacant Property located near the northeast corner of the intersection of State Highway 31 and Dewitt Road was evaluated as part of the geophysical survey. Results of the survey indicated the presence of a small, shallow metal object located near the hand-dug well located on the Vacant Property. Interpretation of the data indicates that it is a piece of unknown debris, possibly equipment or piping associated with the hand-dug well. No other indications of buried USTs were observed.

5.5. Ione Airport Analytical Testing Results

Select soil samples obtained from the 2010 explorations were submitted for chemical analysis of GRPH, DRPH, ORPH, VOCs and lead. GRPH, DRPH, ORPH and BTEX compounds were not detected in any of the analytical samples. Lead and naphthalene were detected in two samples at concentrations below MTCA Method A cleanup levels. 1,2,3-timethylbenzene and

1,3,5-trimethylbenzene was detected in two samples at concentrations slightly greater than the method reporting limits. No other VOCs were detected. The samples were from explorations completed near the footprint of the former USTs at depths of about 17½ feet to 18½ feet bgs.

No explorations were completed on the Ione Airport property as part of RI activities. The Ione Airport also was not included as part of the geophysical survey. Based on the results of previous subsurface explorations, soil and groundwater analytical testing results, and groundwater elevation measurements and interpretation of groundwater flow direction, the Ione Airport does not contribute to the plume which extends from the Airport Kwik Stop downgradient to the Cabin Grill, Vacant Properties or private residences. Therefore, the Ione Airport is no longer considered part of the Site.

6.0 GROUNDWATER INVESTIGATION AND RESULTS

6.1. Summary of Groundwater Monitoring and Testing Activities

This section presents a description of associated groundwater RI activities conducted at the Site. A total of 19 groundwater monitoring wells (MW-1 through MW-19) and 2 monitoring points (MP-1 and MP-2) have been installed at the Site. Monitoring wells MW-1 through MW-8 were installed in July 2010. Wells MW-9 through MW-12 were installed in November 2010. Wells MW-13 through MW-15 were installed in July 2011. Wells MW-16 through MW-19 and monitoring points MP-1 and MP-2 were installed in April/May 2012 as part of RI activities. Following installation, the wells were developed, and then the horizontal and vertical wellhead locations were surveyed by a licensed surveyor. The purposes of the wells were to:

- Characterize the extent of the contaminated groundwater plume and quantify petroleum hydrocarbon concentrations in groundwater.
- Provide hydrogeologic information including groundwater depths, elevations and flow direction.
- Obtained hydraulic testing data as a basis for developing site-specific hydraulic conductivity and groundwater velocity estimates.

A total of nine quarterly groundwater monitoring events were conducted at the site between June 2010 and August 2012. Beginning with the August 2012 monitoring event, the sampling frequency of many of the Site monitoring wells was reduced from a quarterly basis, to a semi-annual or annual basis. These modifications included the following: monitoring wells MW-3, MW-4, MW-6, MW-8, MW-9, MW-13, MW-14 and MW-19 will be sampled on a semi-annual basis; and monitoring wells MW-1 and MW-2 will to be sampled on an annual basis. These wells are located either within or upgradient of the plume of contaminated groundwater. The intent of the reduced sampling frequency is to concentrate resources to those wells that are located near the downgradient or crossgradient edges of the plume.

A supplemental monitoring event also was completed in December 2011 to confirm the presence of contamination detected in several Site wells where the results of previous monitoring events had resulted in the absence of detections of COPCs. The supplemental event consisted of measuring fluid levels in all Site monitoring wells, and collecting groundwater samples from selected wells. Water samples also were collected from private residences during several monitoring events, or during separate site visits.

Four of the quarterly monitoring events (November/December 2011, February 2012 and August 2012) were completed as part of RI activities. The five previous monitoring events (August 2010, November 2010, February 2011, May 2011 and August 2011) were completed as part of previous Site characterization activities.

During each quarterly monitoring event, groundwater levels (and free product, where present) were measured in Site wells. Wells were field screened for the presence of headspace vapors using a PID. In addition, water quality parameters including pH, specific conductivity, turbidity, dissolved oxygen, temperature and oxidation reduction potential were measured during collection of groundwater samples. Detailed results of each groundwater monitoring event are summarized in our referenced reports. Analytical reports from the August 2012 monitoring event are included in this report, as a groundwater monitoring report for that event had not been prepared at the time of this report.

In addition to quarterly sampling of Site monitoring wells, groundwater samples also were collected from select direct-push borings and submitted for chemical analyses. Groundwater samples were collected from direct-push explorations DP-5, DP-17, DP-18, DP-19, DP-21, DP-22, DP-24 and DP-25 as part of previous Site characterization activities. Detailed results of sampling procedures and analytical test results are presented in the Site Characterization Report dated October 14, 2010. Groundwater samples also were collected from direct-push borings DP-26, DP-27, DP-28 and DP-29, completed as part of RI activities, and submitted to a qualified analytical laboratory for analysis of GRPH, DRPH, ORPH and BTEX compounds. Analytical testing results of groundwater samples collected from direct-push borings as part of RI activities are presented in Summary of Groundwater Chemical Analytical Results – Groundwater Samples – RI Direct-Push Borings, Table C-2, in Appendix C. Analytical testing results of groundwater samples collected from monitoring wells as part of recent RI activities and previous Site characterization activities are presented in Summary of Groundwater Chemical Analytical Results – Water Quality Parameters, Table C-3.

Slug tests were completed within five Site monitoring wells in July 2012. Monitoring wells to be tested were selected to achieve areal distribution across the Site and include wells representative of upgradient (MW-7), central (MW-19 and MW-9) and downgradient (MW-6 and MW-10) aquifer conditions. Details of hydraulic conductivity testing are provided in **Section 6.5.**

GRPH and BTEX in Groundwater Samples, Figure 11, shows locations where GRPH and/or BTEX compounds have been detected in groundwater samples at concentrations greater than applicable

MTCA Method A cleanup levels. Groundwater Elevations and Flow Direction – May 2012 (Groundwater Elevations Corrected for LNAPL), Figure 12 presents groundwater elevations and interpreted flow direction for the May 2012 monitoring event, corrected for non-aqueous phase liquid (NAPL) Groundwater Elevations and Flow Direction – May 2012 (Groundwater Elevations Uncorrected for LNAPL), Figure 13 presents groundwater elevation and interpreted flow direction for the May 2012 monitoring event, corrected for NAPL. Groundwater Elevation History in Select Site Monitoring Wells, Figure 14 graphically presents a timeline of groundwater elevation data for select site monitoring wells. GRPH Concentrations in Select Groundwater Samples, Figure 15 present a timeline of GRPH concentrations in groundwater samples from select site monitoring wells. Benzene Concentrations in Select Groundwater Samples, Figure 16 presents a timeline of benzene concentrations in groundwater samples from select site monitoring wells. Estimated GRPH Concentration in Groundwater – May 2012 (Groundwater Elevation Corrected for LNAPL), Figure 17 presents the approximate extent and concentrations of GRPH in groundwater based on the May 2012 monitoring event. Note that the plume extents presented in Figure 17 are slightly different than the plume extents presented in Figure 2 because the plume shown in Figure 17 is based on GRPH concentrations, whereas the plume shown in Figure 2 is based on both GRPH and BTEX concentrations.

6.2. Chemical Characterization

6.2.1. General

Groundwater samples were collected from Site monitoring wells and domestic water wells and submitted to a qualified analytical laboratory for analyses. Additionally, groundwater samples were collected from select direct-push borings and submitted for analytical testing. Due to sampling procedures utilized for collecting groundwater samples from direct-push borings, these groundwater samples were not collected using low-flow sampling procedures and did not meet field water quality criteria, particularly turbidity measurements, associated with the groundwater samples collected from established Site monitoring wells. Therefore, the reliability of analytical results is less than that for groundwater samples collected from established Site monitoring wells. The intent of the groundwater samples collected from the direct-push borings was to qualitatively evaluate the presence of contaminants within downgradient areas, and assist with the siting of downgradient monitoring wells.

Groundwater samples were analyzed for GRPH using Ecology Northwest NWTPH-Gx methods and BTEX compounds using EPA 8260 Methods. Selected samples also were analyzed for diesel- and oil-range petroleum hydrocarbons (DRPH and ORPH) using Ecology Northwest NWTPH-Dx methods, VOCs using EPA 8260 methods and lead using EPA 6000 series methods. Detailed descriptions of groundwater sampling procedures and test methods are available in the referenced Site characterization and groundwater monitoring reports. This section provides a general summary of the results of analytical testing of groundwater samples. The following sections focus strictly on the results of GRPH and BTEX analyses. Figure 11 shows the locations where results of analytical testing of groundwater samples indicated GRPH and/or BTEX concentrations greater than MTCA Method A cleanup levels.

6.2.2. Airport Kwik Stop

Groundwater samples were collected from monitoring wells MW-1 and MW-7, and from MW-8, located near the fuel dispensers, during groundwater monitoring events. Note that a groundwater sample also was collected from well MW-1 during a supplemental December 2011 monitoring event. A groundwater sample was not collected from MW-8 during the May 2011 event because results of previous sampling events indicated groundwater was contaminated above pertinent cleanup levels, and additional groundwater analytical data for that sampling event was not anticipated to provide new insights into the condition of groundwater at MW-8. Groundwater samples were not collected from wells MW-1 and MW8 during the August 2012 monitoring event in accordance with the revised sampling plan. Groundwater samples also were collected from monitoring points MP-1 and MP-2 during the May 2012 event. Monitoring wells MW-1 and MW-7 are located upgradient of the premium fuel dispenser. Monitoring well MW-8 is located about 20 feet downgradient of the fuel dispensers. Monitoring points MP-1 and MP-2 are located about 30 to 40 feet from the premium fuel dispenser. They are located generally crossgradient to the premium fuel dispenser.

