FINAL

2016 RA-O/LTM REPORT

BASE LIVING AREA (ZONE 1)
BASE INDUSTRIAL AREA (ZONE 2)
SOUTH BLUFFS (ZONE 3)
BLUFFS O&M
NAKNEK RIVER STORAGE AREA (ZONE 4)
RAPCON & RED FOX CREEK (ZONE 5)
FT004 (ZONE 5)
PFOA/PFOS SAMPLING
NAKNEK REC CAMP LAND FILL (ZONE 6)
LAKE CAMP (ZONE 7)
LANDFARM O & M
BIOCELL SAMPLING

KING SALMON DIVERT, ALASKA

MAY 2018

CONTRACT NO. FA8903-14-D-0041, TO 0003

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PREFACE AND DISCLAIMER

Paug-Vik Services, LLC (Paug-Vik) prepared this report through a contract with the Air Force Civil Engineering Center (AFCEC), contract number FA8903-14-D-0041, task order 0003. Paug-Vik and its subcontractors performed this work for the United States Air Force (USAF) under the Environmental Restoration Program (ERP). This comprehensive report presents long-term management activities conducted in 2016 at seven King Salmon Divert (KSD) groundwater zones in addition to biocell and landfarm sampling activities.

This report provides a description of work and results performed by contract field personnel during the project. Where relevant, this work generally followed guidance contained in the AFCEE *Technical Protocol for Implementing Intrinsic Remediation with Long-Term Monitoring for Natural Attenuation of Fuel Contamination Dissolved in Groundwater* (Wiedemeier et al., 1999), the *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater* (Wiedemeier et al., 1998), and the AFCEE Handbook for the IRP, Remedial Investigation and Feasibility Studies (RI/FS), dated September 1993.

This document has been prepared for the United States Air Force for the purpose of aiding in the implementation of the Environmental Restoration Program (ERP). The limited objectives of this document and the ongoing nature of the ERP, along with the evolving knowledge of site conditions and chemical effects on the environment and human health, must be considered when evaluating this document since subsequent facts may become known which may make this document incomplete or inaccurate.

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ABBREVIATIONS AND ACRONYMS

611 CES	611th Civil Engineer Squadron
AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
ADWS	Alaska Drinking Water Standards
AFB	Air Force Base
AFCEE	Air Force Center for Engineering and the Environment
AFCEC	Air Force Civil Engineer Center
ARARs	Applicable or Relevant and Appropriate Requirements
AST	Aboveground Storage Tank
AWQS	Alaska Water Quality Standards
bgs	Below Ground Surface
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
COC	Contaminants of Concern
COPCs	Contaminants of Potential Concern
DCE	Dichloroethene
DO	Dissolved Oxygen
DOD	Department of Defense
DRO	Diesel-Range Organics
EDB	1,2-dibromoethane
ERP	Environmental Restoration Program
ERPIMS	Environmental Resources Program Information Management System
FPP	Floating Petroleum Product
FS	Feasibility Study
FSP	Field Sampling Plan
GRO	Gasoline-Range Organics
IDW	Investigation-Derived Waste
KSA	King Salmon Airport
KSD	King Salmon Divert
LFI	Limited Field Investigation
LTM	Long-Term Monitoring
MNA	Monitored Natural Attenuation
ND	Not Detected
NOAA	National Oceanic and Atmospheric Administration
OASIS	OASIS Environmental, Inc.
OSWER	Office of Solid Waste and Emergency Response
ORNL	Oak Ridge National Laboratory
ORP	Oxidation-Reduction Potential
PAH	Polynuclear/polycyclic aromatic hydrocarbon
PCBs	Polychlorinated biphenyl
PCE	Tetrachloroethylene
PDC	Paug-Vik Development Corporation
PEL	Probable Effects Level
PFOA	Perfluorootanoic Acid
PFOS	Perfluorooctane Sulphonic Acid
pH	Measure of acidity and alkalinity
POC	Point of Compliance
POL	Petroleum, Oil, Lubricants

PVS	Paug-Vik Services, LLC
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QAR	Quality Assurance Review
QC	Quality Control
RAO	Remedial Action Objective
RG	Remediation Goal
RI/FS	Remedial Investigation/Feasibility Study
RL	Reporting Limit
ROD	Record of Decision
RPO	Remedial Process Optimization
SAIC	Science Applications International Corporation
SQB	Sediment Quality Benchmark
SQuiRT	Screening Quick Reference Table
TAH	Total aromatic hydrocarbons
TAqH	Total aqueous hydrocarbons
TCE	Trichloroethene
TDS	Total Dissolved Solids
toc	Top of Casing
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
USAF	United States Air Force
USEPA	U.S. Environmental Protection Agency
UST	Underground Storage Tank
VOA	Volatile Organic Analysis
VOCs	Volatile Organic Compounds

UNITS OF MEASURE

ft	Feet
mg/Kg	Milligrams analyte per kilogram of sample
mg/L	Milligrams analyte per liter of sample
µg/L	Micrograms analyte per liter of sample
µS/cm	Microsiemens per centimeter
mV	Millivolts
%/day	percent per day
°C	Degrees Celsius
°F	Degrees Fahrenheit

EXECUTIVE SUMMARY

This comprehensive management report presents analytical and field data collected during the 2016 field season from seven groundwater zones at King Salmon Divert, Alaska (KSD). Descriptions of the sampling events and results from each site are summarized below.

Each appendix is separated into sections based upon groundwater zone. Sample data collection sheets are included in Appendix A. Chain of custody records documenting activities during the field season are in Appendix B. Analytical summary tables of results for groundwater, surface water, and sediment collected during the field activities are presented in Appendix C. A Quality Assurance Review of the analytical results from samples collected and Alaska Department of Environmental Conservation (ADEC) Laboratory Data Review Checklists are presented in Appendix D. PRoUCL Statistical Tests for Trend Analysis for Zone 2, Zone 4, RAPCON, and Zone 7 are presented in Appendix E. Photographic documentation of field activities is presented in Appendix F. Complete laboratory data reports are provided on the accompanying DVD-R.

The Air Force is currently under contract through the Corps of Engineers to complete an Explanation of Significant Difference for Zone 3, as well as Records of Decision for Zone 5 and Zone 7.

GROUNDWATER ZONE 1 – BASE LIVING AREA

Groundwater samples were collected from ten A-Aquifer monitoring wells in September 2016, and analyzed for volatile organic compounds (VOCs), diesel-range organics (DRO), geochemical indicators of intrinsic remediation, and other inorganic analyses. Groundwater samples were also collected from three B-Aquifer wells and analyzed for VOCs and DRO. The B-Aquifer samples and three of the A-Aquifer samples were also analyzed for the solvent 1,4-Dioxane. An institutional control inspection was performed to verify that no drinking water wells have been installed in the A or B Aquifers.

The results from these efforts indicate that none of the sample results from the A-Aquifer monitoring wells exceeded the ADEC groundwater cleanup levels for benzene, toluene, ethylbenzene, and xylenes (BTEX) components. Four well points and two monitoring wells exceeded the cleanup level of DRO. TCE was observed above the ADEC Table C cleanup level of 0.0028 mg/L at ETMW-02 (0.087 mg/L), MW-6 (0.024 mg/L), MW-23 (0.019 mg/L), MW-28 (0.11 mg/L), and MW89-1 (0.0037 mg/L). TCE was also detected above the action level of 0.0027 mg/L at two of the five point-of-compliance (POC) well points. All results for 1,4-Dioxane were ND. Inorganic parameters provide some evidence that natural attenuation of petroleum hydrocarbons is occurring in the A-Aquifer. The majority of concentration trends including that for TCE are stable or decreasing. This indicates that intrinsic remediation is keeping contaminant concentrations stable or decreasing at this site.

TCE was found at a concentration of 0.072 mg/L in MW-41, and 0.048 (0.047) mg/L in MW13-09B. These results exceed the cleanup level of 0.0028 mg/L. TCE contamination in Zone 1 is at the center of an ongoing RI/FS, under a separate contract.

Monitoring and recovering product at Seeps 1 and 2 was done in June 2016. Approximately 0.25 liter of product was removed from PR-11 at Seep 1.

GROUNDWATER ZONE 2 - BASE INDUSTRIAL AREA & ESKIMO CREEK DUMP

Groundwater samples were collected from eleven A-Aquifer monitoring wells in late September/early October of 2016, and analyzed for VOCs, DRO, gasoline-range organics (GRO), geochemical indicators of intrinsic remediation, and other inorganic analytes. Two of the samples (B-02, MW-629) were also analyzed for the solvent 1,4-Dioxane, and two samples (MW00-03, MW-628) were analyzed for PFOA/PFOS.

Monitoring wells B-02 and 629 exceeded the ADEC cleanup level of 2.2 mg/L for GRO. B-02 also exceeded the cleanup level of 1.5 mg/L for DRO. TCE was detected in six wells above the cleanup level of 0.0028 mg/L. As in previous years, B-02 had the highest concentration of GRO (9.5 mg/L), DRO (8.9 mg/L) and TCE (0.015 mg/L). 1,4-Dioxane was not detected in any of the samples.

MW00-03 exceeded ADEC groundwater criteria (ADEC, 2016b) for PFOA and PFOS at 0.41 µg/L and 0.56 µg/L, respectively. PFOA and PFOS were also detected in MW-628 but at concentrations below ADEC criteria.

Surface water samples were collected from three locations along Eskimo Creek and analyzed for VOCs. TCE was not detected in any of the samples.

As has been observed in previous years, the combined lines of evidence of stable to decreasing petroleum hydrocarbon plumes and changes in groundwater chemistry strongly support the occurrence of intrinsic bioremediation of the petroleum hydrocarbons at this site. Decreasing TCE concentration trends suggest that intrinsic remediation of this chlorinated compound has occurred and is occurring. Intrinsic remediation of petroleum and chlorinated hydrocarbons is expected to continue in Zone 2.

An institutional control inspection was performed with no observations of IC noncompliance.

GROUNDWATER ZONE 3 – SOUTH BLUFF

Groundwater samples were collected in September from three South Bluff well points and four surface water locations. Low levels of DRO were detected in all of the samples as well as the equipment blank.

Samples were also analyzed for VOCs, pesticides, PCBs, lead, and total organic carbon. All the samples were ND for pesticides and PCBs. TOC ranged from 5.4-9.0 mg/L.

Quarterly samples were collected from the South Bluff Treatment System lift station after the pumps were replaced. The only exceedance was arsenic in the June 2017 sample.

There were no observations of drinking water wells or excavations out of compliance with institutional controls.

GROUNDWATER ZONE 4 – NAKNEK RIVER STORAGE

Samples were collected in September from three A-Aquifer wells, two B-Aquifer wells, and five residential wells. Three surface water/sediment locations were sampled in early October. Product recovery system maintenance and landfill inspections were performed along with an institutional control inspection to verify that no new drinking water wells have been installed in contaminated aquifers.

Product was detected at MW-57 this year and the well was not sampled. Product thickness measured 0.05 ft, which does not warrant removal. GRO was detected above cleanup level in monitoring wells MW-51 and MW-62. DRO was detected above cleanup level in MW-51 and 502.

Low levels of DRO were detected in both B-Aquifer monitoring wells and five residential wells. These results were flagged by the lab as being between the detection limit and the reporting limit. DRO was also detected in the method blank. All detections are well below the RAOs for DRO.

Petroleum hydrocarbon concentrations in surface water decreased as water flowed through the wetlands (sampling location OT30-01 is upgradient of the wetlands and sampling location OT30-03 is downgradient of the wetlands). Neither of these surface water samples exceeded the ADEC Regulatory Criteria of 10 micrograms per liter (µg/L) for total aromatic hydrocarbons (TAH) or 15µg/L for total aqueous hydrocarbons (TAqH). GRO and DRO were detected in both samples. The sediment sample from OT30-01 exceeded the criteria for ethylbenzene, total xylenes, and naphthalene.

As has been observed in previous years, the combined lines of evidence of stable to decreasing hydrocarbon plumes and changes in groundwater chemistry strongly support the occurrence of intrinsic bioremediation in the hydrocarbon-impacted areas of this groundwater system. Intrinsic bioremediation of fuel-impacted groundwater is expected to continue in Zone 4.

For the fourth consecutive year, OT30-04, located at the base of the Naknek River bank below MW-57, has been included in the sampling program. While ADEC has no standards for GRO or DRO in surface water or sediments, surface water at OT30-04 had GRO and DRO levels of 0.72 mg/L and 2.7 mg/L respectively. Sheen was also present. Sediment had GRO and DRO levels of 35 mg/kg and 4,000 mg/kg, respectively. Sampling results from OT30-04 suggest that the DRO plume at MW-57 is having an impact on the river bank at that location. An interim investigation of the POL contamination around MW-57 and the sediment location OT30-04 was conducted in 2014, under a separate contract.

An institutional control inspection verified that no new drinking water wells have been installed in the in contaminated aquifers. The former landfill areas were inspected and the product recovery pillows were replaced.

GROUNDWATER ZONE 5 – RAPCON & RED FOX CREEK

Samples were collected from six A-Aquifer wells, one surface water/sediment location, and a second sediment only location near Red Fox Creek. An institutional control inspection was also performed to confirm that no drinking water wells have been installed or excavating has occurred.

All six of the monitoring wells were sampled for DRO. Four of the groundwater samples had DRO concentrations that exceeded the cleanup level of 1.5 mg/L. Four of the wells were sampled for GRO and three exceeded the cleanup level of 2.2 mg/L. Two wells were analyzed for VOCs; one result exceeded the cleanup level for TCE. Overall, there was an increase over 2015 concentrations of DRO and GRO.

One downgradient well near the runway and FT01-MW01 were sampled for PFOA/PFOS. The results for FT01-MW01 were 3.3 µg/L for PFOA and 11 µg/L for PFOS. These results are both above the ADEC criteria of 0.40 µg/L. The results for downgradient MW83 were 0.005/0.0044 µg/L.

The surface water sample RFC-04 exceeded the ADEC Regulatory Criteria for TAH and TAqH. RFC-04 also had surface water exceedances for m,p-xylene, and o-xylene. TCE was not detected in the surface water. The RFC-04 sediment sample exceeded criteria for fluorene, naphthalene, and xylenes. TCE was not detected. Naphthalene, acetone, and xylene exceeded the screening criteria in the RFC-05 sediment sample, and a low level of TCE was detected

As has been observed in previous years, the combined lines of evidence of stable to decreasing hydrocarbon plumes and changes in groundwater chemistry suggest that intrinsic bioremediation in the hydrocarbon-impacted areas of this groundwater system is occurring. Intrinsic bioremediation of fuel-impacted groundwater is expected to continue in Zone 5.

A land use inspection confirmed no drinking water wells have been installed or excavating has occurred.

GROUNDWATER ZONE 5 – FIRE TRAINING AREA #4 (FT004)

Six wells at FT004 were sampled and analyzed for VOCs, GRO, DRO, PFOA/PFOS, EDB, and MNA perimeters. An additional downgradient well was also sampled for PFOA/PFOS only.

Three of the wells were above cleanup levels for TCE. Three were above cleanup levels for GRO and none for DRO. Four of the wells exceeded cleanup levels for PFOA/PFOS, and two had detections of EDB below cleanup levels. Downgradient monitoring well FT003-120 located 1,650 feet south of FT004 and near the runway was ND for PFOA, and had a concentration of PFOS below cleanup levels. The detection of PFOS demonstrates the migration of PFOS from upgradient sources through groundwater to well FT003-120.

GROUNDWATER ZONE 6 – NAKNEK REC CAMP LANDFILL

Institutional controls listed in the Zone 6 ROD prohibit drinking water wells within 100 feet of the boundaries of the former generator pad and landfill, excavation of soils deeper than five feet bgs in the area of the former generator pad, and excavation or construction in the area of the landfill. On September 23, 2016, the area that was formerly used as a landfill was inspected. The area is overgrown with indigenous vegetation with little evidence of debris. There were no observations of noncompliance of institutional controls at the former landfill or generator pad.

GROUNDWATER ZONE 7 – LAKE CAMP

Groundwater samples were collected from three of the eight previously sampled monitoring wells at Lake Camp and analyzed for DRO and MNA parameters. Monitoring wells GP01 and MW22 exceeded the RAO of 1.5 mg/L for DRO at 4.1 mg/L and 2.2 mg/L, respectively. These results are increases over last year's results.

Institutional controls prohibit the installation of water supply wells as long as the aquifer fails ADEC Table C cleanup levels, and restricts excavating without a proper soil management plan. There were no observations of noncompliance within the site boundaries.

LANDFARM O & M

Approximately 452,000 gallons of water were pumped from the landfarm and filtered into holding ponds. Once samples confirmed that contaminants of concern were below ADEC criteria, the water was discharged from the ponds. One of the last ponds sampled, Pond 6, has PFOA/PFOS above ADEC criteria. The water from this pond will be retreated and retested next year until it meets discharge criteria.

The landfarm was divided into six decision units and sampled at the beginning of September. Decision units 1, 2, 3, and 4 were above the ADEC cleanup level of 250 mg/kg for DRO (770 – 1,200 mg/kg). Decision units 3, 5, and 6 were above the ADEC cleanup level for PFOA and PFOS. Overall, the results for DRO, PFOA, and PFOS have decreased since the 2015 MI sampling.

BIOCELL SAMPLING

Water samples were collected from the north and south biocells in early October, and analyzed for PFOA/PFOS. Both sample results were well above the ADEC cleanup level of 0.4 µg/L. The results from the north biocell were 120/22 µg/L, respectively, and the results from the south biocell were 36/100 µg/L, respectively.

The north and south biocells were MI sampled in August. DRO results for the north biocell ranged from 2,100 - 2,700 mg/kg. The ADEC cleanup level for DRO is 250 mg/kg. PFOA and PFOS were also detected at 52-210 µg/kg and 140-240 µg/kg respectively. The ADEC cleanup levels are 3.0 µg/kg and 1.7 µg/kg.

DRO results for the south biocell were 1,200 mg/kg. The results for PFOA were 740-1,300 µg/kg and 880-1,400 µg/kg for PFOS.

1 INTRODUCTION

King Salmon is located on the Alaska Peninsula adjacent to Bristol Bay and Katmai National Park and Preserve, approximately 280 miles southwest of Anchorage, and 15 miles east of Kvichak Bay (Figure 1-1). King Salmon Divert (KSD) is located adjacent to the community of King Salmon and encompasses approximately 220 acres along the northern bank of the Naknek River, approximately 15 miles upstream from the mouth of the river and the community of Naknek.

Environmental Restoration Program (ERP) sites at KSD have been grouped into seven environmental management zones called groundwater zones (five at KSD and additional zones at the Naknek Recreation Camp I [Rapids Camp – Zone 6] and Naknek Recreation Camp II [Lake Camp – Zone 7]) (Figure 1-2). Each zone is a geographically and hydrogeologically contiguous area that is amenable to investigative and remedial management as a single unit.

1.1 GROUNDWATER ZONE 1 – BASE LIVING AREA

Groundwater Zone 1 coincides with the KSD Base Living Area. Five source areas have potentially contributed to the contamination at Groundwater Zone 1:

- Dry Well Site (DP023).
- Eskimo Creek (SS011).
- POL Tanks (SS015).
- MOGAS Station (SS019).
- Building 649 (Bowling Alley)

Historical spills and operational practices at Zone 1 resulted in contamination of groundwater with petroleum-based products and chlorinated solvents, specifically floating petroleum product (FPP) on the groundwater, diesel range organics (DRO), and volatile organic compounds (VOC), including trichloroethylene (TCE) dissolved in the groundwater. A comprehensive description of 2016 field activities and results are located in Section 2: *Zone 1 - Base Living Area.*

1.2 GROUNDWATER ZONE 2 – BASE INDUSTRIAL AREA

Groundwater Zone 2 coincides with the KSD Base Industrial Area. Four source areas have potentially contributed to the contamination at Groundwater Zone 2:

- Refueler Shop (SS021).
- Old Power Plant (SS020).
- Eskimo Creek Dump (LF022).
- Dry well site at Building 158 (DP-13).

Contaminants of concern (COCs) identified for the Base Industrial Area include benzene, ethylbenzene, toluene, gasoline range organics (GRO), DRO, TCE, and cis-1,2-dichloroethene (DCE) dissolved in the groundwater; TCE and DCE in surface water; and DRO, benzene, ethylbenzene, toluene, and TCE in soil. A comprehensive description of 2016 field activities and results are located in Section 3: *Zone 2 - Base Industrial Area and Eskimo Creek Dump*.

1.3 GROUNDWATER ZONE 3 – NORTH & SOUTH BLUFFS

Groundwater Zone 3 includes the North Bluff (LF014) and South Bluff (LF005) sites located along the eastern bank of King Salmon Creek, approximately one-half to three-quarters of a mile north-northeast of the main runway. The Bluff sites were reportedly used for disposal of debris, 55-gallon drums, metal, and wood from the 1940s through the 1970s. Residual liquids (primarily petroleum) that may have been present in the drums at the time of disposal have been identified as potential sources of contamination. Other potential contaminants include residual paints, paint thinners, solvents, batteries, insecticides, polychlorinated biphenyls (PCBs), and herbicides. A description of 2016 field activities is located in Section 4: *Zone 3 – South Bluffs*.

Groundwater Zone 3 also includes a pump and treat system (the South Bluff Treatment System or SBTS) designed to capture water from a seep near King Salmon Creek, treat it, and then discharge the effluent to a wetland area. An extended period of monitoring showed that any contaminants detected in the water coming out of the seep were below the applicable cleanup level. For this reason, the treatment part of the SBTS was mothballed. Water is still being captured at the seep and discharged to the wetland without treatment. Monitoring of the untreated water was suspended in July, 2013, and resumed in September 2015.

1.4 GROUNDWATER ZONE 4 – NAKNEK RIVER STORAGE

Groundwater Zone 4 refers to the groundwater flow system that underlies the portion of KSD located between King Salmon Creek and Eskimo Creek, approximately 1 mile southwest of the main KSD base area and north of the Naknek River. Included within Zone 4 are:

- Naknek River Storage Sites (SS012U and SS012L).
- Landfill No. 5 (LF008).

The Naknek River Storage Sites were formerly two tank farms containing underground storage tanks (USTs) and aboveground storage tanks (ASTs) used for storage of petroleum, oil, and lubricants (POLs). A pipeline system connected these tanks to the main base. The dates of the landfill operation are unknown, but the wastes reportedly consisted of empty POL drums covered with sand.

Contaminated groundwater at Zone 4 has been observed in three localized plumes. The primary COCs are DRO, GRO, benzene, toluene, and TCE.

A comprehensive description of 2016 field activities and results are located in Section 5: *Zone 4 – Naknek River Storage*.

1.5 GROUNDWATER ZONE 5 – RAPCON/RED FOX CREEK

Groundwater Zone 5 contains the KSD Fire Training Areas and Landfills. Eight source areas have potentially contributed to the contamination in this zone:

- Fire Training Area 1 and RAPCON (FT001).
- Fire Training Area 2 (FT002).
- Fire Training Area 3 (FT003).
- Fire Training Area 4 (FT004).
- Lower Landfill No. 2 (LF002).
- Upper Landfill No. 2 (LF002).
- Landfill No. 3 (LF003).
- Circle Landfill (LF006).

The 2016 long-term monitoring program covers the RAPCON site, a nearby section of Red Fox Creek, and Fire Training Area 4 (FT004). RAPCON is located on the northwest side of Red Fox Creek. A 500-gallon diesel UST once located here was removed in 1994. The COCs for both soil and groundwater at this site are DRO, GRO, benzene, TCE, and toluene. Tetrachloroethylene (PCE) is also a COC in the soil. Surface water and sediment samples have been collected from a drainage ditch that flows by the RAPCON site and into Red Fox Creek to document any impact to Red Fox Creek resulting from groundwater contamination at the RAPCON site. FT004, located approximately 0.5 miles south of RAPCON, was used as a fire training area until 1980. COCs at this site include PFOA and PFOS. A comprehensive description of 2016 field activities and results are located in Section 6: *RAPCON and Red Fox Creek*, and Section 7: *Fire Training Area 4 (FT004).*

1.6 GROUNDWATER ZONE 6 – RAPIDS CAMP

Groundwater Zone 6 (Rapids Camp) is located on the northern bank of the Naknek River, roughly 4 miles southeast of KSD. The camp occupies about 12.5 acres of land and was established in 1952 as part of a USAF program to build facilities for "morale, recreation, and welfare." Included were boat docks, fish camps, lodging, and a fuel storage area. The camp was closed in 1977, and all structures and tanks have been removed. All groundwater contaminant concentrations in the Rapids Camp area were below the appropriate regulatory requirements, and in 2008, eight monitoring wells were decommissioned. The only remaining data needs are satisfied by long-term monitoring of the landfill site.

A comprehensive description of 2016 field activities is located in Section 8: *Zone 6 – Rapids Camp*.

1.7 GROUNDWATER ZONE 7 – LAKE CAMP

Lake Camp occupies approximately 10 acres of land on the west shore of the Naknek River, approximately nine miles east of the KSD main base area. Historically, this area was used as a recreational camp. Included within Zone 7 are:

- Former Vehicle Maintenance Facility (SS004)
- Former Generator Pad (SS005)
- Drum Landfill (LF001)

In 2009, approximately 1,155 cubic yards of POL-contaminated soil were excavated from sites SS004 and SS005, and 75 drums were removed from site LF001. The contaminant of concern (COC) identified for these sites is DRO. A comprehensive description of 2016 field activities and results are located in Section 9: *Zone 7 – Lake Camp.*

1.8 GROUNDWATER HYDROLOGY

At least three aquifer units are known to exist in the King Salmon area. These aquifers consist of unconsolidated, well-sorted to poorly sorted silty and gravelly sands separated by aquitard units consisting of silty sands, silts, and clays.

1.8.1 A-Aquifer

The shallowest aquifer, the A-Aquifer, is unconfined and exposed in many areas within KSD. The total depth to the A-Aquifer ranges from surface at water bodies and wetlands, to 45 feet below ground surface (bgs) along the northern margin of KSD. The saturated thickness ranges from zero to fifteen feet. Groundwater movement is generally toward local topographic lows and surface drainages such as wetlands, rivers, creeks, and ditches, and is most likely recharged by precipitation and influent stream flow. There are several residential drinking water wells screened in the A-Aquifer in the community surrounding KSD.

The A-Aquitard is between seven and twenty-two feet thick and underlies the A-Aquifer. The surface of the aquitard is not horizontal, which may affect local groundwater flow direction and contaminant distribution.

1.8.2 B-Aquifer

Underlying the A-Aquitard, the top of the B-Aquifer has been encountered at depths ranging from 50 to 80 feet bgs. The known thickness of this aquifer ranges from fifteen to forty feet. Numerous residential drinking-water supply wells are screened in the B-Aquifer. Residential areas near the north bank of the Naknek River in Groundwater Zone 4 are down gradient of potential KSD contamination sources.

The B-Aquitard underlies the B-Aquifer. The thickness of the aquitard varies from ten to 120 feet; only two KSD water supply wells are known to have penetrated the B-Aquitard.

1.8.3 C-Aquifer

The C-Aquifer underlies the B-Aquitard at a depth of approximately 200 feet bgs. KSD's water-supply wells are reported to terminate in the C-Aquifer, which is thought to be a confined aquifer. Aquifer thickness and flow direction are unknown for the C-Aquifer.

1.9 SURFACE WATER HYDROLOGY

Surface water is abundant in the King Salmon area and includes numerous fresh-water lakes, streams, and wetland areas.

1.10 SAMPLING PROGRAM

Sampling activities were performed in accordance with the project work plans: 2016 Long Term Monitoring (Paug-Vik, 2016a), the Field Sampling Plan (FSP) (Paug-Vik, 2016b), and the Quality Assurance Project Plan (QAPP) (Paug-Vik, 2016). Any deviations from the work plan are listed in each section.

Samples were sent to TestAmerica Laboratories, Inc., (TestAmerica) in Sacramento, California.

1.10.1 Water-Level Measurements

Prior to sampling, depth to groundwater measurements were completed for all of the groundwater monitoring locations sampled. Depth to water, measurement time, date, and location were recorded on the zone-specific groundwater parameter data sheets provided in Appendix A.

1.10.2 Monitoring Well & Well Point Sample Collection

Monitoring wells were sampled using the methods outlined in Section 2.1 of the FSP. A-Aquifer groundwater monitoring wells and wells points were purged and sampled with a peristaltic pump following low-flow methods. B-Aquifer monitoring wells were purged and sampled using low-flow methods and a Grunfos® pump. Groundwater samples were placed in the appropriately prepared/preserved containers for storage and shipment to the analytical laboratory. Dissolved metal samples were field-filtered using a peristaltic pump and a new in-line 0.45-micron filter.

1.10.3 Surface Water & Sediment Sample Collection

Surface water samples were collected in Zones 3, 4, and 5. Sediment samples were also collected in Zones 4 and 5. Surface water samples were collected with a peristaltic pump and dedicated tubing. Sediment samples were collected using clean scoops and placing sediment into appropriately prepared/preserved sample jars for storage and shipment to the laboratory. Data collected at the sample site was documented on Surface Water/Sediment Sample Data Sheets provided in Appendix A.

1.10.4 Sample Handling

All samples collected during this project were placed into containers prepared by the laboratory that had required chemical preservatives added by the laboratory. Table 1.1 provides a list of sample containers, preservatives, and holding times for each of the analyses required during this project.

An effort was made to maintain samples at a temperature of 4± 2° C at all times using gel ice. Samples were placed into coolers with gel ice as soon as they were collected. At least six frozen gel ice packs accompanied each standard size cooler during shipment to ensure that the coolers arrived at the laboratory within the require temperature range. Proper cooler temperatures were also dependent on flight schedules and potential delays associated with shipping from a remote location to the laboratory in California.

Table 1-1 Recommended Holding Times, Containers, and Preservatives

Parameters	Method	Container	Preservative Soil	Preservative Water	Holding Time	Container Size Soil	Container Size Water
Volatile Organic Compounds (VOCs)	8260B	Glass, TLC (soil) TLS (water)	Methanol Cool, 4°C	HCL No Head Space	7 days no preservation, 14 days w/ preservation	(1)-4 oz. Amber w/ Septa Lid	(3)-40 mL VOAs
Gasoline-Range Organics (GRO)	AK 101	Glass, TLC (soil) TLS (water)	Methanol Cool, 4°C	HCL No Head Space	14 days (water) 28 days (soil)	(1)-4 oz. Amber w/ Septa Lid	(3)-40 mL VOAs
1,4 Dioxane	8270B	Amber Glass, TLC	Cool, 4°C	Cool, 4°C 0.008% $Na_2S_2O_3$	7 days then 40 (water) 14 days then 40 (soil)	(1)-4 oz. Amber	(2)–1 liter Amber
Diesel-Range Organics (DRO) & Residual-Range Organics (RRO)	AK 102/ AK 103	Amber Glass, TLC	Cool, 4°C	HCL to pH < 2 Cool, 4°C	14 days then 40 (water) 14 days then 40 (soil)	(1)-8 oz. Amber	(2)– 125 mL Amber
Polycyclic Aromatic Hydrocarbons (PAH)	8270 SIM	Amber Glass, TLC	Cool, 4°C	Cool, 4°C 0.008% $Na_2S_2O_3$	7 days then 40 (water) 14 days then 40 (soil)	(1)-4 oz Amber	(2)–1 liter Amber
RCRA 8 + Iron Metals	6020/ 7000	Plastic/ Glass	Cool, 4°C	HNO_3, Field-filtered	6 months (water) 6 months (soil)	(1)-4oz Amber	(1)-500 mL Poly
Pesticides & Polychlorina-ted Biphenyls (PCBs)	8081B/ 8082A	Amber Glass, TLC	Cool, 4°C	Cool, 4°C	None, 40 days to analysis of extract (water & soil)	(1)-4oz Amber	(2)–1 liter Amber
Dioxins	8290	Amber Glass, TLC	Cool, 4°C	Cool, 4°C	None, then 40 (water) None, then 40 (soil)	(1)-4oz Amber	(2)–1 liter Amber
1,2-Dibromomethane (EDB)	504.1	Glass TLC	Cool, 4°C	$Na_2S_2O_3$, Cool, 4°C	28 days (soil and water)	(1)-4oz Amber	(3)-40 mL VOAs
PFOA & PFOS	537	HDPE with unlined no Teflon lid	Cool, 4°C	Cool, 4°C	7 days to extraction 30 days to analyze extract (soil and water)	(1)-4oz HDPE	(2)– 125 mL HDPE

TLS – Teflon-lined septa TLC – Teflon-lined cap
7 days then 40 – 7 days until extraction and analysis 40 days after extraction

1.11 INSTITUTIONAL CONTROLS

Institutional controls (ICs) for all seven groundwater zones include the prohibition of unauthorized excavations and the installation of drinking water wells in contaminated aquifers. There was no evidence of any non-compliance with ICs in any of the groundwater zones. In addition, annual land fill inspections are conducted at the North and South Bluffs in Zone 3 and at the former landfills in Zone 4 and Zone 6.

