FINAL
Remediation System Operation, Maintenance, and Monitoring and Quarterly Groundwater Monitoring Report
Operational Year Three

Former AAFES Underground Storage Tanks Corrective Action Implementation, Former AAFES Service Station, Building 3562
Fort Wainwright, Alaska

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ACRONYMS AND ABBREVIATIONS

µg/L	micrograms per liter
µg/m^3	micrograms per cubic meter
1,2,4-TMB	1,2,4-trimethylbenzene
1,3,5-TMB	1,3,5-trimethylbenzene
AAC	Alaska Administrative Code
AAFES	Army and Air Force Exchange Service
ACS	Alaska Communication Systems
ADEC	Alaska Department of Environmental Conservation
Ahtna	Ahtna Environmental, Inc.
AK	Alaska Test Method
AQOP	Air Quality Operating Permit
Army	United States Department of the Army
AS	air sparging
bgs	below ground surface
CAP	corrective action plan
COC	contaminant of concern
DRO	diesel-range organics
ECO	electric catalytic oxidizer
EPA	United States Environmental Protection Agency
EPH	extractable petroleum hydrocarbon
EW	extraction well
FES	Fairbanks Environmental Services
FTW	Fort Wainwright
GRO	gasoline-range organics
HDPE	high-density polyethylene
HQAES	Headquarters Army Environmental System
ID	identification
mg/L	milligrams per liter
MS	matrix spike
MSD	matrix spike duplicate
NAPL	non-aqueous-phase liquid
NMOC	non-methane organic compound
OM&M	operation, maintenance, and monitoring
OSHA	Occupational Safety and Health Administration
PAH	polycyclic aromatic hydrocarbon
PID	photoionization detector
POL	petroleum, oil, and lubricants
ppm	parts per million
PVC	polyvinyl chloride
PX	Post Exchange
R^2	coefficient of determination

SGS	SGS North America
SIM	selected ion monitoring
STEL	short-term exposure limit
SVE	soil vapor extraction
TVH	total volatile hydrocarbons
U.S.	United States
USACE	United States Army Corps of Engineers
UST	underground storage tank
VOC	volatile organic compound

EXECUTIVE SUMMARY

Air sparging (AS)/soil vapor extraction (SVE) was selected to address the remaining fuel-related contamination present in soil and groundwater at the Fort Wainwright (FTW) Building 3562 former Post Exchange Gas Station underground storage tanks (USTs) 177, 179, 180 CC-FTWW-086 site (Alaska Department of Environmental Conservation [ADEC] File ID 108.26.060). The AS/SVE system was designed to remediate contaminated soil and groundwater at the site over an estimated three to five years of system operation.

Ahtna Environmental, Inc., (Ahtna) was contracted to oversee the design, construction, and installation of the AS/SVE remediation system and perform regular operation, maintenance, and monitoring (OM&M) site visits and quarterly groundwater sampling for the first three years of operation. This report presents the third year of AS/SVE OM&M tasks and quarterly groundwater monitoring results. Ahtna performed this work under Contract Number W911KB-17-C-0020 for the United States Department of the Army (Army), which includes the United States Army Corps of Engineers, the United States Army Environmental Command, and the FTW Garrison.

Ahtna performed regular OM&M site visits to monitor system parameters, perform routine maintenance, and screen and sample SVE effluent. In addition to recording remediation system parameters, the field team screened four soil gas points during each OM&M visit to assess potential vapor intrusion induced by the AS system. Extraction wells are providing adequate engineering controls to effectively mitigate potential vapor intrusion induced by the AS, demonstrated by the presence of induced partial-vacuum and low volatile organic compound (VOC) screening results in the soil gas monitoring points located along the utility corridor and adjacent to Building 3562. Concentrations of contaminants of concern (COCs) in SVE effluent and exhaust remain relatively low and have continued to decline when compared to analytical results from the first year of operation.

Non-routine site visits were necessary to address system alarms/shutdowns and to perform system maintenance and troubleshooting. At the beginning of the second quarter in early May 2021, Wakefield Inc. (Wakefield) was contracted to install a new AS blower to replace the failed blower identified in year two. While on site, Wakefield also disconnected the electric catalytic oxidizer (ECO) from the system and routed SVE exhaust directly to the atmosphere without treatment through a 20-foot-high exhaust stack. Operation of the ECO unit was discontinued in year three because the three conditions for discontinuing its use were met: the benzene concentration in untreated SVE effluent (emissions) is below the Occupational Safety and Health Administration short-term exposure limit (5 parts per million or 5,000 micrograms per cubic meter) for any 15-minute exposure period, untreated SVE effluent emissions do not exceed the annual allowable VOC emissions quantity specified in the FTW Air Quality Operating Permit of 20 tons per year, and untreated SVE emissions have not been observed to cause an odor nuisance to the public.

Four quarterly groundwater sampling events were conducted during the second year of AS/SVE operation to monitor concentrations of COCs and assess remedial progress and AS/SVE system effectiveness. During each groundwater sampling event, 12 monitoring wells were sampled for

VOCs by United States Environmental Protection Agency (EPA) Method 8260, gasoline-range organics by Alaska Test Method (AK)101, diesel-range organics (DRO) by AK102, and polycyclic aromatic hydrocarbons by EPA Method 8270D selected ion monitoring. Groundwater results tend to fluctuate seasonally, however COC concentrations generally remained much lower during year three than prior to AS/AVE system operation. The AS system was not operational during the third and fourth quarter of year two and quarter one of year three due to a failure of the AS blower. Any increased COC concentrations are likely influenced by the AS system being out of commission for the majority of the second half of year two and first quarter of year three.

The Mann-Kendall trend test, linear regression analysis, and time-to-cleanup modeling were performed using results from analytical groundwater samples to assess changes in COC concentrations over time. Mann-Kendall trend tests identified one COC, naphthalene, with an increasing trend in UST source area monitoring well AP-10368MW and one COC, DRO, with an increasing trend in monitoring well AP-10381MW located immediately west of the fuel island source area. Increasing Mann-Kendall trends were not identified in the remaining six monitoring wells sampled during quarterly groundwater monitoring events that were subject to trend analysis. Thirty-six Mann-Kendall trend tests of the 49 COCs analyzed resulted in decreasing trends. With few exceptions, concentrations of COCs in all wells have decreased when compared to pre-remediation system groundwater analytical results. Based on time-to-cleanup modeling, site groundwater may reach ADEC cleanup levels within 7.2 to 7.7 years of AS/AVE system operation. Benzene was used as an indicator for the time-to-cleanup model, however some wells appear to have experienced seasonal fluctuations in concentrations of other COCs, which may reflect seasonal exposure of the water table to smear zone contaminants. Additional analytical data from quarterly groundwater monitoring will improve the robustness and accuracy of these analyses.

Ahtna recommends continued operation of the AS/SVE remediation system with quarterly analytical groundwater sampling. The AS/SVE system should continue to operate until COC concentrations in analytical groundwater sample results are below ADEC cleanup levels and controlled rebound testing can be initiated. Continued data collection and assessment of remedial progress should be performed to monitor site COC concentration trends and improve the robustness and accuracy of the Mann-Kendall trend tests, linear regression trend analysis, and time to-cleanup modeling. Groundwater monitoring with analytical sampling should continue following the eventual shutdown of the remediation system to monitor contaminant rebound and assess whether continued remediation system operation, or continued operation with system optimization modifications, is necessary.

1.0 INTRODUCTION

This report documents the third year of operation, maintenance, and monitoring (OM&M) of the air sparging (AS)/soil vapor extraction (SVE) remediation system and associated quarterly groundwater monitoring at the Army and Air Force Exchange Service (AAFES) Post Exchange (PX) Gas Station site, Building 3562, on Fort Wainwright (FTW), Alaska, conducted between February 2021 and February 2022. Ahtna Environmental, Inc., (Ahtna) performed this work under Contract Number W911KB-17-C-0020 for the United States Department of the Army (Army), which includes the United States Army Corps of Engineers (USACE), the United States Army Environmental Command, and the FTW Garrison. All field activities were performed in accordance with the *Remediation System Design, Installation, Operation, Maintenance, Monitoring, and Closure Work Plan* (Work Plan; Ahtna, 2018a), *Final 2022 Work Plan Addendum, Remediation System Operation, Maintenance, Monitoring, and Closure Work Plan (*Brice, 2022), and applicable USACE and Alaska Department of Environmental Conservation (ADEC) regulations.