Results of analytical testing indicate that upgradient wells MW-1 and MW-7 are not contaminated with petroleum hydrocarbons. Each groundwater sample collected from MW-8 contained GRPH and VOCs at concentrations greater than MTCA Method A cleanup levels. GRPH concentrations from MW-8 samples have ranged from 12,000 micrograms per liter (µg/L) to 126,000 µg/L; these concentrations are 24 to 252 times the MTCA Method A cleanup level (500 µg/L). Benzene concentrations from MW-8 samples have ranged from 907 µg/L to 6,330 µg/L; these concentrations are 181 times to 1,266 times the MTCA Method A cleanup level (5 µg/L). Other BTEX compounds also have been detected at concentrations greater than MTCA Method A cleanup levels. Groundwater samples collected from monitoring points MP-1 and MP-2 in May 2012 also contained GRPH (6,820 µg/L and 3,020 µg/L) and benzene (639 µg/L and 337 µg/L) at concentrations greater than MTCA Method A cleanup levels. Other BTEX compounds were detected, but at concentrations less than MTCA Method A cleanup levels.

Groundwater samples from direct-push borings DP-17, DP-18 and DP-19 were collected and submitted for laboratory analyses. Groundwater samples from all three borings contained GRPH and/or benzene at concentrations greater than MTCA Method A cleanup levels. Other BTEX compounds were either not detected, or were detected at concentrations less than applicable MTCA Method A cleanup levels.

6.2.3. Cabin Grill

Groundwater samples were collected from monitoring wells MW-4 and MW-6, and from the Cabin Grill domestic water well, during each quarterly monitoring event, except the August 2012 event. Groundwater samples were collected from monitoring well MW-5 during the August 2010, November 2010, February 2011 and supplemental December 2012 quarterly monitoring events. Groundwater sampling was discontinued in MW-5 due to the continued presence of floating petroleum product at that well location. Groundwater samples were collected from monitoring well MW-12 beginning with the November 2010 quarterly monitoring event, and from MW-13 beginning with the August 2011 quarterly monitoring event, except for the August 2012 event. A groundwater sample was collected from monitoring well MW-19 during the May 2012 quarterly monitoring event. The wells are all located downgradient of the Airport Kwik Stop. Groundwater samples were submitted for analyses of GRPH and selected VOCs, including BTEX compounds.

GRPH and/or benzene were detected at concentrations greater than MTCA Method A cleanup levels in each of the groundwater samples collected from wells MW-5, MW-6, MW-13 and the Cabin Grill domestic water well. With the exception of the May 2011 groundwater sample from MW-6 and the February 2012 and May 2012 samples from MW-13, other BTEX compounds also were detected in the samples at concentrations greater than applicable MTCA Method A cleanup levels. Other BTEX compounds were detected in the May 2011 groundwater sample collected from MW-6 and from the February 2012 and May 2012 samples from MW-13, but at concentrations less than applicable MTCA Method A cleanup levels.

GRPH and benzene were detected in groundwater samples collected from well MW-4 during the August 2010, November 2010 and November 2011 quarterly monitoring events. GRPH and benzene were detected during the other quarterly monitoring events, but at concentrations less than MTCA Method A cleanup levels. Other analyzed VOCs were either not detected, or detected at concentrations less than applicable MTCA Method A cleanup levels.

GRPH and total xylenes were detected in the May 2012 groundwater sample collected from MW-19 at a concentration greater than the MTCA Method A cleanup level. Benzene was not detected in the groundwater sample.

GRPH and VOCs, including BTEX compounds, have not been detected in the groundwater samples from monitoring well MW-12.

Groundwater samples from direct-push borings DP-21, DP-22, DP-24 and DP-25 were collected and submitted for laboratory analytical testing. Benzene was detected in the samples from DP-21 and DP-22 at concentrations greater than the MTCA Method A cleanup level. Other BTEX compounds and GRPH were either not detected, or were detected at concentrations less than applicable MTCA Method A cleanup levels.

6.2.4. Vacant Properties

Groundwater samples were collected during each quarterly monitoring event from monitoring well MW-3, except for the August 2012 event. Groundwater samples were collected during each quarterly monitoring event from monitoring wells MW-10 and MW-11 beginning with the November 2010 quarterly monitoring event. Groundwater samples also were collected from well MW-9 during each quarterly monitoring event, except the August 2012 event. Monitoring well MW-9 also was sampled during the December 2011 supplemental monitoring event in accordance with the revised sampling plan. Due to access constraints, a groundwater sample was collected from MW-10 in March 2012, about three weeks after the rest of the Site monitoring wells were sampled during the February 2012 monitoring event. Groundwater samples were collected during each quarterly monitoring event from monitoring wells MW-14 and MW-15 beginning with the August 2011 monitoring event with the exception that a sample was not collected from MW-14 during the August 2012 event in accordance with the revised sampling plan. Groundwater samples were collected from monitoring wells MW-16, MW-17 and MW-18 during the May 2012 and August 2012 quarterly monitoring events. A water sample from the hand-dug well located on Property ID No. 6475 also was collected in April 2012.

GRPH and BTEX compounds have been detected in all of the groundwater samples collected from monitoring well MW-3 at concentrations greater than applicable MTCA Method A cleanup levels. GRPH concentrations have ranged from 24,500 µg/L (August 2010) to 78,000 µg/L (November 2011).

GRPH and BTEX compounds were not detected in the groundwater samples from monitoring well MW-9 collected during the November 2010, February 2011, May 2011 and August 2011 monitoring events. GRPH and benzene were detected at concentrations greater than applicable MTCA Method A cleanup levels during the November 2011, December 2011, February 2012 and May 2012 monitoring events. Ethylbenzene and xylenes were detected at concentrations greater than applicable MTCA Method A cleanup levels during the December 2011, February 2012 and May 2012 monitoring events. Toluene was detected at concentrations greater than the MTCA Method A cleanup level during the December 2011 and February 2012 monitoring events.

GRPH and VOCs were not detected in the groundwater samples from monitoring well MW-10 during the November 2010, February 2011, May 2011, August 2011 and November 2011 monitoring events. GRPH and/or benzene were detected in groundwater samples collected from MW-10 at concentrations greater than applicable MTCA Method A cleanup levels during the March 2012, May 2012 and August 2012 quarterly monitoring events.

GRPH and VOCs were not detected in groundwater samples collected from monitoring well MW-11 through the November 2011 monitoring event. GRPH and benzene were detected in the groundwater sample from MW-11 at concentrations greater than applicable MTCA Method A cleanup levels during the February 2012, May 2012 and August 2012 monitoring events.

GRPH and BTEX compounds were not detected in the MW-14 groundwater sample collected during the August 2011 event. GRPH and benzene were detected in the groundwater samples from MW-14 during November 2011, December 2011, February 2012 and May 2012 monitoring events at concentrations greater than applicable MTCA Method A cleanup levels. Total xylenes were detected at concentrations greater than applicable MTCA Method A cleanup levels during the December 2011 event.

GRPH and/or benzene were detected in the MW-15 groundwater samples collected during the August 2011 and November 2011 monitoring events at concentrations greater than applicable MTCA Method A cleanup levels. GRPH and BTEX compounds were either not detected, or detected at concentrations less than applicable MTCA Method A cleanup levels from the February 2012, May 2012 and August 2012 groundwater samples, collected from monitoring well MW-15.

GRPH and BTEX compounds were not detected in the groundwater samples collected from monitoring wells MW-16, MW-17 and MW-18 during the May 2012 monitoring events.

Benzene was detected in the water sample collected from the hand-dug well in April 2012 located on Property ID No. 6475 at a concentration greater than the MTCA Method A cleanup level. GRPH and other BTEX compounds were detected at concentrations less than applicable MTCA Method A cleanup levels.

Groundwater samples were collected from direct-push borings DP-26, DP-27, DP-28 and DP-29, which were completed as part of RI activities, and submitted to a qualified analytical laboratory for analyses of GRPH, DRPH, ORPH, BTEX compounds and MTBE.

Benzene was detected in the groundwater samples from direct-push borings DP-26 and DP-28 at concentrations (33.1 µg/L and 2,240 µg/L, respectively) greater than the MTCA Method A cleanup level. Benzene also was detected in the groundwater sample from boring DP-29 at a concentration less than the MTCA Method A cleanup level. Benzene was not detected in the groundwater sample from DP-27. GRPH, toluene and xylenes were detected in the groundwater samples from DP-26 and DP-28 at concentrations less than the applicable MTCA Method A cleanup levels. GRPH, toluene and xylenes were not detected in the groundwater samples from borings DP-27 and DP-29. MTBE, ethylbenzene, DRPH and ORPH were not detected in any of the direct-push groundwater samples. Laboratory test results for groundwater samples from direct-push borings DP-26 through DP-29 are presented in Table C-2 in Appendix C.

6.2.5. Private Residences

Water samples were collected from domestic water wells located at the following properties: Property ID No. 6606, Property ID No. 6607, Property ID No. 6608/6609, four wells located on Property ID No. 6610, two wells on Property ID No. 6475, Property ID No. 6469 and Property ID No. 6647. The samples were collected from taps on the water supply lines, downstream from the wells, and were submitted to a qualified analytical laboratory for analyses of GRPH and selected VOCs, including BTEX compounds, naphthalene, MTBE, EDB and EDC. PQLS were less than applicable MTCA Method A cleanup levels.

Water samples were collected from the domestic water well serving Property ID No. 6606 on May 1, 2012 and July 27, 2012. GRPH and VOCs were not detected in the water sample.

Water samples were collected from the domestic water well serving Property ID No. 6607 on April 4, 2012 and May 8, 2012. GRPH was detected in the April 2012 sample at a concentration (156 µg/L), less than the MTCA Method A cleanup level. GRPH was detected in the May 2012 sample at a concentration (914 µg/L), greater than the MTCA Method A cleanup level. Benzene was detected both water samples at concentrations (433 µg/L and 1,190 µg/L), greater than the MTCA Method A cleanup level. Other VOCs were either not detected, or detected at concentrations less than applicable MTCA Method A cleanup levels. Refer to **Section 5.5** for a brief discussion regarding PQLs.