1.12 WASTE HANDLING

Purge water and decontamination liquids were treated using an on-site filtration system as specified in Section 8.2.2 of the FSP. The purge water was filtered through a new drum of granulated activated carbon (GAC). Approximately 130 gallons of purge water/decontamination liquid were generated and treated. Samples of purge water were collected before and after treatment and analyzed for GRO, DRO, PAHs, and VOCs. Results are shown in Table 1-1. Treated purge water was discharged to the sanitary sewer system located in Zone 1 after receiving clean confirmation sample results. Other non-hazardous-type field investigation-derived waste (IDW) was also handled in accordance with procedures specified in the FSP.

Table 1-2 Purge Water Analytical Results Summary

Analyte	Cleanup Level[1] (mg/L)	Before Tx Result September (mg/L)	After Tx Result September (mg/L)
GRO	2.2	0.15	ND
DRO	1.5	0.82	0.03
Benzene	0.0046	ND	ND
Toluene	1.1	ND	0.000091*
Ethylbenzene	0.015	ND	ND
Total Xylenes	0.19	ND	ND
Trichloroethylene	0.0028	0.0019	ND

1. Cleanup level based on ADEC 18 AAC 75 Table C, Groundwater Cleanup Levels (as revised November 7, 2017).
mg/L – Milligrams per liter.
* Toluene in Trip Blank = 0.000089 mg/L
Tx – Treatment using the activated carbon drum.
ND – Not detected.

1.13 ASSESSMENT OF DATA QUALITY

A quality assurance review (QAR) was performed to determine any data problems and evaluate the impact of these problems on the intended uses of the data. This QAR is presented in Appendix D. The QAR discusses the data quality assurance/quality control (QA/QC) procedures and presents the results of the QA/QC analysis. Additionally, Alaska Department of Environmental Conservation (ADEC) Laboratory Data Review Checklists have been completed for each laboratory work order associated with this project and are also located in Appendix D. The laboratory analytical data reports for this project are contained electronically on the DVD-R that accompanies this report.

This analytical program included the collection of project samples, QC samples (duplicates), and trip blanks. The duplicate samples were collected at a minimum frequency of ten percent of the project samples per site. The QA/QC procedures for the project were performed in accordance with the QAPP (Paug-Vik, 2016c).

Overall, QA/QC data associated with the base wide sampling program indicate that measurement data are acceptable and defensible for project use. The overall completeness calculated for this project was 100 percent. Based on the data assessment, some of the analytical results were flagged with qualifiers to indicate potential problems with the qualified results. Data qualifiers are displayed with the analytical results that are provided in Appendix C tables.

1.14 MONITORED NATURAL ATTENUATION

Monitored Natural Attenuation (MNA), also commonly known as intrinsic remediation (volatilization, dispersion, dilution, sorption, and biodegradation), refers to the natural chemical, physical, and biological processes that reduce or eliminate contamination in soil, surface water, or groundwater. Intrinsic remediation results from several subsurface attenuation mechanisms that are either destructive or nondestructive to the contaminant. Destructive attenuation removes contaminant mass from the soil or water. Biodegradation is the most important destructive attenuation mechanism (Wiedemeier, et al., 1999). Nondestructive attenuation mechanisms include sorption, dispersion, dilution, and volatilization.

In bioremediation, microorganisms obtain energy by oxidation of an electron donor and reduction of an electron acceptor. Electron donors are fuel hydrocarbons or other organic carbon compounds; they act as a microbial substrate or food source during microbial reactions. The electron acceptors are elements or compounds that are required to complete the electron transfer reaction (coupled redox reaction). In natural groundwater systems, the electron acceptors (in order of preference based on the energy derived from the redox reaction) consist of oxygen, nitrate, manganese, ferric iron (iron [III]), sulfate, and carbon dioxide. Biodegradation of fuel hydrocarbons is usually limited by electron acceptor availability.

Three lines of evidence can be used to support the occurrence of intrinsic remediation: 1) loss of contaminant mass; 2) changes in geochemical parameters; and 3) direct microbial evidence such as microcosm studies. The intrinsic remediation mechanisms bring about measurable changes in the groundwater chemistry in the affected area. By measuring these geochemical changes at the site, intrinsic remediation can be quantitatively evaluated. In general, geochemical indicators for intrinsic remediation can be broken down into three categories.

- Indicators of biological activity such as dissolved oxygen (DO), nitrate, manganese, ferrous iron, sulfate/sulfide, and methane.
- Indicators, such as alkalinity, temperature, pH, and redox potential, used to evaluate the environmental conditions of an aquifer and determine if they are favorable for biological activity.
- Indicators, such as chloride and conductivity, used to determine whether the sampling locations are all within the same groundwater or hydrogeologic unit.

1.14.1 DO and Redox Potential

DO is the most thermodynamically favored electron acceptor in the biodegradation of organic compounds since microorganisms derive the most energy from the reduction of dissolved oxygen. Under aerobic biodegradation, oxygen is reduced to carbon dioxide and water as the dissolved oxygen is removed from the groundwater. Based on stoichiometric relationships it is generally assumed that 3.1 grams of oxygen are required to biodegrade one gram of benzene, toluene, ethylbenzene, and total xylenes (BTEX) compounds. This relationship varies depending on the molecular structure of the hydrocarbon source. A correlation between depleted DO levels and the continued presence of petroleum hydrocarbon concentrations is a strong indication that aerobic biodegradation of the dissolved hydrocarbons has occurred and continues to occur at the site.

Another parameter closely associated with dissolved oxygen concentrations is the redox potential. The redox potential of a groundwater system depends on which electron acceptor (oxygen, nitrate, iron, sulfate, or carbon dioxide) is being reduced. Relatively large positive redox potentials are often referred to as an aerobic environment, whereas low or negative redox potentials are referred to as an anaerobic environment. Some microbial processes only operate in a prescribed range of redox conditions.

1.14.2 Nitrate

After DO is depleted in the treatment zone, anaerobic biodegradation processes can continue hydrocarbon biodegradation. Usually, anaerobic bacteria cannot function in the presence of more than 0.5 mg/L of dissolved oxygen (Wiedemeier, et al., 1999); however varieties of facultative bacteria are known to function at higher dissolved oxygen levels. Under anaerobic conditions, nitrate is the most desired electron acceptor due to the amount of energy gained from its reduction. The anaerobic biodegradation of nitrate is termed denitrification, and it occurs when nitrate is reduced by bacteria to nitrous oxide or nitrogen gas (Hem, 1986). Based on stoichiometric relationships it is generally assumed that 4.9 grams of nitrate are required to biodegrade one gram of BTEX compounds. This relationship varies depending on the molecular structure of the hydrocarbon source.

1.14.3 Manganese

After nitrate, manganese (Mn^{+4}) is the next most thermodynamically favored electron acceptor for microbial energy metabolism. Manganese is generally available in the aquifer material. When manganese is used as an electron acceptor during the anaerobic biodegradation of fuel contamination, Mn^{+4} is reduced to Mn^{+2}. Increased dissolved manganese concentrations can be used as an indicator of anaerobic biodegradation of fuel hydrocarbons or other organic carbon compounds.

Reduced manganese (Mn^{+2}) is soluble in water in the absence of DO. If groundwater with high reduced manganese concentrations comes into contact with oxygen, the manganese is oxidized and forms a manganese oxide precipitate (black-colored solid) commonly observed in bogs and wetland areas.

1.14.4 Ferrous Iron

After manganese, ferric iron (oxidized form of iron called iron [III]) is the next most thermodynamically favored electron acceptor for microbial energy metabolism. Ferric iron is generally available from the mineral grains in the aquifer material. When iron is used as an electron acceptor during the anaerobic biodegradation of fuel contamination, ferric iron, iron (III) is reduced to ferrous iron, iron (II). Based on stoichiometric relationships it is generally assumed that 21.8 grams of ferrous iron are produced to biodegrade one gram of BTEX compounds. This relationship varies depending on the molecular structure of the hydrocarbon source. Increased ferrous iron concentrations can be used as an indicator of anaerobic biodegradation of fuel hydrocarbons or other organic carbon compounds. Generally, ferrous iron concentrations greater than 1.0 mg/L (depending on background concentrations) can be used as an indicator that anaerobic biodegradation is occurring (Wiedemeier, et al, 1999). Ferrous iron is soluble in water in the absence of dissolved oxygen. If groundwater with high ferrous iron concentrations comes into contact with oxygen, the ferrous iron is oxidized and forms a ferric hydroxide precipitate (rust-colored solid) commonly observed in bogs and wetland areas.

1.14.5 Sulfate/Sulfide

Sulfate-reducing bacteria use sulfate for anaerobic biodegradation of fuel contamination. The sulfate is reduced to sulfide, and the reduction in sulfate concentrations or increase in sulfide concentrations can be used as an indicator of anaerobic degradation of fuel contamination. Sulfate-reducing microorganisms are sensitive to environmental conditions, including temperature, inorganic nutrients, and pH. An imbalance in suitable environmental conditions may severely limit the significance of fuel hydrocarbon degradation via sulfate reduction in many groundwater systems. Based on stoichiometric relationships it is generally assumed that 4.7 grams of sulfate are required to biodegrade one gram of BTEX compounds. This relationship varies depending on the molecular structure of the hydrocarbon source.

1.14.6 Methane

The final anaerobic biodegradation process is methanogenesis (carbon dioxide reduction), also called methane fermentation. Methanogenesis results in the consumption of carbon dioxide and the production of methane. This process generally occurs only after the aforementioned electron acceptors have been depleted and requires strongly anaerobic conditions. Based on stoichiometric relationships it is generally assumed that 0.78 grams of methane are produced to biodegrade one gram of BTEX compounds. This relationship varies depending on the molecular structure of the hydrocarbon source. In the presence of petroleum hydrocarbons, methane in groundwater provides strong evidence that anaerobic microbial degradation of fuel hydrocarbons is occurring through methanogenesis (Wiedemeier, et al., 1999).

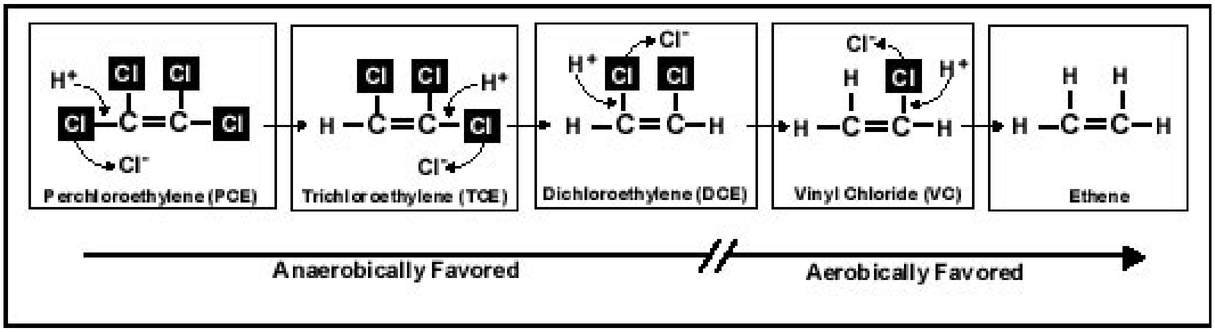
1.14.7 Alkalinity

Alkalinity is a measure of the ability of water to buffer changes in pH caused by the addition of biologically generated acids. Biodegradation of organic compounds produces carbon dioxide which, when mixed with water in the proper conditions, produces carbonic acid. In aquifers that have carbonate minerals as part of the matrix, carbonic acid dissolves the calcium carbonate, thereby increasing the alkalinity of the groundwater. Alkalinity is generally expressed in terms of calcium carbonate ($CaCO_3$).

1.15 EVIDENCE OF REDUCTIVE DECHLORINATION FOR CHLORINATED SOLVENTS

1.15.1 Reductive Dechlorination Process

The most important process for the natural biodegradation of the more highly chlorinated solvents (e.g., PCE and TCE) is reductive dechlorination. During this process, the chlorinated hydrocarbon is used as an electron acceptor, not as a carbon source, and a chlorine atom is removed and replaced with a hydrogen atom. A separate carbon source (e.g., naturally-occurring organic carbon or fuel hydrocarbons) is also required. In general, reductive dechlorination occurs by sequential dechlorination from PCE to TCE to cis-1,2-DCE to vinyl chloride to ethene. The dechlorination sequence is illustrated in the following figure.

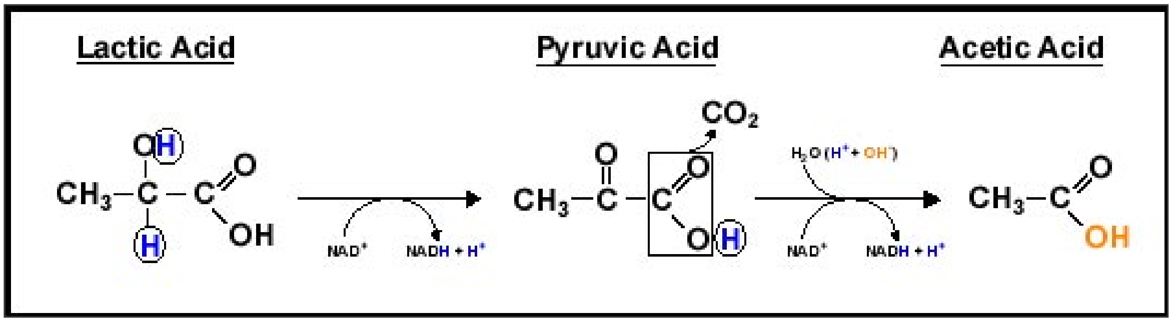


Source: www.regenesis.com/HRCtech/hrctb113.htm

Reductive dechlorination has been demonstrated to occur under nitrate and iron-reducing conditions, but the most rapid rates occur under sulfate-reducing and methanogenic conditions (Wiedemeier, et al., 1998). Because chlorinated hydrocarbons are used as electron acceptors during reductive dechlorination, there must be an appropriate source of carbon for microbial growth in order for this process to occur. Potential carbon sources include natural organic matter, fuel hydrocarbons, or other anthropogenic organic compounds such as those found in landfill leachate.

Bacteria capable of degrading chlorinated aliphatic hydrocarbons require specific geochemical conditions (e.g., near absence of oxygen, availability of free hydrogen ions, and other nutrients). A detailed description of this process follows:

- If the aquifer is aerobic, the total organic carbon (TOC) load provided to the aquifer by fuel hydrocarbons or other organic substrate will provide a food source for resident aerobic bacteria. The bacteria will metabolize the TOC, utilizing most or all of the available oxygen in the process, and drive the aquifer anaerobic.
- Once the aquifer is anaerobic, anaerobic bacteria will mediate the degradation of TOC to lactic acid. The lactic acid also acts as a nutrient source for anaerobic bacteria. As the bacteria metabolize lactic acid, hydrogen ions are released, and the lactic acid degrades to pyruvic acid (primarily). The pyruvic acid degrades to acetic acid; and there is a secondary series of reactions (lactic acid to butyric acid to propionic acid) that also occurs. As shown on the following illustration, most of these reactions release hydrogen ions, which are then available for dechlorination of chlorinated ethenes (such as TCE).
- Multiple studies cited by Koenigsberg and Farone (2000), and others suggest that there is competition between the anaerobic bacteria that degrade chlorinated ethenes (called reductive dehalogenators) and anaerobic bacteria that convert carbon dioxide to methane (called methanogens). It is believed that a relatively low concentration of hydrogen favors the reductive dehalogenators over the methanogens.



Notes: C: Carbon; O: Oxygen; H: Hydrogen; NAD: Nicotinamide Adenine Dinucleotide (a coenzyme occurring in living cells that is utilized alternately as an oxidizing or reducing agent in metabolic processes); NADH: Reduced form of NAD

Source: www.regenesis.com/HRCtech/hrctb113.htm

Changes in groundwater geochemistry, contaminant concentrations, and metabolic acid concentrations provide evidence to indicate how well the reductive dechlorination process is working. The groundwater geochemical data provide a qualitative indicator of the potential success of reductive dechlorination. Table 1-2 provides a list of geochemical parameters and threshold values necessary for reductive dechlorination to occur. A comparison of the groundwater geochemical data between background and fuel hydrocarbon contaminated wells is used to determine whether the fuel hydrocarbon contamination has enhanced the biological conditions for reductive dechlorination by driving the aquifer conditions anaerobic.

Table 1-3 Reductive Dechlorination Parameters of Importance

Parameter	Description	Threshold Level (Wiedemeier et al., 1996)	Significance of Threshold Level
Geochemical Indicators of Natural Attenuation			
pH	pH is a measure of the acidity or alkalinity of the groundwater.	5<pH<9	Optimal range for reductive pathway
Temperature	Groundwater temperature affects the metabolic rate of bacteria. Groundwater temperatures less than 5°C tend to inhibit biodegradation. Biodegradation rates typically double for every 10°C increase in water temperature.	> 20°C	Biochemical process accelerated
DO	Depressed DO levels indicate that the reductive pathway is possible	< 0.5 mg/L	Reductive pathway is not suppressed.
ORP	ORP is an indicator of oxidation potential (aerobic) or reductive potential (anaerobic) of the groundwater system.	< 50 mV < -100 mV	Reductive pathway possible Reductive pathway likely
Nitrate	After DO has been depleted, nitrate may be used as an electron acceptor for anaerobic biodegradation.	< 1 mg/L	At higher concentrations nitrate may compete with reductive pathway
Sulfate	After DO and nitrate have been depleted in the treatment zone, sulfate may be used as an electron acceptor for anaerobic biodegradation (sulfate reduction).	< 20 mg/L	At higher concentrations may compete with reductive pathway
Dissolved iron (ferrous iron)	Ferrous iron (iron II) is produced when ferric iron (iron III) is used as an electron acceptor during anaerobic biodegradation.	>1 mg/L	Indicative that reductive pathway is possible
Methane	The presence of methane in groundwater is indicative of strongly reducing conditions. Methanogenesis generally occurs after the oxygen, nitrate, and sulfate have been depleted in the treatment zone.	> 0.5 mg/L	Indicative that reductive pathway is likely but may also compete with reductive dechlorination process
Ethane, ethene	Produced during reductive dechlorination	> 0.01 mg/L	Indicative that reductive pathway is likely
TOC	Carbon is the energy source that drives reductive dechlorination.	> 20 mg/L	Energy source needed to drive reductive dechlorination
Volatile Organic Acids			
Lactic acid	Nutrient and hydrogen ion source for dechlorinating microbes. Lactic acid is released during anaerobic biodegradation of organic substrate.	Not applicable	Presence indicates anaerobic biodegradation of organic substrate
Pyruvic acid	As lactic acid is metabolized by anaerobic microbes, it is degraded to pyruvic acid.	Not applicable	Presence indicates presence and degradation of lactic acid
Acetic acid	As pyruvic acid is metabolized by microbes, it is degraded to acetic acid.	Not applicable	Presence indicates presence and degradation of pyruvic acid
Butyric acid	In a secondary reaction, lactic acid also degrades to butyric acid and propionic acid.	Not applicable	Presence indicates presence and degradation of lactic acid
Propionic acid	In a secondary reaction, lactic acid also degrades to butyric acid and propionic acid.	Not applicable	Presence indicates presence and degradation of lactic acid
Contaminants/Degradation Products (VOCs)			
PCE	Not present in Zone 1, 2, or 5 groundwater.	Not applicable	

Parameter	Description	Threshold Level (Wiedemeier et al., 1996)	Significance of Threshold Level
TCE	Primary contaminant in Zones 1, 2, and 5 groundwater.	Not applicable	Compare levels among upgradient/ downgradient wells over time
cis-1,2-DCE	TCE daughter product; presence indicates TCE degradation has occurred	Not applicable	Compare levels among upgradient/ downgradient wells over time
trans-1,2-DCE	TCE daughter product; presence indicates TCE degradation has occurred	Not applicable	Compare levels among upgradient/ downgradient wells over time
1,2-DCA	A possible (although uncommon) cis-1,2-DCE daughter product. 1,2-DCA is a less common daughter product than vinyl chloride.	Not applicable	Compare levels among upgradient/ downgradient wells over time
Vinyl chloride	DCE daughter product; presence indicates DCE degradation has occurred	Not applicable	Compare levels among upgradient/ downgradient wells over time

1.15.2 Oxidation (Mineralization) of DCE

Although reductive dechlorination is the primary mechanism for biodegradation of TCE, the less chlorinated daughter products DCE and vinyl chloride (VC) can degrade either by reductive dechlorination or by oxidation processes. In oxidation processes, the DCE and VC are mineralized directly to carbon dioxide. The primary biodegradation mechanism is dependent upon site geochemistry and microbiology.

1.15.3 Cometabolic Biodegradation of TCE

Although reductive dechlorination is the primary mechanism for biodegradation of TCE under anaerobic conditions, other aerobic biodegradation pathways are also known to exist. Cometabolic aerobic biodegradation of TCE has been demonstrated using two bacterial strains: toluene degraders and methanotrophs (methane oxidizing bacterium).

1.16 FIELD-MEASURED PARAMETERS

During groundwater purging activities or while collecting surface water samples, water-quality parameters were measured to determine groundwater and surface water consistency and characteristics relevant to assessing intrinsic remediation. These field parameters included pH, temperature, conductivity (total dissolved solids), dissolved oxygen, and oxidation-reduction (redox) potential. Qualitative field measurements of color and turbidity were also recorded during the purging and sampling process for each groundwater and surface water-sampling site. Field measurement results can be found on the sample data sheets in Appendix A.

pH: Groundwater pH is an environmental indicator that has an effect on the presence and activity of microbial populations. This is especially true for pH-sensitive methanogens. Bacteria capable of degrading petroleum hydrocarbons prefer pH values between 6 and 8 standard units.

Temperature: Groundwater temperature directly affects the solubility of oxygen in water and the metabolic activity rate of bacteria. Oxygen is more soluble at colder temperatures. Temperatures less than 4.4 degrees Celsius (˚C) (40 degrees Fahrenheit [˚F]) tend to inhibit the rate of biodegradation, and the biodegradation rate typically doubles for every 10˚C increase in water temperature.

Conductivity: Conductivity can be reported as total dissolved solids (TDS), which is a general water quality indicator. Elevated TDS levels can be associated with groundwater contamination.

DO: DO is used as an indicator for aerobic biodegradation of dissolved hydrocarbons. Depleted or low DO levels are evidence of aerobic biodegradation.

Redox Potential: Redox potential, also known as reduction potential, is the tendency of a chemical species to acquire electrons and thereby be reduced. Relatively large positive redox potentials are indicators of an aerobic environment, whereas negative redox potentials are of an anaerobic environment.

1.17 PROUCL TREND ANALYSIS

The statistical software ProUCL Version 5.0.00 was used to assess concentration trends in Zones 1, 2, 4, and 5. ProUCL 5.1 is a comprehensive statistical software package for analysis of environmental data sets with and without nondetect (ND) observations.

ProUCL uses the Mann-Kendall test to evaluate concentration trends. The Mann-Kendall Statistic (also referred to as an “S” statistic) is a measure of trend: a large positive S statistic indicates a strong increasing trend and a large negative S statistic indicates a strong decreasing trend. A trend is significant if, at a given confidence level and number of observations (generally four), the absolute value of the S statistic exceeds a minimum threshold. Output from the ProUCL analysis is provided in Appendix E.

Mann-Kendall Trend Tables specific to Zones 1, 2, 4, 5, and 7 summarize the concentration trends observed in key monitoring wells with historical concentrations of contaminants near or above RAOs. The tables list the numbers of wells exhibiting a specific concentration trend for each analyte. For wells that are depicted as having *No Trend*, there is insufficient evidence to identify a significant trend at the specified level of significance. Well location data sets, which did not have the minimum number of four observations, or where the results were all below the detection limit for a specific analyte, are not included in the trend summary table.

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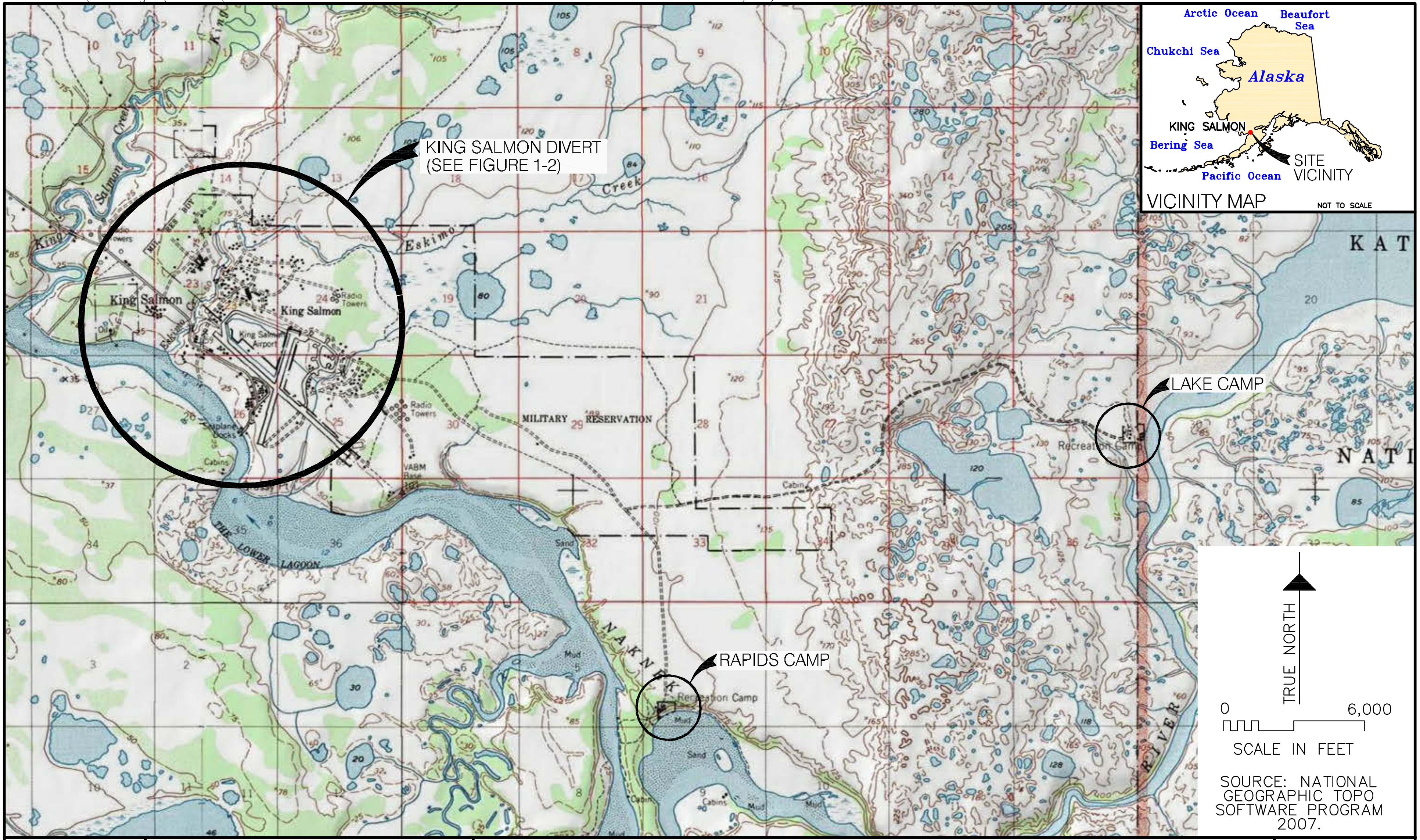

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PACIFIC AIR FORCES REGIONAL SUPPORT CENTER
& AIR FORCE CIVIL ENGINEERING CENTER
JBER, ALASKA

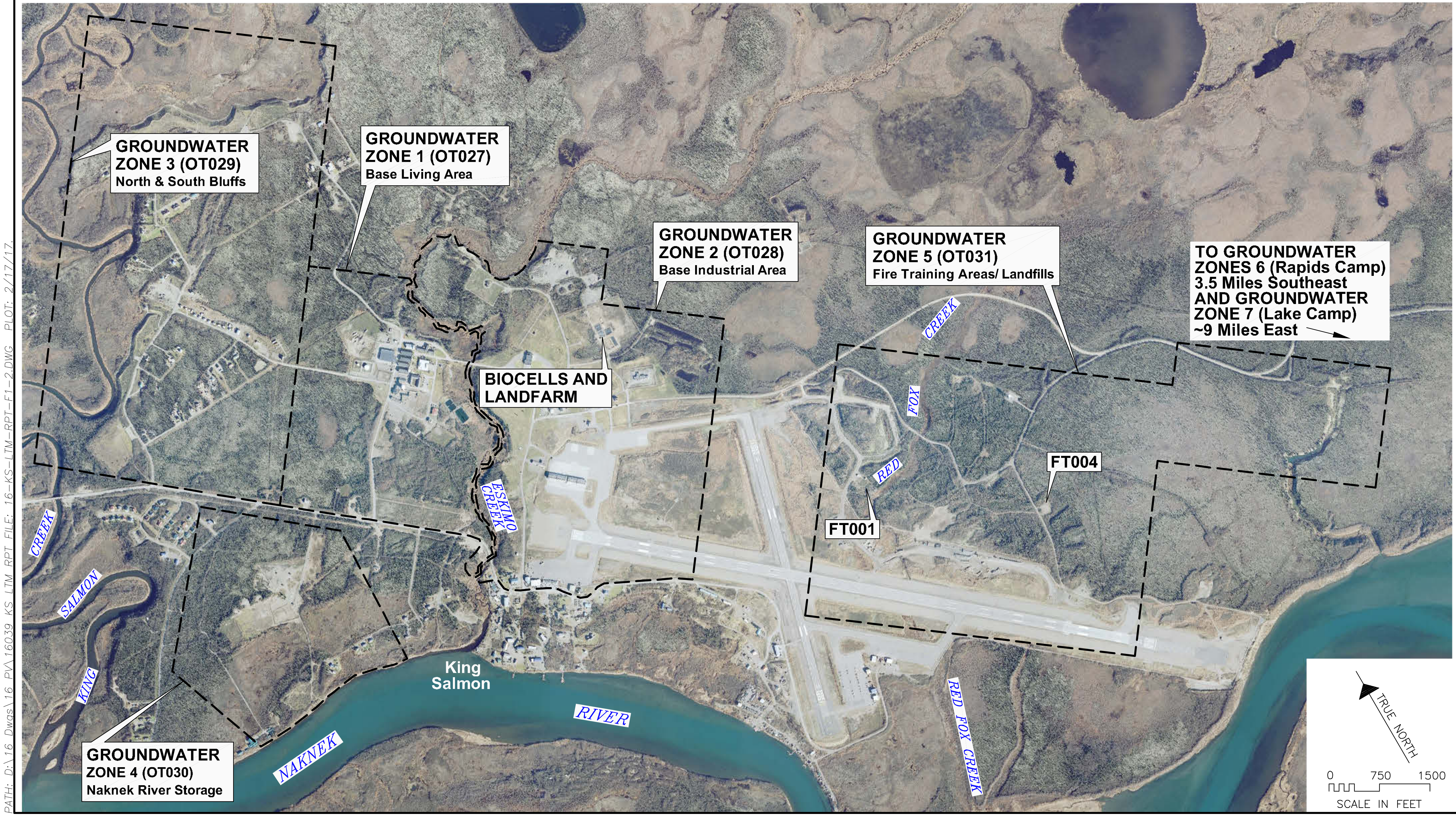
SITE LOCATION MAP

2016 LONG TERM MANAGEMENT
King Salmon Divert, Alaska

FIGURE
1-1

EXPLANATION

GROUNDWATER ZONE BOUNDARIES



GROUNDWATER MONITORING ZONES

2016 LONG TERM MANAGEMENT
King Salmon Divert, Alaska

FIGURE
1-2

PACIFIC AIR FORCES REGIONAL SUPPORT CENTER
& AIR FORCE CIVIL ENGINEERING CENTER
JBER, ALASKA

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2 ZONE 1 - BASE LIVING AREA

Historical spills and operational practices resulted in contamination of groundwater with petroleum-based products and chlorinated solvents, specifically petroleum product floating on the groundwater, and DRO and VOCs including TCE dissolved in the groundwater. Except as otherwise indicated in this report, this monitoring program was designed in accordance with the *Record of Decision for Interim Remedial Action at King Salmon Air Station, King Salmon Alaska, Installation Restoration Program, Groundwater Zone OT027* (ROD; United States Air Force [USAF], 2000).