In response to a Mandatory Compliance Order issued to the Army by ADEC in August 2015, the Army and ADEC entered into a Compliance Order by Consent and Agreement Settling Liability in January of 2016 (Alaska Department of Law, 2016) to initiate a remedial action at the site. The Attorney General's Office File Number is AN2015100890, and the ADEC Enforcement Tracking Number is 2015 R0342.

This report includes discussion of the site background and environmental setting; AS/SVE system OM&M activities; quarterly groundwater monitoring; analytical results and data quality review; waste management; remedial progress assessment; and recommendations for site management going forward. Supporting documents and information are included as appendices and referenced throughout this report.

1.1 Objectives

The project objectives of the site remediation at the former AAFES Service Station are to

- reduce groundwater petroleum hydrocarbon concentrations to below risk-based target or cleanup levels, respectively, within approximately three to five years of AS/SVE system operation;
- manage risk associated with the vapor intrusion pathway while the AS/SVE system operates (acting as an engineering control);
- and manage SVE system emissions to maintain compliance with FTW's Air Quality Operating Permit (AQOP), ID number AQ0236TVP03P (ADEC, 2015).

The objectives of the annual AS/SVE OM&M and quarterly groundwater monitoring tasks are to operate, maintain, and monitor the AS/SVE system so that it may meet the site remediation project objectives, and collect analytical groundwater samples to evaluate remedial progress of the dissolved-phase plume at the site.

1.2 Project Source Area Tracking Number

The source area or contaminated site is referred to as the "Fort Wainwright Bldg. 3562 PX Gas Station underground storage tanks (UST) 177, 179, 180 CC-FTWW-086" in the ADEC Contaminated Sites database and is referred to as the former AAFES Service Station for this project and in this document hereafter.

The former AAFES Service Station source area is tracked in the ADEC Contaminated Sites database, which is maintained by the ADEC Project Manager and, for funding purposes, by the Army in the Headquarters Army Environmental System (HQAES). The ADEC and HQAES tracking numbers are presented in Table 1-1.

TABLE 1-1: CROSSWALK FOR PX GAS STATION SOURCE AREA TRACKING NUMBERS

Source Area	HQAES Number	ADEC File ID	ADEC Hazard ID	Site Status
Former AAFES Service Station, BLDG 3562	02871.1117	108.26.060	26280	Open

Key:

AAFES	Army and Air Force Exchange Service
ADEC	Alaska Department of Environmental Conservation
HQAES	Headquarters Army Environmental System
ID	identification
PX	Post Exchange

1.3 Site Contaminants of Concern and Cleanup Levels

Site contaminants of concern (COCs) are fuel-related contaminants associated with fuel releases from the former USTs. Site COCs were determined through the analysis of soil and groundwater samples collected during the 2013 site investigation (USACE, 2014), 2016 UST removal action (Ahtna, 2016), and 2016 release investigation (Fairbanks Environmental Services [FES], 2016). Site COCs include gasoline-range organics (GRO), diesel-range organics (DRO), polycyclic aromatic hydrocarbons (PAHs), and a short list of volatile organic compounds (VOCs).

Default soil and groundwater cleanup criteria for the site are found in Title 18, Alaska Administrative Code (AAC), Chapter 75.340–75.345 (18 AAC 75.340–75.345; ADEC, 2020). Default soil cleanup levels are the most stringent of either the ADEC Method Two migration-to-groundwater values or the Under 40-Inch Zone human health values. In most cases, the most-stringent soil cleanup levels are Method Two migration-to-groundwater values. ADEC Table C cleanup levels are used to assess groundwater. Site soil gas and indoor air have been assessed using ADEC Target Levels found in *Vapor Intrusion Guidance for Contaminated Sites* (ADEC, 2017a).

2.0 SITE BACKGROUND AND ENVIRONMENTAL SETTING

This section summarizes the former AAFES Service Station site location, general geology and hydrogeology, a brief site history and previous investigations, and the AS/SVE remediation system installed in 2018.

2.1 Site Location

The former AAFES Service Station is located on FTW on the south side of Neely Road near the intersection with 10th Street, immediately west of the Alaska Railroad tracks. It is located on Lot 1300, Section 13, Township 1 South, Range 1 West, Fairbanks Meridian. Two utilidors are present at the AAFES Service Station site: a large (7-foot by 7-foot), east-west trending utilidor on the south side of Neely Road and a small (4-foot by 2-foot), north-south trending utilidor connecting Building 3562 to the large utilidor. The general site location and vicinity are depicted on Figure 1.

The former AAFES Service Station is located in a developed portion of the base. The site is relatively flat, and the ground surface in the immediate vicinity is either gravel, paved, or vegetated with lawn grasses. The Tanana Trails Housing area is located to the southwest; Bassett Army Hospital is located to the northwest; warehouses are located to the northeast; and post supply wells, water treatment building, cooling ponds, and the power generation facility are located southeast of the site.

2.2 Geology and Hydrogeology

Most of the developed portion of FTW, including the former AAFES Service Station site, is located on the combined floodplains of the Tanana and Chena rivers. The Tanana and Chena rivers' fluvial soils in the Fairbanks and FTW area are up to 300–400 feet thick (Péwé et al., 1976). The rolling hills and low mountains of the Yukon-Tanana Upland lie north of the Tanana and Chena rivers' floodplain. The Alaska Range and coalescing alluvial fans on the north side of the Alaska Range lie to the south of the Tanana River floodplain.

The near-surface soils at the former AAFES Service Station site, from ground surface to at least 30 feet below ground surface (bgs), consist primarily of interlayered sands, gravelly sands, and sandy gravels with some silt, which were deposited as fluvial channel and point bar sediments. There are occasional silt lenses and peat soils scattered through the soil column. Permafrost is not present at the site.

The water table at the former AAFES Service Station site fluctuates seasonally between approximately 12 and 17 feet bgs, with low water occurring in late winter or early spring (March or April) and the seasonal high water occurring during spring break-up in the early summer (May and June) or following high precipitation periods in late summer. The approximate regional groundwater flow direction at the site is west-northwest, as shown on Figure 2. The hydraulic gradient across the site is 0.0005 foot/foot, based on September 2016 groundwater level measurements (FES, 2016). The vertical hydraulic conductivity of the fluvial soils is estimated to average 20 feet/day, and the horizontal hydraulic conductivity is estimated at 400 feet/day (United States Geological Survey, 1998).

The two main water supply wells for FTW are located at Building 3559, approximately 250 feet south (upgradient) of the petroleum, oil, and lubricants (POL) releases at the former AAFES Service Station site. The two backup water supply wells are located at Buildings 3563 and 3565, which are approximately 200 feet and 700 feet to the southeast (upgradient), respectively. The main water supply wells are screened at depths of 60−80 feet (both wells at Building 3559), and the backup wells at Buildings 3563 and 3565 are screened at depths of 96−109 feet and 180−200 feet, respectively. Groundwater modeling conducted by CH2M Hill in 1996 showed that groundwater beneath the former AAFES Service Station property is not in the capture zone of the water supply wells (CH2M Hill, 1996).

2.3 Site History and Previous Investigations

Building 3562 was constructed and put into service in 1973. In addition to the garage bays and auto repair facilities, the building housed a Quick Mart store for a period of time. The gas station originally had three 10,000-gallon fuel storage tanks located northeast of Building 3562 and one used oil storage tank located south of Building 3562. Several fuel releases reportedly occurred at the site prior to 1990, and in 1990 the site was listed as a contaminated site in the ADEC Contaminated Sites database (ADEC Hazard Identification [ID]/File Numbers 1099/108.26.025 and 24219/108.26.025; ADEC, 2017b).