Water samples were collected from the well serving Property ID Nos. 6608 and 6609 on May 1, 2012, July 27, 2012 and August 21, 2012. GRPH and VOCs were not detected in the May 2012 water sample. Benzene was detected at concentrations greater than the MTCA Method A cleanup level in the July 2012 and August 2012 samples. GRPH, toluene, ethylbenzene and xylenes also were detected at concentrations less than applicable MTCA Method A cleanup levels in the July 2012 sample. Other VOCs also were detected in the August 2012 sample at concentrations less than applicable MTCA Method A cleanup levels. The August 2012 sample was not analyzed for GRPH.

Water samples were collected from two domestic water wells serving Property ID No. 6610 on May 21, 2012. A hand-dug well was located about 1,300 feet east of the Airport Kwik Stop, and a drilled well was located about 1,250 feet east of the Airport Kwik Stop, and about 100 feet southwest of the hand-dug well. GRPH and VOCs were not detected in either water sample. During the summer of 2012, the property owner installed two new wells on the property. Water samples were collected from the new wells on July 27, 2012. Toluene was detected in the sample from the new west well at concentrations less than the MTCA Method A cleanup level. GRPH and other VOCs were not detected in the samples.

Water samples were collected from two water wells serving Property ID No. 6475 on April 12, 2012. One well is a hand-dug well located about 150 feet east from the Airport Kwik Stop fuel dispensers. The other well is also is a hand dug well located about 950 feet northeast of the Airport Kwik Stop. GRPH was detected in the sample from the hand dug well located nearest to the Airport Kwik Stop at a concentration (458 µg/L), which was less than the MTCA Method A cleanup level. Benzene was detected in the sample at a concentration (23.0 µg/L), greater than the MTCA Method A cleanup level. Other BTEX compounds were detected at concentrations less than applicable MTCA Method A cleanup levels in the groundwater sample from the hand-dug well. GRPH and VOCs were not detected in the groundwater sample from the other hand dug well.

A water sample was collected from the domestic water well serving Property ID No. 6647 (Airport Kwik Stop property) on April 12, 2012. The domestic water well is located about 300 feet west (upgradient) of the fuel dispensers. GRPH and VOCs were not detected in the water sample.

A water sample was collected from the domestic water well serving Property ID No. 6469 (located north (upgradient of the Airport Kwik Stop) on April 12, 2012. The domestic water well is located about 250 feet northwest of the Airport Kwik Stop. GRPH and VOCs were not detected in the water sample.

A water sample was collected from the domestic water well serving Property ID No. 6628 (located about 1,600 feet southeast of the Airport Kwik Stop) on December 12, 2011. GRPH and VOCs were not detected in the water sample.

6.2.6. Water Quality Results

Groundwater samples collected from select Site monitoring wells during the November 2011, February 2012 and May 2012 monitoring events were submitted to a qualified analytical laboratory for analysis of water quality parameters including: alkalinity, dissolved iron, dissolved manganese, nitrates, sulfates and pH. The groundwater samples were collected from monitoring wells MW-7 (an upgradient well), MW-6 (a downgradient, relatively heavily-contaminated well) and MW-14 and MW-15 (downgradient wells which have been less impacted than MW-6).

In general, alkalinity measurements decreased across the site between the November 2011 and the May 2011 events. Alkalinity measurements were lowest in the groundwater samples from monitoring well MW-7. Dissolved iron concentrations remained relatively consistent in the samples. Nitrate and sulfate concentrations generally increased in groundwater samples from MW-14 and MW-15 and decreased in groundwater samples from MW-7 between November 2011 and May 2012. Sulfate concentration also decreased in groundwater samples from MW-6 between November 2011 and May 2012. Nitrate and sulfate concentrations were lowest in groundwater samples from MW-6. Measurement of pH also was lowest in groundwater samples from MW-6. The lowest nitrite concentrations were measured in groundwater samples from MW-6. A summary of water quality results is provided in Summary of Groundwater Chemical Analytical Results - Water Quality Parameters, Table C-4, in Appendix C.

6.2.7. Ione Airport

Groundwater samples were collected during each quarterly monitoring event, except the August 2012 event, from monitoring well MW-2, located downgradient of the former Ione Airport USTs, and generally crossgradient of the premium fuel dispenser at the Airport Kwik Stop and submitted for analyses of GRPH and BTEX compounds and other selected VOCs. GRPH and BTEX compounds have not been detected in any of the groundwater samples. The only detection of VOCs was EDB at the method reporting limit of 0.01 µg/L from the groundwater sample collected during the August 2010 monitoring event.

A groundwater sample was collected from direct-push boring DP-5 and submitted for laboratory analyses. GRPH and BTEX compounds were not detected.

6.3. Fluid Elevations and Field Parameters

Depth to groundwater measurements during the quarterly monitoring events, referenced to the top rim of the polyvinyl chloride (PVC) well casing, ranged from 12.92 feet in MW-10 (March 2012) to 41.56 feet in MW-15 (August 2011). Groundwater elevations have ranged from 2,069.51 feet in MW-10 (February 2011) to 2,078.56 feet in MW-1 August 2011).

Using an interface probe, petroleum product was measured in monitoring well MW-5 during each of the monitoring events. The thickness of floating product at MW-5 ranged from about 0.35 feet to 0.87 feet. About 0.25 feet of petroleum product also was measured once in monitoring well MW-8 (May 2011) and 0.01 feet of petroleum product was measured once in monitoring well MW-4 (December 2011). The relative densities of gasoline and groundwater were used to develop an estimate for the equivalent groundwater elevation (in the absence of petroleum product) in the following equation:

$$GW = (SG \times T) + IE$$

Where
GW = equivalent groundwater elevation;
SG = specific gravity of product (0.75 for gasoline);
T = thickness of product measured in water using oil/water interface probe; and
IE = elevation of water/product interface measured in the well.

Groundwater elevations, as measured in Site wells, generally exhibited the same pattern of fluctuation during the measurement period (August 2010 to May 2012). Groundwater elevations remained fairly constant from the August 2010 to the February 2012 monitoring events. From the February 2011 to the November/December 2011 monitoring events, groundwater elevations in the Site monitoring wells (with the exception of MW-1) increased about 3 feet. From the November/December 2011 to the May 2012 monitoring events, groundwater elevations in the Site wells generally decreased slightly. From the May 2012 to the August 2012 monitoring events, groundwater elevation in the site wells generally increased slightly. Calculated groundwater elevations measured in the Site monitoring wells during each of the monitoring events are presented in Summary of Groundwater Level Measurements, Table C-5, in Appendix C. Groundwater elevations also are presented graphically from the May 2012 quarterly monitoring event in Figure 12 and Figure 13. Field-measured groundwater parameters and results of vapor headspace measurements are provided in Summary of Field Quality Parameters, Table C-6, in Appendix C. A summary of calculated groundwater elevations from select Site monitoring wells is presented graphically in Figure 14.

As a basis for evaluating the measured fluctuations in groundwater elevations at the Site, available precipitation and snowfall data for the nearest weather station in the National Oceanic and Atmospheric Administration (NOAA) cooperative network (Boundary Dam, Station No. 450844), was obtained from the Western Regional Climate Center. The Boundary Dam weather station is located about 20 miles north of the Site. Based on review of the data, the winter preceding initial measurement of groundwater elevations at the Site (winter of 2009-2010) had the lowest snowfall on record (records were available beginning in 1964-1965). The recorded snowfall for that year was 17.3 inches (about 30 percent of the average annual snowfall of 57.46 inches). Additionally, the total precipitation for the three years preceding site characterization work (2007 through 2009) was below average. The total recorded precipitation for those three years ranged from 21.64 inches to 23.85 inches (about 78 percent to 86 percent of average). The total precipitation for 2009 also was the lowest on record since 1985. Based on these, and the recharge mechanism summarized in the following paragraph, we interpret that the groundwater data elevations measured in 2010 during the initial year of monitoring are anomalously low. The recorded snowfall for the 2010-2011 winter was 71.3 inches (about 125 percent above average) and the recorded snowfall for the 2011-2012 winter was 59.3 inches (about 103 percent of average). The total precipitation for 2010 was 27.8 inches (about 100 percent of average) and the total precipitation for 2011 was 23.81 inches (about 86 percent of average). Through October 2012, the total precipitation for 2012 was 27.46 inches (about 100 percent of the yearly average).

Based on the location of the Site and surrounding topography and review of the climate data, it is likely that that precipitation/snowmelt and associated groundwater recharge in upgradient upland areas are the primary controls on aquifer groundwater elevations. Lower groundwater elevations associated with initial groundwater measurements between August 2010 and May 2011 appear to be the result of antecedent below average snowfall and total precipitation. The rise in groundwater elevations observed beginning in May 2011 appear to be the result of increased snowfall and total precipitation beginning with the 2010-2011 winter snowfall.

6.4. Hydraulic Gradient and Groundwater Flow Direction

Interpreted groundwater flow direction during each groundwater monitoring event generally was toward the east in the western portion of the Site and to the east-southeast in the eastern portion of the Site; away from upland recharge areas to the west and towards the Pend Oreille River to the east. However, the local distribution in groundwater elevation and gradient observed at the Site was relatively complex. Within the west portion of the Site (approximately between monitoring wells MW-1 and MW-8), hydraulic gradient was relatively steep. The estimated hydraulic gradient from the monitoring events ranged from about 1.2×10^{-2} feet per foot (about 62 feet per mile) to about 2.0 x 10^{-2} feet per foot (about 110 feet per mile). Within the east portion of the Site (approximately between monitoring wells MW-8 and MW-16), hydraulic gradient flattened significantly. The hydraulic gradient estimated from the monitoring events ranged from about 1.9 x 10^{-3} feet per foot (about 10 feet per mile) to about 2.4 x 10^{-3} (about 13 feet per mile). Variation in hydraulic gradient could be caused by soil permeability variation across the Site (an increase in permeability to the east) or the geometry of perching layers. It is also possible that the steep gradient measured in the western portion of the Site is caused by perched groundwater conditions at the location of monitoring well MW-1. Indications of a cone of depression centered around the Cabin Grill well and groundwater mounding related to the septic drain field located to the east of the Cabin Grill were not observed based on the groundwater elevation measurements corrected for light non-aqueous phase liquids (LNAPL).