2.1 REMEDIAL ACTION OBJECTIVES FOR ZONE 1

RAOs are specific cleanup levels and related requirements to be met in Zone 1. Final RAOs for Zone 1 COCs (e.g., FPP, TCE, and TCE's degradation products) were established in the interim ROD. However, until the ROD is finalized, the RAOs for Zone 1 are the ADEC groundwater cleanup levels listed in 18 AAC 75.345 Table C, and are displayed on Table 2-1 (ADEC, 2016). Preliminary RAOs for other COPCs not addressed in the interim ROD (e.g., BTEX, DRO, GRO, and polynuclear aromatic hydrocarbons [PAHs]) are presented in Table 2-2.

In addition to the regulation-based cleanup levels, action levels were defined for TCE and its degradation products to guide remedial efforts. Action levels are the more stringent standards of ecological surface water quality screening criteria or Alaska Water Quality Standards. If TCE groundwater concentrations at the designated points of compliance (i.e., the Seep No. 2 sentry wells adjacent to Eskimo Creek: RPO-1 (POC-1), RPO-2 (POC-2), RPO-3 (POC-3), GP-1, GP-2, WP03-11) consistently exceed the site action levels, remedial actions other than MNA will be implemented. RPO-1, GP-1A, and WP03-11 were the only Seep No. 2 sentry wells included in the 2016 sampling program.

Table 2-1 Groundwater Zone 1 RAOs

Media	Contaminants of Concern	Maximum Conc.	Maximum Conc. Location (Date)	Maximum Conc. 1997/98/99 data	ARARs				FINAL RAOs	
					Ecological Criteria	Basis	Human Health/ADEC Criteria	Basis	Action Level at POC*	Cleanup Level
Floating Petroleum Product	--	--	--	--	—	—	No FPP	18AAC75	NA	No FPP
Groundwater (mg/L) (A- Aquifer)	TCE	7.4	MW-28 (1994)	1.65 (MW-28)	NE	NE	0.0028	18AAC75	0.0027	0.0028
	cis-1,2-DCE	0.0011	MW-402 (1993)	0.0032 (MW-27)	NE	NE	0.036	18AAC75	0.036	0.036
	trans-1,2-DCE	ND	ND	ND	NE	NE	0.36	18AAC75	0.1	0.36
	1,1-DCE	ND	ND	ND	NE	NE	0.028	18AAC75	3.3E-05	0.0 028
	Vinyl Chloride	ND	ND	ND	NE	NE	0.00019	18AAC75	0.002	0.00019
Groundwater (mg/L) (B-Aquifer)	TCE	0.099	MW-41 (1992)	0.041 (MW-41)	NE	NE	0.0028	18AAC75	NA	0.0028
	cis-1,2-DCE	ND	ND	ND	NE	NE	0.036	18AAC75	NA	0.036
	trans-1,2-DCE	ND	ND	ND	NE	NE	0.1	18AAC75	NA	0.1
	1,1-DCE	ND	ND	ND	NE	NE	0.028	18AAC75	NA	0.028
	Vinyl Chloride	ND	ND	ND	NE	NE	0.00019	18AAC75	NA	0.00019
Surface Water (mg/L)	TCE	0.0153	SW-1 (1997)[a]	0.0153	0.35	Ecotox	0.0027[b]	18AAC70	--	0.0027
	cis-1,2-DCE	ND	ND	ND	0.59	ORNL PRGs	0.07	18AAC70	--	0.07
	trans-1,2-DCE	ND	ND	ND	0.59	ORNL PRGs	0.1	18AAC70	--	0.1
	1,1-DCE	ND	ND	ND	0.025	ORNL PRGs	3.3E-05[b]	18AAC70	--	3.3E-05
	Vinyl Chloride	ND	ND	ND	0.782	ORNL PRGs	0.002[b]	18AAC70	--	0.002
Sediment (mg/Kg)	TCE	0.0018	SWF-15 (1999)	0.0018	0.041[c]	NOAA SQuiRTs	—	—	--	0.04
	cis-1,2-DCE	0.2	SS011-37 (1996)	NA	0.4[b]	SQB	—	—	--	0.4
	trans-1,2-DCE	ND	ND	NA	0.4[b]	SQB	—	—	--	0.4
	1,1-DCE	ND	ND	NA	0.031[b]	SQB	—	—	--	0.031
	Vinyl Chloride	ND	ND	NA	—	—	—	—	--	—

*** The points of compliance are the sentry wells established at the groundwater/surface water interface adjacent to Eskimo Creek. Action levels in these wells are the ecological surface water quality criteria.**

[a] TCE exceeded the RAO in one of six surface water samples collected from Eskimo Creek (SW-1, downgradient of Seep No. 2) during 1996 and 1997. There were no exceedance in 1999 surface water samples collected from Eskimo Creek.

[b] Based on the consumption of water and organisms, and 10^{-6} carcinogenic risk.

[c] Apparent Effects Threshold level for exposure of Neanthes bioassays to TCE in marine sediments (adverse effects to Neanthes bioassays would be expected when exposed to this level of TCE). Freshwater values are not available.

[d] Sediment quality benchmark (SQB) presented by Jones et al, 1997; values normalized to 1% total organic carbon.

Definitions

18 AAC 75 Oil and Hazardous Substances Pollution Control Regulations (ADEC, 2017)
18 AAC 70 Alaska Water Quality Standards (ADEC, 2017a)
Ecotox – USEPA Tier II Water Quality Criteria for freshwater (USEPA, 1996)
ORNL PRG – Oak Ridge National Laboratory Preliminary Remediation Goals for Ecological Receptors (Jones et al., 1997)
NOAA SQuiRTs – National Oceanic and Atmospheric Administration Screening Quick Ref. Tables (Buchman, 1999)
POC – Point of Compliance
SQB – ORNL Sediment Quality Benchmark (Jones et al, 1997)
TCE – Trichloroethylene
DCE – Dichloroethene
ARAR – Applicable or Relevant and Appropriate Requirements
— No criteria available
FPP – Floating Petroleum Product
ND – Not detected
NE – Not evaluated
NA – Not analyzed
mg/L – milligrams per liter
mg/Kg – milligrams per kilogram

Table 2-2 Preliminary RAOs for other Groundwater Zone 1 COPCs (not included in Interim ROD)

Contaminants of Concern	A-Aquifer Groundwater (mg/L)		Surface Water (mg/L)		Sediments (mg/Kg)	
	Criteria	**Basis**	**Criteria**	**Basis**	**Criteria** (Freshwater Sediment)	**Basis**
Benzene	0.0046	18AAC75	0.005	18AAC70	0.057	OSWER
Ethylbenzene	0.015	18AAC75	0.0073	ORNL SW	0.089	SQB
Toluene	1.1	18AAC75	0.0098	ORNL SW	0.05	SQB
Xylenes	0.19	18AAC75	0.013	ORNL SW	0.025	OSWER
Benzo(a)pyrene	0.000034	18AAC75	0.000014	ORNL SW	0.0324	SQuiRTs
Benzo(a)anthracene	0.00012	18AAC75	0.000027	ORNL SW	0.01572	SQuiRTs
Benzo(b)fluoranthene	0.00034	18AAC75	0.0012	18AAC70	1.8[b]	SQuiRTs
Benzo(k)fluoranthene	0.00080	18AAC75	0.012	18AAC70	0.0272	SQuiRTs
Dibenzo(a,h)anthracene	0.000034	18AAC75	0.00012	18AAC70	0.01	SQuiRTs
Indeno(1,2,3-cd)pyrene	0.00019	18AAC75	0.0012	18AAC70	0.0173	SQuiRTs
Naphthalene	0.0017	18AAC75	0.012	18AAC70	0.01465	SQuiRTs
GRO	2.2	18AAC75	No Sheen	18AAC70	NA	
DRO	1.5	18AAC75	No sheen	18AAC70	NA	
TAH	NA		0.01	18AAC70	NA	
TAqH	NA		0.015	18AAC70	NA	

[a] Freshwater sediment criteria does not exist for Benzo(b)fluoranthene, so marine sediment criteria is used.

<u>Definitions</u>

18 AAC 75 Oil and Hazardous Substances Pollution Control Regulations (ADEC, 2017)
18 AAC 70 Alaska Water Quality Standards (ADEC, 2017a)
SQB – Sediment Quality Benchmark from Oak Ridge National Laboratory (ORNL) *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment Associated Biota: 1997 Revision*
SQuiRT – NOAA Screening Quick Reference Tables
ORNL SW – *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Aquatic Biota: 1996 Revision*
OSWER – EPA Office of Solid Waste and Emergency Response Sediment Screening Benchmarks
NA – No criteria available
mg/L – milligrams per liter **mg/Kg – milligrams per kilogram**

2.2 PROJECT TASKS

2.2.1 Groundwater Sampling Program

Ten A-Aquifer groundwater samples and three B-Aquifer groundwater samples were collected. Data collected from each monitoring well/well point were documented on the Zone 1 Groundwater Sample Data Sheets provided Appendix A. Table 2-3: *Groundwater Zone 1 Sample Analysis Summary* includes a complete list of groundwater sample locations and analytical methods.

2.2.2 Institutional Control Inspection

Groundwater use restriction is part of the selected remedy. Only water from the C-Aquifer, the current source of water for KSD, will be used for drinking. Drinking water wells will not be installed in the A and B Aquifers until RAOs are met.

A visual inspection was performed to verify that no water wells have been installed in the A or B Aquifers.

2.2.3 Product Monitoring at Seeps 1 & 2

Approximately 0.25 liter of product was recovered from product probe PR-11 located at Seep No. 1 in June 2016. PR-11, -12, -13, -14, and -15 at Seep No. 1 had measurable amounts of product, but not enough to remove. Product is removed only from seeps with a product layer more than 0.3 ft.

2.2.4 Work Plan Deviations

There were no deviations from the work plan.

Table 2-3: Groundwater Zone 1 Sample Analyses Summary

			Analytical Methods															
A-Aquifer Wells Location ID	Matrix	Location Type	EPA Method 8260B VOCs	Alaska Method AK101/GRO	1,4-Dioxane 8270B	Alaska Method AK102/DRO	EPA Method 2320B Alkalinity	EPA Method 9056 Chloride + Sulfate	EPA Method 353.2 Nitrate + Nitrite	EPA Method RSK-175 Methane	EPA Method 6020/ Dissolved Fe and Manganese	8081A Pesticides	8082 PCBs	EPA Method 504.1 EDB	9060 Total Organic Carbon	EPA Method 8270 PAHs	537 PFCs	Sample ID
RPO-1	Groundwater	Well Point	1			1	1	1		1	1							16KS1ZMWRPO1-110WG
WP03-09	Groundwater	Well Point	1			1	1	1		1	1							16KS1ZWP0309-111WG
WP03-11	Groundwater	Well Point	1			1	1	1		1	1							16KS1ZWP0311-112WG
GP-1A	Groundwater	Well Point	1			1	1	1		1	1							16KS1ZMWGP1A-113WG
ETMW-2	Groundwater	Monitoring Well	1			1	1	1		1	1							16KS1ZETMW2-114WG
MW-9	Groundwater	Monitoring Well	1			1	1	1		1	1							16KS1ZMW9-115WG
MW89-1	Groundwater	Monitoring Well	1			1	1	1		1	1							16KS1ZMW891-116WG
MW-6	Groundwater	Monitoring Well	1		1	1	1	1		1	1							16KS1ZMW06-117WG
MW-23	Groundwater	Monitoring Well	1		1	1	1	1		1	1							16KS1ZMW23-118WG
MW-28	Groundwater	Monitoring Well	1		1	1	1	1		1	1							16KS1ZMW28-119WG
Duplicate Sample	Groundwater	Monitoring Well	1		1	1	1	1		1	1							16KS1ZMW99-120WG
MS/MSD	Groundwater	Monitoring Well	2		2	2	2	2		2	2							16KS1ZMW28-119WG
Equipment Blank	Water	QA/QC-Peri Pump		1	1	1	1	1	1	1	1	1	1	1	1	1	1	16KS1ZEBMMDD
Trip Blanks	Water	QA/QC	4															16KS1ZTB-MMDD
A-Aquifer Sample Totals			17	1	7	14	14	14	1	14	14	1	1	1	1	1	1	
B-Aquifer Wells Location ID	Matrix	Location Type	EPA Method 524.2/VOCs	Alaska Method AK101/GRO	1,4-Dioxane 8270	Alaska Method AK102/DRO	EPA Method 2320B Alkalinity	EPA Method 9056 Chloride + Sulfate	EPA Method 353.2 Nitrate + Nitrite	EPA Method RSK-175 Methane	EPA Method 6020/ Dissolved Fe and Manganese	8081A Pesticides	8082 PCBs	EPA Method 504.1 EDB	9060 Total Organic Carbon	EPA Method 8270 PAHs	537 PFCs	
MW-41	Groundwater	Monitoring Well	1		1	1												16KS1ZMW41-201WG
MW-13-13B	Groundwater	Monitoring Well	1		1	1												16KS1ZMW1313B-202WG
MW-13-09B	Groundwater	Monitoring Well	1		1	1												16KS1ZMW1309B-203WG
Duplicate Sample	Groundwater	Monitoring Well	1		1	1												16KS1ZMW44-204WG
MS/MSD	Groundwater	Monitoring Well	2		2	2												16KS1ZMW41-201WG
Purge Water Inf	Groundwater	GAC Pre-treatment	1	1		1										1		16KS1ZPURGEINFMMDD
Purge Water Eff	Groundwater	GAC Post treatment	1	1		1										1		16KS1ZPURGEEFFMMDD
Equipment Blank	Water	QA/QC-Grundfos	1	1	1	1												16KS1ZEBMMDD
Equipment Blank	Water	QA/QC-Peri Pump	1															16KS1ZEBMMDD
Trip Blanks	Water	QA/QC	2	1														16KS1ZTB-MMDD
B-Aquifer Sample Totals			12	4	7	9	0	0	0	0	0	0	0	0	0	2	0	

2.3 ZONE 1 FINDINGS

Historical and current analytical data for A- and B-Aquifer results are shown on Tables 2-4, 2-7, and 2-8. Figure 2-1 shows DRO and TCE analytical results for the 2016 Zone 1 sampling. Results for MNA parameters are depicted on Figure 2-2 and Table 2-4. Sampling for BTEX constituents was continued in 2016 since the analysis includes TCE. However, the BTEX results are no longer reported since they have never exceeded the RAOs for Zone 1 A-Aquifer.

Field measurements can be found on the Zone 1 Sample Data Sheets in Appendix A. Complete analytical results are provided in Appendix C, Zone 1 Tables. Photographs of field activities are located in Appendix F.

2.3.1 A-Aquifer Analytical Results

2.3.1.1 DRO

Results from six of the ten A-Aquifer monitoring wells/well points sampled were above the ADEC cleanup level of 1.5 mg/L for DRO. DRO concentrations ranged from 0.12 to 7.3 mg/L. On average, these results are slightly higher than last year's results.

2.3.1.2 TCE

Five of the six A-Aquifer monitoring wells had detectable TCE concentrations above the ADEC cleanup level of 0.0028 mg/L. Results for the six monitoring wells ranged from ND to 0.11 mg/L. Two of the four POC well points sampled exceeded the action level of 0.0027 mg/L for TCE. Results from the four well points ranged from ND to 0.0034 mg/L.

2.3.1.3 1,4-Dioxane

Three of the A-Aquifer well samples were analyzed for the solvent 1,4-Dioxane. All results were ND.

2.3.1.4 1,2,4-Trimethylbenzene

The result from one of the ten A-Aquifer monitoring wells/well points sampled was above the ADEC cleanup level of 15 µg/L for 1,2,4-Trimethylbenzene. Concentrations from all wells/well points were below the detection limit, except for ETMW-2 and MW-9. Their concentrations were 0.56 µg/L and 130 µg/L, respectively.

2.3.1.5 Naphthalene

The result from one of the ten A-Aquifer monitoring wells/well points sampled (MW-9) was above the ADEC cleanup level of 1.7 µg/L for naphthalene. Concentrations from all wells/well points were below the detection limit, except for ETMW-2 and MW-9. Their concentrations were 0.98 µg/L and 280 µg/L, respectively.

2.3.1.6 Inorganics

Several inorganic analyses were performed to provide some analysis on whether natural attenuation of petroleum hydrocarbons is taking place in Zone 1. Please see Section 1.11 for an explanation of the methods used to evaluate natural attenuation.

Table 2-4 presents the results of natural attenuation parameter analyses for Zone 1. Also presented are field measurements of DO, oxidation reduction potential (ORP, also known as redox potential), and pH.

- DO measurements in six of the wells with DRO contamination were below 1.0 mg/L. Three of the wells with lower DRO concentrations had higher DO measurements. Depressed DO at wells containing levels of DRO above the RAO suggests that biodegradation occurring at this site.
- Ferrous iron concentrations ranged from ND in MW-6 and MW-23, to 100 mg/L in GP-1A. All of the samples with high concentrations of DRO, excluding MW89-1, had iron concentrations greater than 1.0 mg/L which can be used to indicate that aerobic biodegradation is occurring.
- Manganese concentrations ranged from 1.5 to 35 mg/L in wells with higher DRO results. Manganese concentrations ranged between ND to 2.1 mg/L in wells with DRO results below RAOs. In the past, wells with higher concentrations of DRO had a general tendency for higher levels of manganese. This correlation is somewhat apparent with the current sampling results.
- Methane concentrations in wells with DRO were 1.1 mg/L to 6.2 mg/L. In four wells with low DRO results, methane concentrations were ND to 1.9 mg/L. The presence of methane is evidence that intrinsic bioremediation of the fuel hydrocarbons is occurring.
- Alkalinity measurements ranged from 110 to 140 mg/L in wells with lower DRO concentrations, and 190 to 370 in wells with DRO concentrations above the RAO. Generally, elevated petroleum hydrocarbon levels correlated with increased alkalinity concentrations.

Table 2-4: Summary of Zone 1 A-Aquifer Analytical Data

Well Number	DRO (mg/L	TCE (mg/L)	Chloride (mg/L)	Alkalinity (mg/L)	Ferrous Iron (mg/L)	Manga-nese (mg/L)	Methane (mg/L)	DO (mg/L)	ORP (mV)	pH
RAO	**1.5**	**0.0027*/ 0.0028**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
RPO-1*	**2.7**	**0.0029**	3.7	290	11	7.6	6.2	0.66	16.5	6.34
GP-1A*	**3.3**	ND	3.3	310	100	12.0	4.2	1.2	-97.9	6.7
WP03-09*	**3.2**	ND	2.1	190	130	3.9	5.9	0.74	-33.2	6.39
WP03-11*	**2.5**	**0.0034**	3.3	300	3.1	35.0	1.6	0.67	23.9	6.36
ETMW-02	1.0	**0.087**	2.9	140	0.029	2.1	1.9	0.7	169.4	6.06
MW-9	**7.3**	ND	5.3	200	7.9	7.4	3.7	0.98	92.3	6.43
MW89-1	**3.4**	**0.0037**	19	370	0.82	1.5	1.1	0.74	119.8	5.97
MW-6	0.096	**0.024**	4.6	110	ND	0.0032	ND	4.13	301.7	6.02
MW-23	0.24/0.27	**0.019**	2.2	110	ND	ND	ND	8.48	321.1	5.62
MW-28	0.12	**0.11**	2.6	120	0.66	0.011	0.28	4.17	259.3	5.73

* TCE Action Level at POC Well Points
NS - Not Sampled/Analyzed
NA - Not Applicable
ND - Not detected above method reporting level (MRL)
RAO - Remedial action objectives
Analytical results exceeding RAOs shown in **BOLD.**

2.3.2 B-Aquifer Analytical Results

2.3.2.1 DRO

DRO was detected in all three B-aquifer wells in concentrations ranging from 0.13 mg/L to 1.1 mg/L (MW-41). All results are below the groundwater cleanup level of 1.5 mg/L.

2.3.2.2 TCE

TCE was detected in MW-41 at a concentration of 0.072 mg/L, and in MW13-09B at 0.048 mg/L. These results are above the 0.0028 mg/L cleanup level. MW-41 has had TCE concentrations from the previous twelve sampling events ranging between 0.031 mg/L and 0.094 mg/L. TCE was ND in MW13-13B.

2.3.2.3 1,4-Dioxane

1,4-Dioxane was not detected in the sampled B-Aquifer wells.

2.3.2.4 Chloroform

Two of the three B-Aquifer monitoring wells had detectable chloroform concentrations above the ADEC cleanup level of 2.2 µg/L. Results for the three wells ranged from ND to 6.7 µg/L.

2.3.2.5 Naphthalene

The result from one of the three B-Aquifer wells sampled was above the ADEC cleanup level of 1.7 µg/L for naphthalene. The concentration from one of the wells was below the detection limit. The other two wells had concentrations of 0.70 and 14 µg/L.

2.3.3 DRO and TCE Concentration Trends

The statistical software ProUCL, Version 5.1 was used to assess DRO and TCE concentration trends for seven Zone 1 monitoring wells. Output from the ProUCL evaluation can be found in Appendix E. Table 2.5 and Table 2.6 summarize the concentration trends observed in the seven monitoring wells with historical concentrations of contaminants near or above RAOs. The tables list the numbers of wells exhibiting a specific concentration trend for each analyte. Well location data sets, which did not have the minimum number of four observations, or where the results were all below the reporting limit for a specific analyte, are not included in the trend summary table. Note that 36% of the concentration trends were decreasing, 7% were increasing, and 57% had no trend. Please note that one half the method detection limit for ND values was used, thus making it difficult to assess trends at or near the detection limit. Overall, since the majority of concentration trends are stable or decreasing, the trend analysis supports the conclusion that intrinsic remediation is keeping contaminant concentrations stable or decreasing at this site.

Table 2-5 Zone 1 MANN-Kendall Analysis Summary

Trend	DRO	TCE	% of Total
Decreasing	1	4	36%
Increasing	0	1	7%
No Trend	6	2	57%
Totals	7	7	14

Table 2-6 Zone 1 MANN-Kendall Trend Summary

Well	DRO	TCE
MW-41	NT	**I**
GP1A	NT	NT
MW89-1	**D**	**D**
MW-9	NT	**D**
EKMW-2	NT	NT
WP0309	NT	**D**
WP0311	NT	**D**

D- Decreasing I - Increasing
NT – No trend

2.4 ZONE 1 CONCLUSIONS

2.4.1 A-Aquifer Monitoring

Four well points and two monitoring wells exceeded the cleanup level of 1.5 mg/L for DRO. TCE was detected above the action level of 0.0027 mg/L in two of the point of compliance (POC) well points. TCE was also detected in five monitoring wells above the RAO. 1,4-Dioxane was ND in the three monitoring wells sampled for this solvent. Monitoring well MW-9 exceeded the ADEC cleanup level for 1,2,4-trimethylbenzene and naphthalene. Inorganic parameters measured in Zone 1 groundwater provide some evidence that natural attenuation of petroleum hydrocarbons is occurring in the A-Aquifer. The Mann-Kendall statistics analysis of groundwater contaminants revealed that 36% of concentration trends are decreasing at this site, while 57% indicate no trend. Since the majority of concentration trends are decreasing or stable, this analysis provides more evidence that intrinsic remediation is attenuating contaminants, or at least keeping contaminant concentrations in check.

2.4.2 B-Aquifer Monitoring

All DRO detections in the Zone 1 B-Aquifer monitoring wells were below RAOs. 1,4-Dioxane was not detected in any of the B-Aquifer wells sampled. MW-41 and MW13-09B exceeded the RAO of 0.0028 mg/L for TCE. MW-41 is at the center of an ongoing RI/FS for TCE contamination in GWZ 1, under a separate contract. MW-41 and MW13-09B exceeded the ADEC cleanup level of 2.2 µg/L for chloroform.

2.4.3 Product Recovery

Product probe PR-11 located in Seep 1 was the only probe with more than the requisite 0.3 ft of product present for recovery. Approximately 0.25 liter of product was removed in June 2016.

2.4.4 Institutional Control Inspection

There were no observations of drinking water wells present, or being installed in the A-Aquifer or the B-Aquifer.

2.4.5 Condition of Wells

All wells scheduled for Zone 1 were sampled. However, one well and one well point had extremely slow recharge rates:

- MW-6 had a recharge rate of 1.5 liters per hour. Sample containers were filled over the course of several hours or the next day.

- GP-1A (well point) had a slow recharge rate. The peri-pump was set at the lowest setting, but the drawdown still exceeded the 0.3 ft limit.

2.5 ZONE 1 RECOMMENDATIONS

- Monitoring should continue without any changes.

- Because 1,4-Dioxane was not detected in the three A-Aquifer monitoring wells and the in the B-Aquifer monitoring wells sampled for this year or in 2015, sampling of 1,4-Dioxane is no longer required.

Table 2-7: Zone 1 Historical Analytical Data (2000-2016)

Well	Analyte (mg/L)	RAOs (mg/L)	2002	2004	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
POC-1 (RPO-1)	DRO	1.5			**1.7**	**1.5**	1.3	0.80	NS	1.3	**1.6**	**1.9**	**2.5**	**2.7**
	TCE	0.0027*			**0.0737**	**0.039**	**0.04**	**0.018**	NS	**0.003**	**0.005**	**0.0071**	**0.0044**	**0.0029**
	Alkalinity	None			197	185	172	187	NS	250	270	300	230	290
	Iron	None			9.34	10.6	12.2	0.086	NS	22	13	9	7.8	11
	DO	None			5.74	0.82	0.4	2.15	NS	1.55	0.48	0.43	0.46	0.66
GP-1 *GP1A sampled in 2014 as a substitute	DRO	1.5	0.707		**2.76**	**4.2**	**4.2**	1.2	NS	0.99	**1.5**	1.2	**3.7**	**3.3**
	TCE	0.0027*	**0.616**		**0.0053**	**0.0059**	0.0012	ND	NS	ND	ND	ND	0.00032	ND
	Alkalinity	None	259		272	243	235	47	NS	52	NA	100	210	310
	Iron	None	ND		4.22	45.9	111	40.9	NS	100	NA	66	100	100
	DO	None	NS		2.95	0.36	0.47	3.2	NS	2.92	NA	0.86	2.11	1.2
GP-2 (or alt WP03-07 in 2008, WP03-09 in 2009-2014)	DRO	1.5			0.685	**6.0**	**4.9**	**3.7**	**3.4**	**2.6**	**2.5**	**2.3**	**2.8**	**3.2**
	TCE	0.0027*			ND	**0.0052**	0.0024	**0.0028**	**0.0073**	ND	ND	ND	ND	ND
	Alkalinity	None			56.2	292	287	294	149	43	99	29	97	190
	Iron	None			10.4	44.5	61.3	57.7	89	46	87	21	55	130
	DO	None			4.8	0.21	0.44	1.32	0.36	1.7	0.37	2.26	0.59	0.74
WP03-11	DRO	1.5			**3.65**	**3.7**	**4.2**	**2.0**	NS	**2.0**	**1.8**	**2.6**	**3.7**	**2.5**
	TCE	0.0027*			**0.0272**	**0.013**	**0.0088**	**0.0078**	NS	**0.0082**	**0.0049**	**0.0044**	**0.0045**	**0.0034**
	Alkalinity	None			291	240	307	338	NS	300	270	300	300	300
	Iron	None			ND	0.0705	0.047	0.30	NS	4.8	1.5	2.7	4	3.1
	DO	None			4.77	0.74	0.5	1.62	NS	0.34	0.34	0.55	0.76	0.67
EKMW-01 was replaced with ETMW-02 in 2012.	DRO	1.5	**29**	6.4	**3.05**	**3.9**	**1.9**	**1.7**	NS	0.73	0.56	0.5	0.61	1
	TCE	0.0028	0.0499	0.017	**0.0062**	**0.0058**	**0.0038**	**0.011**	NS	**0.046**	**0.073**	**0.062**	**0.089**	**0.087**
	Alkalinity	None	269	203	202	203	192	WP0	NS	170	190	160	160	140
	Iron	None	1.83	1.03	0.93	0.544	1.9	2.95	NS	0.71	0.52	0.2	0.49	0.029
	DO	None	0.22	0.29	0.64	1.10	1.02	1.52	NS	0.47	0.42	0.6	0.83	0.7
MW-9	DRO	1.5	**3.32**	**15.5**	**11.4**	**3.7**	**4.8**	**3.9**	**4.6**	**2.8**	**4.5**	**5.9**	**3.1**	**7.3**
	TCE	0.0028	0.0019	0.0011	ND	0.00066	ND	ND	ND	0.00025	0.0015	ND	0.00084	ND
	Alkalinity	None	314	316	162	192	281	292	277	230	230	230	210	200
	Iron	None	1.14	1.29	1.2	1.54	3.1	4.2	6.68	6.4	7	7.4	8	7.9
	DO	None	1.27	0.82	5.23	3.61	2.55	4.05	0.77	0.88	0.48	0.76	0.68	0.98
MW89-1	DRO	1.5	**19.9**	**53.3**	**5.14**	**3.8 /3.5**	**2.8/3.8**	**2.2/2.5**	**5.4/5.2**	**2.3/2.6**	**3.2/3.5**	**3.4/3.9**	**3.9**	**3.4**
	TCE	0.0028	**0.0104**	0.0003	**0.0047**	**0.0040/0.0042**	**0.0033**	**0.0034/0.0035**	**0.0038/0.0037**	**0.0031/0.0035**	**0.0034**	**0.0037/0.0039**	**0.0041**	**0.0037**
	Alkalinity	None		18.8	315	311/313	297/291	314	333/336	350	370	390	390	370
	Iron	None	0.694	18.8	2.04	1.84/1.93	3.7/3.4	3.68/2.98	3.16/2.19	1.2/1.1	1.1	0.72/0.78	0.68	0.82
	DO	None	0.11	0.43	0.8	0.29	0.49	2.09	0.76	0.45	0.39	0.64	0.79	0.74
MW-6	DRO	1.5											0.2	0.096
	TCE	0.0028											**0.022**	**0.024**
	Alkalinity	None											110	110
	Iron	None											0.04	ND
	DO	None											3.54	4.13
MW-23	DRO	1.5											**0.4**	0.24/0.27
	TCE	0.0028											**0.026**	**0.019**
	Alkalinity	None											130	110
	Iron	None											0.02	ND
	DO	None											6.74	8.48
MW-28	DRO	1.5											**0.2**	0.12
	TCE	0.0028											**0.095/0.12**	**0.11**
	Alkalinity	None											110/120	120
	Iron	None											0.46/0.56	ND
	DO	None											2.66	4.17

Notes: * Action level at POCs for TCE is the ecological surface water quality criteria.