In the early 1990s, the former AAFES Service Station was subject to several release investigations that identified the extent of soil and groundwater contamination at the site. The original three 10,000-gallon USTs were removed in 1992, and three new 10,000-gallon USTs with double-walled tanks, leak detection, and double-walled piping were installed at the same location as the original tanks. The USTs included two gasoline tanks and one diesel tank. An AS/SVE remediation system was installed in 1994 and operated until 1997. Routine groundwater monitoring was conducted from 1993 until 2001, when the monitoring results indicated that the groundwater met 18 AAC 75.345 Table C cleanup levels for at least two consecutive sampling events. The former AAFES Service Station site (24219/108.26.025) was closed in the ADEC Contaminated Sites database on December 11, 2009.

In 2013, the former AAFES Service Station stopped dispensing fuel, and Building 3562 became an American Tire and Auto store. Also in 2013, a soil and groundwater site investigation was conducted to support plans for future decommissioning of USTs located on the site. The 2013 site investigation revealed contaminated soil and groundwater at the former AAFES Service Station location, indicating that a new release had occurred (USACE, 2014), and ADEC opened a Contaminated Site in the ADEC database with Hazard ID/File Number 26280/108.26.060 (ADEC, 2017c). In 2016, the fuel storage USTs, piping, and dispensers were decommissioned; approximately 1,885 tons of contaminated soil were removed and thermally treated; and a remedial investigation was conducted (Ahtna, 2016; FES, 2016).

The USTs removal and initial abatement report and the remedial investigation report (Ahtna, 2016) identified two non-aqueous-phase liquid (NAPL) contaminated soil source areas and downgradient dissolved-phase plumes at the former AAFES Service Station site. One source area is associated with the UST location and the other with the former fuel-dispensing island.

Results of previous investigations are summarized in the Work Plan (Ahtna, 2018a) and not repeated here for brevity. A detailed discussion of previous investigations and remedial actions at the former AAFES Service Station site, including comprehensive data tables and figures, can be found in the Corrective Action Plan (CAP; Ahtna, 2017).

The CAP evaluated remedial options, and the Army selected AS/SVE to remediate the site. A contract for a remedial design supplemental site characterization followed by design, installation, and initial operation of an AS/SVE system was awarded to Ahtna by the Army in 2017. Ahtna conducted the remedial design supplemental site characterization during the winter of 2018 to address remaining data gaps to aid in final design of the remediation system and provide additional baseline information prior to system installation and operation. The groundwater monitoring well network was expanded, soil gas monitoring probes were installed, and vapor intrusion was assessed in proximal site structures. The dissolved-phase plume and NAPL source area extents were refined, and vapor intrusion did not appear to be occurring in proximal site structures (Ahtna, 2018b).

In 2018 Ahtna installed an AS/SVE remediation system consisting of 11 SVE wells, 33 AS wells, an SVE blower, an AS blower, and an electric catalytic oxidizer (ECO). Subsurface conveyance piping was installed across the site and plumbed to a manifold enclosure located on site. The AS/SVE remediation system was activated in November 2018. Groundwater sampling of 12 monitoring wells located on site was performed quarterly during the first year of operation from February 2019 through February 2020. A remediation system installation and OM&M report detailing the installation of the AS/SVE system and first year of operation, including quarterly groundwater sample results with Mann-Kendall and linear regression trend analyses, was finalized in August 2020 (Ahtna, 2020). Technical details and AS/SVE system specifications are presented in the 2020 installation and OM&M report and have been omitted from this report for brevity; a brief overview of the remediation system components and configuration is discussed in Section 2.4. Based on Mann-Kendall tests for trend and linear regression trend analysis using analytical groundwater sample results from monitoring wells on site, groundwater concentrations of site COCs have generally declined significantly during the first three years of AS/SVE system operation.

2.4 AS/SVE Remediation System

Thirty-three welded steel AS wells were installed with a 2-foot screened interval at the bottom of each casing at approximately 25−27 feet bgs. The screened sections consist of 1.25-inch-diameter schedule 40 stainless steel pipe, with 2-inch-long, 0.015-inch-wide, laser-cut slots on 6-inch centers that are parallel to the length of the pipe. No-hub Fernco® couplings were used to couple the top of each riser to a 1.25-inch-diameter polyvinyl chloride (PVC) tee equipped with a 1.25-

inch-diameter king nipple on the horizontal leg and a 20−24-inch-long, 1.25-inch-diameter PVC stub-up on the vertical leg. AS wells were completed with 8-inch-diameter manhole covers set in concrete approximately 1 inch below finish grade.

Eleven SVE wells were installed to a depth of 14 feet bgs, with a 5-foot screened interval from 9 to 14 feet bgs. The screened sections consisted of 4-inch-diameter Schedule 40 PVC pipe, with 0.020-inch double-slot screen. Riser pipe sections consisted of flush-threaded, 4-inch-diameter Schedule 40 PVC. The annular space was filled with an 8/12 silica sand filter pack from 8 to 14 feet bgs, a hydrated bentonite chip seal from 5 to 8 feet bgs, and uncontaminated native soil from 5 feet bgs to the surface.

The AS and SVE wellheads are completed with tees and stub-ups. AS and SVE conveyance piping are co-located in common trenches. High-density polyethylene (HDPE) pipe (1.25-inch in diameter) was connected to king nipples on the AS wells and 2-inch-diameter HDPE pipe connected to king nipples on the SVE wells.

Self-regulating, 3-watt-per-foot, explosion-proof heat trace is secured along the length of each SVE conveyance pipe to prevent frost buildup and ice formation during the winter months. AS conveyance pipe accepts warm air from the AS blower, so heat trace was not required. Expanding polyurethane spray-foam insulation was applied to encapsulate the entire piping bundle in each trench.

The blower and metering manifold enclosure exterior shells consist of steel shipping containers commonly referred to as conex containers. The blower enclosure exterior dimensions are 8 feet wide by 20 feet long by 8 feet high and the manifold enclosure dimensions are 8 feet wide by 10 feet long by 8 feet high. The blower enclosure consists of separate AS and SVE blower rooms, both containing rotary lobe positive displacement blowers driven by 20-horsepower motors and ancillary equipment. The metering manifold enclosure contains AS and SVE pressure and vacuum gauges, flow controls, and effluent sample ports.

Alaska Communication Systems (ACS) provides a telephone service line to the blower enclosure, routed from Building 3562, for the remediation system alarm notification auto-dialer.

3.0 REMEDIATION SYSTEM OPERATION, MAINTENANCE, AND MONITORING

AS/SVE system OM&M events were conducted to document system operational parameters and perform system adjustments, maintenance, and effluent screening and sampling. Table 1, attached, presents a summary of all project analytical samples collected during the third year of AS/SVE system operation. It includes pre-treatment SVE effluent, post-treatment SVE exhaust, and groundwater sample information.

Four quarterly AS/SVE OM&M and groundwater monitoring site visits were performed between February 2021 and February 2022. Quarterly technical memoranda were drafted to detail field activities and results following each quarterly field event. AS/SVE OM&M and groundwater monitoring activities are summarized in the body of this report in Sections 3.0 and 4.0; detailed information for each quarterly event including figures, tables, data quality assessment, and field notes are provided in each quarterly technical memorandum located in Appendix B. Remediation system OM&M field activities were conducted in accordance with procedures outlined in the Work Plan (Ahtna, 2018a) and overseen by Ahtna personnel meeting the ADEC definition of a "qualified environmental professional," as defined by 18 AAC 78.088 (b) (ADEC, 2019a). Work was conducted through coordination, as appropriate, with the current tenant at Building 3562, Quick Lane Tire and Auto, and FTW Directorate of Public Works.

A remediation system OM&M data sheet was developed and modified as necessary to record relevant AS/SVE system operating parameters, screening, and sampling data collected during OM&M events. Completed AS/SVE system OM&M data sheets are attached to the quarterly technical memoranda located in Appendix B. The following parameters were recorded on the AS/SVE system OM&M data sheet:

- SVE blower and AS blower operation hour-meter readings
- System alarm status
- Flow rate and vacuum from each SVE well
- Flow rate and pressure into each AS well
- Total flow and vacuum from the SVE manifold
- Total flow and pressure from the AS manifold
- SVE blower exhaust temperature
- AS manifold temperature
- SVE system moisture separator fluid level
- SVE system exhaust screening data
- Soil gas point screening data

Additional items recorded during OM&M visits were maintenance tasks performed and observations that required corrective action. SVE effluent screening and sampling methods and results are presented in Section 3.1.