The interpreted groundwater elevation contours and flow direction for the May 2012 monitoring event are presented in Figure 12 and Figure 13. In general, groundwater flow direction remained relatively constant within the west portion of the site. However, beginning around the August 2011 monitoring event, the groundwater flow direction within the eastern portion of the Site began to shift towards a more easterly direction. The change in flow direction appears to coincide with the observed long-term increase in groundwater elevations across the Site and associated increase in groundwater recharge in adjacent upland areas.

6.5. Hydraulic Conductivity Testing

6.5.1. Method Selection

Rising head slug testing of selected Site wells was conducted as a basis for estimating saturated hydraulic conductivity and, ultimately, groundwater velocity, within the shallow aquifer beneath the Site. A number of techniques for estimating hydraulic conductivity were considered, including (in order of decreasing complexity) aquifer testing, slug testing, laboratory permeability testing and empirical analysis of grain-size distribution data. In our opinion, in-place hydraulic testing (aquifer or slug testing) provide more accurate hydraulic conductivity estimates in sand and gravel aquifers than laboratory or empirical grain-sized based analyses. Aquifer testing (via a conventional pumping test) initially was selected. A test well was planned for the Vacant Property located east of the Airport Kwik Stop within an area not impacted by the contaminant plume. However, due to the swing in groundwater flow direction and expansion of the plume between the work plan and Site activities, the planned test well location fell within the plume. Moving the test well to a uncontaminated area was considered, but not selected, because of the distance from the Site to the test well would have been significant, making correlations between the pump test location and the Site questionable. The pumping test also was not completed because of the following additional considerations:

- Large volume of potentially contaminated groundwater that would have to be treated and discharged, or hauled off site and disposed at a permitted facility for a pumping test completed near the Site;
- Large increased cost in testing infrastructure and treatment and discharge/disposal costs from initial cost estimates due to groundwater contamination; and
- Permitting and associated schedule constraints.

Based on these considerations, slug testing was selected for use. However, the following limitations are inherent to the selected methodology;

- Slug tests provide a point estimate of hydraulic conductivity near the tested well screen (as opposed to pumping tests which stress a larger volume of aquifer material);
- Inadequate well development can cause slug testing to underestimate the hydraulic conductivity of the subject aquifer;
- In highly permeable formations (such as those encountered beneath portions of the Site), water level response can be too rapid to achieve precise hydraulic conductivity estimates. In these cases, water level recovery within the tested well could actually be limited by the permeability of the well's sand pack, rather than the surrounding native formation.

6.5.2. Test Methodology

The saturated hydraulic conductivity of the aquifer beneath the Site was estimated by performing slug tests in monitoring wells MW-6, MW-7, MW-9, MW-10 and MW-19 on July 27, 2012. Monitoring wells to be tested were selected to achieve areal distribution across the site and include wells representative of upgradient (MW-7), central (MW-19 and MW-9) and downgradient (MW-6 and MW-10) aquifer conditions. The locations of the selected monitoring wells are shown on Figure 3.

A rising-head slug test is performed by rapidly lowering the water level in a well and measuring the subsequent rate of water level change as head conditions recover. Lowering the water level is achieved by quickly removing a slug (in this case a sealed PVC pipe filled with impermeable material) from the water column.

Water level data were recorded by a pressure transducer and data logger. After slug testing, the data were downloaded, reduced and analyzed for hydraulic conductivity using a solution derived by Bouwer and Rice (1976) and updated by Bouwer (1989).

Slug test data are presented for monitoring wells MW-6, MW-7, MW-9, MW-10 and MW-19 in Rising Head Test Plots, Figures D-1 through D-5, respectively of Appendix D. Three to four rising head tests were performed at each test location and generally good agreement was achieved between tests at respective locations. A summary of the inputs and results of the hydraulic conductivity analyses are presented in Rising Head Test Analyses, Table D-1 of Appendix D.

6.5.3. Results

Water level recovery during slug testing was very rapid in monitoring wells MW-6, MW-9, MW-10 and MW-19. In these wells, full recovery generally was achieved in less than 10 seconds, which is indicative of permeable soil conditions. The average hydraulic conductivity estimates at these well locations are in close agreement, ranging from about 4.8×10^2 feet per day at MW-10 to 8.3×10^2 feet per day at MW-6.

Water level recovery was less rapid in upgradient monitoring well MW-7, achieving full recovery in about two minutes. The average hydraulic conductivity estimate at MW-7 is over an order of magnitude lower than the other four wells, at about 2.4×10^1 feet per day.

Results of hydraulic conductivity analyses are summarized in Table 6 below.

TABLE 6. HYDRAULIC CONDUCTIVITY SUMMARY

Monitoring Well	Average Hydraulic Conductivity[1] (feet per day)
Upgradient	
MW-7	2.4×10^1
Central and Downgradient	
MW-6	8.3×10^2
MW-9	5.8×10^2
MW-10	4.8×10^2
MW-19	6.2×10^2
Geometric Mean[2]	6.2×10^2

Notes:

[1] Hydraulic conductivity estimates represent average result of rising-head slug tests conducted at each location.

[2] Geometric mean of the central and downgradient monitoring wells.

Based on the results of the analyses, the saturated hydraulic conductivity of the aquifer near the selected monitoring wells ranges from about 24 feet per day near upgradient monitoring well MW-7 to about 830 feet per day within the approximate center of the Site near MW-6. These saturated hydraulic conductivity estimates are, on balance, relatively high and generally indicative of a permeable aquifer that has potential for transport of significant quantities of groundwater and, consequently, associated soluble groundwater contaminants.

6.5.4. Groundwater Velocity

6.5.4.1. GENERAL

Groundwater flow velocity for the shallow unconsolidated aquifer underlying the Site was estimated using a standard Darcy's Law-based analysis:

$$V = -(K/n_e) * dh/dl$$

where
V = groundwater flow velocity,
K = saturated hydraulic conductivity,
n_e = effective porosity of the aquifer material, and
dh/dl = hydraulic gradient.

An effective porosity of 25 percent, based on typical values for sand and gravel aquifers presented in Domenico and Schwartz (1990).

Two groundwater velocities were calculated, one for the upgradient portion of the Site (based on the hydraulic properties observed in monitoring well MW-7 and approximately situated northwest of cross section line B-B' [Figure 3]) and the other for the central and downgradient portion of the Site (based on the hydraulic properties observed in monitoring wells MW-6, MW-9, MW-10, and MW-19 and approximately situated southeast of cross section line B-B').

6.5.4.2. UPGRADIENT GROUNDWATER VELOCITY

For the upgradient portion of the Site, the following inputs were assumed:

- A hydraulic gradient of 1.6 x 10^{-2} feet per foot, based on historic groundwater elevation distribution data.
- A hydraulic conductivity of 24 feet per day, based on the hydraulic conductivity estimate associated with slug testing in monitoring well MW-7.

Based on these inputs, we estimate the groundwater flow velocity within the shallow unconsolidated aquifer underlying the upgradient portion of the Site is about 1.5 feet per day.

6.5.4.3. CENTRAL AND DOWNGRADIENT GROUNDWATER VELOCITY

For the central and downgradient portion of the Site, the following inputs were assumed:

- A hydraulic gradient of 2.1 x 10^{-3} feet per foot, based on historic groundwater elevation distribution data.
- A hydraulic conductivity of 620 feet per day, based on the geometric mean of hydraulic conductivity estimates associated with slug testing in central and downgradient monitoring wells.

Based on these inputs, we estimate the groundwater flow velocity within the shallow unconsolidated aquifer underlying the central and downgradient portions of the Site is about 5.2 feet per day.

6.6. Summary and Conclusions of Groundwater Investigation

A graph of GRPH concentrations detected in groundwater samples from monitoring wells MW-3, MW-4, MW-6, MW-8, MW-9, MW-10, MW-13 and MW-14 are presented in Figure 15. A graph of benzene concentrations detected in groundwater samples from monitoring wells MW-3, MW-4, MW-6, MW-8, MW-9, MW-10 and MW-14 is presented in Figure 16. For analytical results in which GRPH or benzene was not detected, a concentration equal to the PQL was ascribed to the particular sample to create the graphs. PQLs were below the applicable MTCA Method A cleanup levels.

Relatively high concentrations of GRPH and BTEX compounds were detected in groundwater samples from monitoring wells MW-3, MW-5, MW-6 and MW-8 during the initial groundwater monitoring event in August 2010. These relatively high concentrations are attributed to source contamination at the Airport Kwik Stop. Additionally, floating product present at monitoring well MW-5 likely is an additional source of contaminants for groundwater contamination measured in groundwater samples from MW-5 and MW-6.

Concentrations of GRPH and BTEX compounds in groundwater samples collected from monitoring well MW-3, the nearest downgradient well from the Airport Kwik Stop, exhibited a spike beginning with the May 2011 monitoring event. Concentrations of GRPH and BTEX compounds in groundwater samples collected from monitoring wells MW-4 and MW-8 exhibited a spike during the subsequent monitoring event in August 2011 (a sample was not collected from MW-8 during the May 2011 monitoring event). Concentrations of GRPH and BTEX compounds in groundwater samples collected from monitoring wells MW-9, MW-13 and MW-14 also exhibited a spike during the November 2011 monitoring event.

GRPH and benzene concentrations in groundwater samples from wells MW-3 and MW-8 generally decreased between the August 2011 and May 2012 monitoring events. Concentrations of benzene and/or GRPH in groundwater samples from wells MW-14 and MW-13 decreased between the November 2011 and May 2012 monitoring events. GRPH concentrations in groundwater samples from wells MW-9 and MW-10 have generally increased between the November 2011 and May 2012 monitoring events. Benzene concentrations in groundwater samples from well MW-10 have increased between the November 2012 and May 2012 monitoring events.