** RAO at monitoring wells for TCE (ADEC Table C)

Results shown in **BOLD** exceed ADEC Table C Cleanup Levels

GRO- Gasoline Range Organics; DRO - Diesel Range Organics; RRO - Residual Range Organics

NS- Well Not sampled; NA - Analyte Not Analyzed; ND - Analyte Not Detected

Table 2-8: Zone 1 Selected B-Aquifer Data (2002 - 2016)

Well	Analyte (mg/L)	RAOs (mg/L)	2002	2004	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
MW-41	GRO	2.2	0.112	0.046	0.0236	0.0335	0.068	0.072	0.052	0.074	0.014	NA	NA	NA	NA
	DRO	1.5	1.48	0.961	**1.85**	**2.34**	1.1	0.66	0.81	1.3	0.79	0.98	1.1	1.4	1.1
	TCE	0.0028	**0.031**	**0.051**	**0.042**	**0.048**	**0.038**	**0.035**	**0.039**	**0.035**	**0.049**	**0.084**	**0.094**	**0.091**	**0.072**
MW13-13B	GRO	2.2												NA	NA
	DRO	1.5												0.17	0.13
	TCE	0.0028												ND	ND
MW13-09B	GRO	2.2												NA	NA
	DRO	1.5												0.23/0.15	0.14/0.17
	TCE	0.0028												**0.043/0.043**	**0.048/0.047**
MW-42	GRO	2.2	ND	0.033	NS	ND	0.057/ND	0.012	ND	ND	ND/0.0049	NA	NA	NS	NS
	DRO	1.5	ND	0.241	NS	0.97/0.315	0.12/0.064	0.056/0.059	0.059/0.067	0.16/0.12	0.099/0.089	0.086/0.082	0.27/0.28	NS	NS
	TCE	0.0028	ND	0.0012	NS	ND/0.00207	0.00067/0.00031	0.00046/0.00038	ND/0.00038	0.0017/0.0019	0.0023/0.0017	0.0021/0.0022	0.0023/0.0022	NS	NS
MW-43	GRO	2.2	ND	ND	NS	ND	0.015	0.018	ND	ND	ND	NA	NA	NS	NS
	DRO	1.5	ND	0.551	NS	0.339	0.50	0.36	0.32	0.52	0.33	0.39	0.62	NS	NS
	TCE	0.0028	ND	ND	NS	0.00157	ND	ND	ND	ND	ND	ND	ND	NS	NS

Results in **BOLD** exceed RAOs.
ND - Not Detected
NA - Not Analyzed
NS - Not Sampled

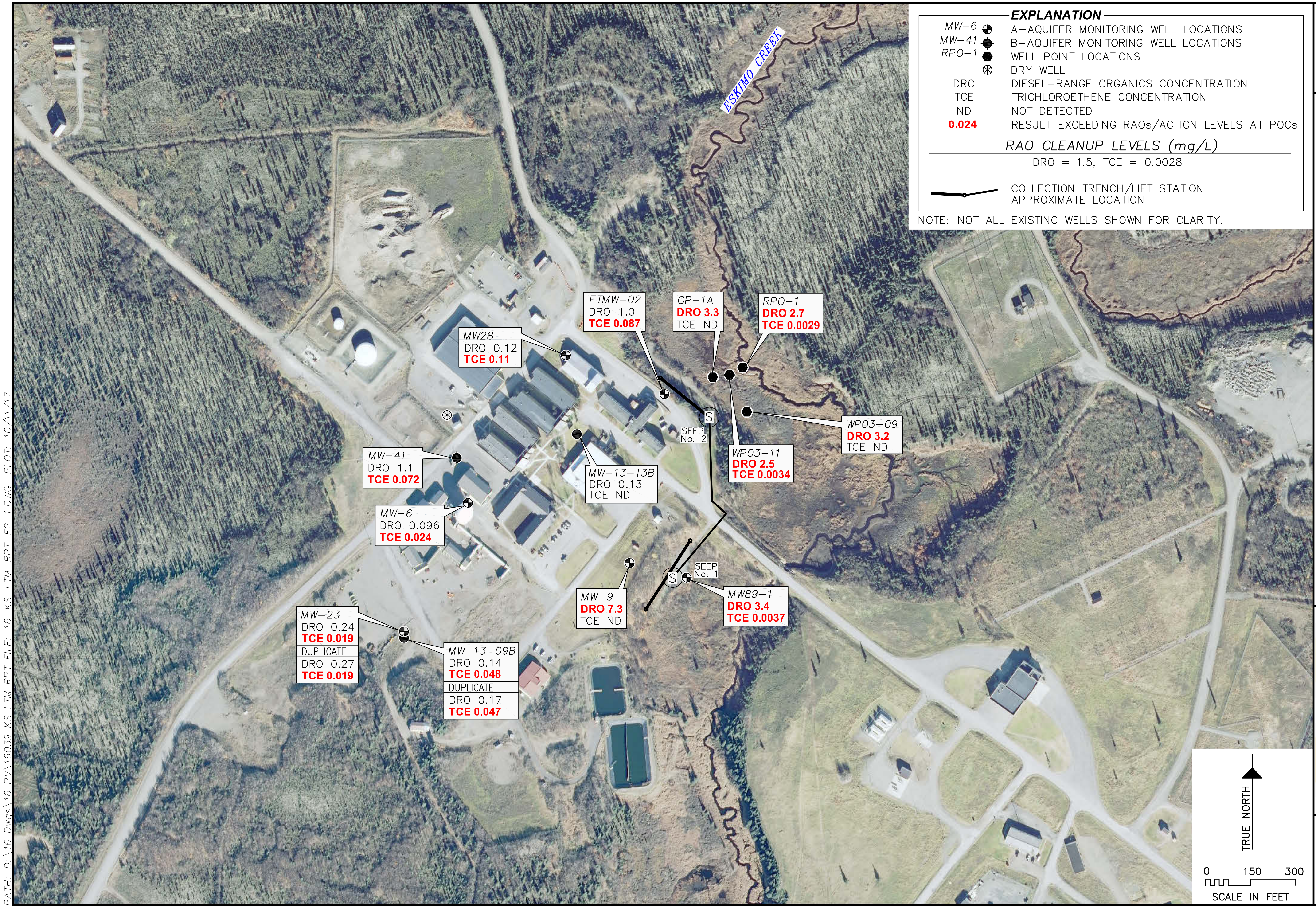

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FIGURE
2-1

DRO AND TCE ANALYTICAL RESULTS GROUNDWATER ZONE 1

GROUNDWATER ZONE 1 (OT-027)
2016 LONG TERM MANAGEMENT
King Salmon Divert, Alaska

PACIFIC AIR FORCES REGIONAL SUPPORT CENTER
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JBER, ALASKA

DATE
OCT. 2017
CHKD
H.L.H.
DRAWN
C.E.H.
PROJ. NO
16039

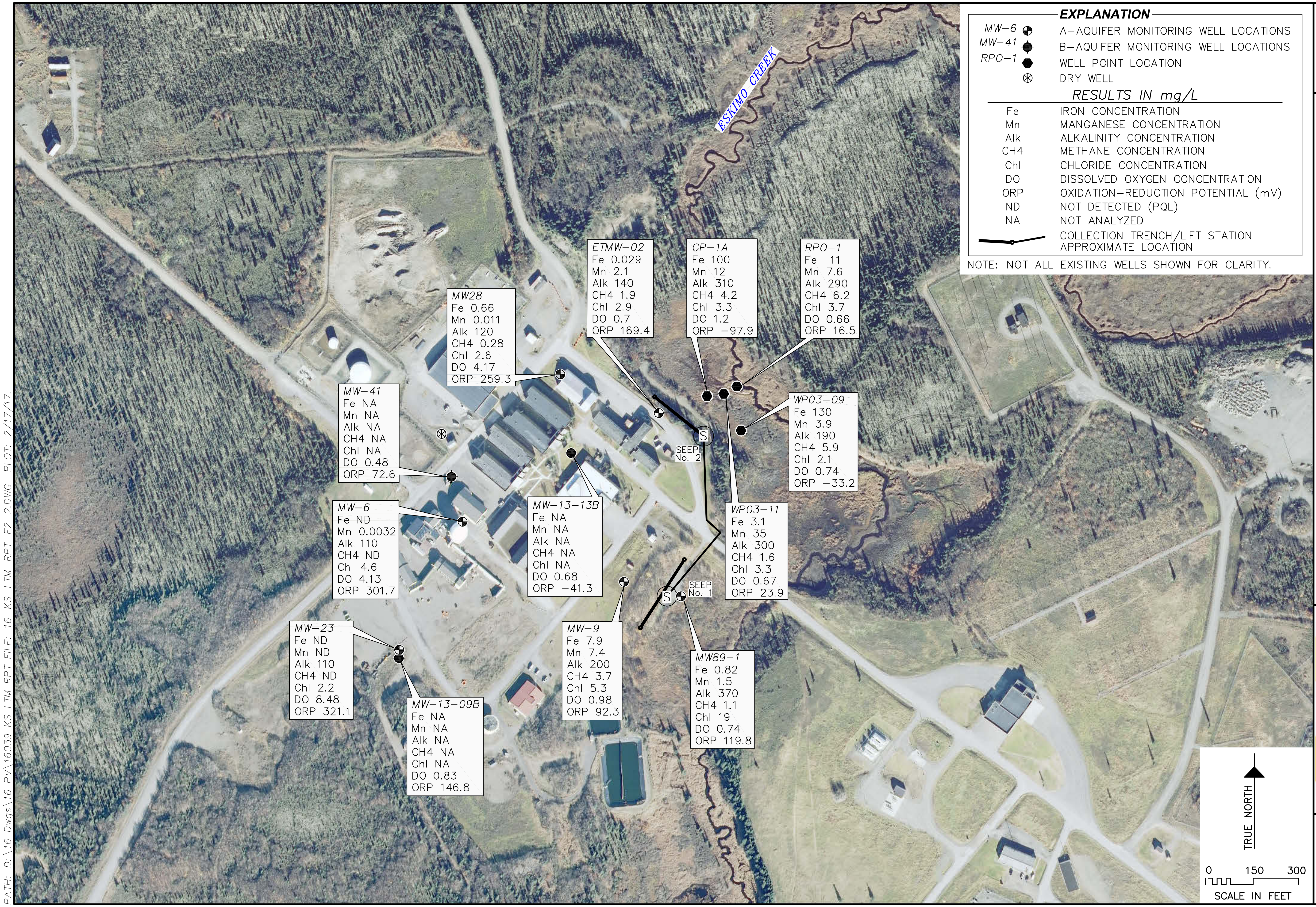

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FIGURE
2-2

MONITORED NATURAL ATTENUATION RESULTS
GROUNDWATER ZONE 1

GROUNDWATER ZONE 1 (OT-027)
2016 LONG TERM MANAGEMENT
King Salmon Divert, Alaska

PACIFIC AIR FORCES REGIONAL SUPPORT CENTER
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JBER, ALASKA

DATE
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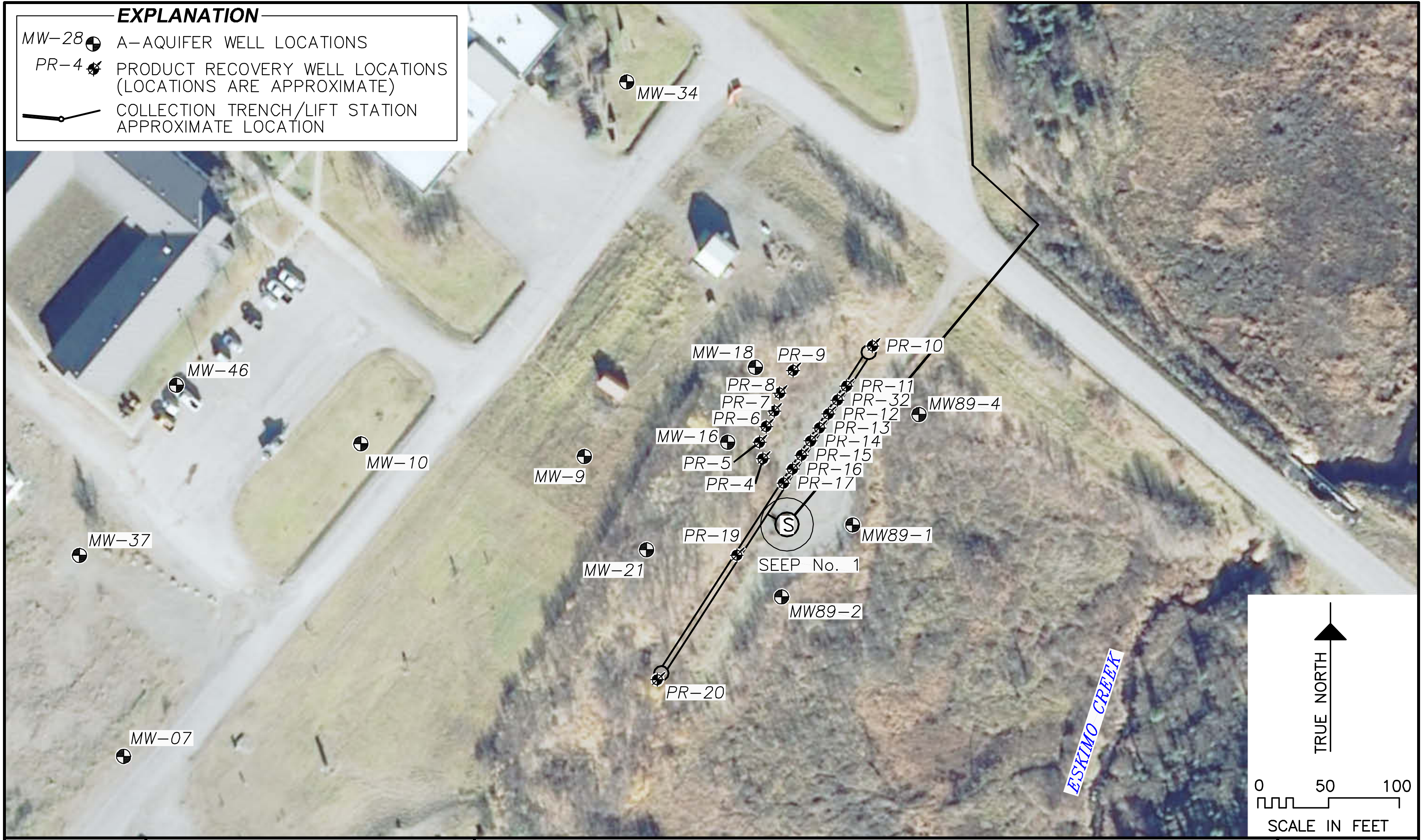

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C.E.H.
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JBER, ALASKA

PRODUCT PROBES NEAR SEEP No. 1

GROUNDWATER ZONE 1 (OT-027)
2016 LONG TERM MANAGEMENT
King Salmon Divert, Alaska

FIGURE

2-3

PATH: D:\16 Dwgs\16 PV\16039 KS LTM RPT FILE: 16-KS-LTM-RPT-F2-3_4.DWG PLOT: 2/17/17.

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H.L.H.
DRAWN
C.E.H.
PROJ. NO
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PRODUCT PROBES NEAR SEEP No. 2

GROUNDWATER ZONE 1 (OT-027)
2016 LONG TERM MANAGEMENT
King Salmon Divert, Alaska

FIGURE

2-4

3 ZONE 2 - BASE INDUSTRIAL AREA & ESKIMO CREEK DUMP

This section describes the results of sampling at the KSD Base Industrial Area (Groundwater Zone 2 – OT028) and Eskimo Creek Dump (LF022, formerly SS022). Historical spills and operational practices at Zone 2 resulted in contamination of the water table with petroleum-based products and chlorinated solvents, specifically DRO, GRO, BTEX, and TCE dissolved in the groundwater.

The primary objective of the monitoring program at the Base Industrial Area is to determine if MNA is occurring. The primary objective of the Eskimo Creek Dump monitoring project is to determine whether there is any contamination above cleanup levels emanating from Eskimo Creek Dump toward Eskimo Creek. TCE dissolved in groundwater is the COC at Eskimo Creek Dump.

In addition to sampling for GRO, DRO, and VOCs, two monitoring wells were sampled for PFOA and PFOS in 2016.

Details regarding the site history, previous investigation results, existing remedial actions, and other information relevant to Groundwater Zone 2 are provided in the final ROD located in the electronic version of this report.

3.1 REMEDIAL ACTION OBJECTIVES FOR ZONE 2

RAOs are specific cleanup levels and related requirements to be met at Groundwater Zone 2 and Eskimo Creek Dump. Groundwater and soil RAOs listed in the final Zone 2 ROD were developed in accordance with the ADEC contaminated site regulations (18 AAC 75). Groundwater RAOs were the 18 AAC 75 Table C groundwater cleanup levels, modified in accordance with 18 AAC 75.345 (g). Soil RAOs were the 18 AAC 75.341 Table B1 and B2 soil cleanup levels, modified in accordance with 18 AAC 75.345 (g). Surface water RAOs were developed in accordance with the AWQS, 18 AAC 70.

The use of the “10 times rule” used to develop cleanup levels in the ROD is no longer used by ADEC. Current regulatory cleanup levels are now used. Final RAOs presented in the ROD and current ADEC cleanup levels are displayed on Table 3-1.

In addition to the regulation-based cleanup levels, action levels were defined for TCE and its degradation products to guide remedial efforts. Action levels are ecological surface water quality screening criteria.

According to the ROD, sampling may be discontinued at a sampling point once two consecutive sampling events are below RAOs. There was only one RAO exceedance in the last nine years of sampling the seven Eskimo Creek well points (ECWP04-06 exceeded the RAO for TCE in 2004). Sampling of the well points was discontinued in 2013, and the well points were decommissioned in September, 2014. Collecting surface water samples at three locations along Eskimo Creek has continued.

Table 3-1 RAOs for ERP Sites in the KSD Base Industrial Area (Zone 2)

Media	Contaminants of Concern	Maximum Conc.	Maximum Conc. Location (Date)	Maximum Conc. 2000 data	Screening and Regulatory Criteria				RAOs		
					Ecological Criteria	Basis	Human Health/ADEC Criteria	Basis	Action Level at POC*	Cleanup Level from ROD	Current ADEC Cleanup Level
Groundwater (mg/L) (A- Aquifer)	TCE	0.750	B-02 (1988)[a]	0.062 (MW00-05)	--	--	0.0028	18AAC75	0.35	0.05[b]	0.0028
	cis-1,2-DCE	0.13	145 (1996)	0.053 (MW00-02)	--	--	0.036	18AAC75	0.59	0.7[b]	0.036
	Benzene	2.0	(1988)[a]	0.48 (MW-00-04)	--	--	0.0046	18AAC75	0.046[c]	0.05[b]	0.0046
	Ethylbenzene	2.3 AX	MW-708 (1997)	1.700 (MW00-04)	--	--	0.015	18AAC75	0.29[c]	7[b]	0.015
	Toluene	7.8	AP-12 (1994)	3.4 (MW00-04)	--	--	1.1	18AAC75	0.13[c]	10[b]	1.1
	DRO	26.1	B-06 (1993)	13.0 (MW00-03)	--	--	1.5	18AAC75	na	15[b]	1.5
	GRO	30	MW00-04 (2000)	30 (MW00-04)	--	--	2.2	18AAC75	na	13[b]	2.2
Surface Water (mg/L)	TCE	0.013[d]	SS-7 (1997)	NS	0.35	Ecotox	0.005	18AAC70	--	0.005	0.005
	cis-1,2-DCE	0.0014	138 (1993)	NS	0.59	ORNL	0.07	18AAC70	--	0.07	0.07
Soil (mg/Kg)[e]	DRO	12,100	VP-9 at 19 ft bgs (1988)	28 (MW00-03 at 9 ft bgs)	--	--	250	18AAC75	--	2,500[b]	230
	Benzene	1.8	(1988)[a]	ND	--	--	0.022	18AAC75	--	0.22[b]	0.022
	Ethylbenzene	94	629 (1994)	0.25 (MW00-04 at 13 ft bgs)	--	--	0.13	18AAC75	--	1.3[b]	0.13
	Toluene	97	629 (1994)	ND	--	--	6.7	18AAC75	--	67[b]	6.7
	TCE	1.7	(1988)[a]	0.066 (MW00-05 at 15 ft bgs)	--	--	0.011	18AAC75	--	0.11[b]	0.011

***Action levels at the POC (point of compliance) refer to groundwater concentration detected in monitoring wells adjacent to Eskimo Creek that would signal the need for active groundwater cleanup for protection of the creek. The action levels are equal to the surface water ecological screening criteria. Note that there has been no exceedance of the action levels at the POC; the maximum groundwater concentrations shown in Table 1 were not detected at locations adjacent to Eskimo Creek.**

[a] This information was obtained from the EMCON, 1995 KSD Remedial Investigation (RI) (EMCON, 1995a), which did not provide specific sample locations. The RI stated that the results were obtained from 1988 sampling by the Corps of Engineers at the Refueler Shop site.

[b] Basis for the soil and groundwater cleanup levels is 18 AAC 75 using the tabulated cleanup levels (Table B1 and B2 for soil and Table C for groundwater) adjusted (multiplied by 10) for the situation where groundwater is determined to not be a drinking water source.

[c] These action levels correspond to the USEPA Ecotox (defined below in "Definitions" thresholds for surface water.

[d] The reported TCE concentration was detected in a sample from Eskimo Creek Dump surface water (not from Eskimo Creek itself). TCE has been detected in only one sample from Eskimo Creek adjacent to Groundwater Zone 2 (0.00055 mg/L in 1999). TCE was also detected in 1997 surface water sample collected from Eskimo Creek upgradient of Zone 2; the detection is considered to be unrelated to Zone 2 impacts.

[e] Sediment has been investigated and is not considered a medium of concern because no criteria were exceeded.

<u>Definitions</u>

18 AAC 75 Oil and Hazardous Substances Pollution Control Regulations (ADEC, 2017)
18 AAC 70 Alaska Water Quality Standards (ADEC, 2017)
Ecotox – USEPA Office of Solid Waste and Emergency Response (OSWER) Ecotox Threshold benchmark values for freshwater (ECP Update, Publication 9345.0-12FSI; EPA 540/F-05/038, January 1996)
ORNL PRG – Oak Ridge National Laboratory Preliminary Remediation Goals for Ecological Receptors (RAIS database at http://risk.lsd.ornl.gov/rap_hp.shtml, 2002)

ARAR – Applicable or Relevant and Appropriate Requirement
POC – Point of Compliance
SQB – Sediment Quality Benchmark
TCE – Trichloroethene
DCE – Dichloroethene
— Not applicable
mg/Kg – milligrams per kilogram

RAO – Remedial Action Objective
FPP – Floating Petroleum Product
ND – Not detected
NE – Not evaluated
NA – Not analyzed
mg/L – milligrams per liter
bgs – below ground surface

3.2 PROJECT TASKS

3.2.1 Groundwater Sampling Program

Groundwater samples were collected in September 30 – October 1, 2016, from the eleven A-Aquifer groundwater monitoring wells identified in Table 3-2 and shown on Figure 3-1. Data collected from each monitoring well were documented on the Zone 2 Groundwater Sample Data Sheets provided in Appendix A.

3.2.2 Surface Water Sample Collection

On October 2, 2016, surface water samples were collected from three locations along Eskimo Creek (SS022/LF022) as shown on Figure 3-3. Table 3-2 has a complete list of analyses. Data collected from each sampling point were documented on the Surface Water/Sediment Sample Data Sheets provided in Appendix A.

3.2.3 Institutional Control Inspection

Institutional controls, which are land use restrictions, are part of the selected remedy. Only water from the C-Aquifer, the current source of water for KSD, will be used for drinking. Drinking water wells will not be installed in the A and B Aquifers in Zone 2 or Eskimo Creek Dump (SS022). Excavations and other subsurface activities will be restricted from sites SS020 (Old Power Plant Building), SS021 (Refueler Shop), and SS022 (Eskimo Creek Dump).

A visual inspection was performed to verify that no water wells have been installed or that no soil excavation has been conducted at the above mentioned sites.

3.2.4 Work Plan Deviations

There were no deviations from the work plan.

Table 3-2: Groundwater Zone 2 Sample Analyses Summary

			Analytical Methods									
Location ID	Matrix	Location Type	EPA Method 8260B VOCs	1,4-Dioxane	Alaska Method AK101/GRO	Alaska Method AK102/DRO	537 PFOA PFOS	EPA 2320B Alkalinity	EPA Method 9056 Chloride	E353.2 Nitrate + Nitrite	6020 Dissolved Fe+Mn	Sample ID
B-02	Groundwater	Monitoring Well	1	1	1	1		1	1	1	1	16KS2ZB02-107WG
MW00-05	Groundwater	Monitoring Well	1		1	1		1	1	1	1	16KS2ZMW0005-108WG
MW-446	Groundwater	Monitoring Well	1		1	1		1	1	1	1	16KS2Z446-109WG
MW-447	Groundwater	Monitoring Well	1		1	1		1	1	1	1	16KS2Z447-110WG
AP-11	Groundwater	Monitoring Well	1		1	1		1	1	1	1	16KS2ZAP11-111WG
MW-708	Groundwater	Monitoring Well	1		1	1		1	1	1	1	16KS2Z708-112WG
MW-629	Groundwater	Monitoring Well	1	1	1	1		1	1	1	1	16KS2Z629-113WG
MW00-03	Groundwater	Monitoring Well	1		1	1	1	1	1	1	1	16KS2ZMW0003-114WG
MW-628	Groundwater	Monitoring Well	1		1	1	1	1	1	1	1	16KS2Z628-115WG
MW00-02	Groundwater	Monitoring Well	1		1	1		1	1	1	1	16KS2ZMW0002-116WG
MW-202	Groundwater	Monitoring Well	1		1	1		1	1	1	1	16KS2Z202-117WG
Duplicate Sample	Groundwater	Monitoring Well	1	1	1	1		1	1	1	1	16KS2Z626-118WG
Duplicate Sample	Groundwater	Monitoring Well	1		1	1		1	1	1	1	16KS2Z627-119WG
MS/MSD	Groundwater	Monitoring Well	2	2	2	2		2	2	2	2	16KS2Z629-113WG
MS/MSD	Groundwater	Monitoring Well					2					16KS2ZMW0003-114WG
Trip Blanks	Water	QA/QC	5		5							16KS2ZTB-MMDD
Total Samples - A-Aquifer			20	5	20	15	4	15	15	15	15	

Location ID	Matrix	Location Type	EPA Method 8260B/VOCs	**Surface Water**
OT28-01	Surface Water	Surface Water	1	16KS2ZOT281-301WS
OT28-02	Surface Water	Surface Water	1	16KS2ZOT282-302WS
OT28-03	Surface Water	Surface Water	1	16KS2ZOT283-303WS
Duplicate Sample	Surface Water	Surface Water	1	16KS2ZOT284-304WS
MS/MSD	Surface Water	Surface Water	2	16KS2ZOT283-303WS
Trip Blanks	Water	QA/QC	1	16KS2ZTB-MMDD
Total Samples - Surface Water			7	

3.3 ZONE 2 FINDINGS

Historical and current analytical data results are shown on Tables 3-3, 3-4, and 3-5. The RAOs for A-Aquifer groundwater in Zone 2 are the current ADEC Table C groundwater cleanup levels (18 AAC 75). Analytical results are provided in Appendix C, Zone 2 Tables. Photographs of field activities are located in Appendix F.

3.3.1 Groundwater Analytical Results

3.3.1.1 GRO and DRO

Two of the Zone 2 monitoring wells sampled exceeded the RAO of 2.2 mg/L for GRO and one monitoring well exceeded the RAO 1.5 mg/L for DRO. GRO levels ranged between ND and 9.5 mg/L (B-02). DRO levels ranged from 0.033 to 8.9 mg/L (B-02).

GRO and DRO levels detected in Zone 2 groundwater are shown on Figure 3-1.

3.3.1.2 BTEX

One well exceeded the ADEC cleanup level for benzene, three wells exceeded for ethylbenzene, and two exceeded for total xylenes. There were no exceedances for toluene. BTEX detections are summarized below and shown on Figure 3-1.

- Benzene was detected above the 0.0046 mg/L RAO in monitoring wells MW-629 (0.047 mg/L).
- Toluene was detected at concentrations below the 1.1 mg/L RAO in two groundwater samples (B-02, MW-629). The maximum detection was 0.8 mg/L in MW-629.
- Ethylbenzene concentrations in B-02, MW-629, and MW00-03 were above the cleanup level of 0.015 mg/L. Concentrations in those wells were 0.44, 0.55, and 0.16 mg/L, respectively. Ethylbenzene was also detected in AP-11 at 0.0032 mg/L.
- Total xylene concentrations in B-02 and MW-629 were above the cleanup level of 0.19 mg/L. Concentrations in those wells were 2.50 and 1.57 mg/L, respectively. Total xylenes were non-detect in all other Zone 2 wells except AP-11 and MW00-03, which had concentrations of 0.002 and 0.158 mg/L, respectively.

3.3.1.3 TCE

TCE was detected above the 0.0028 mg/L cleanup level in six monitoring wells. TCE levels were non-detect in the other five wells.

The TCE concentrations detected in Zone 2 groundwater are shown on Figure 3-2 which also depicts the inferred plume where A-Aquifer TCE concentrations exceed 0.0028 mg/L.

3.3.1.4 1,4-Dioxane

Two monitoring wells (B-02 and MW00-03) were sampled for the solvent 1,4-Dioxane. Results were ND for both wells.

3.3.1.5 Naphthalene

The result from A-Aquifer monitoring well B-02 was 110 µg/L, which is above the ADEC groundwater cleanup level of 1.7 µg/L for naphthalene. All other Zone 2 wells were non-detect for naphthalene.

3.3.1.6 1,2,4-Trimethylbenzene

The results from two of the eleven A-Aquifer monitoring wells sampled were above the ADEC groundwater cleanup level of 15 µg/L for 1,2,4-Trimethylbenzene. The sample result from B-02 was 380 µg/L and MW-629 was 110 µg/L.

3.3.1.7 1,3,5-Trimethylbenzene

The result from the A-Aquifer monitoring well B-02 was 120 µg/L, which is at the ADEC groundwater cleanup level of 120 µg/L for 1,2,4-Trimethylbenzene. Concentrations from the other monitoring wells ranged from non-detect to 36 µg/L.