Non-routine visits to the AS/SVE system were required when unplanned system shutdowns or alarms occurred. The AS/SVE alarm notification auto-dialer is programmed to call Ahtna personnel in Fairbanks when an alarm or shut-down condition is experienced. Fairbanks office personnel visited the site as soon as possible following a system call-out or shutdown notification to diagnose the condition and perform appropriate corrective action. Non-routine site visits and maintenance are discussed in Section 3.2.

3.1 SVE System Effluent Screening and Sampling

During each SVE system effluent screening and sampling event, AS/SVE system parameters including flow rate, pressure, and partial-vacuum were documented in OM&M data sheets. SVE effluent vapor screening measurements for VOCs, total volatile hydrocarbon (TVH), oxygen, and carbon dioxide were also recorded. SVE effluent vapor screening samples for each extraction well were collected from sample ports installed on the SVE manifold using a peristaltic pump to fill a Tedlar® bag. SVE effluent vapor was screened from the Tedlar bag using a MiniRAE photoionization detector (PID) (VOC assessment) and an RKI Eagle® Multi-Gas Meter (TVH, oxygen, and carbon dioxide assessment). Soil gas points located near Building 3562 and along the utility corridor were screened with a PID and the RKI Eagle Multi-Gas Meter, and partial-vacuum was measured using a vacuum gauge.

Vapor samples were collected from SVE system effluent upstream and downstream of the ECO treatment unit. Pre-treatment effluent vapor consists of the combined vapor extracted from the 11 SVE wells that has not passed through the SVE blower to the ECO unit. Post-treatment effluent vapor consists of vapor that has passed through the SVE blower and ECO unit, collected just upstream of the ECO unit exhaust stack. Pre- and post-treatment effluent analytical results are included in attached Table 2 and in quarterly technical memoranda located in Appendix B. Note that use of the ECO unit was discontinued following the first-quarter OM&M event in May 2021 (discussed in Section 3.2.3) and no post-treatment effluent analytical samples were collected in the following quarterly events.

In addition to screening SVE effluent vapor, four soil gas points were also screened for VOCs, total petroleum hydrocarbons, oxygen, and carbon dioxide during each OM&M event. Two soil gas points are installed adjacent to Building 3562 and two are installed near the utility corridor that runs parallel to Neely Road. Each soil gas point has three screened intervals, installed at 6 feet bgs, 9 feet bgs, and 12 feet bgs, except SG-4, which is screened at 9 feet bgs. Soil gas was screened to monitor soil gas conditions near structures that may be at risk of vapor intrusion induced by AS. The partial-vacuum at each soil gas point was also measured to ensure the partial-vacuum induced by the SVE system exceeds the positive pressure generated by the AS system to mitigate the risk of vapor intrusion.

3.1.1 Pre-Treatment SVE Effluent Sampling Methods

Pre-treatment SVE effluent vapor analytical grab samples were collected for VOC analysis using United States Environmental Protection Agency (EPA) Method TO-15. These samples are collected to document changes in SVE effluent VOC concentrations over time.

Pre-treatment SVE effluent vapor analytical samples were collected using batch-certified 1-liter SUMMA® canisters. Initial canister vacuums, typically 30 inches of mercury, were verified and documented using a high-quality vacuum gauge. A laboratory-supplied 2-micron filter was attached to the canister inlet, and a sampling manifold equipped with a vacuum gauge was connected to the filter. Teflon™ tubing was used to connect the sampling manifold to the pre-treatment vapor sample port. A peristaltic pump was connected to the remaining port of the manifold and used to purge air through the manifold and sample tubing and induce a vacuum on the manifold for leak testing prior to sample collection. Samples were obtained by repeatedly opening and closing the canister valve to collect SVE system vapor while monitoring remaining canister vacuum each time the canister valve is closed. Sampling ceased when the remaining canister vacuum reached 6.5–4.5 inches of mercury. The final canister vacuum was recorded prior to shipping samples to the laboratory, and again by the laboratory upon receipt of the canister to confirm the integrity of the sample and canister.

No quality-control sample (field duplicate) was collected during the third year of SVE system vapor sampling because the data are considered screening level, used primarily for establishing rough trends and monitoring remediation system performance, and secondarily as a tool to evaluate short-term exposure limits (STELs) that may be experienced if operating the SVE system without the ECO unit treating the effluent. Analytical canister samples were shipped to Folsom, California, where analytical services were provided by Eurofins Air Toxics.

3.1.2 Post-Treatment SVE Effluent Sampling Methods

One post-treatment (post-ECO) exhaust sample was collected during the second year of AS/SVE system operation before the ECO was discontinued. The post-treatment SVE effluent vapor sample port is located on the ECO unit exhaust stack. The post-treatment vapor analytical sample was collected per requirements stipulated in FTW's AQOP to document VOC emissions. After the ECO was discontinued, biannual sampling per FTW's AQOP continued through sampling SVE effluent at the manifold sample port and analyzing with EPA Method TO-12.

Post-treatment effluent grab samples were collected using a batch certified 1-liter SUMMA canister. One sample was collected from a sample port located on the ECO exhaust stack and the second sample was collected at the manifold sample port. The sample procedure for post-treatment exhaust sampling was identical to the pre-treatment effluent sample methodology. Analytical post-treatment SVE effluent samples were submitted to Eurofins Air Toxics in Folsom, California, for analysis of total non-methane organic compounds (NMOCs) using EPA Method TO-12.

3.1.3 Quarter 1 SVE Effluent Sampling and OM&M Results

Ahtna conducted the first-quarter AS/SVE system OM&M and effluent screening and sampling site visit on May 5, 2021. One pre-treatment SVE effluent sample and one post-treatment SVE effluent sample were collected during the first-quarter OM&M field effort.

SVE effluent field screening was conducted prior to effluent sample collection. Extraction well (EW) effluent PID screenings varied but were generally lower than year one OM&M screening results. The highest EW PID screening result measured during the first quarter was 2.9 parts per million (ppm) in EW-1 and the combined manifold screening was measured at 0.2 ppm. TVH concentrations ranged from 0 to 10 ppm. Oxygen and carbon dioxide remained consistent with atmospheric conditions; oxygen was 20.9% and carbon dioxide 0% in all extraction wells.

Soil gas point PID screenings ranged from 0 to 0.1 ppm, TVH ranged from 0 to 10 ppm, and oxygen and carbon dioxide remained consistent with atmospheric conditions. Partial vacuum was detected at all soil gas points and ranged between 0.15 and 9.8 inches of water column.

At the time of SVE effluent sampling, the AS system was inoperable due to a mechanical failure in the AS blower; as a result, VOC concentrations in the first-quarter SVE effluent sample were extremely low. Benzene concentrations were reported at 1.2 micrograms per cubic meter ($\mu g/m^3$) and xylenes were reported at 148 $\mu g/m^3$; concentrations of other COCs were similarly low. Post-treatment ECO exhaust had a NMOC concentration of 0.11 $\mu g/m^3$.

3.1.4 Quarter 2 SVE Effluent Sampling and OM&M Results

Ahtna conducted the second-quarter AS/SVE system OM&M and effluent screening and sampling site visit on August 5, 2021. One pre-treatment SVE effluent sample was collected during the OM&M field effort and no post-treatment exhaust sample was collected.

SVE effluent field screening was conducted prior to effluent sample collection. The highest PID screening was measured was 4.5 ppm in EW-5 and the combined manifold screening was measured at 0.6 ppm. TVH concentrations were generally low and ranged from 0 to 10 ppm, with 0 ppm in the combined manifold. Oxygen and carbon dioxide remained consistent with atmospheric conditions; oxygen was 20.9% in all EW effluent and carbon dioxide ranged from 0 to 0.2%.

Soil gas point PID screenings ranged from 0 to 0.1 ppm, TVH ranged from 0 to 20 ppm, and oxygen and carbon dioxide remained consistent with atmospheric conditions. Partial vacuum was detected at all soil gas points and ranged between 1.2 and 9.5 inches of water column.