The spikes in contaminant concentrations measured in groundwater samples from Site monitoring wells during the May 2011 through November 2011 monitoring events correspond with the measured rise in the groundwater table across the site, which began sometime between the February 2011 and August 2011 monitoring events. The spike in contaminant concentrations in groundwater samples generally was measured earlier at monitoring wells located closest to the Airport Kwik Stop fuel dispensers, with a lag in the time of measurement of the spike with increased distance between monitoring wells and the Airport Kwik Stop fuel dispensers. The spike could be caused by the increase in the elevation of the groundwater table, which could mobilize contaminants within the smear zone, and possibly increase vertical migration of contaminants through the vadose zone to the groundwater table, as a result of increased infiltration of precipitation and/or snowmelt. Artificial recharge from increased water usage and subsequent infiltration in the on-site septic system, which is located northwest of the fuel dispensers at the Airport Kwik Stop, due to the temporary restarting of operations between the spring/summer of 2011 and the fall/winter of 2011/2012, also could have contributed to the migration of contaminants from the vadose zone to groundwater.

The observed general decline in GRPH and/or benzene concentrations measured in groundwater samples from wells MW-3, MW-8 could be the result of the measured slight decrease in groundwater elevations since the November 2011 monitoring event. The observed general increase in GRPH and benzene concentrations in groundwater samples from MW-9 and MW-10, and decrease in GRPH and benzene concentrations could be the result of the leading edge of the plume reaching MW-9 and MW-10 sometime between the August 2011 and November 2011 monitoring events, and the easterly shift in the groundwater flow direction observed since the August 2011 monitoring event, away from wells MW-13 and MW-14, and towards wells MW-3 and MW-9.

Results of slug testing and groundwater elevation measurements indicate that the saturated portion of the shallow aquifer underlying the Site has a relatively high hydraulic conductivity and groundwater within the aquifer has a correspondingly high velocity. Based on anecdotal evidence of observed contamination in the Cabin Grill domestic well in April 2008 and the most recent observation of contamination in the domestic well serving Property ID No.6608/6609 in July 2012, and a distance between the Cabin Grill well and the well serving Property ID No. 6608/6609 of about 1,300 feet, suggests that contaminant velocity is slightly less than the groundwater velocity estimated, in part, from the slug tests, perhaps on the order of about 1 foot per day.

7.0 ESTIMATES OF CONTAMINANT MASS

7.1. General

Results of subsurface explorations and analytical laboratory testing were utilized to estimate the mass of contaminants in the affected media (vadose zone soil, floating product and groundwater). The purpose of the assessment was to evaluate the general areas on the Site where most of the petroleum contaminants are located as a basis for evaluating potential future Site impacts and to focus on areas for evaluating potential remediation alternatives. It should be noted that the estimates of contaminant mass presented in this section are based on the available data. A number of interpretations and assumptions were made related to the data in order to complete the estimates, as presented herein. As such, the quantities presented in this section should be considered very approximate, particularly estimates for the mass of floating product.

7.2. Vadose Zone Soil

The mass of petroleum contaminants located within vadose zone soil at the Airport Kwik Stop was estimated using the following procedures and assumptions:

Based on the results of subsurface explorations, and laboratory testing, we assumed that a truncated cone of petroleum contamination was present within the vadose zone at the Airport Kwik Stop. We estimated that the truncated cone extended from the ground surface to groundwater (about 35 feet bgs). We also estimated that the radius of the truncated cone at the groundwater table is about 30 feet, and the radius of the truncated cone at the ground surface is about 15 feet. Within the zone of contamination, we assumed a cylindrical-shaped zone of heavily contaminated soil. Therefore, two distinct volumes were evaluated: the cylindrical-shaped zone of heavy contamination, and the remaining portion of contamination within the truncated conical-shaped zone.

- Heavily Contaminated Zone
    - We assumed that the cylindrical-shaped zone of heavily contaminated soil was present directly beneath the premium fuel dispenser. We assumed the radius of the heavily contaminated zone was 15 feet (the approximate distance between the premium fuel dispenser and explorations SVE-1, DP-18, DP-34 and DP-40). We also assumed the length of the cylindrical zone was 25 feet (distance from the ground surface to a depth of about 25 feet). The total volume of the estimated heavily-contaminated zone was therefore:

      $$\text{Volume} = \pi \times r^2 \times h = \pi \times 15^2\ (ft^2) \times 25\ (ft) = 17{,}700\ ft^3$$

      We assumed a dry unit weight of 110 pounds per cubic foot (pcf) for site soil (assumed moist unit weight of 120 pcf with a moisture content of 9 percent.

      On this basis, we estimated a weight of soil within the heavily-contaminated zone of:

Weight of Soil = dry unit weight x volume = 110 pcf x 17,700 ft^3 = 1,947,000 pounds

1,947,000 pounds x (1 kilograms/ 2.2 pound) = 885,000 kilograms

- Based on the results of analytical laboratory testing, we assumed an average concentration of petroleum products (based on dry weight of soil) within the heavily contaminated zone of 15,000 mg/kg. This includes an estimated concentration of 12,500 mg/kg for GRPH, 800 mg/kg for toluene, 350 mg/kg for ethylbenzene, and 1,350 mg/kg for xylenes.

  On this basis, we estimated a weight of contaminants within the heavily contaminated zone of:

  Mass of contaminants = concentration in soil x weight of soil = 15,000 mg/kg x 885,000 kilograms (kg) = 1.33×10^{10} milligrams (mg)

  1.33×10^{10} mg x 1 kg/1 x 10^6 mg = 13,300 kg

  13,300 kg x (2.2 pound/1 kilograms) = 29,200 pounds of petroleum

- Assuming a specific gravity of 0.75, the approximate volume of petroleum estimated within the heavily contaminated vadose zone is:

  Volume of contaminants = 29,200 pounds / (0.75 x 62.4 pounds per cubic foot [pcf]) = 625 ft^3

  625 ft^3 x 7.48 gallons/ft^3 = 4,670 gallons

- Remainder of Contaminated Vadose Zone Soil

  - For the remainder of the vadose zone contamination outside of the heavily contaminated zone, we assumed that the volume of contaminated soil equaled the total volume of contaminated soil minus the volume of heavily contaminated soil:

    Volume of contaminated soil = volume of truncated zone – volume of heavily contaminated cylindrical area

    Volume of truncated cone = $(1/3\ \pi \times 30^2 \times 70) - (1/3\ \pi \times 15^2 \times 35)$ = 57,700 ft^3

    Volume of remaining vadose zone contamination = 57,700 ft^3 – 17,700 ft^3 = 39,000 ft^3

  - We assumed the same dry unit weight of soil for the remainder as we assumed for the heavily contaminated portion. Therefore, we estimated the weight of soil within the remainder of the vadose zone contamination as:

    Dry weight of contaminated soil = 110 pcf x 39,000 ft^3 = 4,290,000 pounds

    4,290,000 pounds x (1 kilograms/2.2 pound) = 1,950,000 kilograms

- Based on the results of laboratory analytical testing, we assumed an average concentration of petroleum products (based on dry weight of soil) within the remainder of the contaminated zone of 130 mg/kg (GRPH). On this basis, we estimated the mass of petroleum contaminants within the remainder of the vadose zone contamination of:

  Mass of contaminants = 130 mg/kg x 1,950,000 kg = 253,500,000 mg

  2.5×10^8 mg x 1kg/10^6 mg =250 kg

  250 kg x (2.2 pound/1 kilograms) = 560 pounds

- Assuming a specific gravity of 0.75, we estimated the volume of contaminants within the remainder of the vadose zone contamination as:

  Volume of contaminants = 560 pounds / (0.75 x 62.4 pcf) = 12 ft^3

  12 ft^3 x 7.48 gallons/ft^3 = 90 gallons

- Therefore, we estimated that the total mass of petroleum contaminants within the vadose zone at the Airport Kwik Stop is approximately 29,800 pounds. The corresponding estimated volume of petroleum contaminants is approximately 4,800 gallons, most of which we estimated to be located within a heavily contaminated zone beneath the premium fuel dispenser.

7.3. Floating Product

We completed simplified estimates of the mass of floating product located near monitoring well MW-5 based on review of groundwater monitoring results. It should be noted that estimates of floating product mass are based on a single data point (MW-5). Therefore, the estimated mass is very approximate. The thickness of floating product measured at the location of MW-5 has varied from 0.35 feet to 0.87 feet, with an average thickness during quarterly monitoring events of 0.67 feet. We assumed that floating product extended radially outward from MW-5 a distance of 75 feet, about one-half the distance from MW-5 to neighboring wells MW-3, MW-4 and MW-19. We also assumed that the floating product was conical in shape, with a maximum thickness of 0.67 feet located at MW-5, and tapering to a thickness of zero at the radial boundary. In the absence of results of bail-down tests, and based on the coarse-grained nature and relatively low silt and clay content of the sand material within the saturated zone, we further assumed that the measured thickness of floating product in MW-5 equaled the actual thickness of floating product within the formation (i.e., no correction was applied to account for discrepancies between measured product thickness in the well and actual product thickness within the formation due to capillary forces). We also assumed a porosity of 0.25. On this basis, we estimated the volume of floating product to be:

Volume of floating product = volume of conical shape of product x volume of pore space within soil (porosity) = $1/3 \times \pi \times 75^2 \times 0.67 \times 0.25$ = 980 ft^3 x 7.48 gallons/ft^3= 7,400 gallons

Assuming a specific gravity of 0.75, we estimated the mass of floating product to be:

Mass of floating product = (0.75 x 62.4 pcf) x 980 ft^3 = 45,900 pounds

Based on the limited data available, this estimate should be considered very approximate.

7.4. Groundwater

We estimated the mass of contaminants dissolved in groundwater using the GRPH concentration contours shown in Figure 17. The contour locations presented in Figure 17 are approximate in nature, and were estimated based on the results of recent and previous groundwater monitoring and analytical test results. The average concentration within each contour interval was multiplied by the estimated volume of water within each contour interval, to obtain the estimated mass of contaminants within each contour interval. The estimated masses for each contour interval were then added together to obtain the total estimated mass of dissolved contaminants within the plume of petroleum-contaminated groundwater. To estimate the volume of water within each contour interval, the area of each contour interval was multiplied by the estimated saturated thickness of water within the upper unconfined aquifer, and by the estimated porosity of the sand comprising the unconfined aquifer.