3.3.1.8 PFOA and PFOS

Samples from MW-628 and MW00-03 were analyzed for PFOA and PFOS. PFOA/PFOS were detected in both samples. The results from MW-628 were 0.033/0.31 µg/L, which are below the ADEC cleanup level of 0.40 µg/L, but above the EPA's Health Advisory Levels for PFOA and PFOS in drinking water (USEPA, 2016a). MW00-03 had PFOA (0.41 µg/L) and PFOS (0.56 µg/L), above the cleanup levels.

3.3.1.9 Inorganics

The monitoring well samples were analyzed for several inorganic parameters to evaluate the progress of MNA. The MNA assessment is discussed in Section 3.4.

3.3.2 Surface Water Analytical Results

Surface water contaminant levels are compared to regulatory criteria and benchmark screening levels. As discussed in Section 3.1, 18 AAC 70 provides regulatory criteria for surface water. Analytical results are provided in Appendix C, Zone 2 Tables. Table 3-4 presents historical analytical results for the COCs (BTEX and TCE) along with the appropriate water quality criteria for comparison.

3.3.2.1 BTEX

There were no BTEX constituents detected in any of the samples.

3.3.2.2 TCE

TCE was not detected in any of the samples.

Table 3-3: Historical Zone 2 Groundwater Results

Site Area	Well Location	Analyte	RAO	1988 Analytical Results	1992 Analytical Results	1993 Analytical Results	1994 Analytical Results	1996 Analytical Results	1997 Analytical Results	1998 Analytical Results	2000 Analytical Results	2004 Analytical Results	2005 Analytical Results	2006 Analytical Results	2007 Analytical Results	2008 Analytical Results	2009 Analytical Results	2010 Analytical Results	2011 Analytical Results	2012 Analytical Results	2013 Analytical Results	2014 Analytical Results	2015 Analytical Results	2016 Analytical Results
Near Eskimo Creek	628	GRO	2.2 mg/L	NI	NI	NI	NS	NS	NS	NS	ND	0.0223	ND	ND	0.0168	NS	NS	0.014	ND	0.005	0.027	0.023	0.044	0.025/ND
		DRO	1.5 mg/L	NI	NI	NI	NS	ND	0.12	0.138	0.11	0.293	ND	0.0835	0.201	NS	NS	ND	ND	0.025	0.017	0.15	0.074	0.033
		BTEX	mg/L	NI	NI	NI	ND	ND	ND	ND	ND	ND	ND	ND	0.33	ND	ND	ND	ND	ND	ND	ND	ND	ND
		Benzene	4.6 µg/L	NI	NI	NI	ND	ND	ND	ND	ND	ND	ND	ND	0.33	ND	ND	ND	ND	ND	ND	ND	ND	ND
		TCE	2.8 µg/L	NI	NI	NI	**13.0**	**6.6**	**8.4/6.1**	**7.9**	**8.2**	**11.8**	**10.8**	**10.8**	**6.63**	**10.0/11.0**	**8.6/11**	**9.3**	**8.6**	**9**	**9.4**	**9.8**	**9.2**	**11/8.2**
		PFOA	0.4 µg/L																					0.033
		PFOS	0.4 µg/L																					0.31
Near Eskimo Creek	202	GRO	2.2 mg/L	NI	NI	NI	NI	NS	NS	NS	ND	0.0319	ND	0.0137/0.0276	0.0101/0.0101	NS	NS	ND	ND	ND	ND	ND	0.03	ND
		DRO	1.5 mg/L	NI	NI	NI	NI	0.2	ND	NS	0.86	0.215	0.0942	0.287/0.278	0.495/0.151	NS	NS	0.074	0.070	0.073	0.056	0.230	0.120	0.13
		BTEX	mg/L	NI	NI	NI	NI	ND	ND	NS	ND	ND	0.00123	ND/ND	ND/ND	NS	NS	ND	ND	ND	ND	ND	ND	ND
		Benzene	4.6 µg/L	NI	NI	NI	NI	ND	ND	NS	ND	ND	ND	ND/ND	ND/ND	NS	NS	ND	ND	ND	ND	ND	ND	ND
		TCE	2.8 µg/L	NI	NI	NI	NI	ND	**19**	NS	ND	0.3	ND	0.18/0.16	ND/ND	NS	NS	0.13	0.14	0.16	ND	ND	ND	ND
Building 149	B-02	GRO	2.2 mg/L	NS	NS	2.48	NS	NS	NS	NS	NS	**14.5**	**6.13**	**7.09/7.30**	**4.95**	NS	NS	**9.2**	**13.0**	**13.0**	**9.2**	**13.0**	**15.0**	**9.5/9.5**
		DRO	1.5 mg/L	25*	ND*	10.50	NS	NS	3.0	NS	NS	**7.41**	**16.5**	**7.25/6.29**	**7.29**	NS	NS	**2.8**	**6.6**	**4.3**	**3.8**	**4.3**	**3.1/3.0**	**8.9/8.6**
		Total BTEX	mg/L	8.679	5.34	1.148	NS	NS	1.6	NS	NS	2.03461	2.7773	3.264/3.22	4.11	NS	NS	3.35	3.3	3.376	2.87	3.42	3.2/3.4	2.96/2.79
		Benzene	4.6 µg/L	**140**	ND	**7.6**	NS	NS	3.7	NS	NS	**4.61**	2.6	**5.18/5.21**	**9.82**	NS	NS	**5.2**	ND	ND	ND	ND	ND	ND
		TCE	2.8 µg/L	**750**	**390**	**56**	NS	NS	**35**	NS	NS	**54.4**	**37.2**	**37.06/39.36**	ND	NS	NS	**28**	**28**	**28**	**20**	**23**	**16/20**	**15/12**
Building 149	MW00-05	GRO	2.2 mg/L	NI	NI	NI	NI	NI	NI	NI	0.46	0.844/0.773	0.209/0.198	0.174	0.537	NS	NS	0.39/0.43	0.88	0.16	0.26	0.35	0.088	0.27
		DRO	1.5 mg/L	NI	NI	NI	NI	NI	NI	NI	1.9	1.02/0.995	0.677/0.720	0.658	0.633	NS	NS	0.54/0.49	0.53	0.25	0.43	0.64	0.25	0.37
		BTEX	mg/L	NI	NI	NI	NI	NI	NI	NI	0.0063	0.00431/0.00386	0.00758/0.00275	0.12	ND	NS	NS	ND	ND	ND	ND	ND	ND	ND
		Benzene	4.6 µg/L	NI	NI	NI	NI	NI	NI	NI	ND	ND/ND	ND/ND	ND	ND	NS	NS	ND	ND	ND	ND	ND	ND	ND
		TCE	2.8 µg/L	NI	NI	NI	NI	NI	NI	NI	**62**	**18.8/17.2**	**17.8/22.2**	**13.46**	ND	NS	NS	**4.7/5.1**	**4.1**	**7.4**	**6.5**	**7.1**	**6.6**	**6**
Building 149	446	GRO	2.2 mg/L	NI	NI	ND	NS	NS	NS	NS	0.15/0.14/0.157	0.0228	ND	ND	0.0123	NS	NS	0.015	0.021	0.006	0.011	ND	0.044	ND
		DRO	1.5 mg/L	NI	NI	0.206	NS	NS	0.47	NS	0.49/0.44/ND	0.269	0.132	0.558	0.0984	NS	NS	0.11	0.035	0.1	0.1	0.22	0.17	0.13
		BTEX	mg/L	NI	NI	0.006	NS	NS	ND	NS	ND/ND/ND	ND	ND	ND	0.00057	NS	NS	ND	ND	ND	0.0003	ND	ND	ND
		Benzene	4.6 µg/L	NI	NI	ND	NS	NS	ND	NS	ND/ND/ND	ND	ND	ND	ND	NS	NS	ND	ND	ND	ND	ND	ND	ND
		TCE	2.8 µg/L	NI	NI	**16**	NS	NS	**33**	NS	**23/20/16.9**	**12.2**	**13.8**	**12.44**	**8.16**	NS	NS	**7.7**	**4.6**	**4.4**	**5.4**	**4.1**	**6.3**	**5.7**
Building 157 & 159	447	GRO	2.2 mg/L	NI	NI	NS	NS	NS	NS	NS	NS	0.0264	ND	ND	0.0119	NS	NS	ND	0.017	ND	0.017	0.02	0.035	ND
		DRO	1.5 mg/L	NI	NI	0.672	0.2	NS	0.52	NS	NS	0.206	0.0809	0.173	0.177	NS	NS	0.032	0.040	0.062	0.054	0.110	0.130	0.340
		BTEX	mg/L	NI	NI	0.009	ND	NS	ND	NS	NS	2.66159	0.00242	ND	0.0030	NS	NS	0.00042	ND	ND	ND	ND	ND	ND
		Benzene	4.6 µg/L	NI	NI	ND	ND	NS	ND	NS	NS	ND	ND	ND	ND	NS	NS	ND	ND	ND	ND	ND	ND	ND
		TCE	2.8 µg/L	NI	NI	0.8	**7.2**	NS	1.6	NS	NS	**3.8**	**3.25**	**3.49**	**4.12**	NS	NS	**4.4**	**4.9**	**4.3**	**3.9**	**5.8**	**4.4**	**3.1**
Building 157 & 159	629	GRO	2.2 mg/L	NI	NI	NI	NS	NS	NS	NS	**10/9.5/8.03**	**25.9**	**18.9**	**6.48**	0.0789	NS	NS	2.6	0.86	**2.9**	**2.6**	**6.1**	**3.1**	**8.8**
		DRO	1.5 mg/L	NI	NI	NI	1.7	NS	3.1	NS	4.0/4.9/4.83	7.12	3.47	1.93	0.0999	NS	NS	0.40	0.30	0.60	1.10	0.77	0.31	0.58
		BTEX	mg/L	NI	NI	NI	6.20	NS	2.8	NS	4.91/5.52/3.98	11.288	9.148	2.747	0.0256	3.69 /9.06	2.08/7.54	0.947	0.20	0.92	0.88	2.19	0.66	2.97
		Benzene	4.6 µg/L	NI	NI	NI	**700**	NS	**400**	NS	**370/390/325**	**642**	**449**	**185.4**	3.41	**130/310**	**110/360**	**50.00**	**25**	**40**	**35**	**40**	**15**	**47**
		TCE	2.8 µg/L	NI	NI	NI	**10**	NS	**19**	NS	**ND/13/10.9**	**6.8**	**8.33**	**7.97**	1.19	**13/4.8**	**6.6/7.8**	**6.2**	**3.1**	**8.4**	**8.8**	**7.7**	**9**	**9.7**
Building 157 & 159	MW00-04 (AP11 sampled 2014-17 as substitute)	GRO	2.2 mg/L	NI	NI	NI	NI	NI	NI	NI	**30**	**32.3**	**14.9**	2.05	**21.3**	NS	NS	**30**	NS-DAM	NS	NS	1.2	1.7	0.4
		DRO	1.5 mg/L	NI	NI	NI	NI	NI	NI	NI	8.6	3.94	4.21	0.741	1.28	NS	NS	6.2	NS-DAM	NS	NS	0.33	0.34	0.14
		BTEX	mg/L	NI	NI	NI	NI	NI	NI	NI	12.08	11.67	6.967	1.127	16.56	NS	NS	12.53	NS-DAM	NS	NS	0.016	0.228	0.0052
		Benzene	4.6 µg/L	NI	NI	NI	NI	NI	NI	NI	**480**	**260**	**116**	**15.86**	**95**	NS	NS	**25**	NS-DAM	NS	NS	0.63	0.56	ND
		TCE	2.8 µg/L	NI	NI	NI	NI	NI	NI	NI	ND	ND	ND	ND	ND	NS	NS	ND	NS-DAM	NS	NS	ND	ND	ND
Building 157 & 159	MW00-03	GRO	2.2 mg/L	NI	NI	NI	NI	NI	NI	NI	3.5	1.76	0.421	0.245	0.869	NS	NS	2.0	**8.5**	0.45	0.78	**3.2**	**4.6**	1.3
		DRO	1.5 mg/L	NI	NI	NI	NI	NI	NI	NI	13	1.87	0.457	0.604	0.789	NS	NS	0.43	1.3	0.27	0.48	1.5	0.58	0.39
		BTEX	mg/L	NI	NI	NI	NI	NI	NI	NI	ND	4.02268	0.02309	0.02797	0.17	NS	NS	0.412	1.32	0.127	0.16	0.664	0.78	0.32
		Benzene	4.6 µg/L	NI	NI	NI	NI	NI	NI	NI	ND	3.92	0.77	1.31	**7.56**	NS	NS	**11**	**28**	3.4	**5.4**	**19**	**7.2**	2.7
		TCE	2.8 µg/L	NI	NI	NI	NI	NI	NI	NI	ND	0.68	1.16	0.58	0.47	NS	NS	0.19	ND	0.27	ND	ND	ND	ND
		PFOA	0.4 µg/L																					**0.41**
		PFOS	0.4 µg/L																					**0.56**
Downgradient of Bldg 157 & 159 (betwn MW-202 & MW-628)	MW00-02	GRO	2.2 mg/L	NI	NI	NI	NI	NI	NI	NI	ND	0.482	0.252	0.112	0.348	NS	NS	0.33/0.31	0.57/0.54	0.5/0.37	0.17/0.19	0.2/0.18	0.16	0.18
		DRO	1.5 mg/L	NI	NI	NI	NI	NI	NI	NI	0.96	0.325	0.202	0.464	0.561	NS	NS	0.10/0.14	0.20/0.21	0.16/0.2	0.19/0.18	0.35/0.41	0.22	0.24
		BTEX	mg/L	NI	NI	NI	NI	NI	NI	NI	ND	0.00034	0.00023	0.00024	0.00058	0.00024/0.00047	0.00025/0.00087	0.00027/0.00023	0.00018/0.0002	0.0002/ND	ND	ND	ND	ND
		Benzene	4.6 µg/L	NI	NI	NI	NI	NI	NI	NI	ND	0.34	0.23	0.24	0.58	0.24/0.47	0.25/0.87	0.27/0.23	0.18/0.2	0.2/ND	ND	ND	ND	ND
		TCE	2.8 µg/L	NI	NI	NI	NI	NI	NI	NI	**25**	**12.8**	**8.68**	**5.21**	**4.05**	**3.4/4.1**	2.7/**4.1**	2.5	2.2/2.4	1.3/1.1	1.1/1.2	1.5	2	ND
Building 157 & 159	708	GRO	2.2 mg/L	NI	NI	NI	NS	NS	NS	NS	NS	**30.8/30.3**	**3.54/3.14**	0.103	6.32	NS	NS	**15**	**34**	NS	0.028	0.13/0.034	0.48/0.42	ND
		DRO	1.5 mg/L	NI	NI	NI	**2.8**	NS	**4.5**	NS	NS	3.54/3.71	0.428/0.388	0.0796	0.509	NS	NS	0.52	**1.6**	NS	0.024	0.16/0.15	0.067/0.092	0.05
		BTEX	mg/L	NI	NI	NI	3.29	NS	8.8	NS	NS	13.64/11.52	1.682/1.863	0.01408	3.291	NS	NS	6.32	11.7	NS	0.00274	0.0011/0.0084	0.124/0.106	ND
		Benzene	4.6 µg/L	NI	NI	NI	**68**	NS	**86**	NS	NS	**527/612**	**103/108**	0.3	**93**	NS	NS	**110**	**180**	NS	0.49	1.1/0.39	1.5/1.3	ND
		TCE	2.8 µg/L	NI	NI	NI	ND	NS	ND	NS	NS	ND/ND	ND/ND	ND	ND	NS	NS	ND	ND (0.25)	NS	ND	ND	ND	ND

Notes:

ND - not detected above method dete
PROD - product in well
NS - not sampled for specified analyte
NI - well not yet installed
DRO - diesel-range organics
TCE - trichloroethene
GRO - gasoline range organics
DAM - Damaged Well
* Result of Total Petroleum Hydrocarbon (TPH) analysis, not DRO analysis
mg/L - milligrams per liter
BTEX - benzene, toluene, ethylbenzene, and xylene
Multiple results have been reported at locations with field duplicates and lab split replicates.

Information Sources
1988 Results are from COE sampling at the Refueler Shop (Thomas, 1988)
1992 Results are from the SAIC RI (SAIC, 1993).
1993 results for B-02, B-06, 446, 447 are from the KSA RI/FS (EMCON, 1995a); Nov 1993 results for 135 are from the KSA LFI (EMCON, 1995b)
May 1994 Results for 628, 629 and 708 are from the KSA RI/FS (EMCON, 1995a); July 1994 Results for B-06, 135 and 447 are from the Final Trip Report for Groundwater Monitoring (EMCON, 1995c)
1996 results are from the Eskimo Creek Dump RI/FS (EMCON, 1996)
Aug 1997 results for 202, 135 and 628 are from the Zone 1 Monitoring Report (Bristol/OASIS, 1999c)
Sept 1997 results for B-02, B-06, 446, 447, 628, 629, and 708 are from the Zone 2 and 4 Intrinsic Remediation Study (Bristol/OASIS, 2000)
In 1997, MW-628 was sampled for both the Zone 2 and the Zone 1 investigation: results are reported as Zone 2/Zone 1
July 1998 results for 135 and 628 are from the Zone 1 Monitoring Report (Bristol/OASIS, 2000)
2000 Results are from the Final Report Groundwater Zone 2 2000 Sampling and Feasibility Study (Paug-Vik/OASIS, 2001)
2004 results are from the Final Report for Long-term Monitoring for Groundwater Zone 2 (OT022 and Eskimo Creek Dump - LF022) (Paug-Vik/OASIS, 2005)
2005 results are from the Final Report for Long-term Monitoring for Groundwater Zone 2 (OT022 and Eskimo Creek Dump - LF022) (Paug-Vik/OASIS, 2007)

Table 3-4: Historical Surface Water Results for Zone 2

Location ID	Analyte	Water Quality Criteria (mg/L)	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
OT28-01	Benzene	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Ethylbenzene	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Toluene	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0002	ND	ND	ND
	Xylenes	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	TCE	0.005	0.00175	0.00123	ND	ND	0.0027/0.0037	0.0018/0.0030	0.0017	0.00044	0.00094	0.00089	0.0021	0.0014	ND
OT28-02	Benzene	0.005	ND	ND	ND	ND	ND	ND	0.00014	ND	ND	ND	ND	ND	ND
	Ethylbenzene	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Toluene	1	ND	ND	ND	ND	ND	ND	ND	ND	0.00019	ND	ND	ND	ND
	Xylenes	10	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	TCE	0.005	ND	ND	0.00031	**0.0118**	0.00037	0.00069	0.00072	0.00093	0.00055	0.00017	0.00062	ND	ND
OT28-03	Benzene	0.005	ND	ND	ND	ND	NS	NS	ND	ND	ND	ND	ND	ND	ND
	Ethylbenzene	1	ND	ND	ND	ND	NS	NS	ND	ND	ND	ND	ND	ND	ND
	Toluene	1	ND	ND	ND	ND	NS	NS	ND	0.00034/0.00035	0.00034/0.00035	0.0021/0.0022	0.0004	0.00035	ND
	Xylenes	10	ND	ND	ND	ND	NS	NS	ND	ND	ND	ND	ND	ND	ND
	TCE	0.005	ND	ND	ND	ND	NS	NS	ND/0.00014	0.0025/0.0029	0.0045/0.0041	0.002/0.0017	ND	0.0017	ND

Notes: Results shown in **BOLD** indicate criteria exceedence.

ND - Not detected above method reporting limit.

3.4 ZONE 2 MNA EVALUATION

The COCs for Groundwater Zone 2, petroleum hydrocarbons and TCE, are both biologically degradable, but the biodegradation mechanisms are different. Petroleum hydrocarbons degrade both aerobically and anaerobically, whereas anaerobic conditions are generally considered a prerequisite for significant biodegradation of TCE.

3.4.1 Petroleum Hydrocarbon MNA

Two lines of evidence were evaluated for the Zone 2 A-Aquifer groundwater to determine whether intrinsic bioremediation of petroleum hydrocarbons is occurring: 1) decreasing or stable contaminant concentration trends and plume size and 2) groundwater geochemistry data.

3.4.1.1 2016 DRO/GRO/Benzene Plume Behavior

Table 3-3 presents a summary of historical and current DRO, GRO, BTEX, and TCE results from selected Zone 2 monitoring wells. Figure 3-1 shows DRO/GRO/BTEX results. A statistical analysis of petroleum analyte concentration trends can be found in section 3.4.3.

- In 2011-2012, detectable dissolved GRO encompassing monitoring well B-02 returned to levels last seen in 2004. The GRO concentration in 2013 decreased to 9.2 mg/L which is what it was in 2010. In 2014 and 2015, GRO again increased to 13 mg/L and 15 mg/L respectively. In 2016, GRO had once again decreased to 9.5 mg/L.
- After a decrease in 2011, GRO and BTEX concentrations in monitoring well MW-629 have again increased for the past five years.
- Benzene levels at MW-629 have been above cleanup levels since 2008. The 2016 benzene concentration of 0.047 mg/L is similar to the 2012-2015 detections.
- In 2010 and 2011, monitoring well 708 exceeded the RAO for benzene. The results for benzene from 2013 through 2015 were well below the cleanup level and non-detect in 2016.
- GRO has been detected above the cleanup level of 2.2 mg/L in the following monitoring wells: MW-629, B-02, and MW-708. MW-629 has shown an almost steady GRO concentration since 2011, with a recent high of 8.8 mg/L this year. Monitoring well 708 had more than twice the concentration of GRO in 2011 compared to 2010. In 2013-2015 the GRO concentration was below cleanup levels and non-detect in 2016.
- Benzene levels in B-02 were above the 0.0046 mg/L cleanup level between 2004 and 2010. B-02 and MW00-05, located near B-02, were both non-detect for benzene in 2001-2016.

3.4.1.2 Geochemical Parameters

DO levels measured using the low flow sampling protocol in the Zone 2 A-Aquifer monitoring wells ranged from 0.94 mg/L (in B-02) to 9.42 mg/L (in 708) (Figure 3-3). The area of depressed DO concentrations includes the area of detectable dissolved hydrocarbons shown in Figure 3-1. The area of depressed DO has decreased from what has been found previously. The overall pattern suggests that biodegradation of petroleum hydrocarbons in Groundwater Zone 2 is occurring.

A parameter closely associated with DO concentrations is redox potential. The Zone 2 redox potentials ranged from 215.9 mV in monitoring well MW00-05 to -4.8 mV in B-02. A correlation between reduced redox potentials and petroleum-contaminated areas was observed, especially at B-02. The redox data somewhat correlates with the DO data (i.e. wells with high DO also have positive redox potential, and vice versa).

Several inorganic analyses were performed to evaluate MNA of petroleum hydrocarbons at Groundwater Zone 2. A summary of Zone 2 A-Aquifer analytical data can be found in Table 3-5.

- Nitrate-nitrite was detected in all the sampled wells at concentrations between 0.029 mg/L (B-02) and 2.1 mg/L (708). Some wells that had nitrate-nitrite concentrations less than 1 mg/L also exhibited detectable dissolved hydrocarbons (Figure 3-1). This pattern suggests that nitrate reduction may be an important biodegradation mechanism for petroleum hydrocarbon contamination in Zone 2.
- Previous sulfate results suggested that sulfate reduction does not appear to be an important biodegradation mechanism for petroleum hydrocarbon contamination in Zone 2. Therefore, sulfate analysis was deleted from the sampling program in 2015.
- Manganese was detected in ten of the monitoring wells sampled in 2016, at concentrations ranging from 0.0086 mg/L to 5.1 mg/L (Figure 3-3). The inferred area where manganese concentrations exceed 1 mg/L is generally similar to the areas of increased hydrocarbon detections (Figure 3-1). This pattern suggests that petroleum hydrocarbons are being naturally attenuated in Zone 2.
- Ferrous iron was detected in eight of the monitoring wells at concentrations between 0.1 and 70 mg/L (Figure 3-3). The inferred area where ferrous iron concentrations exceed 1 mg/L generally correlates with the area of detectable dissolved hydrocarbons. This pattern suggests that petroleum hydrocarbons are being naturally attenuated in Zone 2.
- The absence of methane from previous sampling results indicated that methanogenesis is not a significant biodegration mechanism in Zone 2. Sampling for methane was discontinued in 2015.
- Alkalinity measurements ranged from 18 mg/L at 708 to 150 mg/L at MW-629. Generally, elevated petroleum hydrocarbon levels correlated with higher alkalinity concentrations.
- Conductivity ranged between 66 µS/cm and 293 µS/cm. Groundwater temperature ranged between 5.96 (MW-202) and 8.69 (MW00-05) degrees Celsius. Groundwater pH ranged between 5.27 (MW00-05) and 6.74 (MW-628). These groundwater environmental conditions (pH and temperature) are suitable for biodegradation to occur.

Table 3-5: Summary of Zone 2 A-Aquifer Analytical Data

Well Number	GRO (mg/L)	DRO (mg/L)	Benzene (mg/L)	Toluene (mg/L)	Total BTEX (mg/L)	TCE (mg/L)	PFOA/PFOS ug/L	Choride (mg/L)	Nitrate-Nitrite (mg/L)	Alkalinity (mg/L)	Fe (mg/L)	Mn (mg/L)	DO (mg/L)	ORP (mV)	pH
RAO	**2.2**	**1.5**	**0.0046**	**1.1**	**NA**	**0.0028**	**0.4**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
628	0.025/ND	0.033	ND	ND	ND	**0.011/0.0082**	0.31/0.033	3.6	0.031/0.03	72/73	0.4/0.34	1.7/1.6	0.95	43.9	6.74
202	ND	0.13	ND	ND	ND	ND	NA	3.1	0.024	140	70	3.9	1.3	30.9	5.9
B-02	**9.5/9.5**	**8.9/8.6**	ND	0.015/0.015	2.96/2.79	**0.015/0.012**	NA	4.1/4.2	0.029/0.028	120/130	19	3.3	0.94	-4.8	6.25
MW00-05	0.27	0.37	ND	ND	ND	**0.006**	NA	2.6	1.2	40	ND	0.059	5.93	215.9	5.27
446	ND	0.13	ND	ND	ND	**0.0057**	NA	3.5	0.58	32	ND	ND	8.55	207.3	5.9
447	ND	0.34	ND	ND	ND	**0.0031**	NA	2.5	0.55	54	0.1	0.063	4.09	92.5	5.82
629	**8.8**	0.58	**0.047**	0.8	2.97	**0.0097**	NA	2.6	0.51	150	4.6	5.1	1.17	26.4	5.99
MW00-03	1.3	0.39	0.0027	ND	0.32	ND	**0.41/0.56**	2.9	1.2	81	2	1.7	4.73	101.7	5.67
MW00-02	0.18	0.24	ND	ND	ND	ND	NA	2.7	1.4	65	ND	0.26	5.09	110.7	5.72
AP-11	0.4	0.14	ND	ND	0.0052	ND	NA	2.1	0.83	40	1.6	0.75	6.67	98.1	5.57
708	ND	0.05	ND	ND	ND	ND	NA	2.4	2.1	18	ND	0.0086	9.42	67.6	5.28

NA - Not Applicable
ND - Not detected above method reporting level (MRL)
RAO - Remedial Action Objectives
Primary/Duplicate Sample Result (MW00-02 and 708)
BOLD results are above RAO

3.4.2 TCE Reductive Dechlorination at Zone 2

As explained in section 1.15, the dominant TCE intermediate daughter product generated by reductive dechlorination is usually DCE. In 2016, DCE was not detected in any of the monitoring wells at Zone 2. This suggests that either reductive dechlorination is not occurring at this site or that DCE is quickly being degraded to carbon dioxide. This could occur if the redox environment varies throughout the aquifer (reductive dechlorination where the aquifer is reducing and aerobic degredation of DCE where more oxidized), or if the aquifer is just reduced enough to allow reductive dechlorination. In any case, the decreasing trend of TCE concentrations discussed in the next section suggest that TCE is degrading at this site so some reductive dechlorination or some other TCE degradation process must be occurring.

3.4.3 DRO, GRO, Benzene and TCE Concentration Trends

ProUCL software, Version 5.1 was used to assess DRO, GRO, benzene, and TCE concentration trends for ten monitoring wells. Output from this program can be found in Appendix E.

Table 3-7 and Table 3-8 summarize the concentration trends observed in the monitoring wells. The tables list the numbers of wells exhibiting a specific concentration trend for each analyte. Well location data sets which did not have the minimum number of four observations, or where the results were all below the detection limit for a specific analyte, are not included in the trend summary table. Note that 29% of the concentration trends were decreasing and 3% were increasing. There was no trend for 68%. This analysis supports the conclusion that intrinsic remediation is keeping contaminant concentrations stable or decreasing at this site.

Table 3-6 Zone 2 Mann-Kendall Analysis Summary

Trend	Benzene	DRO	GRO	TCE	% of Total
Decreasing	2	3	0	5	29%
Increasing	0	0	1	0	3%
No Trend	3	7	9	4	68%
Totals	5	10	10	9	34

Table 3-7 Zone 2 Mann-Kendall Trend Summary

Site Area	Well	Benzene	DRO	GRO	TCE
Building 149	B-02	NT	NT	**I**	**D**
Near Eskimo Creek	MW-628	N/A	NT	NT	NT
Near Eskimo Creek	MW-202	N/A	NT	NT	NT
Building 149	MW00-05	N/A	**D**	NT	D
Building 149	MW-446	N/A	NT	NT	**D**
Building 157 and 159	MW-447	N/A	NT	NT	NT
Building 157 and 159	MW-629	**D**	**D**	NT	NT
Building 157 and 159	MW-708	**D**	**D**	NT	N/A
Downgradient of Building 157 and 159	MW00-03	NT	NT	NT	D
Downgradient of Building 157 and 159	MW00-02	NT	NT	NT	**D**

D- Decreasing
NT – No Trend
I - Increasing
N/A – Not applicable due to insufficient data or no detectable concentrations

3.5 ZONE 2 CONCLUSIONS

3.5.1 Petroleum Hydrocarbons

Two of the eleven Zone 2 monitoring well samples exceeded cleanup levels for GRO and one for DRO. One well exceeded cleanup level for benzene, three for ethylbenzene, and two for xylenes. Monitoring data from 1997 through 2016 suggest the presence of a stable or decreasing benzene plume near and downgradient of Buildings 157/159.

The lines of evidence indicating that intrinsic bioremediation is occurring in Groundwater Zone 2 fuel hydrocarbon plumes include stable or decreasing contaminant concentrations over time, decreasing plume sizes, and changes in the groundwater geochemistry within the petroleum hydrocarbon impacted areas.

There were no BTEX constituents detected in the surface water samples.

3.5.2 TCE

TCE was detected in six monitoring wells above the cleanup level of 2.8 µg/L. Detected TCE concentrations have declined or remained relatively stable since 2007. The highest TCE value detected in 2016 was 15/12 µg/L at B-02.

TCE was not detected in any of the surface water samples. The only surface water detection was cis-1,2-Dichloroethene in OT28-03 at 4 µg/L.

Intrinsic remediation of the Groundwater Zone 2 TCE plume is suggested by the declining and stable TCE concentration trends. Potential mechanisms for the intrinsic remediation include the non-biological processes of dilution, dispersion, volatilization, or sorption and the biological processes of reductive dechlorination or cometabolic biodegradation.

The absence of daughter products (primarily DCE) in samples from the Zone 2 monitoring wells suggest that biologically-mediated reductive dechlorination is not a significant attenuation process, the intrinsic remediation may be resulting primarily from non-biological processes, or TCE may be reductively dechlorinating to DCE which is then rapidly oxidized to carbon dioxide. Cometabolic biodegradation of TCE would also be consistent with the absence of daughter products.