VOC concentrations in the pre-treatment effluent sample were generally low, however concentrations increased when compared to the first quarter results, likely as a result of the re-introduction of air sparging following the AS blower replacement in May 2021. Benzene concentrations were reported at 4.9 $\mu g/m^3$ and xylenes were reported at 290 $\mu g/m^3$. Other analytes showed similar increases in concentrations when compared to year-three quarter-one results.

3.1.5 Quarter 3 SVE Effluent Sampling and OM&M Results

Ahtna conducted the third-quarter AS/SVE system OM&M and effluent screening and sampling site visit on November 4, 2021. One pre-treatment effluent sample and one post-treatment exhaust sample were collected during the OM&M field effort.

SVE effluent field screening was conducted prior to effluent sample collection. EW effluent PID screening results ranged from 0 to 1.9 ppm. TVH concentrations in EW effluent ranged between 5 and 15 ppm. Carbon dioxide and oxygen concentrations were consistent with atmospheric conditions, with oxygen concentrations of 20.9% and carbon dioxide ranging from 0 to 0.2%.

Soil gas point PID screenings ranged from 0 to 0.3 ppm, and TVH ranged from 0 to 10 ppm. Oxygen and carbon dioxide remained consistent with atmospheric conditions. Partial vacuum was detected at all soil gas points and ranged between 1.9 to 9.7 inches of water column.

VOC concentrations in the pre-treatment SVE effluent sample collected during the third quarter of year two were lower than VOC concentrations in the first two quarters of year two. Benzene concentrations were reported at 3.3 $\mu g/m^3$ and total xylenes were 86 $\mu g/m^3$. One SVE exhaust sample was collected during the third quarter: NMOC was detected with a concentration of 0.76 $\mu g/m^3$.

3.1.6 Quarter 4 SVE Effluent Sampling and OM&M Results

Ahtna conducted the fourth-quarter AS/SVE system OM&M and effluent screening site visit on February 3, 2022. One SVE effluent sample was collected during the OM&M field effort from a sample port located on the SVE manifold using a 1-liter laboratory supplied, batch-certified SUMMA canister.

EW effluent PID screening results ranged from 0.2 to 17.6 ppm; the highest concentration was observed in EW-6. TVH concentrations were similar to the previous OM&M field screening results, with concentrations ranging from 0 to 15 ppm. Carbon dioxide and oxygen concentrations were consistent with atmospheric conditions across all EWs.

Soil gas point PID screening results were 0 ppm in all soil gas points, and TVH ranged from 0 to 5 ppm. Oxygen and carbon dioxide were consistent with atmospheric conditions at 20.9% and 0% respectively. Partial vacuum was detected at all soil gas points and ranged between 0.242 and 9 inches of water column.

VOC concentrations in the pre-treatment effluent sample were similar to the previous quarter and remain well below concentrations observed during the first year of system operation. Benzene concentrations were reported at 5.2 $\mu g/m^3$ during the fourth quarter, compared to 3.3 $\mu g/m^3$ reported during the third quarter and 860–180,000 $\mu g/m^3$ reported during the first year of system operation. Similarly, total xylenes were reported at 430 $\mu g/m^3$ compared to 37,000–740,000 $\mu g/m^3$ reported during year one.

3.2 Remediation System Maintenance and Modifications

In addition to the scheduled OM&M site visits, Ahtna was on site periodically to perform routine maintenance, respond to alarm conditions, perform system modifications and repairs, and troubleshoot system deficiencies identified during OM&M visits. Scheduled AS/SVE system maintenance and modifications planned for year three are also discussed in this section.

3.2.1 Routine Maintenance

The AS and SVE blowers require oil changes approximately once every six months of operation. As part of the routine maintenance program, Ahtna performed oil changes on both the AS and SVE blowers twice during year three using the manufacturer-recommended AEON® PD synthetic lubricant. The bearings on each blower were periodically greased using AEON PD blower grease, per manufacturer recommendation. Blower intake filters were inspected during each OM&M event and cleaned or replaced, as necessary.

3.2.2 Remediation System Alarms and Shutdowns

Non-routine site visits were necessary following unscheduled system shutdowns. Unscheduled shutdowns are automated system shutdowns triggered by system faults; the remediation system alarm notification auto-dialer is programmed to alert Ahtna personnel after a system fault is triggered. Two types of unscheduled system shutdowns can occur depending on the faults that prompt the shutdown—partial and complete system shutdowns. Partial system shutdowns are shutdowns in which the AS blower is shut down while the SVE, ECO unit, and auto-dialer remain in operation. Complete system shutdowns are system shutdowns that cause all remediation system components to shut down except the auto-dialer. System faults that trigger shutdowns and/or alarms include high AS blower pressure, high AS blower temperature, high SVE vacuum, high fluid level in the SVE moisture separator, VOC concentrations exceeding 10% lower explosive limit in the SVE blower or metering enclosures, and loss of power.

Three unscheduled system shutdowns occurred during the third year of operation; all three alarms were attributed to power fluctuations or loss of power conditions. On April 30, 2021, during a routine site visit, the SVE system was not in operation; no system alarms were active and no auto dialer callout was received by the operator. The second system shutdown occurred during May 2021, and the auto dialer successfully reported the shutdown. On May 27, 2021, Ahtna investigated the reported system shutdown, and found the AS/SVE system operating normally. Since the ECO bypass was installed in early May 2021, the AS/SVE system now automatically restarts when power is restored to the system following a loss of power system shutdown, because the ECO catalyst temperature requirement has been removed from the system startup sequence. The third system shutdown occurred on July 26, 2021; the auto-dialer successfully called the operator and reported a system shutdown, and again the system automatically returned to normal operation when power was restored to the remediation system.

3.2.3 Non-routine AS/SVE System Maintenance and Modifications

Due to a mechanical failure of the AS blower experienced in October during the third quarter of 2020, the AS system was not operable during the first quarter of 2021. Wakefield Inc. was contracted to perform a complete AS blower replacement. On May 7 and 8, 2021, Wakefield completed the AS blower replacement task, and monitored AS operation during startup.

In the 2020 installation and OM&M report (Ahtna, 2020), Ahtna recommended discontinuing the ECO unit. Prior to discontinuing the ECO unit, three criteria needed to be satisfied per the Work Plan (Ahtna, 2018a):

- Benzene concentrations in the exhaust must be below the Occupational Safety and Health Administration (OSHA) STEL of 5 ppm (5,000 $\mu g/m^3$).
- Total VOC emissions cannot exceed the annual allowable quantity of 20 tons per year specified in the AQOP.
- Emissions cannot cause an odor nuisance to the public.

Compliance with the first two criteria was documented in the *2020 Installation and OM&M Report* (Ahtna, 2020). Pre-treatment SVE effluent analytical results from the second year of operation confirm continued compliance with the first two requirements: the highest benzene concentration measured in untreated SVE effluent during the second year of operation was 110 $\mu g/m^3$, and potential emissions were well below the 20-ton limit with a total potential of 117.48 pounds during year two. The third stipulation is qualitative, however based on Good Engineering Practice EPA Regulation No. 62.7 (EPA, 1987), an adequate exhaust stack height promotes effluent dispersion and can mitigate odor nuisance. Qualitative observation of odor within the breathing zone was performed during OM&M site visits following the ECO bypass and exhaust stack modification and no hydrocarbon odor was observed.

Wakefield installed a new 20-foot SVE exhaust stack and ECO bypass during the May 2021 site visit. Operation of the ECO unit was discontinued following the installation of the new exhaust stack and bypass. The ECO bypass task was performed in accordance with the criteria outlined in the Work Plan (Ahtna, 2018a), and the recommendations provided in the *Year Two OM&M Report* (Ahtna, 2021).