Because the concentrations of GRPH in groundwater generally were at least an order of magnitude greater than BTEX concentrations, we only used GRPH concentrations to estimate the mass of contaminants dissolved in groundwater. Based on groundwater elevation measurements from the May 2012 groundwater monitoring event, we estimated the thickness of the saturated zone within the upper unconfined aquifer located at the location of contaminated monitoring wells was between about 7 feet and 11 feet, with an average estimated saturated thickness of about 9 feet. Therefore, we assumed a saturated thickness of 9 feet throughout the plume of contaminated groundwater in estimating the mass of dissolved contaminants. We also assumed a porosity of 0.25 for the sand comprising the unconfined aquifer material. Therefore, the estimated mass of contaminants was:

Mass of dissolved GRPH (µg) = $\sum_{i}^{n} Area_i \times H_i \times \eta \times C \times 28.32$

Where

i = contour area of interest (dim.)

n= total number of contour areas (dim.) (8 contour areas total)

$Area_i$ = measured area of each groundwater contour from Figure 16 (ft^2)

H_i = thickness of saturated zone within $Area_i$ (ft) (assumed to be 9 feet for all areas)

η= porosity of sand aquifer (dim.) (assumed to be 0.25)

C = estimated concentration of GRPH within $Area_i$ (µg/L) (for example C = 25,000 µg/L for the 20,000 µg/L to 30,000 µg/L contour interval area.

28.32 = conversion factor from ft^3 to L

Based on this method, we estimated the total mass of dissolved GRPH within the plume to be about 9.6×10^{11} µg. This equates to a mass of about 2,100 pounds (about 335 gallons).

7.5. Summary of Contaminant Mass Estimates

Based on the methods previously described, we estimated the total mass of contaminants to be approximately 77,800 pounds (about 12,500 gallons). We estimated about 38 percent of the mass of contaminants is located within the vadose zone at the Airport Kwik Stop, about 59 percent is floating product near the Cabin Grill, and about 3 percent is in the dissolved phase within the plume of contaminated groundwater. As stated previously, these estimates are approximate in nature, especially estimates of the mass of floating product, but they do, in our opinion, reliably indicate that most of the contaminants are located within source areas, and could potentially contribute to continued contamination of groundwater and subsequent expansion of the plume of petroleum-contaminated groundwater.

8.0 SVE AND AIR SPARGE PILOT TESTING

8.1. General

Before commencing with SVE and AS pilot testing, three groundwater monitoring wells (MP-1, MP-2 and MW-8), one air sparge pilot test well (AS-1) and two pilot SVE test wells (SVE-1 and SVE-2) were installed at the site. The SVE pilot test wells are screened within the vadose (unsaturated) zone above the water table. The AS pilot test well was screened below the water table.

SVE pilot tests were performed on May 8, 2012 in the area of known vadose-zone contamination at the Airport Kwik Stop, generally east of the former fuel dispensers and USTs. Test results were utilized to ascertain the effectiveness of SVE to address source contamination, and were used to design an interim SVE remediation system.

AS pilot tests were performed on May 9, 2012 to assess if AS techniques could be an effective remedial approach to address gasoline-contaminated groundwater at the Airport Kwik Stop.

8.2. SVE Pilot Testing

8.2.1. General

During pilot testing, the SVE pilot test wells were connected to a blower, which applied a vacuum to the wells. The applied vacuum pulled air from the surrounding soil, into the well screens, and then through piping to an exhaust stack. Air flow through the soil enhances volatilization of petroleum products located within the vadose zone. The volatilized petroleum products are pulled into the SVE wells, thereby removing them from the ground. A conceptual layout of an SVE system is presented in Typical Soil Vapor Extraction System, Figure 18.

Three SVE tests were performed by drawing a vacuum from wells SVE-1 and SVE-2, first individually, then collectively, for a period ranging from 1¾ to 3 hours per test. Tests were conducted using a Rotron EN 404 regenerative blower to apply a vacuum to piping connected to the wellhead(s) of SVE-1 and/or SVE-2. Vacuums were measured at adjacent monitoring wells, specifically wells MP-1, MP-2, and MW-8 (and the other SVE well during the individual tests). The locations of the wells at the Airport Kwik Stop site are shown in Figure 3 and Figure 4.

Test equipment included a trailer-mounted remediation system consisting of the regenerative blower, a moisture knockout tank, and an exhaust stack, and both flex and rigid pipe connecting the remediation system to the wellhead(s). The rigid pipe (5-foot-long, 2-inch-diameter) was placed at the wellhead and sample ports were located at the end of the pipe furthest from the wellhead (the straight, rigid pipe can reduce the air flow turbulence and result in more reliable air flow readings); about 50 feet of 2-inch-diameter flex pipe connected the rigid pipe to the moisture knockout tank at the remediation system. Sample ports also were placed at the exhaust stack. Each test was performed in a stepped approach, beginning each test with low applied vacuum and ample dilution air, and increasing the vacuum by closing the dilution air valve in steps. The end of each test was performed with the dilution air valve completely closed (maximum applied vacuum). The moisture knockout tank was located in line between the wellhead and the blower to reduce the potential for moisture damage to the blower.

During each test, the following parameters were measured in the sample ports located on the rigid pipe and exhaust stack: air velocity, vacuum, VOCs, oxygen levels, and carbon dioxide levels. Observed vacuum was measured at regular intervals during the tests using magnehelic gauges placed at the wellheads of observation wells; applied vacuum at the blower was increased after observed vacuum at observation wells stabilized. Depth to groundwater was measured in air sparge well AS-1 to monitor if applied vacuum affected groundwater elevations. At the conclusion of the individual tests at SVE-1 and SVE-2, a vapor sample was collected into a Summa canister from the sample port located at the exhaust stack.

Well screen information is provided below:

- Well SVE-1 is a 4-inch-diameter well screened from about 10 to 20 feet bgs
- Well SVE-2 is a 4-inch-diameter well screened from about 25 to 35 feet bgs
- Wells MP-1 and MP-2 are 2-inch-diameter wells screened from about 10 to 40 feet bgs
- Well AS-1 is a 4-inch-diameter well screened from about 40 to 42 feet bgs (submerged screen)
- Well MW-8 is a 2-inch-diameter well screened from about 28½ to 43½ feet bgs

8.2.2. SVE Test Results Using SVE-1

The test conducted at well SVE-1 began at a measured vacuum of 10 inches of water (iow) at the moisture knockout tank and 6.0 iow at the wellhead; the dilution valve was about 50 percent open. Air velocity through the 2-inch-diameter exhaust stack was measured between about 4,670 feet per minute (fpm) to 5,070 fpm; this converts to about 102 to 109 cubic feet per minute (cfm), which matches the manufacturer's blower rating curves for the applied vacuum. After about one hour into the test, the dilution valve was fully closed, which resulted in a measured vacuum of 16 iow at the moisture knockout tank and about 8.3 iow at the wellhead. The test at SVE-1 was operated at this vacuum for about 75 minutes, and the entire test was completed after about 2¼ hours. Air flows decreased slightly during the second half of the test at SVE-2 and ranged from about 87 cfm to 103 cfm with the dilution valve fully closed. Air flows generally remained constant throughout the test at SVE-1. Field data is provided in SVE-1 Test Data, Figure E-1 in Appendix E and a summary of measurements is listed below:

- Oxygen levels at the wellhead ranged from about 2.6 percent to 5.6 percent during the test. Oxygen levels at the exhaust stack were measured at 7.1 percent during the first hour of the test; then decreased to about 1.2 percent to 1.4 percent after the dilution valve was closed.
- Carbon dioxide levels were consistently measured greater than 5 percent at both the wellhead and exhaust stack during the test.

- Temperatures ranged from about 58.0 to 65.5 degrees Fahrenheit at the wellhead and from about 88.5 to 96.5 degrees Fahrenheit at the exhaust stack; temperatures gradually increased in the exhaust stack during the test.
- VOCs, as measured using a PID consistently exceeded the maximum range of the PID within 1 to 2 seconds. The PID was removed from the air flow after the pre-set alarm sounded because extended readings could have damaged the equipment. Results shown in Figure E-1 represent the last reading observed before the alarm sounded.
- Applied vacuums at four monitoring wells were measured during the test; wells ranged in linear distance from about 12½ to 39½ feet from SVE-1. Actual distances, as measured from the closest point between screened intervals of SVE-1 and observation wells, ranged from about 22½ to 39½ feet. Observed vacuum at observation wells at the conclusion of each stepped test ranged from about 4.7 percent to 7.6 percent of the applied vacuum at the wellhead.
- The depth to groundwater, as measured in well AS-1, remained steady at 34.75 feet below the top of well casing throughout the test.
- Analytical results of the vapor sample collected at the conclusion of the SVE-1 test indicate concentrations of total petroleum hydrocarbons were 16,500 parts per million by volume (ppmv) and benzene concentrations were 870 ppmv. Results are shown in Table 7.