3.5.3 PFOA/PFOS

MW00-03 exceeded the ADEC criteria 0.40 µg/L for PFOA and PFOS at 0.41 µg/L and 0.56 µg/L respectively. PFOA and PFOS were also detected in MW-628 at concentrations below the criteria.

3.5.4 Institutional Control Inspection

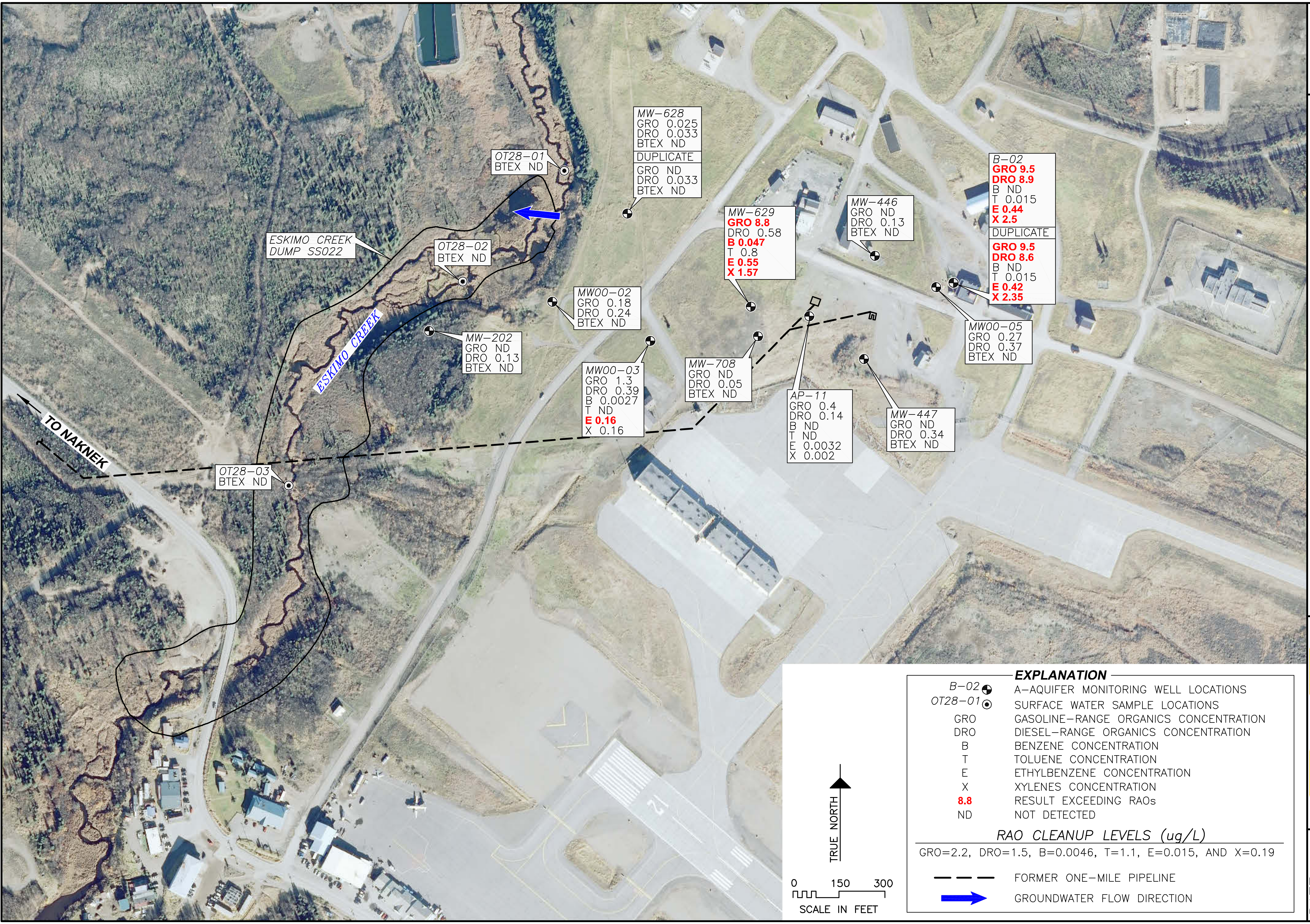
There were no observations of IC noncompliance in Zone 2.

3.5.5 Condition of Wells

All wells scheduled for sampling in Zone 2 were sampled and in good condition.

3.6 ZONE 2 RECOMMENDATIONS

- The use of the “10X Rule” used to develop cleanup levels listed in the Final Zone 2 ROD is no longer used by ADEC. The cleanup levels in the ROD should be addressed in the next 5 Year Review, to reflect current regulatory cleanup levels.
- Sampling for PFOA and PFOS should continue at MW00-03.
- Because 1,4-Dioxane was not detected in the two A-Aquifer monitoring wells sampled for this year or in 2015, sampling of 1,4-Dioxane is no longer required.



PATH: D:\16 Dwgs\16 PV\16039 KS LTM RPT FILE: 16-KS-LTM-RPT-F3-1.DWG PLOT: 5/17/18.

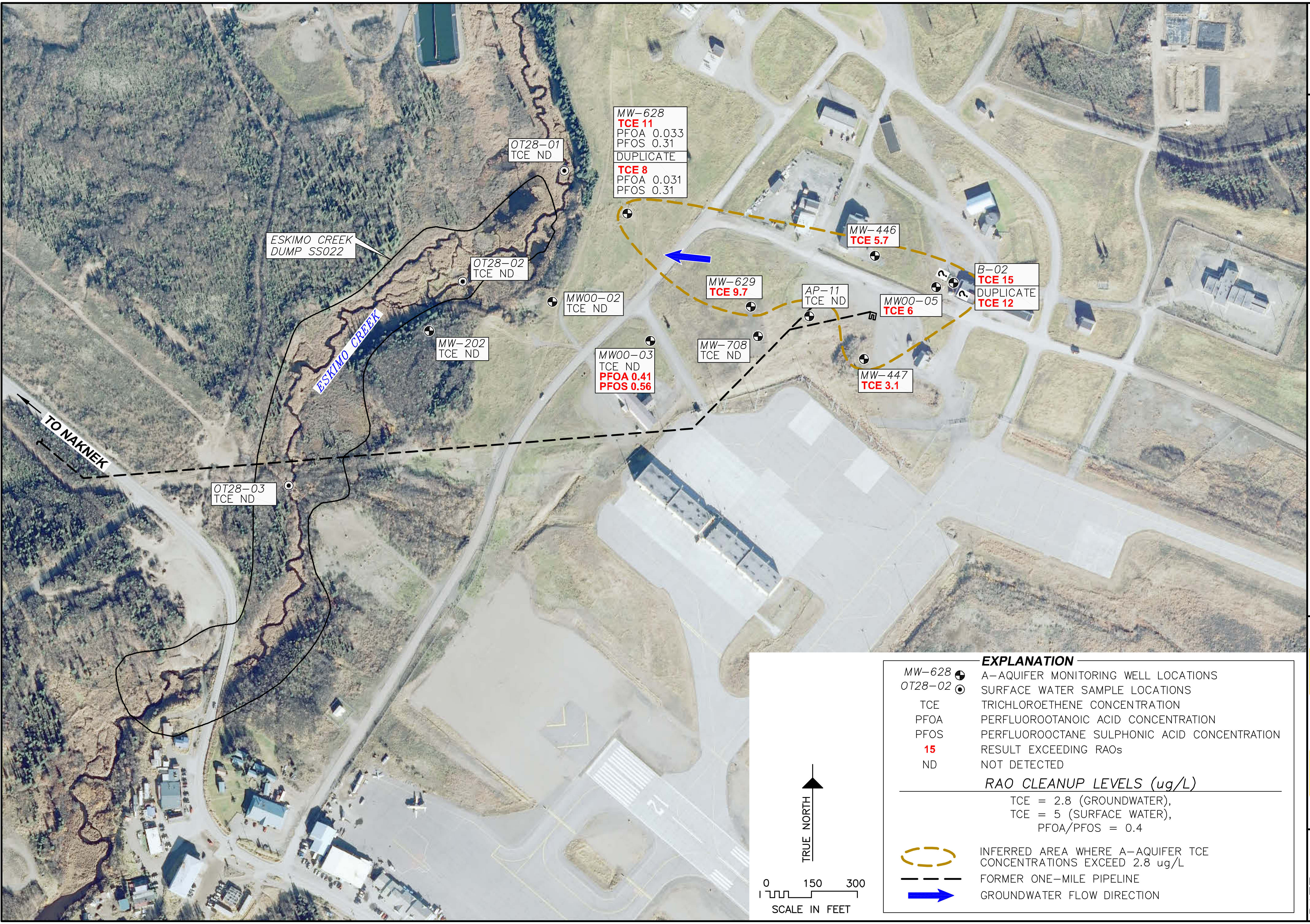
FIGURE
3-1

GROUNDWATER GRO, DRO, AND BTEX ANALYTICAL RESULTS GROUNDWATER ZONE 2

GROUNDWATER ZONE 2 (OT–028)
2016 LONG TERM MANAGEMENT
King Salmon Divert, Alaska

PACIFIC AIR FORCES REGIONAL SUPPORT CENTER
& AIR FORCE CIVIL ENGINEERING CENTER
JBER, ALASKA

DATE
MAY 2018
CHKD
H.L.H.
DRAWN
C.E.H.
PROJ. NO
16039



EXPLANATION

MW-628 ⊕	A-AQUIFER MONITORING WELL LOCATIONS
OT28-02 ⊙	SURFACE WATER SAMPLE LOCATIONS
TCE	TRICHLOROETHENE CONCENTRATION
PFOA	PERFLUOROOTANOIC ACID CONCENTRATION
PFOS	PERFLUOROOCTANE SULPHONIC ACID CONCENTRATION
15	RESULT EXCEEDING RAOs
ND	NOT DETECTED

RAO CLEANUP LEVELS (ug/L)

TCE = 2.8 (GROUNDWATER),
TCE = 5 (SURFACE WATER),
PFOA/PFOS = 0.4

⬭	INFERRED AREA WHERE A-AQUIFER TCE CONCENTRATIONS EXCEED 2.8 ug/L
— —	FORMER ONE-MILE PIPELINE
→	GROUNDWATER FLOW DIRECTION

FIGURE
3-2

GROUNDWATER AND SURFACE WATER TCE, PFOA, AND PFOS ANALYTICAL RESULTS GROUNDWATER ZONE 2

GROUNDWATER ZONE 2 (OT-028)
2016 LONG TERM MANAGEMENT
King Salmon Divert, Alaska

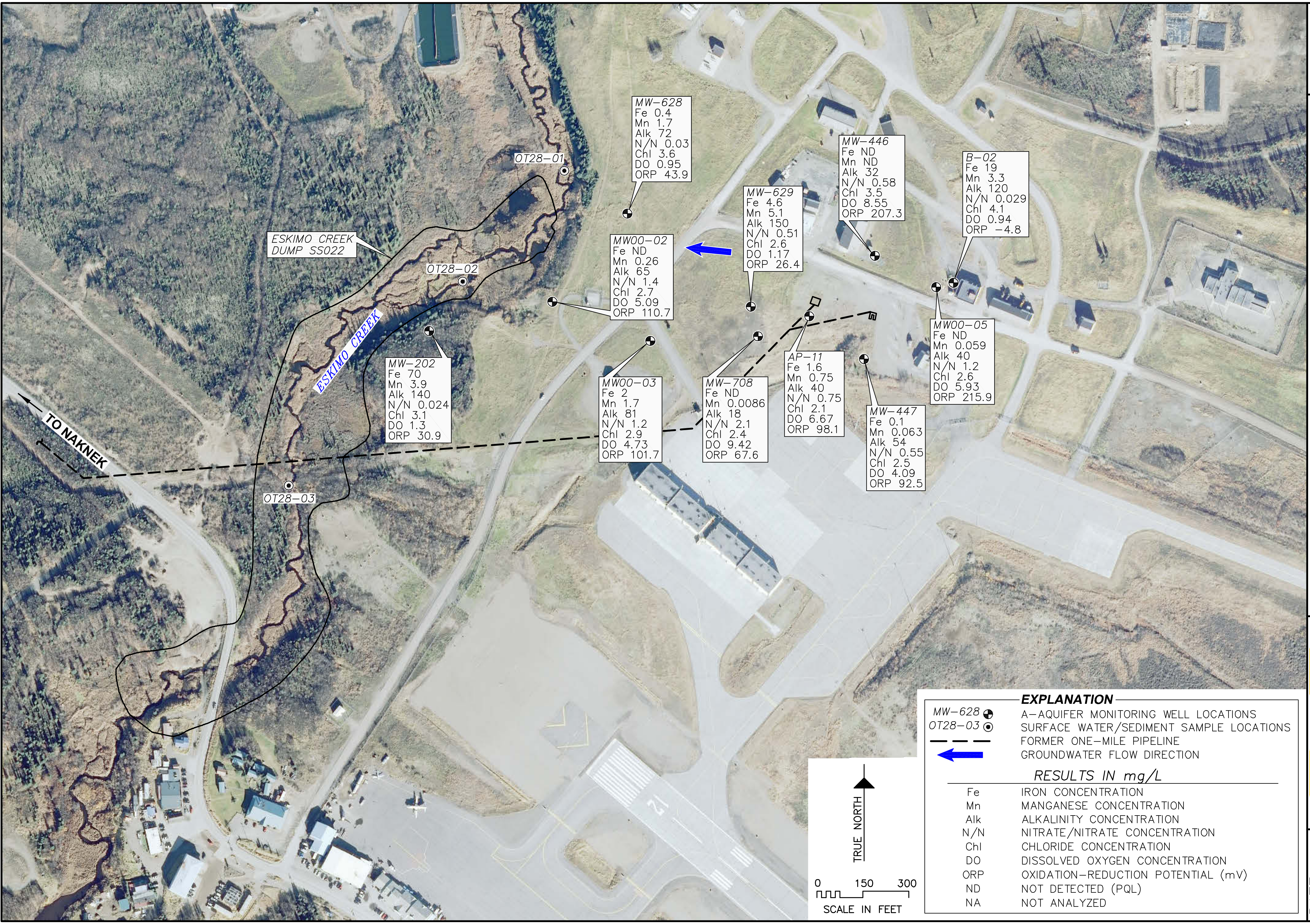
PACIFIC AIR FORCES REGIONAL SUPPORT CENTER
& AIR FORCE CIVIL ENGINEERING CENTER
JBER, ALASKA

DATE
MAY 2018
CHKD
H.L.H.
DRAWN
C.E.H.
PROJ. NO
16039

PATH: D:\16 Dwgs\16 PV\16039 KS LTM RPT FILE: 16-KS-LTM-RPT-F3-2.DWG PLOT: 15/17/18.

MONITORED NATURAL ATTENUATION RESULTS GROUNDWATER ZONE 2

GROUNDWATER ZONE 2 (OT-028)
2016 LONG TERM MANAGEMENT
King Salmon Divert, Alaska



EXPLANATION

MW-628 ◆	A-AQUIFER MONITORING WELL LOCATIONS
OT28-03 ⊙	SURFACE WATER/SEDIMENT SAMPLE LOCATIONS
— — —	FORMER ONE-MILE PIPELINE
←	GROUNDWATER FLOW DIRECTION

RESULTS IN mg/L

Fe	IRON CONCENTRATION
Mn	MANGANESE CONCENTRATION
Alk	ALKALINITY CONCENTRATION
N/N	NITRATE/NITRATE CONCENTRATION
Chl	CHLORIDE CONCENTRATION
DO	DISSOLVED OXYGEN CONCENTRATION
ORP	OXIDATION-REDUCTION POTENTIAL (mV)
ND	NOT DETECTED (PQL)
NA	NOT ANALYZED

PACIFIC AIR FORCES REGIONAL SUPPORT CENTER
& AIR FORCE CIVIL ENGINEERING CENTER
JBER, ALASKA

DATE FEB. 2017
CHKD H.L.H.
DRAWN C.E.H.
PROJ. NO 16039

PATH: D:\16 Dwgs\16 PV\16039 KS LTM RPT FILE: 16-KS-LTM-RPT-F3-3.DWG PLOT: 2/17/17.

4 ZONE 3 – NORTH & SOUTH BLUFFS

The North Bluff (LF005) and South Bluff (LF014) sites (Groundwater Zone 3 – OT029) are former drum disposal sites at KSD. In accordance with the ERP, the 611 CES has implemented a Post-Closure Monitoring Plan (PCMP) for these sites. The primary PCMP objectives are to evaluate the effectiveness of closure actions at the Bluff sites, provide compliance with the requirements of the *Record of Decision for Final Remedial Action North Bluff (LF005) and South Bluff (LF014) Groundwater Zone 3 (OT029*) (Paug-Vik/OASIS, 2000b), and provide an early warning system for detecting contaminant releases from the North and South Bluff landfill sites.

This report addresses post-closure activities that include South Bluff groundwater and surface water monitoring, North and South Bluffs' landfill inspections, and inspection, maintenance, and sampling activities for the South Bluff Treatment System (SBTS).

The revised protocol for Zone 3, North and South Bluff recommends groundwater and surface water sampling for all locations at a minimum of every 5 years. Comprehensive sampling was conducted in 2014.

Annual sampling at South Bluff well points SWP-9, -10, and -11, and four surface water locations (SS-8, -9, -10, -11) situated below the SBTS was conducted between 2008 through 2012. No contaminants exceeded the ADEC cleanup criteria. According to the *Explanation of Significant Differences for North & South Bluff, Groundwater Zone 3, King Salmon Air Station, Alaska (USAF, 2005),* if three consecutive sampling rounds show that the contaminant concentrations are below the ADEC cleanup standards, then sampling frequency should be reduced to once every three years. However, they were included in the 2014 and 2015 sampling event, and again in 2016.

The inspection and maintenance program of the Bluffs is performed in accordance with the Final Operation, Monitoring, and Maintenance Manual, North and South Barrel Bluffs (Hart Crowser, 2000), except as specified in the 2016 work plan. In 2005, the EPA, ADEC, and the Air Force agreed to modify the inspection and monitoring frequency to quarterly instead of monthly and to reconfigure the SBTS to bypass the treatment system and discharge water directly to the leach field. Based on past monitoring results, recommendations from the 2013 Comprehensive Monitoring Report (Paug-Vik, 2014c), and Explanation of Significant Difference, sampling was not conducted at the South Bluff Treatment System in 2014. Sampling at the South Bluff Treatment System was resumed in 2015.

Details of the history of this site can be found in the North and South Bluffs Final Monitoring Report (PDC, 2006). The most recent results for the Bluffs can be found in Final 2014 Long Term Monitoring Report (Paug-Vik, 2015c) and Final 2015 Long Term Monitoring Report (Paug-Vik, 2016) for the South Bluff only.

The Air Force has contracted through the Corps of Engineers to complete an Explanation of Significant Difference for Zone 3.

4.1 REMEDIAL ACTION OBJECTIVES FOR SOUTH BLUFF

The RAOs for the Bluffs are set "to restore groundwater to drinking water quality standards, restore surface water to water quality standards, protect human and ecological receptors from unacceptable exposure to contaminated water..." A table of chemical-specific RAOs is not provided in the ROD.

In the *Statistical Analysis of Sampling Events, Revision of Post-Closure Monitoring Plan* (Bristol/OASIS, 1999b), COPCs were defined as all compounds detected above either regulatory criteria or ecological (non-regulatory) screening criteria. Compounds for which no screening criteria were available were also retained as COPCs. The COPCs are listed as Tables 1 and 2 in the ROD (provided on the attached DVD). Cleanup criteria were defined as either primary or secondary criteria. Primary criteria are regulatory criteria, and secondary criteria are non-regulatory screening criteria. Secondary criteria were only employed if primary criteria were not available for a specific analyte.

The primary criteria for evaluating analyte concentrations are ADEC 18 AAC 75 for groundwater (amended through July 2017) and 18 AAC 70 (amended through February 2017) for surface water, and 18 AAC 80 for drinking water (amended through February 2017). Human-health and ecological screening criteria are also used to evaluate analytical results and are presented in Tables 4-1and 4-2. If an analyte is not included on the ADEC standards, then the most conservative (e.g., lowest value) U.S. Environmental Protection Agency (USEPA) current Regional Screening Level (for humans based on ADEC screening requirements of a Hazard Quotient (HQ) = 0.1 and cancer risk 1 × 10-6) or Oak Ridge National Laboratory (ORNL) value (for ecological receptors) is selected as the secondary evaluation criteria for that analyte.

Table 4-1. Groundwater Quality Criteria

Analyte	Primary Criteria*	Screening Criteria*
	ADEC 18 AAC 75 Table C Groundwater Cleanup Levels^A mg/L	EPA Regional Screening Levels^B Tap Water mg/L
Bulk Hydrocarbons		
Diesel Range Organics	1.5	--
Metals		
Arsenic	0.00052	0.000052
Barium	3.8	0.38
Cadmium	0.0092	0.00092
Chromium (VI)	0.00035	0.000035
Iron	--	1.4
Lead	0.015	0.015
VOCs		
1,2-Dichloroethane	0.0017	0.00017
Methylene Chloride	0.11	0.011
Toluene	1.1	0.11
Trichloroethene	0.0028	0.00028
PAHs		
Benzo(a)anthracene	0.00012	0.000030
Benzo(a)pyrene	0.000034	0.000025
Benzo(b)fluoranthene	0.00034	0.00025
Benzo(g,h,i)perylene	0.00026	--
Benzo(k)fluoranthene	0.00080	0.0025
Chrysene	0.0020	0.025
Dibenzo(a,h)anthracene	0.000034	0.000025
Indeno(1,2,3-cd)pyrene	0.00019	0.00025
Pyrene	0.12	0.012
Pesticides		
Endrin	0.0023	0.00023
Endrin Aldehyde	--	--
Methoxychlor	0.037	0.0037
Other		
Nitrogen, Nitrate-Nitrite	10	$NO_3 = 3.2$, $NO_2 = 0.20$

NOTES:

A = ADEC 18 AAC 75 Table C Groundwater Cleanup Levels (as amended through November 6, 2016), except for nitrate-nitrite which are ADEC 18 AAC 80 Drinking Water MCLs (as amended through May 20, 2011).

B = USEPA Regional Screening Levels for Chemical Contaminants at Superfund Sites (TR=1E-06 ,THQ=0.1)(June 2017).

* Remedial Action Objectives are from the ROD. See text for further explanation.

-- No criteria exist for the analyte specified

mg/L = milligrams per liter or parts per million

Table 4-2. Surface Water Quality Criteria

Analyte	Primary Criteria*	Human-Health Screening Criteria*		Ecological Screening Criteria*			
	ADEC 18 AAC 70 Water Quality Standards^A mg/L	EPA National Recommended Water Quality Criteria^B mg/L	EPA Regional Screening Levles^C (Tap Water) mg/L	ORNL Surface Water PRGs for Ecological Endpoints^D mg/L	EPA OSWER Surface Water Threshold Values (EcoTox)^E mg/L	EPA Region IV Chronic Surface Water Screening Values^F mg/L	NOAA SQuiRTs Surface Water Quality Criteria^G mg/L
Bulk Hydrocarbons							
Diesel Range Organics	**	--	--	--	--	--	--
Metals/Other Inorganics							
Barium	2	1	0.38	0.004	0.0039	--	0.0039
Iron	1	0.3	1.4	--	--	1	1
Arsenic	0.05	0.000018	0.000052	--	0.19	0.19	
Cadmium	0.000094	--	0.00092		0.00113		0.25
Chromium (VI)	0.024 ^{H}	0.011 (eco)	0.000035	--	0.18	0.207	
Lead	0.00054^H	0.0025 (eco)	0.015	--	0.0025	0.00318	0.0025
VOCs							
Benzene	0.005	0.0006	0.00046				
1,2,-Dichlorobenzene	0.6	2.7	0.030	--	--	--	0.0007
1,3,-Dichlorobenzene	--	0.32	--	--	--	--	0.038
1,4,- Dichlorobenzene	0.075	0.4	0.00048	--	--	--	0.0094
Naphthalene	0.012		0.00017				
Toluene	1	1.3	0.11	0.0098	0.13	0.175	0.002
Pesticides							
Endrin Aldehyde		0.00029	--				
Endosulfan I		0.062	0.010				0.028

NOTES:

A = ADEC Water Quality Standards 18 AAC 70, as amended through February, 2017.

B = USEPA National Recommended Water Quality Criteria (as amended in 2004).
Human health criteria are based on the consumption of water and organism, and 10^{-6} carcinogenic risk.

C = USEPA Regional Screening Levels for Chemical Contaminants at Superfund Sites (TR=1E-06 ,THQ=0.1)(June 2017).

D = Oak Ridge National Laboratory (ORNL) Tier II Secondary Chronic Surface Water Benchmarks; from http://risk.lsd.ornl.gov/homepage/eco_tool.shtml.

E = USEPA Office of Solid Waste and Emergency Response (OSWER) Ecotox Thresholds (January, 1996); from http://risk.lsd.ornl.gov/homepage/eco_tool.shtml.

F = USEPA Region IV Chronic Surface Water Screening Benchmarks; from http://risk.lsd.ornl.gov/homepage/eco_tool.shtml.

G = NOAA SQuiRTs Surface Waters/Fresh/Chronic

H = Chromium and lead criteria are hardness-dependent; the value shown is for hardness of 25 mg/L as $CaCO_3$. Maximum allowable metals concentration increases with increasing water hardness.

-- = No criteria exist for the analyte specified

mg/L = milligrams per liter or parts per million

* = Remedial Action Objectives are from the ROD. See text for further explanation.

** No numeric standards exist for Diesel Range Organics; however, the following standards apply to hydrocarbons in surface water:
They may not cause a visible sheen upon the surface of the water, and may not exceed concentrations that individually, or in combination impart odor or taste as determined by organoleptic tests (18 AAC 70).

4.2 PROJECT TASKS

4.2.1 Groundwater Sampling Program

Sampling activities included the collection of three South Bluff groundwater samples from the A-Aquifer well points located in wetlands below the South Bluff Treatment System Figure 4-1.

A list of the sample identification numbers and analytical parameters for each sample location is provided in Table 4-3: South Bluff Groundwater Sample Analyses Summary. Data collected from each monitoring well, including field measurement information, were documented on the Groundwater Sample Data Sheets, which are provided in Appendix A.

4.2.2 Surface Water Sampling Program

Surface water samples were collected from four South Bluff locations in the wetland areas below the South Bluff Treatment System as shown on Figure 4-1. Table 4-3 includes a complete list of surface water analytical methods. Data collected at each sample location were documented on Surface Water Sample Data Sheets, which are provided in Appendix A.

4.2.3 South Bluff Treatment System Sampling Program and Inspection

An annual inspection was done at the SBTS and Lift Station on November 17, 2016. Inspections activities are summarized on the Inspection Form in Appendix B.

Quarterly influent samples were collected from the lift station on November 17, 2016, March 26, May 11, and June 27, 2017, after both lift station pumps were replaced. Table 4-4 includes a complete list of analytical methods.

4.2.4 Annual Inspection

Slopes, vegetation, erosion-control features, culverts, downdrains, toe roads, and access roads at the North and South Bluffs are inspected on an annual basis. The last inspection occurred on September 23, 2016.

- There were no observations of rill or channel erosion or sliding of the cap and/or underlying materials taking place.
- All the downdrains and culverts were inspected. The wetland sides of many of the North Bluff culverts are being overgrown by grass. Three culverts required work to remove root mats to allow drainage.
- Gabions were placed along King Salmon Creek at the South Bluff site to provide stability and erosion protection to the stream bank. Approximately six gabions are out of alignment, and the stream bank

beneath the gabions has been undercut due to high water levels in King Salmon Creek. A gabion near the lift station appears to have slid further toward King Salmon Creek, but it is not yet in the creek.

- Toe roads and access roads were designed to provide vehicle access to both the North Bluff and South Bluff for maintenance purposes. Vegetation (mainly alder) along toe and access roads needs to be trimmed to improve visibility and access, and to prevent vegetation growth in the roadbed. Alder is beginning to grow on the South Bluff road. Some was trimmed to allow access by truck. Most of the North Bluff roads are now impassable by truck and difficult to walk in a few sections due to overgrown alder.

- The heat terrace control box for downdrain 2 was destroyed. A few control box posts at culverts are becoming jacked out of the ground and leaning.

4.2.5 Institutional Control Inspection

The goals of ICs are to restrict site access, prevent the installation of drinking-water wells, and minimize direct exposure to subsurface debris. Specifically, excavation into or construction within 50 feet of the landfill boundaries will be restricted and the installation of drinking water wells will be prohibited within 100 feet of the landfill boundary.

A visual inspection was performed to verify that no water wells have been installed or that no soil excavation has been conducted within the specified boundaries.

The barrier fence and snow fence were inspected for unauthorized access to the North and South Bluffs. While the barrier fence is adequate in preventing access, the snow fence needs repairs most years. Approximately 100 feet of snow fencing is down at the North Bluff, and 50 feet of the fencing has been destroyed by ATV accessing the area.

4.2.6 Work Plan Deviations

There were no deviations from the work plan.

Table 4-3: South Bluff Sample Analyses Summary

Location ID Sample Point	Comments	Matrix	Location Type	EPA Method 8260B/ VOCs	Alaska Method AK 102/DRO	EPA Method 8081A Pesticides	EPA Method 8082 PCBs	EPA Method 6020 Pb only (dissolved)	Total Organic Carbon 9060A	Sample Number
South Bluff A-Aquifer										
SWP-9	Well Point	Groundwater	WP	1	1	1	1	1	1	16KS3ZSWP09-111WG
SWP-10	Well Point	Groundwater	WP	1	1	1	1	1	1	16KS3ZSWP10-112WG
SWP-11	Well Point	Groundwater	WP	1	1	1	1	1	1	16KS3ZSWP11-113WG
Filed Duplicate	Well Point	Groundwater	WP	1	1	1	1	1	1	16KS3ZSWP13-114WG
MS/MSD	Well Point	Groundwater	WP	2	2	2	2	2	2	16KS3ZSWP09-111WG
Zone 3 Surface Water										
SS-7		Surface Water	SW	1	1	1	1	1	1	16KS3ZSS07-111WS
SS-8		Surface Water	SW	1	1	1	1	1	1	16KS3ZSS08-112WS
SS-9		Surface Water	SW	1	1	1	1	1	1	16KS3ZSS09-113WS
SS-10		Surface Water	SW	1	1	1	1	1	1	16KS3ZSS10-114WS
Filed Duplicate		Surface Water	SW	1	1	1	1	1	1	16KS3ZSS11-115WS
MS/MSD		Surface Water	SW	2	2	2	2	2	2	16KS3ZSS09-113WS
QA/QC										
Project Trip Blanks	Trip Blank	Water	QA/QC	4						16KS3ZTB-MMDD
SAMPLE ANALYSES TOTAL				**17**	**13**	**13**	**13**	**13**	**13**	

Table 4-4: South Bluff Treatment System Sample Analyses Summary

			Analytical Methods						
Month/Year	Sample Point	Comment	VOCs EPA Method 8260B	GRO Method AK 101	DRO Method AK 102	PAH EPA Method 8270 SIM	PCBs & Pesticides EPA Method 8081A/8082	Metals EPA Method 6020/7470	Sample Number
November 2016	Influent	Primary Sample	1	1	1	1	1	1	16KSSBTS1117IN01
Mar-17	Influent	Primary Sample	1	1	1	1	1	1	17KSSBTSINF-0326
May-17	Influent	Primary Sample	1	1	1	1	1	1	17KSSBTSINF-0511
Jun-17	Influent	Primary Sample	1	1	1	1	1	1	17KSSBTSINF-0627
-	-	Trip Blank	4	4					1XKSSBTS-TBMMDD
WATER ANALYSES TOTALS			**8**	**8**	**8**	**8**	**8**	**8**	

4.3 ZONE 3 FINDINGS

The complete analytical results of the Zone 3 sampling are presented in Appendix C, Zone 3 Tables. Laboratory analytical reports can be found on the attached DVD-R. Sampling results are summarized below.