In mid-October Ahtna was notified by the Quick Lane Tire and Auto business operating in Building 3562 that the suspended phone line running from Building 3562 to the AS/SVE control room had been damaged by a vehicle passing through the parking lot. An Ahtna field technician mobilized to the site to inspect the damages. The mounting hardware for the mast installed on the AS/SVE control room was broken, the mast mounted to Building 3562 was severely bent, and the phoneline was severed during the incident. Ahtna contacted the phone service provider (ACS), regarding the interruption of service. An ACS technician inspected the phoneline and provided recommendations for replacement mast specifications. On November 11, 2021, Ahtna mounted a 10-foot section of 2-inch conduit to the northeast corner of Building 3562 to serve as a mast for the phoneline. Per ACS recommendations, a 20-foot section of 1.5-inch rigid conduit was mounted to the AS/SVE control room, with 5 feet of the rigid pipe section anchored below the top edge of the conex, creating a mast that extends 15 feet above the top of the AS/SVE control room. On November 12, 2021, ACS restored the phone connection to the AS/SVE control room, and Ahtna tested the AS/SVE system auto-dialer to confirm the system was functioning as intended. The interruption of phone service to the AS/SVE control room did not affect AS/SVE operations.

4.0 QUARTERLY GROUNDWATER MONITORING METHODS AND RESULTS

Four quarterly groundwater monitoring events were conducted during the third year of remediation system operation from February 2021 through February 2022. Quarterly technical memoranda were drafted to detail field activities and results for each quarterly field event. Groundwater monitoring activities and results are summarized in this section. Detailed information for each quarterly event, including a data quality assessment, is provided in each quarterly technical memorandum located in Appendix B.

4.1 Groundwater Sampling Methods

Twelve monitoring wells were sampled during each quarterly groundwater monitoring event, unless noted otherwise in this section. Monitoring well locations are shown on Figure 2. Each well was sampled for GRO, VOCs, DRO, and PAHs. Wells were sampled in order of increasing contamination based on analytical results from previous groundwater sampling events and analytical samples were collected in each well in order of decreasing contaminant volatility at each well. Twelve primary samples, two duplicate samples, and one matrix spike (MS)/matrix spike duplicate (MSD) sample were collected during each sampling event. VOC and GRO samples were accompanied by a laboratory-supplied trip blank. An equipment blank was collected at the conclusion of each sampling event to assess the effectiveness of decontamination procedures. Analytical groundwater samples were submitted to SGS of Anchorage, Alaska, for the following analyses.

- GRO by Alaska Test Method (AK)101
- DRO by AK102
- VOCs by EPA Method 8260C
- PAHs by EPA Method 8270D selected ion monitoring

A submersible pump was used for purging and sampling groundwater following the EPA low-flow sampling procedure (Puls & Barcelona, 1996), and a Solinst® oil/water interface probe was used to monitor groundwater levels. Dedicated polyethylene tubing was used for purging and sample collection at each well, and the oil/water interface probe and submersible pump were decontaminated following use at each well. Samples were collected after groundwater quality parameters met the stabilization criteria identified in the ADEC *Field Sampling Guidance* (ADEC, 2019b) and the Work Plan (Ahtna, 2018a). Groundwater parameters including dissolved oxygen, potential Hydrogen, oxidation-reduction potential, temperature, turbidity, and specific conductivity were measured using a YSI 556 or YSI Pro water quality meter. Groundwater sampling details including groundwater quality parameters were recorded on groundwater sampling data sheets, included in Appendix B.

Table 3, attached, presents the analytical results for GRO, VOCs, DRO, and PAHs compared to ADEC groundwater cleanup levels listed in 18 AAC 75.345 Table C (ADEC, 2020). Figure 2 presents the analytical results from monitoring wells with COC concentrations exceeding groundwater cleanup levels and shows revised dissolved-phase plumes resulting from COC concentrations recorded during the fourth quarter of year three.

4.2 Quarter 1 Groundwater Sampling Results

Two field team members mobilized to the site on May 3 and 4, 2021, to perform the scheduled quarterly groundwater monitoring sample event. Twelve primary samples, two duplicate samples, and one MS/MSD groundwater sample was collected for analysis of GRO, VOCs, DRO, and PAHs.

Source area wells AP-10379MW, located within the fuel island source area, and AP-10368MW, located within the UST source area, remain the locations with the highest number of COCs exceeding ADEC cleanup levels. Samples from AP-10379MW exceeded cleanup levels for benzene (40.1 µg/L), ethylbenzene (44.6 µg/L), and naphthalene (20.7 µg/L). AP-10368MW groundwater samples exceeded cleanup levels for GRO (5.12 milligrams per liter [mg/L]), 1,2,4-trimethylbenzene (1,2,4-TMB; 304 µg/L), 1,3,5-trimethylbenzene (1,3,5-TMB; 103 µg/L), benzene (177 µg/L), ethylbenzene (193 µg/L), naphthalene (13.7 µg/L), and xylenes (1130 µg/L). Concentrations of COCs in the source area wells during the first quarter of year three were significantly lower than the previous two sampling events (November 2020 and February 2021). Increased COC concentrations observed in the February 2021 groundwater sample results were attributed to possible concentration rebounding in the absence of the air sparging. Concentrations of COCs in the May 2021 results are elevated when compared to groundwater results from May 2020, which supports the notion that COC concentrations began rebounding in the absence of the AS system operation. The significant decrease in COC concentrations from February 2021 to May 2021 may be a result of seasonal fluctuations in the groundwater elevation at the site.

In addition to the COC exceedances identified in the source areas, samples from three other monitoring well locations exceeded ADEC cleanup levels for one or more COCs. AP-10381MW exceeded cleanup levels for DRO (4.19 mg/L) and benzene (8.6 µg/L). AP-10380MW and AP-10383MW exceeded benzene cleanup levels with concentrations of 6.67 µg/L and 13.6 µg/L, respectively.

4.3 Quarter 2 Groundwater Sampling Results

The field team mobilized to the site on August 3 and 4, 2021, to perform the scheduled quarterly groundwater monitoring sample event. Twelve primary samples, two duplicate samples, and one MS/MSD groundwater sample was collected for analysis of GRO, VOCs, DRO, and PAHs.

Source area wells AP-10379MW, located within the fuel island source area, and AP-10368MW, located within the UST source area, remain the locations with the most site COCs exceeding ADEC cleanup levels. Concentrations of COCs in samples collected from the source areas generally increased when compared to 2021 first-quarter results, possibly as a result of the reintroduction of the AS, however concentrations remain significantly lower than historic concentrations reported prior to AS/SVE installation and during the first year of operation. Samples from AP-10379MW exceeded cleanup levels for GRO (4.35 mg/L), DRO (4.2 mg/L), benzene (183 µg/L), ethylbenzene (415 µg/L), and naphthalene (20.7 µg/L). Samples collected from the UST source area well, AP-10368MW, exceeded ADEC cleanup levels for GRO (13.1 mg/L), DRO (1.83 mg/L), 1,2,4-TMB (421 µg/m^3), 135-TMB (124 µg/m^3), benzene (349 µg/m^3), ethylbenzene (555 µg/m^3), naphthalene (15.5 µg/m^3), toluene (1,510 µg/m^3), and xylenes (4,170 µg/m^3). Monitoring well AP-10381MW was the only monitoring well located outside of the source areas with concentrations of COCs that exceeded ADEC cleanup levels. The sample collected from AP-10381MW exceeded cleanup levels for DRO (2.90 mg/L), no other analytes were detected above cleanup levels in the sample collected from AP-10381MW.

4.4 Quarter 3 Groundwater Sampling Results

The field team mobilized to the site on November 2 and 3, 2021, to perform the scheduled quarterly groundwater monitoring event. Twelve primary samples, two duplicate samples, and one MS/MSD groundwater sample was collected for analysis of GRO, VOCs, DRO, and PAHs.