TABLE 7. SVE PILOT TESTING VAPOR SAMPLE ANALYTICAL RESULTS

Sample ID		**SVE-1-050812**	**SVE-2-0508-012**
Date Sampled		**5/8/12**	**5/8/12**
TO-15 (micrograms per cubic meter [µg/m³])	Benzene	5,870,000	5,150,000
	Cyclohexane	13,800,000	12,700,000
	Ethanol	82,000	<11,600
	Ethylbenzene	1,400,000	1,340,000
	4-ethyltoluene	117,000	187,000
	n-Heptane	3,720,000	3,130,000
	n-Hexane	5,610,000	4,990,000
	Toluene	9,360,000	8,840,000
	1,2,4-Trimethylbenzene	199,000	356,000
	1,3,5-Trimethylbenzene	80,800	149,000
	m&p-Xylene	4,390,000	4,510,000
	0-Xylene	1,350,000	1,490,000
TO-3 Air (ppmv)	Benzene	870	677
	BTEX (Total)	3,960	3,470
	Ethylbenzene	107	102
	n-Hexane	730	641
	Methyl-tert-butyl ether (MTBE)	274	243
	THC as Gas	16,500	14,700

Sample ID		SVE-1-050812	SVE-2-0508-012
Date Sampled		**5/8/12**	**5/8/12**
	Toluene	2,510	2,180
	1,2,4-Trimethylbenzene	<14.9	22.9
	1,3,5-Trimethylbenzene	<14.9	<14.9
	Xylene (Total)	473	516
	m&p-Xylene	370	396
	o-Xylene	103	121

8.2.3. SVE Test Results Using SVE-2

The test conducted at well SVE-2 began at a measured vacuum of 5 iow at the moisture knockout tank and 1.8 iow at the wellhead; the dilution valve was about 50 percent open. Air velocity through the 2-inch-diameter exhaust stack was measured between about 4,700 fpm to 5,800 fpm; this converts to about 102 to 126 cfm, which generally matches the manufacturer's blower rating curves for the applied vacuum (the highest reading exceeds the rating curves and is assumed to be an anomaly). After about one hour into the test, the dilution valve was about ¾ closed, which resulted in a measured vacuum of 10 inches of water (iow) at the moisture knockout tank and about 3.4 iow at the wellhead. After about another hour, the dilution valve was fully closed, which resulted in a measured vacuum of 12 iow at the moisture knockout tank and about 4.1 iow at the wellhead. The test at SVE-2 was completed after about 2¾ hours. Air flows decreased slightly during the test at SVE-2 and ranged from about 89 cfm to 102 cfm with the dilution valve fully closed. Field data is provided in SVE-2 Test Data, Figure E-2 in Appendix E and a summary of measurements is listed below:

- Oxygen levels at the wellhead ranged from about 2.8 percent to 4.5 percent during the test. Oxygen levels at the exhaust stack were measured at about 11 percent during the first hour of the test; then decreased to about 1.3 percent after the dilution valve was closed.
- Carbon dioxide levels were consistently measured greater than 5 percent at both the wellhead and exhaust stack during the test.
- Temperatures ranged from about 59.7 to 66.2 degrees Fahrenheit at the wellhead and from about 88.8 to 94.4 degrees Fahrenheit at the exhaust stack; temperatures gradually increased in the exhaust stack during the test.
- VOCs, as measured using a PID, consistently exceeded the maximum range of the PID within 1 to 2 seconds. The PID was removed from the air flow after the pre-set alarm sounded because extended readings could have damaged the equipment. Results shown in Figure E-2 represent the last reading observed before the alarm sounded.
- Applied vacuums at four monitoring wells were measured during the test; wells ranged in distance from about 15 to 46½ feet from SVE-2. Actual distances, as measured from the closest point between screened intervals of SVE-2 and observation wells, also ranged from about 15 to 46½ feet. Observed vacuum at observation wells ranged from about 10.0 percent to 23.3 percent of the applied vacuum at the wellhead.

- The depth to groundwater, as measured in well AS-1, remained steady at 34.75 feet below the top of well casing throughout the test.
- Analytical results of the vapor sample collected at the conclusion of the SVE-2 test indicate concentrations of total petroleum hydrocarbons were 14,700 ppmv and benzene concentrations were 677 ppmv. Results are shown in Table 7.

8.2.4. Combined SVE Test Results Using SVE-1 and SVE-2

A combined test was conducted by drawing a vacuum from both SVE-1 and SVE-2 simultaneously. The test was started with the dilution valve at the knockout tank fully closed and valves at both wellheads fully open. This portion of the test operated for about one hour, but resulted in uneven vacuum applied at the wellheads. The second portion of the test operated for about 40 minutes, but the valves at the wellheads were adjusted to result in roughly equal applied vacuum at both wellheads.

The combined test began at a measured vacuum of 8.5 iow at the moisture knockout tank, 3.5 iow at SVE-1, and 2.3 iow at SVE-2. Air velocity through the 2-inch-diameter exhaust stack was measured between about 4,230 fpm to 4,490 fpm; this converts to about 92 to 98 cfm, which matches the manufacturer's blower rating curves for the applied vacuum. After one hour into the test, the vacuums were balanced at each wellhead, which resulted in a measured vacuum of 10 iow at the moisture knockout tank and about 2.8 iow at each wellhead. Air flows remained steady after balancing the vacuums. The combined SVE-1 and SVE-2 test was completed after about 1¾ hours. Field data is provided in SVE-1 and SVE-2 Combined Test Data, Figure E-3 in Appendix E and a summary of measurements is listed below:

- Oxygen and carbon dioxide levels were not measured during the combined test.
- Temperatures ranged from about 61.3 to 65.8 degrees Fahrenheit at the SVE-1 wellhead, from about 59.5 to 60.9 degrees Fahrenheit at the SVE-2 wellhead, and from about 89.0 to 91.5 degrees Fahrenheit at the exhaust stack; temperatures generally remained steady during the test.
- VOCs as measured using a PID consistently exceeded the maximum range of the PID within 1 to 2 seconds. The PID was removed from the air flow after the pre-set alarm sounded because extended readings could have damaged the equipment. After a few minutes into the test, the PID was less frequently used because of concerns regarding damaged equipment; therefore, results were not listed in Figure E-3.
- Applied vacuums at three monitoring wells were measured during the test; wells ranged in distance from about 12½ to 20½ feet from either SVE-1 or SVE-2 (whichever was closer); observed vacuum at observation wells at the conclusion of the test (under balanced vacuum) ranged from about 17.1 percent to 24.3 percent of the applied vacuum at the wellheads.
- The depth to groundwater, as measured in well AS-1, remained steady at 34.75 feet below the top of well casing throughout the test.
- No vapor sample was collected during the combined test.

8.2.5. SVE Test Analysis

Results of the individual tests conducted at both SVE-1 and SVE-2, and the combined SVE-1/SVE-2 test, indicate SVE is a viable remedial approach to remove petroleum hydrocarbons from vadose zone soil. Vacuum was observed in all monitoring points utilized during the test, and frequently was 5 percent or greater than the applied vacuum at the wellhead. Results of field measurements of VOCs (which consistently exceeded the range of the instrument) and analytical results of vapor samples collected during the tests indicated petroleum hydrocarbons could be readily removed from the subsurface soil. Petroleum hydrocarbon concentrations (as gasoline) were greater than 10,000 ppm by volume (greater than 1 percent in air). Based on removal rates of 100 cfm and the total petroleum hydrocarbons (TPH) concentrations in vapor samples collected during the pilot tests, approximately 600 pounds of TPH (about 90 gallons) could be removed daily using an SVE system.

The effective radius of influence was calculated by plotting the ratio of measured to applied vacuum at monitoring points and the distance from the monitoring point to the SVE wellhead on a semi-log graph. The distance from the monitoring point to the extraction well was placed on the logarithmic scale and the average ratio of monitored vacuum to applied vacuum was placed on the arithmetic scale for each applied vacuum. A best-line fit was placed on each graph. The distance where the ratio was 1 percent was considered to be within the zone of influence and the distance where a ratio of 5 percent was considered to be an acceptable distance for remedial design purposes. The distance where the ratio was greater than 10 percent was considered to be strongly influenced. Considering the SVE and monitoring wells are screened at varying depths, the effective distance between two points was measured from the top of screened interval in the SVE well to the closest point within the screened interval in the monitoring wells.

Based on the SVE test data, and utilizing the measured and applied vacuum at the conclusion of each stepped test, the approximate radius of influence was about 30 feet for the test conducted using SVE-1 (shallow), and more than 100 feet for the test conducted using SVE-2. The larger radius of influence for the test conducted at SVE-2 likely is because of the coarser soil conditions encountered at depth and relative ease of air flow through coarser soil compared to finer soil. Considering none of the wells was located further than 46½ feet from SVE-2, a more conservative radius of influence for the test conducted at SVE-2 is 50 feet.

8.3. Air Sparge Pilot Testing

8.3.1. General

During pilot testing, an air compressor was connected to the AS pilot test well. The compressor supplied pressurized air to the well. Ambient above-ground air was pushed into the well screen from the compressor. Supplied air was discharged out of the AS pilot test well through a 2-foot-long well screen located at the bottom of the well. At the time of testing, the water table was approximately 4½ feet above the top of the sand pack surrounding the well screen, and about 4 feet above the top of the well screen. Air flow through the water enhances the transfer of VOCs from the aqueous phase to the vapor phase. Air sparging also can aid in biodegradation of dissolved and sorbed contaminants below the water table by increasing the concentration of dissolved oxygen in groundwater, thereby providing available oxygen for microbial activity.

Two AS tests were performed by applying pressure to well AS-1 for a period ranging from about 1½ hours to 4 hours per test. Groundwater was allowed to recover for a period of about 1 hour between the two tests. The tests were conducted using a Gast 6066-P102 rotary vane compressor to apply pressure to piping connected to the AS-1 wellhead. Air pressure was measured at the well heads of adjacent monitoring wells, specifically monitoring points MP-1 and MP-2, and monitoring well MW-8. Air pressure also was measured at the well heads of SVE pilot test wells SVE-1 and SVE-2 during the second AS test. The locations of the wells at the Airport Kwik Stop site are shown in Figure 4.

Test equipment included a trailer-mounted remediation system consisting of the rotary vane compressor, a heat exchanger, a piping manifold, and flex pipe connecting the remediation system to the wellhead of AS test well AS-1. A sample port and pressure gauge were installed in the flex pipe near the wellhead to measure the air velocity (used to calculate air flow) and pressure applied at the wellhead. Air flow and pressure also were measured from gauges installed on the remediation system trailer near the compressor. Each test was performed in a stepped approach, beginning with low applied pressure and increasing the pressure incrementally.

During each test, the following parameters were measured from the monitoring points and MW-8: pressure, temperature, oxidation-reduction potential (ORP), dissolved oxygen (DO), pH and depth to water, ORP, DO, and pH were not measured during the first AS test from MW-8 because damage to the well casing prevented the probe from fitting into the well. The damaged section was removed prior to initiating the second test. Air pressure measurements also were collected from SVE-1 and SVE-2 during the second test and downgradient measurements were collected from MW-19 prior to the second test and at the end of the second test.