4.3.1 A-Aquifer

Groundwater samples were collected from three A-Aquifer well points at the South Bluff site. The samples were submitted to Test America in Sacramento for analyses by methods listed in Table 4-3: South Bluffs Groundwater Sample Analyses Summary.

Table 4-5 presents a summary of analytical detections in the South Bluff A-Aquifer groundwater samples. A comprehensive list of analytical results is included in Appendix C. There were no detections of PCBs, pesticides, or lead in any of the samples.

- DRO was detected in all three well points at concentrations between 0.058 mg/L and 0.081 mg/L, which are below the ADEC groundwater cleanup level of 1.5 mg/L. DRO was also detected in the equipment blank at 0.048 mg/L.
- Total Organic Carbon (TOC) ranged between 5.4 and 9.2 mg/L.

Table 4-5 Summary of Zone 3 South Bluff A-Aquifer Analytical Data

	Sample Location		**SWP-9**	**SWP-10**	**SWP-10(D)**	**SWP-11**	**Equipment Blank**
Analyte	**RAO**	**Units**					
Lead	10	µg/L	ND	ND	ND	ND	ND
TOC	N/A	mg/L	5.4	9	9.2	8.7	ND
DRO	1.5	mg/L	0.072	0.058	0.061	0.081	0.048
PCBs	0.5	µg /L	ND	ND	ND	ND	ND
4,4'-DDE	2.5	µg /L	ND	ND	ND	ND	ND
4,4'-DDT	2.5	µg /L	ND	ND	ND	ND	ND
Aldrin	0.05	µg /L	ND	ND	ND	ND	ND

ND - Not Detected
NA - Not Analyzed
N/A – Not applicable.
RAO - Remedial Action Objective

4.3.2 Surface Water

Surface water samples were collected from four locations at the South Bluff site. The samples were submitted to Test America in Sacramento for analyses by methods listed in Table 4-3: South Bluff Surface Water Sample Analyses Summary. A comprehensive list of analytical results is included in Appendix C.

Table 4-6 presents a summary of the surface water analytical result at the South Bluff site. There were no PCBs, pesticides, or lead detected in any of the samples.

- DRO was detected at all locations at levels between 0.03 mg/L to 0.065 mg/L.
- Total Organic Carbon (TOC) ranged between 1.9 and 7.5 mg/L.

Table 4-6 Summary of South Bluff Surface Water Analytical Data

Sample Location			SS-7	SS-7 (D)	SS-8	SS-9	SS-10
Analyte	**Screening Levels**	**Units**					
Lead	54	µg/L	ND	ND	ND	ND	ND
TOC	N/A	mg/L	1.9	2.0	5.9	2.8	7.5
DRO	*	mg/L	0.03	0.03	0.037	0.034	0.065
PCBs	**		ND	ND	ND	ND	ND
Pesticides	**		ND	ND	ND	ND	ND

ND - Not Detected
TOC – Total Organic Carbon
* No numeric standards exist for Diesel Range Organics; however, the following standards apply to hydrocarbons in surface water: They may not cause a visible sheen upon the surface of the water, and may not exceed concentrations that individually, or in combination impart odor or taste as determined by organoleptic tests (18 AAC 70).
** - No Screening levels listed because all analytes were ND.

4.3.3 South Bluff Treatment System

Quarterly samples collected from the South Bluff Treatment System lift station. The samples were submitted to Test America in Sacramento for analyses by methods listed in Table 4-4.

Tables 4-7, 4-8, 4-9, and 4-10 present a summary of the quarterly SBTS sampling results. Arsenic was detected above the effluent limitation of 0.52 µg/L in June 2017. Low levels of GRO were detected in November 2016, and low levels of DRO were detected in May and June 2017. Various pesticides were detected in March and May 2017 below the effluent limitations. A comprehensive list of all analytical results is included in Appendix C, Table C-40.

4.3.4 Condition of Well Points

The three well points scheduled for Zone 3 sampling were in good condition.

Table 4-7
Laboratory Analytical Results for November 2016
South Bluff Treatment System, King Salmon Alaska

Sample Identification				
Analytical Parameters	EPA Method	Units	Effluent Limitation (Note 1)	Influent Sample 16KSSBTS1117IN01
VOCs	8260B	ug/L	2.8	TCE - ND
GRO	AK 101	mg/L	2.2	0.016
DRO	AK 102	mg/L	1.5	ND
PAH	8270 SIM	mg/L		ND
Metals	6020	ug/L	0.52 3,800 9.2 0.35 300 (Note 2) 15	Arsenic - ND Barium - 3.6 Cadmium - ND Chromium - ND Iron -30 Lead - ND
PCBs/Pesticides	8081/8082	ug/L	Varies	ND

Sampling was performed November 17, 2016

Legend:
VOC's - Volatile Organic Compounds
GRO - Gasoline Range Organics
DRO - Diesel Range Organics
PAH - Polynuclear Aromatic Hydrocarbons
PCBs - Polychlorinated Biphenyls
TCE - Trichloroethene
ND - None Detected
mg/L - milligrams per liter
ug/L - micrograms per liter

Notes:
1. Effluent limitations are based on Table C, Groundwater Cleanup Levels, 18 AAC 75
2. Effluent limitations for iron based on secondary MCL, 18 AAC 80.

Table 4-8
Laboratory Analytical Results for March 2017
South Bluff Treatment System, King Salmon Alaska

Sample Identification			Effluent Limitation (Note 1)	Influent Sample 17KSSBTSINF-0326
Analytical Parameters	EPA Method	Units		
VOCs	8260B	ug/L	2.8	ND
GRO	AK 101	mg/L	2.2	ND
DRO	AK 102	mg/L	1.5	ND
PAH	8270 SIM	mg/L	0.15	1-Methylnaphthalene - 0.0032
Metals	6020	ug/L	0.52 3,800 9.2 0.35 300 (Note 2) 15	Arsenic - ND Barium - 4.1 Cadmium - ND Chromium - ND Iron -ND Lead - 1.0
PCBs/Pesticides	8081/8082	ug/L	3.5 ug/L 0.053 ug/L 2.3 ug/L	4,4-DDD - 0.0016 Dieldrin - 0.001 Endrin aldehyde - 0.026

Sampling was performed March 26, 2017.

Legend:
VOC's - Volatile Organic Compounds
GRO - Gasoline Range Organics
DRO - Diesel Range Organics
PAH - Polynuclear Aromatic Hydrocarbons
PCBs - Polychlorinated Biphenyls
TCE - Trichloroethene
ND - None Detected
mg/L - milligrams per liter
ug/L - micrograms per liter

Notes:
1. Effluent limitations are based on Table C, Groundwater Cleanup Levels, 18 AAC 75
2. Effluent limitations for iron based on secondary MCL, 18 AAC 80.

Table 4-9
Laboratory Analytical Results for May 2017
South Bluff Treatment System, King Salmon Alaska

Sample Identification			Effluent Limitation (Note 1)	Influent Sample 17KSSBTSINF-0511
Analytical Parameters	EPA Method	Units		
VOCs	8260B	ug/L	2.8	ND
GRO	AK 101	mg/L	2.2	ND
DRO	AK 102	mg/L	1.5	0.2
PAH	8270 SIM	mg/L	varies	ND
Metals	6020	ug/L	0.52 3,800 9.2 0.35 300 (Note 2) 15	Arsenic - ND Barium - 3.9 Cadmium - ND Chromium - ND Iron -ND Lead - ND
PCBs/Pesticides	8081/8082	ug/L	3.5 2.5 2.3	4,4-DDD - 0.0011 4,4-DDT - 0.0011 Endrin aldehyde - 0.0031

Sampling was performed May 11, 2017.

Legend:
VOC's - Volatile Organic Compounds
GRO - Gasoline Range Organics
DRO - Diesel Range Organics
PAH - Polynuclear Aromatic Hydrocarbons
PCBs - Polychlorinated Biphenyls
TCE - Trichloroethene
ND - None Detected
mg/L - milligrams per liter
ug/L - micrograms per liter

Notes:
1. Effluent limitations are based on Table C, Groundwater Cleanup Levels, 18 AAC 75
2. Effluent limitations for iron based on secondary MCL, 18 AAC 80.

Table 4-9
Laboratory Analytical Results for May 2017
South Bluff Treatment System, King Salmon Alaska

Sample				
Identification			Effluent Limitation (Note 1)	Influent Sample 17KSSBTSINF-0511
Analytical Parameters	EPA Method	Units		
VOCs	8260B	ug/L	2.8	ND
GRO	AK 101	mg/L	2.2	ND
DRO	AK 102	mg/L	1.5	0.2
PAH	8270 SIM	mg/L	varies	ND
Metals	6020	ug/L	0.52 3,800 9.2 0.35 300 (Note 2) 15	Arsenic - ND Barium - 3.9 Cadmium - ND Chromium - ND Iron -ND Lead - ND
PCBs/Pesticides	8081/8082	ug/L	3.5 2.5 2.3	4,4-DDD - 0.0011 4,4-DDT - 0.0011 Endrin aldehyde - 0.0031

Sampling was performed May 11, 2017.

Legend:
VOC's - Volatile Organic Compounds
GRO - Gasoline Range Organics
DRO - Diesel Range Organics
PAH - Polynuclear Aromatic Hydrocarbons
PCBs - Polychlorinated Biphenyls
TCE - Trichloroethene
ND - None Detected
mg/L - milligrams per liter
ug/L - micrograms per liter

Notes:
1. Effluent limitations are based on Table C, Groundwater Cleanup Levels, 18 AAC 75
2. Effluent limitations for iron based on secondary MCL, 18 AAC 80.

Table 4-10
Laboratory Analytical Results for June 2017
South Bluff Treatment System, King Salmon Alaska

Sample Identification			Effluent Limitation (Note 1)	Influent Sample 17KSSBTSINF-0627
Analytical Parameters	EPA Method	Units		
VOCs	8260B	ug/L	2.8	ND
GRO	AK 101	mg/L	2.2	ND
DRO	AK 102	mg/L	1.5	0.09
PAH	8270 SIM	mg/L		ND
Metals	6020	ug/L	0.52 3,800 9.2 0.35 300 (Note 2) 15	Arsenic - **1.8** Barium - 3.9 Cadmium - ND Chromium - ND Iron -ND Lead - ND
PCBs/Pesticides	8081/8082	ug/L	Varies	ND

Sampling was performed June 27, 2017.

Legend:
VOC's - Volatile Organic Compounds
GRO - Gasoline Range Organics
DRO - Diesel Range Organics
PAH - Polynuclear Aromatic Hydrocarbons
PCBs - Polychlorinated Biphenyls
TCE - Trichloroethene
ND - None Detected
mg/L - milligrams per liter
ug/L - micrograms per liter

Notes:
1. Effluent limitations are based on Table C, Groundwater Cleanup Levels, 18 AAC 75
2. Effluent limitations for iron based on secondary MCL, 18 AAC 80.

4.4 ZONE 3 CONCLUSIONS

Low levels of DRO were detected in all of the wellpoint and surface water samples. Detections ranged from 0.3 mg/L to 0.08 mg/L. DRO was also detected in the equipment blank at 0.048 mg/L.

Lead, PCBs, and Pesticides were not detected any of the samples.

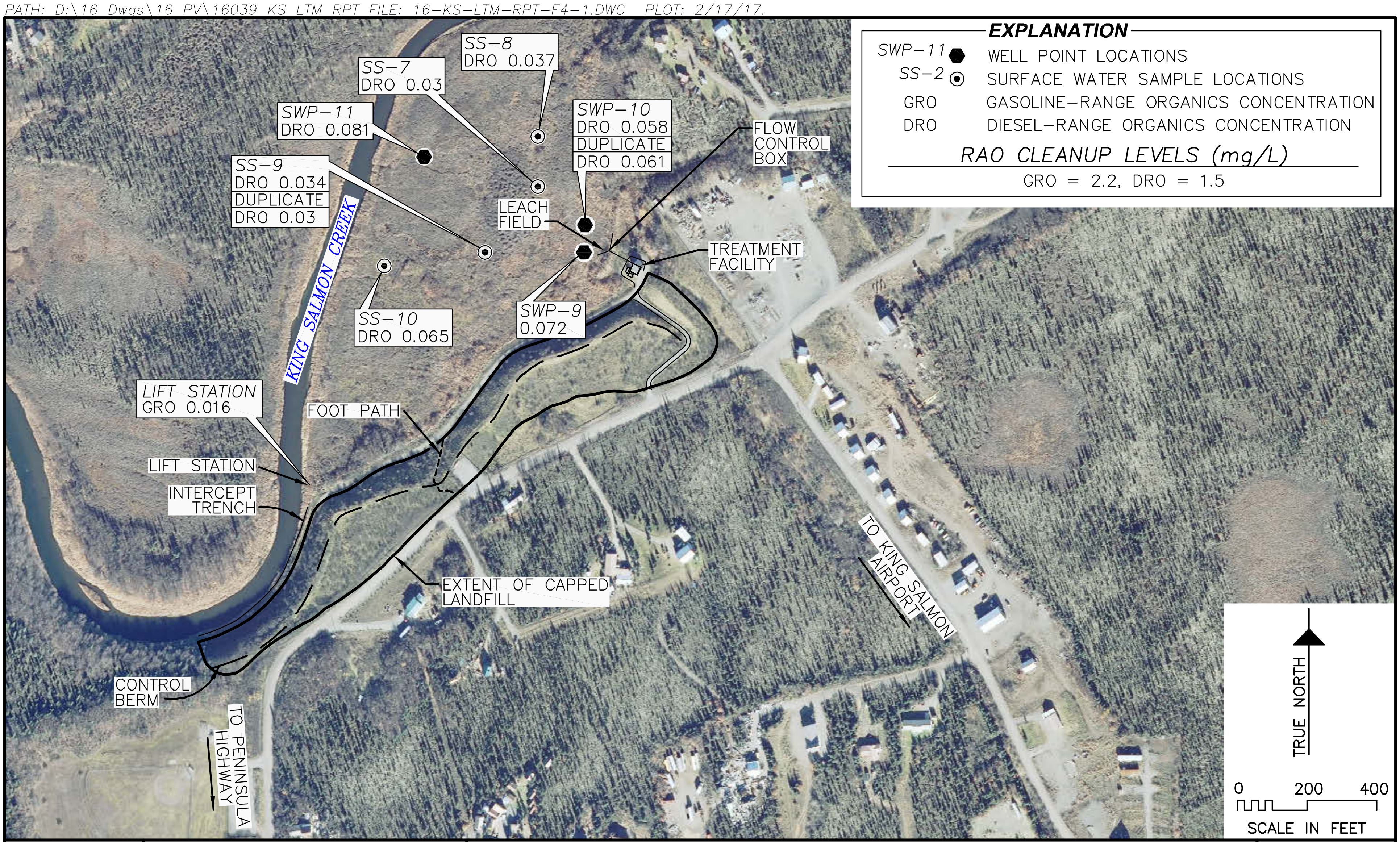
Low levels of GRO, DRO, and various pesticides were detected in the SBTS quarterly samples collected at the lift station. The only exceedance for the effluent limitation was arsenic in the June 2017 sample.

There were no observations of drinking water wells or excavations out of compliance with institutional controls listed in the ROD.

4.5 ZONE 3 RECOMMENDATIONS

- Sampling at the North and South Bluffs should be reduced to once every five years in coordination with the Five Year Review. The next complete sampling event for the North and South Bluffs should be planned for 2019.
- Recent high water levels in King Salmon Creek have caused bank erosion below approximately eight gabions pulling them out of alignment and towards the creek. This section of gabions should be monitored for any erosion. The location is several hundred feet downstream from the South Bluff lift station.
- Overgrown alder should be cleared from the access roads at the North and South Bluffs.
- The Air Force should discuss security options at the North Bluff site with ADEC and the public at the next RAB meeting.

PATH: D:\16 Dwgs\16 PV\16039 KS LTM RPT FILE: 16-KS-LTM-RPT-F4-1.DWG PLOT: 2/17/17.



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C.E.H.

PROJ. NO
16039

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JBER, ALASKA

GROUNDWATER GRO AND DRO ANALYTICAL RESULTS GROUNDWATER ZONE 3

GROUNDWATER ZONE 3 – SOUTH BLUFF
2016 LONG TERM MANAGEMENT
King Salmon Divert, Alaska

FIGURE
4-1

EXPLANATION

C–2	CULVERT LOCATION AND NUMBER
DD–2	DOWNDRAIN LOCATION AND NUMBER

NOTE: SOURCE OF CULVERT AND DOWNDRAIN LOCATIONS TAKEN FROM FINAL OPERATION, MONITORING, AND MAINTENANCE MANUAL, NORTH AND SOUTH BLUFFS, HART CROWSER, 2000.

FIGURE

4-2

SOUTH BLUFF
CULVERT AND DOWNDRAIN LOCATIONS

GROUNDWATER ZONE 3 (OT–029)
2016 LONG TERM MANAGEMENT
King Salmon Divert, Alaska

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EXPLANATION

C-2	CULVERT LOCATION AND NUMBER
DD-2	DOWNDRAIN LOCATION AND NUMBER

NOTE: SOURCE OF CULVERT AND DOWNDRAIN LOCATIONS TAKEN FROM FINAL OPERATION, MONITORING, AND MAINTENANCE MANUAL, NORTH AND SOUTH BLUFFS, HART CROWSER, 2000.

FIGURE
4-3

NORTH BLUFF
CULVERT AND DOWNDRAIN LOCATIONS

GROUNDWATER ZONE 3 (OT-029)
2016 LONG TERM MANAGEMENT
King Salmon Divert, Alaska

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5 ZONE 4 – NAKNEK RIVER STORAGE

Long-term monitoring at Zone 4 is performed in accordance with the *Record of Decision for Final Remedial Action at Naknek River Storage Site, Landfill No. 5, and Zone 4 Groundwater* (USAF, 1999). The purpose of this long-term monitoring program is to ensure that the selected remedies presented in the ROD are implemented properly and are effective.

5.1 DESCRIPTION OF CURRENT STUDY

The primary objective of this project is to determine the status of the groundwater contaminant plumes and to ensure that intrinsic remediation is addressing the groundwater, surface water, sediment, and soil contamination. B-Aquifer sampling was also performed in Groundwater Zone 4 to determine if this drinking water aquifer has suffered any negative impacts.

Petroleum hydrocarbon and VOC concentrations are monitored to evaluate the groundwater, surface water, and sediment contaminant plumes for possible trends and changes in the size of the contaminant plumes. The loss of contaminant plume mass may also be used as evidence for intrinsic remediation by biodegradation. Additionally, groundwater geochemical data are collected as a second line of evidence in the evaluation of intrinsic remediation by biodegradation.

Additional project objectives included the completion of annual landfill inspection for visual monitoring of Landfill No. 5 and maintenance of the product recovery system.

5.2 REMEDIAL ACTION OBJECTIVES FOR ZONE 4

Groundwater Zone 4 cleanup levels were developed in accordance with the ADEC contaminated site regulations found in 18 AAC 75. Direct application of the ADEC Table C cleanup levels was used for all groundwater cleanup levels. The B-Aquifer groundwater is assessed using the Alaska Drinking Water Standards (18 AAC 80). Groundwater and surface water cleanup levels for contaminants specified in the ROD and current ADEC cleanup levels are presented in Table 5-1.

Because sediment cleanup levels are not provided in the AWQS (18 AAC 70), ORNL sediment quality benchmarks, EPA (OSWER) Sediment Screening Benchmarks, and NOAA SQuiRTs Sediment Screening Values were used to provide screening levels for analytical results. The ORNL sediment quality benchmarks were taken from *Toxicological Benchmarks for Screening for Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision*. Please note that these screening values are not meant to represent cleanup levels, but instead provide guidance for data quality objectives and provide a basis on which to evaluate the analytical results. Sediment sampling began after the ROD was signed, and thus no sediment COCs are specified by the ROD. The compounds listed in Table 5-2 were chosen for their common appearance at fuel spill sites and knowledge of site activities.

Table 5-1 Remedial Action Objectives (RAOs) for Zone 4

		Screening Concentrations					
Media	Contaminants of Concern	Ecological Risk-Based RG	Human Health Risk-Based RG[a]	ARARs		Cleanup Levels from Final ROD	Current ADEC Cleanup Levels
				RG	Basis		
A-Aquifer and	Benzene	NC	NC	0.005	ADWS	0.005	0.0046
B-Aquifer	Toluene	NC	NC	1.0	ADWS	1.0	1.1
Groundwater	TCE	NC	NC	0.005	ADWS	0.005	0.0028
(mg/L)	GRO	NC	NC	1.3	18 AAC 75	1.3[d]	2.2
	DRO	NC	NC	1.5	18 AAC 75	1.5[d]	1.5
Free Product				No Free Product	18 AAC 75	No Free Product	No Free Product
Surface Water	TAH (BTEX)[b]	NC	NC	0.01	AWQS	0.01	
(mg/L)	TAqH (BTEX+PAH)[c]	NC	NC	0.015	AWQS	0.015	
	DRO	NC	NC	NONE	N/A	N/A	

[a] Concentrations based on 10^{-5} risk

[b] TAH are defined as the sum of BTEX compounds

[c] TAqH are defined as the sum of TAH plus PAHs, as detected by EPA Method 610. The list of PAHs includes: naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,I)perylene.

[d] Basis for the GRO cleanup level is the final ROD and DRO cleanup levels is ADEC Table C.

Definitions:

ADWS - Alaska Drinking Water Standards (18 AAC 80)
TCE – Trichloroethene
DRO - Diesel-range organics
TAqH - Total aqueous hydrocarbons (BTEX + PAH)
PAH - Polynuclear aromatic hydrocarbons
AWQS - Alaska Water Quality Criteria (18 AAC 70)
RG - Remediation goal
FP – Free product indicated
TAH - Total aromatic hydrocarbons (BTEX)
BTEX - Sum of benzene, toluene, ethylbenzene, and xylene isomers
NC - Not calculated. Either not a primary risk contributing chemical for this pathway or the chemical was not detected

Table 5-2 Sediment Benchmark Screening Levels for Groundwater Zone 4

		Screening Criteria	
Media	Contaminants of Concern	Ecological Risk-Based RG	Basis
	Benzene	0.057	OSWER
	Toluene	0.050	ORNL
	Ethylbenzene	0.004*	NOAA
Sediment	Xylene	0.025	OSWER
(mg/Kg)	TCE	0.041*	NOAA
	Benzo(a)anthracene	0.01572	NOAA
	Benzo(a)pyrene	0.0324	NOAA
	Benzo(b)fluoranthene	NA	
	Benzo(k)fluoranthene	0.0272	NOAA
	Indeno(1,2,3-cd)pyrene	0.01732	NOAA
	Naphthalene	0.01465	NOAA

The list of PAHs includes: naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,I)perylene.

Also note: DRO detections in surface water and sediments are not addressed in this table, because there are no cleanup levels applicable for bulk hydrocarbons in surface water or sediments.

*Apparent Effects Threshold level for exposure in marine environments. Freshwater values are not available.

Definitions:

OSWER – EPA OSWER Sediment Screening Benchmark
NOAA – NOAA SQuiRT Sediment Screening Value

5.3 PROJECT TASKS

5.3.1 Zone 4 Groundwater Sampling

Groundwater samples were collected from three A-Aquifer monitoring wells and two B-Aquifer monitoring wells (Figure 5-1) in September 2016. A list of the sample identification numbers and analytical parameters for each A-Aquifer sample location is provided in Table 5-3. A list of sample identification numbers and analytical parameters for each B-Aquifer sample is provided in Table 5-4. Data collected from each monitoring well, including field measurement information, were documented on the Groundwater Sample Data Sheets, which are provided in Appendix A.

5.3.2 Residential Well Sample Collection

Five residential well samples were collected from the kitchen faucet (King and Marsh), or outdoor hose bib (Smith, Bowers, and King Apartments). Data collected from each residential well were documented on Groundwater Sample Data Sheets (Appendix A). A list of the sample identification numbers and analytical parameters for each residential well sample is shown in Table 5-4.

5.3.3 Surface Water/Sediment Sample Collection

Surface water/sediment sample pairs were collected from three locations in Groundwater Zone 4 as shown on Zone 4 Figure 5-3. Table 5-5 includes a complete list of surface water/sediment pair locations and analytical methods. Data collected at each sample location were documented on Surface Water and Sediment Data Sheets, which are provided in Appendix A.

Table 5-3: Zone 4, A-Aquifer Sample Analyses Summary

			Analytical Methods								
Location ID Sample Point	Matrix	Location Type	EPA Method 8260B VOCs	Alaska Method AK 101 GRO	Alaska Method AK 102 DRO	EPA Method 2320B Alkalinity	EPA Method 9056 Chloride & Sulfate	EPA Method 353.2 Nitrate + Nitrite	EPA Method 6020 Fe and Mn (dissolved)	RSK175 Methane	Sample ID
MW-57	Groundwater	Monitoring Well	Not sampled due to product in well.								
MW-51	Groundwater	Monitoring Well	1	1	1	1	1	1	1	1	16KS4ZMW51-110WG
502	Groundwater	Well Point	1	1	1	1	1	1	1	1	16KS4ZWP502-112WG
MW-62	Groundwater	Monitoring Well	1	1	1	1	1	1	1	1	16KS4ZMW62-113WG
Duplicate Sample	Groundwater	Well Point	1	1	1	1	1	1	1	1	16KS4ZWP801-114WG
MS/MSD	Groundwater	Monitoring Well	2	2	2	2	2	2	2	2	16KS4ZMW51-110WG
Trip Blanks	Water	QA/QC	2	2							16KS4ZTB-MMDD
TOTAL SAMPLES			**8**	**8**	**6**	**6**	**6**	**6**	**6**	**6**	

Table 5-4: Zone 4, B-Aquifer and Residential Well Sample Analyses Summary

				Analytical Methods			
Location ID Sample Point	Comments	Matrix	Location Type	EPA Method 524.2 VOCs	Alaska Method AK 101 GRO	Alaska Method AK 102 DRO	Sample Number
B-Aquifer Sample Locations							
506		Groundwater	B-Aquifer	1	1	1	16KS4Z506-101WG
MW97-9		Groundwater	B-Aquifer	1	1	1	16KS4ZMW979-102WG
MW97-9(D)	Duplicate	Groundwater	B-Aquifer	1	1	1	16KS4ZFARLEY-103WG
506	MS/MSD	Groundwater	B-Aquifer	2	2	2	16KS4Z506-101WG
Residential Wells							
SMITH		Groundwater	Residential Well				16KS4ZSMITH-104WG
KING		Groundwater	Residential Well	1	1	1	16KS4ZKING-105WG
BOWERS		Groundwater	Residential Well	1	1	1	16KS4ZBOWERS-106WG
KING APARTMENTS		Groundwater	Residential Well	1	1	1	16KS4ZKINGAPTS-107WG
MARSH		Groundwater	Residential Well				16KS4ZMARSH-108WG
Trip Blank		Water	QA/QC	2	2		16KS4ZTB-MMDD
Sample Totals				**12**	**10**	**8**	

Table 5-5: Zone 4, Surface Water/Sediment Sample Analysis Summary

				Analytical Methods					
Location ID Sample Point	Comments	Matrix	Location Type	EPA Method 8260B VOCs	EPA Method 5035A/ 8260B VOCs-LL	Alaska Method AK 101 GRO	Alaska Method AK 102 DRO	EPA Method 8270 SIM PAHs	Sample Number
OT30-01		Surface Water	Surface Water	1		1	1	1	16KS4ZOT301-101WS
OT30-03		Surface Water	Surface Water	1		1	1	1	16KS4ZOT303-102WS
OT30-04		Surface Water	Surface Water	1		1	1	1	16KS4ZOT304-103WS
OT30-05	Duplicate	Surface Water	Surface Water	1		1	1	1	16KS4ZOT305-104WS
OT30-01	MS/MSD	Surface Water	Surface Water	2		2	2	2	16KS4ZOT301-101WS
Trip Blank		Water	QA/QC	1		1			16KS4ZTB-MMDD
OT30-01		Sediment	Sediment	1	1	1	1	1	16KS4ZOT301-201SE
OT30-03		Sediment	Sediment	1	1	1	1	1	16KS4ZOT303-202SE
OT30-04		Sediment	Sediment	1	1	1	1	1	16KS4ZOT304-203SE
OT30-05	Duplicate	Sediment	Sediment	1	1	1	1	1	16KS4ZOT305-204SE
OT30-05	MS/MSD	Sediment	Sediment	2	2	2	2	2	16KS4ZOT301-201SE
LL Trip Blank		Water	QA/QC		1				16KS4ZTB-MMDD
Sed Trip Blank		MeOH & Sand	QA/QC	1		1			16KS4ZTB-MMDD
Surface Water and Sediment Sample Totals				**14**	**7**	**14**	**12**	**12**	

Notes:

Method 8260B-LL (low level) for sediment samples analyzed using a low level technique requiring samples be frozen for preservation.

5.3.4 Landfill Cap Inspection Activities

Slopes, vegetation, and erosion-control features at Zone 4 sites LF008 and SS012 were inspected on September 23, 2016. The document entitled *Final Operation, Monitoring, and Maintenance Manual, North and South Barrel Bluffs, King Salmon, Alaska* (Hart Crowser, 2000) was used as a guide for the inspection activities performed at the landfill.

5.3.5 Product Recovery System

The Zone 4 product recovery system is located at a seep down gradient of the former bulk fuel storage area (Figure 5-2). It consists of an impermeable fabric barrier that directs groundwater flow to a manhole containing absorbent pillows. As the water passes through the manhole, the absorbent pillows remove product. The product recovery system replaced a French drain system, which was located upgradient of the present system.

On October 4, 2016, two absorbent pillows in the product recovery system were replaced. There was some petroleum odor and a small amount of product present in the pillows, but they were mostly saturated with water.

5.3.6 Work Plan Deviations

MW-57 was not sampled due to 0.05 feet of product present in the well.

5.4 ZONE 4 FINDINGS

5.4.1 Field-Measured Parameters

While collecting groundwater samples from monitoring wells, several water-quality parameters were recorded to determine groundwater consistency and characteristics relevant to assessing intrinsic remediation. Field measurements can be found on the sample data sheets for Zone 4 in Appendix A and in Table 5-6.

Free Product: Free product found was found only in MW-57. Free product had been found in MW-57 in 2011-2013, 2015, and 2016, but not in 2014.

Temperature: Groundwater temperatures measured in the A-Aquifer wells at the end of September were between 7.27 and 8.96˚C. These temperatures are suitable for biodegradation processes.

pH: Measurements were between 5.71 and 6.61 pH units. These levels are suitable for biodegradation processes.

Conductivity: The conductivity measurements for Zone 4 wells and wells points ranged from 120 to 161 micro Siemens per centimeter (µS/cm).

Dissolved Oxygen: DO levels ranged from 0.61 mg/L to 0.84 mg/L (Figure 5-4). Comparison of previous DO concentrations indicate that areas with elevated petroleum hydrocarbons in Groundwater Zone 4 generally have depressed DO levels (<2.0 mg/L).

The depression of DO levels in relation to the known areas of contamination suggests that microbiological activity is consuming the available DO as a terminal electron acceptor during the metabolism of fuel hydrocarbon compounds. The correlation between depleted DO levels and elevated petroleum hydrocarbon concentrations is a strong indication that aerobic biodegradation of the dissolved hydrocarbons has occurred and continues to occur at this site.