Source area wells AP-10379MW, located within the fuel island source area, and AP-10368MW, located within the UST source area, remain the locations with the greatest number of site COCs exceeding ADEC cleanup levels. Concentrations of COCs in samples collected from the fuel island source area increased significantly when compared to the previous quarter. GRO concentrations in AP-10379MW increased from 4.2 to 17.4 mg/L, similarly DRO concentrations increased from 4.35 to 8.19 mg/L. Samples from AP-10379MW also exceeded cleanup levels for: 1,2,4-TMB (1,320 micrograms per liter [µg/L]), 1,3,5-TMB (355 µg/L), 1-methylnaphthalene (20.3 µg/L), benzene (222 µg/L), ethylbenzene (1,310 µg/L), naphthalene (241 µg/L), and total xylenes (8,400 µg/L). Concentrations of COCs in the UST source area well, AP-10368MW, were similar to the previous-quarter results. Samples collected from AP-10368MW exceeded ADEC cleanup levels for GRO (7.33 mg/L), DRO (2.93 mg/L), 1,2,4-TMB (516 µg/L), 135-TMB (166 µg/L), benzene (133 µg/L), ethylbenzene (256 µg/L), naphthalene (20.6 µg/L), and total xylenes (2,180 µg/L). Monitoring well AP-10381MW was the only monitoring well located outside of the source areas with concentrations of COCs exceeding ADEC cleanup levels. The sample collected from AP-10381MW exceeded cleanup levels for DRO (2.76 mg/L) and naphthalene (2.82 µg/L). No other analytes were detected above cleanup levels in the sample collected from AP-10381MW.

4.5 Quarter 4 Groundwater Sampling Results

Two field team members mobilized to the site on February 7 and 18, 2022, to perform the fourth-quarter groundwater monitoring sample event. Twelve primary samples, two duplicate samples, and one MS/MSD groundwater sample was collected for analysis of GRO, VOCs, DRO, and PAHs. The AS system was inactive during the year-two, quarter-four groundwater sampling event.

Source area wells AP-10379MW, located within the fuel island source area, and AP-10368MW, located within the UST source area, remain the locations with the greatest number of site COCs exceeding ADEC cleanup levels. Concentrations of DRO, GRO, and numerous other site COCs in samples collected from the fuel island source area remain above cleanup levels. The GRO concentration in AP-10379MW was 12.0 mg/L and the DRO concentration was 7.32 mg/L. Samples from AP-10379MW also exceeded cleanup levels for: 1,2,4-TMB (1,130 µg/L), 1,3,5-TMB (327 µg/L), 1-methylnaphthalene (13.3 µg/L), benzene (42 µg/L), ethylbenzene (707 µg/L), naphthalene (97.6 µg/L), and total xylenes (4,900 µg/L). Concentrations of COCs in the UST source area well, AP-10368MW, were similar to the previous-quarter results with several COCs exceeding ADEC cleanup levels. Samples collected from AP-10368MW exceeded ADEC cleanup levels for GRO (3.94 mg/L), 1,2,4-TMB (260 µg/L), 135-TMB (79 µg/L), benzene (99.5 µg/L), ethylbenzene (284 µg/L), naphthalene (16.9 µg/L), and total xylenes (1,350 µg/L).

Monitoring wells AP-10381MW and AP-10366MW, located immediately west of the fuel island source area, were the only monitoring wells located outside of a source area with COC concentrations exceeding ADEC cleanup levels, with DRO concentrations of 3.05 and 1.89 mg/L, respectively.

5.0 WASTE MANAGEMENT

Waste streams generated during AS/SVE OM&M and quarterly groundwater monitoring activities included POL-contaminated monitoring-well purge water and nonhazardous solid waste. Copies of waste manifests and other disposal documents are included in Appendix C.

POL-contaminated groundwater, or purge water, was generated while purging monitoring wells during groundwater monitoring activities. Purge water was containerized in 55-gallon drums. A total of five drums containing purge water were labeled and taken to the Defense Environmental Restoration Account Building on FTW for temporary storage. Analytical groundwater sample results were used for waste characterization and profiling. The sample results were provided to US Ecology to guide appropriate disposal of the water in accordance with its permit. Following manifesting and receipt of an approved ADEC transport and disposal form, drums were delivered to US Ecology in Fairbanks for transport and disposal.

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6.0 REMEDIAL PROGRESS ASSESSMENT

Analytical groundwater and SVE effluent data are analyzed to provide remedial progress assessment at the site. Groundwater COCs exceeding ADEC cleanup levels have been plotted graphically for each well and the dissolved-phase plumes have been updated to reflect COC concentrations across the site through the end of year three on Figure 2. Site COC concentration trends in groundwater are quantitatively assessed using Mann-Kendall trend analysis and linear regression trend analysis. Benzene concentration data obtained from analytical groundwater samples are used to estimate time to site cleanup. Remedial progress assessment is summarized in the following subsections. Mann-Kendall, linear regression, and time-to-cleanup calculations are included in Appendix D.

6.1 Change in Distribution and Magnitude of Site Contaminants of Concern

Of the 12 monitoring wells sampled during the 2018 supplemental site investigation prior to remediation system installation, 10 monitoring wells contained at least one COC that exceeded cleanup levels. At the conclusion of the first year of AS/SVE system operation (February 2020) only three wells contained COC concentrations exceeding ADEC cleanup levels. During the third quarter of the second year of AS/SVE operation, the AS blower experienced a mechanical failure that prevented the AS system from operating for the remainder of the second year. As a result, COC concentrations in several wells appear to have rebounded during the fourth quarter of year two, and the first quarter of year three, in the absence of AS action. The AS system was repaired and AS operation resumed in May 2021 and continued for the remainder of year three.

DRO concentrations in wells located within the source areas (AP-10368MW and AP-10379MW) exceeded historical concentrations and ADEC cleanup levels during the third year of operation. Five monitoring wells contained COC concentrations above ADEC cleanup levels at the conclusion of the third year of remediation system operation.

6.2 Mann-Kendall and Linear Regression Trend Analyses

Ahtna performed the Mann-Kendall trend test on groundwater analytical results from samples collected during AS/SVE system operation and the 2018 supplemental site characterization event (pre-AS/SVE system operation) to assess the stability of the hydrocarbon plume at the site. The Mann-Kendell trend test was performed for 10 monitoring wells with COC concentrations that exceeded ADEC cleanup levels during the 2018 supplemental site characterization. Trend analysis was not performed for monitoring well locations that have not exceeded groundwater cleanup levels, or COCs in wells that have not exceeded ADEC cleanup levels for at least five consecutive sampling events.

Analytical data were compared using the nonparametric Mann-Kendall trend test (Gilbert, 1987) to assess whether concentrations of COCs exhibited an increasing trend, decreasing trend, stable trend, or no trend over time for a given well. The Mann-Kendall test assumes a no-trend null hypothesis, does not assume a distribution, and is resistant to outlier influence. The Mann-Kendall test compares a later-measured value to each earlier-measured value and assigns an integer value of -1, 0, or 1, which indicates whether the later value decreased, remained the same, or increased compared to earlier values. Integer values are summed to compute the Mann-Kendall test statistic "S". Ahtna selected a significance level of 10%. If the probability "p" of obtaining a computed "S" is less than 10%, the confidence level is greater than 90%; if "p" is less than 10%, the null hypothesis is rejected. If the confidence level is greater than 90%, the sign of "S" indicates the trend direction, positive "S" indicates an increasing trend, and negative "S" indicates a decreasing trend.

A linear regression analysis was also performed on the data as a parametric alternative to the Mann-Kendall test. The analysis assesses the slope and computes the coefficient of determination (R^2) value of the least-squares regression on the sample mean. The R^2 value indicates the fit of the data, or distance of data points from the regression line. Higher R^2 values (> 0.8) indicate a close fit of the data and a strong correlation, suggesting that there is a trend. Values of R^2 between 0.5 and 0.8 suggest some correlation in the data and the possibility of a trend. Linear regression assumes that the data approximately follow a normal distribution and can confidently be used with eight or more data points.

Concentrations of contaminants in wells with a confidence level greater than 95% are considered likely to have a trend. Of the 49 Mann-Kendall tests assessed, 23 had a negative "S" value with > 95% confidence level, indicating a decreasing trend. No linear regression analyses had R^2 values equal to or greater than 0.8, which would indicate likely decreasing trends. All six Mann-Kendall tests assessing benzene concentrations resulted in decreasing or probable decreasing trends. Linear regression analysis indicated possible decreasing trends in two benzene assessments. Mann-Kendall analysis identified increasing concentration trends for naphthalene in AP-10368MW (UST source area) and DRO in AP-10381MW. Table 6-1 summarizes the Mann-Kendall and linear regression results for GRO, DRO, and benzene at seven of the site groundwater monitoring wells that currently or previously exceeded cleanup levels.