8.3.2. AS Test 1 Results

The first AS test lasted for a duration of about one hour. Background measurements of the parameters described above were collected from each of the monitoring points prior to beginning the test. Initial gauge air pressure (measured at the wellhead) was about 1 pound per square inch (psi). The pressure was increased to about 1.5 psi after about one-half hour of operation. Air flow was measured between about 7 to 8 cubic cfm while the pressure was maintained at about 1 psi. Flow increased to between 63 to 85 cfm after increasing the pressure to about 1.5 psi. The following observations were noted from the monitoring points during the first test:

- Air pressure increased in MP-1 (from 0.02 to 0.15 psi) and in MW-8 (from 0.03 to 0.32 psi) after increasing the pressure at the injection point from about 1 psi to 1.5 psi. Air pressure measurements in MP-2 dropped slightly (from 0.30 to 0.19 psi) and rebounded (from 0.19 to 0.27 psi) after increasing the system pressure.
- DO increased in MP-1 over the time of the test (from 0.09 to 0.88 mg/L). DO remained between 1.26 to 1.33 mg/L in MP-2 with a single reading of 0.88 mg/L.
- ORP dropped in both MP-1 (283 to 254 millivolts [mV]) and MP-2 (285 to 201 mV) over the duration of the test.
- pH measurements also dropped in both MP-1 (from 6.97 to 6.82) and MP-2 (from 7.20 to 6.72) over the duration of the test.

AS-1 Test Data, Figure E-4 and AS-2 Test Data, Figure E-5 in Appendix E depict the pressure and DO measurements recorded during the first test.

8.3.3. AS Test 2 Results

The second AS test was conducted for a duration of about four hours. Initial air pressure (measured at the wellhead) was about 1 psi. The air pressure was maintained between a minimum of about 0.5 psi to a maximum of about 1.2 psi throughout the test. Air flow was initially measured at 35 cfm and increased to between 27 to 87 cfm for the duration of the test. The following observations were noted from the monitoring points during the second test:

- Air pressure in MP-1 was measured between 0.10 and 0.20 psi. Pressure measurements at MP-2 were measured between about 0.18 and 0.30 psi. Air pressure in MW-8 was measured between about 0.30 and 0.45 psi. Air pressure at SVE -1 and SVE-2 were measured between about 0.11 to 0.20 psi and 0.12 to 0.19 psi, respectively.
- DO ranged between about 0.60 to 0.94 mg/L in MP-1. DO in MP-2 generally ranged between about 1.45 and 2.0 mg/L with a lone spike of 4.64 mg/L. DO measured in MW-8 generally ranged between about 1.0 and 1.79 mg/L with a lone spike of 6.0 mg/L.
- ORP dropped in MP-1 (284 to 239 mV), MP-2 (311 to 248 mV), and MW-8 (297 to 252 mV) over the duration of the test.
- pH measurements in MP-1 ranged between 6.71 to 7.02 and in MP-2 from 6.67 to 7.0 over the course of the test. pH in MW-8 was measured between 6.74 and 6.94.

8.3.4. AS Test Analysis

Results of the tests indicate AS is not a viable option for groundwater remediation at the Site. Based on the test results (high air flow rates and low air pressures), it appears that the air pressure applied to the AS well easily displaced the groundwater out of the well screen into the saturated zone. After the top of the well screen was exposed, the air injected into the well pushed out into the surrounding soil formation with relatively little resistance. The low air pressure and high flow rates observed indicate there is little resistance to the applied air pressure and sparging is likely not occurring, or only occurring in a limited area immediately adjacent to the well screen and casing.

Based on well logs from the construction of AS-1 and the other wells located near the Site, the saturated zone primarily consists of coarse sand. This material generally exhibits low air entry pressures, meaning relatively low air pressure is required to displace water within the saturated zone of the formation because of the large pore spaces and correspondingly low surface tension forces. Coupled with the relatively limited distance between the well screen and top of the water table, the low air entry value of the formation likely resulted in air flow essentially short-circuiting (traveling from the top of the well screen along the side of the casing and into the vadose zone). In both tests, high flows (greater than 63 cfm) and low pressure were observed for the most of the duration of the tests.

9.0 CONCEPTUAL SITE MODEL

9.1. General

This section provides the conceptual model for the Site based on the data presented in this RI report and additional detail from the "Exposure Pathways and Receptors" discussed in **Section 2.6.** The CSM includes a discussion of the sources of COPCs at the Site, the subsequent potential migration of those hazardous substances in environmental media, and complete exposure pathways. The model was developed to help direct remediation at the site, where necessary.

A complete exposure pathway consists of: (1) an identified contaminant source; (2) a transport pathway to locations (exposure points) where potential receptors might come in contact with COPCs; and (3) an exposure route (e.g., soil ingestion) through which potential receptors might be exposed to COPCs. Exposure pathways deemed to be incomplete need not be considered further.

Contamination sources and mechanisms are shown in Conceptual Site Model-Flowchart, Figure 19, and Conceptual Site Model-Graphical, Figure 20, and include the following:

- Confirmed leak from the premium fuel dispenser at the Airport Kwik Stop. Contaminants of concern include GRPH and VOCs. Contaminants have leached and/or been transported downwards by infiltrating water to the water table.
- A plume of gasoline-contaminated groundwater is located beneath and downgradient of the former fuel dispensers at the Airport Kwik Stop. Groundwater movement has caused the plume to migrate to the east-southeast at least 1,400 lineal feet. Two downgradient domestic water wells have been impacted by the plume. Based on the groundwater analytical data it appears that the plume has not stabilized, and continues to expand.
- LNAPL is present at the location of MW-5. Floating product likely is contributing to groundwater contamination and expansion of the plume of petroleum-contaminated groundwater at the Site.

As discussed previously in **Section 2.5**, potential exposure pathways and receptors include:

- Ecological
  - Direct contact with contaminated soil– small mammals, birds, soil biota, plants.
  - Ingestion of contaminated soil – small mammals and birds.
  - Ingestion of plants or fauna that have ingested or absorbed contaminants from the Site – predatory small mammals and birds.
  - Possible ingestion of contaminated surface water (Pend Oreille River) or groundwater (seeps along the river banks) – aquatic and terrestrial food chain.
- Human
  - Ingestion of contaminated groundwater from on-site domestic water wells – residents and patrons of the Cabin Grill and residents of other impacted downgradient domestic water wells.

- Dermal contact with contaminated groundwater removed from on-site wells – residents and restaurant patrons of the Cabin Grill and residents of other impacted downgradient domestic water wells.
- Inhalation of contaminated vapors – residents and patrons of the Cabin Grill, residents of other impacted downgradient domestic wells and on-site workers during sampling and remediation activities.
- Dermal contact with contaminated soil during excavation work – on-site workers and trespassers.
- Dermal contact with contaminated groundwater removed from on-site wells or from seeps – on-site workers.
- Possible dermal contact and ingestion of contaminated surface water (Pend Oreille River).

9.2. Soil

Site soil generally consists of sand with variable silt content (generally grading with less silt with increasing depth), overlying thick deposits of silt and clay. Analytical and field screening results indicate that soil at the Airport Kwik Stop contaminated with GRPH and/or BTEX compounds extends from near the ground surface in the area of the former premium fuel dispenser, to groundwater (about 34½ feet to 38½ feet bgs).

The following potential exposure pathways and receptors were previously identified in **Section 2.5.1** for contaminants in Site soil:

- Contact (dermal, incidental ingestion or inhalation) by visitors, workers (including excavation workers) and potential future residents or other Site users with hazardous substances in soil;
- Contact (dermal, incidental ingestion or inhalation) by terrestrial wildlife with hazardous substances in soil.

Constituents detected in the upper 15 feet of soil were evaluated to assess the potential risk to humans, plants and animals posed by contaminated soil. Based on the results of the simplified ecological evaluation, there are no expected impacts to wildlife from the shallow soil contamination at the Airport Kwik Stop which is further diminished by the presence of low permeable surfaces (asphalt and concrete) at the Airport Kwik Stop. Possible impacts to humans and wildlife could occur if the plume of contaminated groundwater emerges as surface water within springs and/or seeps along the Pend Oreille River.

9.3. Groundwater

Based on the results of site explorations and laboratory analytical testing, petroleum contamination at the Airport Kwik Stop has reached the groundwater table, and the plume of contaminated groundwater has migrated from the Airport Kwik Stop, downgradient at least 1,400 feet to the southeast, and has impacted the domestic water well at the Cabin Grill property, the domestic water wells at Property ID No. 6607 and Property ID No. 6608/6609.

10.0 LOCATIONS AND MEDIA REQUIRING CLEANUP ACTION

This section identifies the locations and environmental media (soil and groundwater) at the Site that require evaluation in the FS. Based on the results of this RI the following areas should be evaluated in the FS: (1) petroleum-contaminated soil and groundwater at the Airport Kwik Stop; (2) floating product (LNAPL) and petroleum-contaminated soil and groundwater at the Cabin Grill; and (3) petroleum-contaminated groundwater within the Vacant Property and downgradient private residences.

At the time of this report, interim action activities to remediate contaminated vadose-zone soil at the Airport Kwik Stop were planned to start in September/October 2012. Because of the observed growth in the size of the contaminated groundwater plume, and the relatively large estimated volume of contaminated soil at the Airport Kwik Stop, Ecology elected to begin interim action activities at the Airport Kwik Stop to remediate contaminated soil at the source of the groundwater plume. Soil vapor extraction and bioventing were selected for the interim action based on the results of pilot SVE testing. Remedial excavation also was evaluated. However, due to the vertical and lateral extent of the zone of contaminated soil beneath the Airport Kwik Stop, and the proximity of structures, utilities and State Highway 31 to the zone of contaminated soil, remedial excavation was estimated to be more expensive (due to excavation and disposal costs, and costs for temporary shoring and underpinning or demolition of structures on at the Airport Kwik Stop) and posed a greater risk to the public, than SVE, because a large excavation would be present immediately adjacent to a state highway. Therefore, remedial excavation was not selected as a component of the interim action.

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