TABLE 6-1: GRO, DRO, AND BENZENE MANN-KENDALL TREND TEST AND LINEAR REGRESSION RESULTS

Location	Contaminant	Number of Events	Confidence Level	R^2	Statistical Method	Result
AP-10368MW	GRO	14	99.9	0.4677	Linear Regression	No trend
					Mann-Kendall	Decreasing trend
	DRO	14	82.4	0.0651	Linear Regression	No trend
					Mann-Kendall	Likely no trend
	Benzene	14	99.2	0.4333	Linear Regression	No trend
					Mann-Kendall	Decreasing trend
AP-10379MW	GRO	14	69.0	0.2889	Linear Regression	No trend
					Mann-Kendall	Likely no trend
	DRO	14	58.7	0.0017	Linear Regression	No trend
					Mann-Kendall	Stable trend

Location	Contaminant	Number of Events	Confidence Level	R^2	Statistical Method	Result
	Benzene	14	97.9	0.3794	Linear Regression	No trend
					Mann-Kendall	Decreasing trend
AP-10383MW	Benzene	14	96.9	0.4251	Linear Regression	No trend
					Mann-Kendall	Decreasing trend
AP-10366MW	Benzene	14	99.9	0.5207	Linear Regression	Decreasing trend
					Mann-Kendall	Decreasing trend
AP-10381MW	GRO	14	99.0	0.3432	Linear Regression	No trend
					Mann-Kendall	Decreasing trend
	DRO	14	98.2	0.142	Linear Regression	No trend
					Mann-Kendall	Increasing trend
AP-10378MW	Benzene	13	99.9	0.427	Linear Regression	Possible decreasing trend
					Mann-Kendall	Decreasing trend
	GRO	13	95.6	0.4568	Linear Regression	No trend
					Mann-Kendall	Decreasing trend
AP-10380MW	Benzene	14	97.9	0.3319	Linear Regression	No trend
					Mann-Kendall	Decreasing trend

Key:

DRO	diesel-range organics
GRO	gasoline-range organics
R^2	coefficient of determination

6.3 Time-to-Cleanup Modeling

Time-to-cleanup modeling was performed using benzene as an indicator for remedial progress. Benzene concentrations from the past three years of quarterly groundwater monitoring following remediation system installation were graphed against time and fitted with linear and exponential trend lines. The first data point considered in the analyses was collected after approximately three months of AS/SVE operation. The exponential trends are generally more applicable for contaminant cleanup modeling; linear interpretations were included for comparison. Monitoring wells with analytical benzene results that have exceeded ADEC cleanup levels since AS/SVE installation were considered for this analysis. The trendline equations were used to estimate the time to reduce benzene concentrations below ADEC cleanup levels. Time-to-cleanup estimates varied by well location and proximity to the source areas. Note that current time-to-cleanup estimates are the estimated number of years to achieve cleanup from the first sampling event conducted following AS/SVE system startup in February 2019. The estimated time to cleanup for the UST source area monitoring well AP-10368MW is 7.7 years with AS/SVE system operation. The time-to-cleanup estimation using the fuel-dispenser island source area monitoring well AP-10379MW is 7.2 years. Time-to-cleanup estimates may be affected by COC concentrations rebounding in the absence of the AS system during the second half of year two and the first quarter of year three, causing the estimated time to cleanup to increase. Benzene concentrations in numerous monitoring wells located outside the source areas have been below cleanup levels for numerous monitoring events. System operation time has already exceeded the total estimated time to cleanup at many of these locations; analyses of these locations are provided for informational purposes. Decisions regarding the status of the site should consider the more conservative estimates provided by results from the source area wells. Additional analytical data from quarterly groundwater monitoring will improve the robustness and accuracy of this estimate. Time-to-cleanup modeling is included in Appendix D.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Based on groundwater monitoring data and remedial progress assessment, the AS/SVE remediation system has effectively reduced petroleum hydrocarbon concentrations within the fuel-dispenser island and UST source areas since it began operating in 2018. Benzene concentrations within the two source zones have decreased significantly over the first three years of remediation system operation. Site cleanup is expected to be achieved within the source areas after approximately 7.2–7.7 years of system operation based on the results of time-to-cleanup modeling using benzene concentrations. The 7.7-year time-to-cleanup estimate exceeds the estimate of three to five years proposed in the Work Plan (Ahtna, 2018a), however it is probable that the current time-to-cleanup estimate has been affected by COC concentrations rebounding during the second half of year two and first quarter of year three while the AS system was out of commission. Conversely, numerous wells outside of the source areas have cleaned up with respect to benzene concentrations, affirming early time-to-cleanup estimates. The estimated time to cleanup will be updated after the fourth year of AS/SVE system operation and quarterly groundwater monitoring. Benzene was used as an indicator for the time-to-cleanup model; however, some wells appear to have experienced seasonal fluctuations in concentrations of other COCs, which may reflect seasonal exposure of the water table to remaining contamination in the smear zone. Continued monitoring and data analysis is recommended for site decision-making.

Mann-Kendall trend tests identified one COC, naphthalene, with an increasing trend in UST source area monitoring well AP-10368MW and one COC, DRO, with an increasing trend in monitoring well AP-10381MW located immediately west of the fuel island source area. Increasing Mann-Kendall trends were not identified in the remaining six monitoring wells sampled during quarterly groundwater monitoring events that were subject to trend analysis. Thirty-six Mann-Kendall trend tests of the 49 COCs analyzed resulted in decreasing trends. With few exceptions, concentrations of COCs in all wells have decreased when compared to pre-remediation system groundwater analytical results. Any increased COC concentrations are likely influenced by the AS system being out of commission for the majority of the second half of year two and first quarter of year three. Continued monitoring and analysis of COC concentrations in groundwater is recommended to assess remedial progress and identify hot spot locations that may be candidates for remediation system optimization.

Extraction wells are providing adequate engineering controls to effectively mitigate potential accelerated vapor intrusion from AS, demonstrated by the presence of induced partial vacuum and low VOC screening results in the soil gas monitoring points installed along the utility corridor and adjacent to Building 3562.

Operation of the ECO unit was discontinued in year three because the three conditions for discontinuing its use were met. The benzene concentration in untreated SVE effluent (emissions) is below the OSHA STEL (5 ppm or 5000 µg/m^3) for any 15-minute exposure period, untreated SVE effluent emissions do not exceed the annual allowable VOC emissions quantity specified in the FTW AQOP of 20 tons per year, and untreated SVE emissions have not been observed to cause an odor nuisance to the public. As discussed in Section 3.2.3, an exhaust stack with a total height of 20 feet above ground surface, which bypasses the ECO unit, was installed in May 2021. The 20-foot exhaust stack is consistent with recommended engineering practices and provides adequate dispersion to protect the breathing zone and eliminate nuisance odors in the vicinity, satisfying the third requirement for ECO discontinuance. As an ancillary benefit, bypassing the ECO in the remediation system control logic improves the reliability of the AS/SVE system operation, eliminating potential shutdowns due to ECO unit faults. The ECO unit will remain in place and can be reincorporated in AS/SVE system operation if any of the three conditions stipulating its operation necessitate its use.

Ahtna recommends continued operation of the AS/SVE remediation system with quarterly analytical groundwater sampling. The AS/SVE system should continue to operate until COC concentrations in analytical groundwater sample results are below ADEC cleanup levels and controlled rebound testing can be initiated. Continued data collection and assessment of remedial progress should be performed to monitor site COC concentration trends and improve the robustness and accuracy of the Mann-Kendall trend tests, linear regression trend analysis, and time to-cleanup modeling. Groundwater monitoring with analytical sampling should continue following the eventual shutdown of the remediation system to monitor contaminant rebound and assess whether continued remediation system operation, or continued operation with system optimization modifications, is necessary.

8.0 REFERENCES

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TABLES

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APPENDIX A

PHOTOGRAPHIC LOG

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APPENDIX B

QUARTERLY TECHNICAL MEMORANDA

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APPENDIX C

DISPOSAL DOCUMENTS

APPENDIX D

MANN-KENDALL, LINEAR REGRESSION, AND TIME-TO-CLEANUP CALCULATIONS

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APPENDIX E

COMMENTS AND RESPONSE TO COMMENTS

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