5.4.2 A-Aquifer Analytical Results

Table 5-6 presents a summary of 2016 analytical results. Table 5-7 presents the historical and current sample analytical results with the appropriate RAOs for comparison. Appendix C, Zone 4 Tables, provides a complete list of the Zone 4 A-Aquifer analytical results and all detected analytes for the Zone 4 A-Aquifer analyses.

5.4.2.1 GRO and DRO

The petroleum hydrocarbon levels (GRO and DRO) detected in Zone 4 groundwater are shown on Figure 5-1. Monitoring wells MW-51 and MW-62, exceeded the RAO of 2.2 mg/L for GRO. Monitoring wells 502 and MW-51 exceeded the RAO of 1.5 for DRO. Overall, GRO concentrations ranged from 1.7 to 2.8 mg/L, and DRO concentrations ranged from 0.35 to 2.5 mg/L.

5.4.2.2 BTEX and TCE

The benzene, toluene, ethylbenzene, total xylenes, total BTEX, and TCE levels detected in groundwater are shown on Figure 5-2. The results from all three of the A-Aquifer monitoring wells sampled were above the RAO of 15 µg/L for ethylbenzene. Ethylbenzene concentrations ranged from 28 to 96 µg/L. Total xylene concentrations exceed the RAO of 190 µg/L in monitoring wells MW-51 and 502. Their concentrations were 660 µg/L and 260 µg/L, respectively. The RAOs for benzene, toluene, and TCE were not exceeded in any of the sampled Zone 4 wells. MW-502 had a benzene concentration 0.0036 mg/L. Total BTEX concentrations ranged from 0.085 mg/L (MW-62) to 0.822 mg/L (MW-51). TCE was not detected in any of the wells sampled.

5.4.2.3 1,2,4-Trimethylbenzene

The results from all three of the A-Aquifer monitoring wells sampled were above the RAO of 15 µg/L for 1,2,4-Trimethylbenzene. Concentrations for MW-51, MW-62, and 502 were 230, 62, and 20 µg/L, respectively.

5.4.2.4 Naphthalene

The results from all three of the A-Aquifer monitoring wells sampled were above the RAO of 1.7 µg/L for naphthalene. Concentrations ranged from 2.9 to 120 µg/L .

5.4.2.5 Inorganics

Various geochemical indicators important for assessing aerobic biodegradation of fuel hydrocarbons were measured to evaluate if intrinsic remediation is taking place.

- Nitrate-nitrite as nitrogen was detected at low levels in all three wells sampled, at concentrations ranging from 0.009 to 0.015 mg/L. These results are similar to past results which have not shown a correlation between contamination levels and nitrate-nitrite concentrations. Current and past nitrate-nitrite results would suggest nitrate reduction is not a significant biodegradation mechanism for petroleum hydrocarbon contamination in Zone 4.
- Sulfate concentrations were 0.16 to 0.78 mg/L. Sulfate reduction does not seem to be a significant biodegradation mechanism in Zone 4.
- Ferrous iron concentrations ranged from 6.8 mg/L in MW-51 to 31 mg/L in 502. Generally, ferrous iron concentrations greater than 1.0 mg/L can be used as an indicator that aerobic biodegradation is occurring.
- Manganese concentrations ranged from 2.8 mg/L in 502 to 3.4 mg/L in MW-51. Manganese concentrations are generally higher in wells with increased levels of DRO and GRO.
- Methane concentrations ranged from 0.49 mg/L in MW-51 to 20 mg/L in 502. The presence of methane is evidence that intrinsic bioremediation of the fuel hydrocarbons is occurring.
- Alkalinity measurement for MW-51 was 93 mg/L, and generally, elevated petroleum hydrocarbon levels correlate with increased alkalinity concentrations. The lab did not run alkalinity analysis for MW-62 and 502 even though it was submitted.

Table 5-6: Summary of Zone 4 A-Aquifer Analytical Results

Well	GRO (mg/L)	DRO (mg/L)	Benzene (mg/L)	Toluene (mg/L)	Total BTEX (mg/L)	TCE (mg/L)	Chloride (mg/L)	Nitrate-Nitrite (mg/L)	Sulfate (mg/L)	Alkalinity (mg/L)	Ferrous Iron (mg/L)	Manga-nese (mg/L)	Methane (mg/L)	DO (mg/L)	ORP (mV)	Temp (°C)	pH	Conduc-tivity (µs/cm)
RAO	**2.2**	**1.5**	**0.005**	**1**	**NA**	**0.005**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**			**NA**		
502	1.7	**1.6**	0.0036	ND	0.287	ND	1.5	0.009	0.21		31	2.8	20.0	0.84	45.9	8.4	5.71	158
MW-51	**2.8**	**2.5**	0.00014	0.066	0.822	ND	2.1	0.015	0.78	93	6.8	3.4	0.49	0.74	-7.3	7.27	6.28	161
MW-57	**PRO**	**PRO**	**PRO**	**PRO**	**PRO**	**PRO**	**PRO**	**PRO**	**PRO**	**PRO**	**PRO**	**PRO**	**PRO**	**PRO**	**PRO**	**PRO**	**PRO**	**PRO**
MW-62	**2.2**/2.0	0.35/0.38	0.00045/ 0.00041	0.00066 / 0.00062	0.089/ 0.085	ND	1.8	0.009/0.01	0.16		7.3/7.5	3.1/3.2	5.7/5.4	0.61	-33.7	8.96	6.61	120

NA - Not Applicable
NS - Not sampled
ND - Not detected above method reporting level (MRL)
PROD - Product Present in well
RAO - Remedial action objectives
Analytical results exceeding RAOs shown in **BOLD**
Results in parentheses are Duplicate samples.

Table 5-7: Historical Results for Groundwater Zone 4 A-Aquifer

Well	Analyte	Cleanup Levels (mg/L)	1992 Analytical Results	1993 Analytical Results	1994 Analytical Results	1997 Analytical Results	2000 Analytical Results	2001 Analytical Results	2002 Analytical Results	2003 Analytical Results	2004 Analytical Results	2005 Analytical Results	2006 Analytical Results	2007 Analytical Results	2008 Analytical Results	2009 Analytical Results	2010 Analytical Results	2011 Analytical Results	2012 Analytical Results	2013 Analytical Results	2014 Analytical Results	2015 Analytical Results	2016 Analytical Results
MW-51	GRO	2.2	NS	1.4	NS	NS	**2.38 VJ**	1.98 VJ	0.788	1.4/1.7	1.76 /1.19	1.16/1.71	NS	1.42	0.79 VM	2.1	0.62	1.9	0.63	1.7/1.6	1.2	1.2	**2.8**
	DRO	1.5	NS	**6.23**	**5.0**	**3.96**	**9.77**	**6.8 VJ**	**2.39 VJ**	**4.2/3.4**	**9.09/7.32**	**5.3/2.42**	NS	**5.29 VJ**	**1.9**	**2.9**	0.92	**3.1**	**1.6**	**5.9/5.6**	1.3 (1.4)	1.4	**2.5**
	Benzene	0.005	**0.048**	**0.016**	**0.012**	0.0010	0.0037	0.0042	0.0007	0.0011 F JD	0.00115 F	0.0006	NS	0.00026	0.00016 FVM	ND	0.00018	ND	ND	ND	ND	ND	0.00014
	Toluene	1	0.640	0.180	0.390 J	0.0063	0.187	0.257	0.0098	0.081	0.138 D VJ	0.133	NS	0.150	0.039	0.15	0.019	0.064	0.032	0.067/0.060	0.034	0.037	0.066
	BTEX	NA	1.36	0.338	0.921 J	0.301	0.666	0.787	0.0778	0.418	0.537	0.393	NS	0.596	0.218	0.632	0.158	0.289	0.197	0.435/0.53	0.272 (0.281)	0.404	0.822
	TCE	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NS	0.00034	0.00014 FVM	0.00026 FVM	ND	ND	ND	0.00015/ND	ND	0.00078	ND
MW-62	GRO	2.2	NS	NS	NS	NS	**2.88**	1.98	2.07	1.8	1.87 VJ	1.15 VJ	NS	2.05	**2.5 VM**	**2.4**	**2.2**	**4.2**	2	1.9	**2.3**	**2.5/2.7**	**2.2**/2.0
	DRO	1.5	NS	NS	**2.3**	0.984	**3.16**	**1.62 VJ**	1.19 VJ	1.4	1.38 VJ	1.14 VJM	NS	0.762	0.54	0.59	0.65	**1.5**	0.6	0.47	0.32	0.36/0.29	0.35/0.38
	Benzene	0.005	NS	NS	**0.200 JB**	**0.086**	**0.0171**	**0.0082**	**0.0051**	0.0042	0.00346	0.00186	NS	0.00146	0.0015 VM	0.00098 VM	0.00056	0.00052	ND	0.001	ND	0.00042/0.00048	0.00045/0.00041
	Toluene	1	NS	NS	0.0049 J	0.041	0.0010	ND	ND	ND	0.00101 VJ	0.00092 F	NS	0.00297	0.0014 VM	0.0015	0.0010	0.00072	0.00076	0.00064	0.00067	0.0011/0.0012	0.00066/0.00062
	BTEX	NA	NS	NS	0.815 J	0.692	0.702	0.659	0.282	0.382	0.367	0.188	NS	0.342	0.381	0.273	0.287	0.215	0.173	0.1	0.0996	0.136/0.147	0.09/0.085
	TCE	0.005	NS	NS	ND	ND	ND	ND	ND	ND	ND	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
502	GRO	2.2	NS	NS	NS	NS	1.87	**2.13**	**3.42**	1.8	**2.44 VJ**	1.91 VJ	NS	1.29	2.1 VM	1.7	**2.7**	**2.5**	0.52	1.5	**2.5**	**2.4**	1.7
	DRO	1.5	NS	**3.8**	NS	**13.5**	**2.44**	**16.7 VJ**	**7.86**	**3.2**	**6.48 D VJ**	**2.13 VJM**	NS	**3.89**	1.4 VJ	**5.3**	**5.2**	**4.2**	0.61	**2.4**	**1.5**	**1.6**	**1.6**
	Benzene	0.005	NS	**0.21**	NS	**0.073**	**0.0174**	**0.0207**	**0.0102**	0.004 D	**0.00805**	**0.00685**	NS	0.0013	0.0014 VM	0.0024 VM	**0.0078**	0.0023	0.0011	0.0025	0.0031	0.0043	0.0036
	Toluene	1	NS	0.011	NS	0.047	0.0087	0.0964	0.0067	0.002 F JD	0.00375 VJ	0.00153	NS	0.00361	0.0083 VM	0.0051 VM	0.036	0.0022	0.00054	0.0055	0.0016	0.0015	ND
	BTEX	NA	NS	2.90	NS	2.30	0.740	1.33	1.522	0.691	1.027	0.851	NS	0.0769	0.420	0.288	0.639	0.083	0.11	0.271	0.375	0.335	0.287
	TCE	0.005	NS	ND	NS	ND	ND	ND	ND	ND	ND	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	0.0021	ND
MW-57	GRO	2.2	NS	NS	NS	NS	0.94 VJ	0.909 VJ	1.02	0.99	0.72 VJ	0.384	NS	0.531	0.71 VM	0.54	0.19	**PROD**	**PROD**	**PROD**	0.54	**PROD**	**PROD**
	DRO	1.5	NS	**13.4**	**4.3**	**5.62**	**5.64**	**6.97 VJ**	**13.4**	**6.3**	**5.99 D VJ**	**3.71 VJM**	NS	**12.8 VJ**	**6.1 VJ**	**11**	**6.4**	**PROD**	**PROD**	**PROD**	**8.7**	**PROD**	**PROD**
	Benzene	0.005	NA	ND	**0.034 J**	ND	ND	ND	ND	ND	ND	ND	NS	ND	ND	ND	ND	**PROD**	**PROD**	**PROD**	ND	**PROD**	**PROD**
	Toluene	1	NA	0.0027	0.039 J	0.0017	0.0014 VJ	0.0012	0.0012	0.0013	0.00126 VJ	0.00102	NS	0.00191	0.0023 VM	0.0011	0.00033	**PROD**	**PROD**	**PROD**	0.0012	**PROD**	**PROD**
	BTEX	NA	NA	0.0256	0.161 J	0.075	0.114 VJ	0.102	0.104	0.174	0.190	0.0464	NS	0.0881	0.110	0.634	0.0087	**PROD**	**PROD**	**PROD**	0.0789	**PROD**	**PROD**
	TCE	0.005	**0.0766**	**0.0089**	NA	0.0011	0.0014 VJ	ND	ND	ND	0.00106	0.00144	NS	0.00082 F	0.0011 VM	0.0007 FVM	0.0003	**PROD**	**PROD**	**PROD**	0.00092	**PROD**	**PROD**

NOTES:
ND - Not detected above the method reporting limit
NS - Not sampled for this analyte
J or VJ - Data qualifier meaning estimated value
Analytical results exceeding the RAOs are shown in**BOLD**
DRO - Diesel-range organics

5.4.3 Benzene, DRO, GRO and TCE Concentration Trends

The ProUCL software, Version 5.1 was used to assess benzene, ethylbenzene, DRO, GRO, and TCE concentration trends for three Zone 4 monitoring wells. Output from the ProUCL evaluation can be found in Appendix E.

Table 5-8 and Table 5-9 summarize the concentration trends observed in the three key monitoring wells (MW-51, MW-62, MW-502) with historical concentrations of contaminants near or above RAOs. The tables list the numbers of wells exhibiting a specific concentration trend for each analyte. Well location data sets, which did not have the minimum number of four observations, or where the results were all below the reporting limit for a specific analyte, are not included in the trend summary table. Note that 62% of the concentration trends were decreasing, 0% were increasing, and 38% had no trend. Please note that one half the method detection limit was used for ND values, thus making it difficult to assess trends at or near the detection limit. Overall, since the majority of concentration trends are decreasing, the trend analysis supports the conclusion that intrinsic remediation is keeping contaminant concentrations stable or decreasing at this site.

Table 5-8 Zone 4 Mann-Kendall Analysis Summary

Trend	Benzene	Ethyl-benzene	GRO	DRO	TCE	% of Total
Decreasing	3	2	0	3	0	62%
Increasing	0	0	0	0	0	0%
No Trend	0	1	3	0	1	38%
Totals	3	3	3	3	1	13

Table 5-9 Zone 4 Mann-Kendall Trend Summary

Well	Benzene	Ethyl-benzene	GRO	DRO	TCE
MW-51	**D**	NT	NT	**D**	**D**
MW-62	**D**	**D**	NT	**D**	N/A
MW-502	**D**	**D**	NT	**D**	N/A

D- Decreasing
NT – No trend
N/A Not applicable due to insufficient data or no detectable concentrations

5.4.4 B-Aquifer & Residential Well Analytical Results

Groundwater samples were collected from two B-Aquifer monitoring wells and five residential wells within Zone 4 to determine if contaminants present in the A-Aquifer have impacted the underlying B-Aquifer. Table 5-10 presents the historical and current sample analytical results for the contaminants of concern and the appropriate RAO or cleanup levels for comparison. Appendix C, Zone 4 Tables provide a complete list of the Zone 4 B-Aquifer analytical results.

Both B-Aquifer monitoring wells, the duplicate, and the five residential wells had low level detections of DRO (0.028 - 0.052 mg/L). GRO was detected in one residential well at 0.015 mg/L. BTEX constituents and GRO were not detected in any of the other B-Aquifer or residential wells.

Table 5-10: Historical Results for Zone 4 B-Aquifer

Well Number	Analyte	RAO mg/L	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
506	GRO	2.2	ND	0.0178	0.0477	ND	0.0101	ND	0.018(0.015)	ND	ND	ND	ND	0.024	ND	ND
	DRO	1.5	0.032	0.0509	0.112	ND	ND	ND	ND	ND	ND	0.017 (0.016)	0.016(ND)	0.056 (0.062)	0.055	0.049
	Benzene	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Toluene	1	0.00013	ND	ND	ND	ND	ND	ND	ND	ND	ND (0.00028)	0.00025(0.00027)B	ND	ND	ND
	BTEX	NA	0.00013	ND	ND	ND	ND	0.00023	ND	ND	ND	ND (0.00028)	0.00025(0.00027)B	ND	ND	ND
	TCE	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MW97-9	GRO	2.2	ND	0.00955	ND	ND	ND	ND	ND	ND	ND	0.009 B	ND	0.026	ND	ND
	DRO	1.5	0.085	0.04665	0.184	ND	ND	ND	ND	ND	ND	0.017	ND	0.036	0.037/0.044	0.042/0.044
	Benzene	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Toluene	1	ND	ND	ND	ND	ND	ND	0.00028	ND	ND	ND	ND	ND	ND	ND
	BTEX	NA	ND	ND	ND	ND	ND	ND	0.00028	ND	ND	ND	ND	ND	ND	ND
	TCE	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Residential Wells			**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Smith	GRO	2.2	NS	ND	ND	ND	ND	0.024 F	ND	ND	ND	ND	0.024	ND	ND	ND
	DRO	1.5	NS	ND	0.177	0.0859	ND	ND	ND	ND	ND	0.018	ND	0.059	0.049	0.036
	Benzene	0.005	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Toluene	1	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	BTEX	NA	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	TCE	0.005	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
King	GRO	2.2	NS	ND	ND	ND	ND	0.029 F	ND	ND	ND	ND	ND	ND	ND	ND
	DRO	1.5	NS	ND	0.193	ND	ND	ND	ND	ND	ND	0.017	ND	0.048	0.04	0.047
	Benzene	0.005	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Toluene	1	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	BTEX	NA	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	TCE	0.005	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bowers	GRO	2.2	NS	NS	NS	NS	NS	NS	0.012 F VB	ND	ND	ND	0.03	ND	ND	ND
	DRO	1.5	NS	NS	NS	NS	NS	NS	ND	ND	ND	0.02	ND	0.086	0.067	0.034
	Benzene	0.005	NS	NS	NS	NS	NS	NS	ND	ND	ND	ND	ND	ND	ND	ND
	Toluene	1	NS	NS	NS	NS	NS	NS	ND	ND	ND	ND	ND	ND	ND	ND
	BTEX	NA	NS	NS	NS	NS	NS	NS	ND	ND	ND	ND	ND	ND	ND	ND
	TCE	0.005	NS	NS	NS	NS	NS	NS	ND	ND	ND	ND	ND	ND	ND	ND
King Apt	GRO	2.2	NS	NS	NS	NS	NS	NS	0.012 F VB	ND	ND	ND	ND	0.016	ND	ND
	DRO	1.5	NS	NS	NS	NS	NS	NS	ND	ND	ND	0.018	ND	0.05	0.05	0.028
	Benzene	0.005	NS	NS	NS	NS	NS	NS	ND	ND	ND	ND	ND	ND	ND	ND
	Toluene	1	NS	NS	NS	NS	NS	NS	ND	ND	ND	ND	ND	ND	ND	ND
	BTEX	NA	NS	NS	NS	NS	NS	NS	ND	ND	ND	ND	ND	ND	ND	ND
	TCE	0.005	NS	NS	NS	NS	NS	NS	ND	ND	ND	ND	ND	ND	ND	ND
Marsh	GRO	2.2	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	ND	0.015
	DRO	1.5	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.041	0.052
	Benzene	0.005	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	ND	ND
	Toluene	1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	ND	ND
	BTEX	NA	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	ND	ND
	TCE	0.005	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	ND	ND

ND - Not detected above method reporting level.
RAO - Remedial action objectives.
NS - Not Sampled.
F- The analyte was positively identified but the associated numerical value is below the Reporting Limit (RL).
V - The flag was assigned during the A/E's data review process.
B - The analyte was found in an associated blank, as well as in the sample.
Results in parentheses indicate duplicate sample.

5.4.5 Surface Water/Sediment Analytical Results

Surface water and sediment contaminant concentrations were compared to RAOs and benchmark screening levels. RAOs are available for surface water only, and are developed in accordance with AWQS 18 AAC 70. Analytical results for the sediment samples were evaluated using the screening criteria shown in Table 5-2. In accordance with the ADEC *Sediment Quality Guidelines* technical memorandum (ADEC, 2013), analytes detected in the 2016 Zone 4 sediment samples that did not have criteria listed in Table 5-2 were compared to criteria found in the NOAA SQuiRTs (NOAA, 2008). Table 5-11 presents the historical and current sample analytical results for the contaminants of concern and the appropriate cleanup levels for comparison. Appendix C, Zone 4 Tables provide a complete list of the Zone 4 detected analytes and analytical results, along with the appropriate cleanup levels or benchmark screening levels. Sample locations and analytical results are shown on Figure 5-3.

Topography and vegetation of the wetland just down-gradient of Landfill No. 5 suggests that surface water flows south and east to a culvert, running under the road, about 150 feet south of monitoring well 502. Samples from OT30-01 and OT30-03 were taken to assess the change in contaminant levels in water as it flows along this likely surface water drainage pattern. The sample from OT30-01 was collected about ten feet south of the Upper Naknek Area product recovery system. The OT30-03 sample was collected from just up-gradient of the culvert draining the wetland west of the road. A sample was also collected from OT30-04 which is located below the edge of the river bank and MW-57. MW-57 had product present during five of six sampling events since 2011. A strong fuel odor was observed at OT30-01 and OT30-04. Sheen was observed on the sample from OT30-04, but not on the other two surface water samples.

5.4.5.1 Surface Water GRO and DRO

GRO and DRO concentrations detected at three surface water locations are shown on Figure 5-3. GRO was detected in OT30-04 (0.72 mg/L). DRO was detected in all three surface water samples ranging from 0.17 mg/L in OT30-03 to 2.7 mg/L in OT30-04. There are no criteria for bulk hydrocarbons in surface water. There was sheen observed on the surface water at OT30-04.

5.4.5.2 Surface Water TAH and TAqH

TAH are determined by adding together all of the BTEX concentrations. The AWQS cleanup level for TAH in surface water (0.01 mg/L) was not exceeded in any of the surface water samples. TAH results were 0.0048 (0.0043) mg/L for OT30-01, and ND for OT30-03 and OT0-04. TAqH are determined by adding together the TAH and PAH concentrations. The AWQS cleanup level for TAqH (0.015 mg/L) wasn’t exceeded in any of the samples. TAqH results were 0.00717 (0.00693) mg/L at OT30-01, ND at OT30-03, and 0.014 mg/L at OT30-04.

5.4.5.3 Sediment GRO and DRO

The petroleum hydrocarbon levels detected in the Zone 4 sediment samples are depicted in Figure 5-3. DRO and GRO were detected in the primary/duplicate sample from OT30-01 (500/510 mg/kg and 6.4/7.6 mg/kg respectively). GRO and DRO were detected in the sample from OT30-03 (0.86 mg/kg and 7 mg/kg, respectively). GRO and DRO were also detected in the sample from OT30-04 at 35 mg/kg and 4,000 mg/kg, respectively. There are no criteria for GRO and DRO in sediments.

5.4.5.4 Sediment TCE, VOCs, and PAHs

Benzene and TCE were not detected in any of the sediment samples. Ethylbenzene (0.012 mg/kg), total xylenes (0.108 mg/kg) and naphthalene (0.26 mg/kg) concentrations in OT30-01 exceeded the ecological risk-based remediation goal listed in Table 5-2 (NOAA SQuiRTs, NOAA, 2008). Naphthalene (0.78 mg/kg), benzo[a]anthracene, and benzo[a]pyrene exceeded the screening criteria at OT30-04. There are no sediment cleanup levels listed in the Zone 4 ROD.

Table 5-11: Historical Results for Zone 4 Surface Water/Sediment

Surface Water

Location ID	Analyte	Screening Levels (mg/L)	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
OT30-01	GRO	NA	0.100	0.234	0.768	NS	0.0304	0.080	0.021	0.10 (0.11)	ND	ND (0.0096)	0.051 (0.050)	0.039 (0.047)	0.018	ND
	DRO	NA	8.50	4.38	3.81	NS	1.61	2.8	2.6	2.7 (2.9)	1.9(2.2)	0.4	2.0 (2.1)	1.1 (1.0)	1.4	0.93/1.0
	TAH	0.01	0.00789	**0.0130**	**0.1560**	NS	ND	0.0023	0.00012	0.00240	ND	0.00077(ND)	0.0051 (0.0052)	0.00132 (0.00156)	0.00144(0.00103)	0.0048/0.0043
	TAqH	0.015	0.0115	0.0149	**0.1664**	NS	0.00014	0.0033	0.00028	0.0034 (0.0026)	ND (0.00061)	0.00085(0.00013)	0.0079 (0.0085)	0.00217(0.00245)	0.00205(0.00169)	0.00717/0.00693
OT30-03	GRO	NA	0.024	0.0361	ND		ND	0.020(0.057)	ND	ND	ND	ND	0.0095	ND	0.019	ND
	DRO	NA	0.64	0.588	0.404	NS	0.178	0.28(0.28)	0.22(0.23)	0.18	0.25	0.082	0.16	0.19	0.15	0.17
	TAH	0.01	ND	0.00088	ND	NS	0.00071	ND(0.00041)	ND	ND	ND	ND	0.00054	ND	ND	ND
	TAqH	0.015	0.00245	0.00238	ND	NS	0.00078	0.000138 (0.00055)	0.000124 (0.000108)	0.000073	0.000032	0.000031	0.00073	0.000042	0.000017	ND
OT30-04	GRO	NA	0.077	0.26	0.0701	NS	NS	NS	NS	NS	NS	NS	4.4	2.6	0.47	0.72
	DRO	NA	0.016	0.014	ND	NS	NS	NS	NS	NS	NS	NS	42 (Sheen)	16 (Sheen)	11 (Sheen)	2.7 (Sheen)
	TAH	0.01	ND	ND	ND	NS	NS	NS	NS	NS	NS	NS	ND	ND	0.00023	ND
	TAqH	0.015	0.00179	0.00159	ND	NS	NS	NS	NS	NS	NS	NS	**0.048**	**0.03741**	0.00985	0.014

Sediment

Location ID	Analyte	Screening Levels (mg/Kg)	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
OT30-01	GRO	NA	7.15	2.75	15.5	NS	6.51	16	7.1	13 (33)	28 (46)	58 (17)	8.1 (9.6)	37 (46)	8.3/5.8	ND
	DRO	NA	157	1,190	185	NS	213	250	150	380 (350)	240 (320)	480 (240)	220 (170)	470 (670)	200/270	500
	Benzene	0.01	0.0044	ND	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Toluene	0.05	0.0069	ND	ND	NS	ND	0.0036	0.011	0.010 (0.012)	0.017 (0.037)	0.0028/0.0035	ND	ND	ND	ND
	Ethylbenzene	0.004	**0.339**	ND	**0.123**	NS	ND	**0.013**	**0.012**	**0.055 (0.052)**	**0.058 (0.076)**	ND(0.0026)	**0.084 (0.081)**	ND **(0.023)**	**0.01**	**0.012**
	Naphthalene	0.01465											**1.1 (0.9)**	**1.2**	**0.36/0.38**	**0.26**
	Xylenes	0.025	**1.217**	**0.0842**	**0.881**	NS	**0.0698**	**0.149**	**0.166**	**0.70 (0.64)**	**0.84 (1.05)**	**0.043 (0.035)**	**1.2 (1.16)**	**0.163 (0.206)**	**0.139/0.194**	**0.108**
OT30-03	GRO	NA	ND	0.396	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	3.2	0.86
	DRO	NA	75.2	220	35.8	NS	ND	ND	17(14)	21	18	3.1	3.4	7.4	6.1	7
	Benzene	0.01	0.0009	ND	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Toluene	0.05	ND	ND	ND	NS	ND	ND	ND/0.0066	ND	ND	ND	0.00052 (LL)	ND	ND	0.0013
	Ethylbenzene	0.004	ND	ND	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Xylenes	0.025	0.0025	ND	ND	NS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
OT30-04	GRO	NA	45	102	186	NS	NS	NS	NS	NS	NS	NS	120	84	19	35
	DRO	NA	ND	0.673	13	NS	NS	NS	NS	NS	NS	NS	7,500	3,300	980	4,000
	Benzene	0.01	0.0009	ND	ND	NS	NS	NS	NS	NS	NS	NS	ND	ND	ND	ND
	Toluene	0.05	0.0027	ND	ND	NS	NS	NS	NS	NS	NS	NS	ND	ND	ND	ND
	Ethylbenzene	0.004	ND	ND	0.0022	NS	NS	NS	NS	NS	NS	NS	ND	ND	ND	ND
	Naphthalene	0.01465				NS	NS	NS	NS	NS	NS	NS	**0.44**	**0.66**	**0.17**	**0.78**
	Benzo (1)	0.01572			**0.126**	NS	NS	NS	NS	NS	NS	NS	**0.083**	**0.076**	**0.069**	**0.2**
	Benzo(2)	0.0324			**0.127**	NS	NS	NS	NS	NS	NS	NS	**0.04**	**0.05**	**0.039**	**0.12**
	Benzo(3)	0.0272			**0.0492**	NS	NS	NS	NS	NS	NS	NS	**0.048**	**0.049**	0.02	**0.061**
	Xylenes	0.025	ND	ND		NS	NS	NS	NS	NS	NS	NS	ND	ND	ND	ND

Analytical results exceeding screening levels shown in **BOLD**

TAH (BTEX)

TAqH (BTEX + PAH)

Results in parentheses indicate duplicate sample.

Benzo(1): Benzo[a]anthracene

Benzo(2): Benzo[a]pyrene

Benzo(3): Benzo[k]fluoranthene

5.4.6 Land Fill Inspection Results

Slopes, vegetation, and erosion-control features at Landfill No. 5 (LF008) and SS012 were inspected on September 23, 2016. The inspections were documented on the Landfill Inspection Form, which has been included in Appendix A. During this inspection, Landfill No. 5 had no evidence of erosion of the landfill cap. No sinkholes were observed. Vegetation cover was estimated at 60-100% and the vegetation was in good condition with increasing growth of alder and grass. The eastern side had very little vegetation, while the western side had some grass and alder. Any willow and spruce trees growing are small.

Upper Naknek Area of SS012 is located between the Alaska Peninsula Highway and LF008. It is comprised of mostly bare sand and is frequently used by ATVs, which have probably prevented any vegetation from taking hold.

Lower Naknek Area (SS012) located on the southern edge of Zone 4 and near the bank of the Naknek River, is overgrown with alder and other indigenous vegetation. There is a path just wide enough to drive a vehicle around the perimeter of SS012.

5.4.7 Institutional Control Inspection

Institutional Controls (ICs) are part of the selected remedy necessary to meet the RAOs. The goals of the ICs are to prevent the drinking of groundwater contaminated above 18 AAC 75.345 Table C groundwater cleanup levels and to help ensure the proper management of soil contaminated above Method Two cleanup levels in order to comply with State regulations (18 AAC 75.375). ICs within the site boundaries consist of prohibiting the installation of water supply wells as long as the aquifer fails ADEC Table C cleanup levels. A visual inspection was performed to verify that no drinking water wells have been installed.

5.4.8 Condition of Wells

The wells and well points scheduled for Zone 4 were sampled and in good condition, with the exception of MW57, which had product present.

5.5 ZONE 4 CONCLUSIONS

5.5.1 General Conclusions

Intrinsic bioremediation has been evident from previous sampling events at the Zone 4 A-Aquifer monitoring wells. The combined lines of evidence of a stable benzene plume, as well as changes in the groundwater chemistry strongly support the occurrence of intrinsic bioremediation in the hydrocarbon-impacted areas of this groundwater system. Intrinsic bioremediation of fuel-impacted groundwater is expected to continue in Zone 4.

Free-phase hydrocarbons were observed in MW-57 for the fifth time in six years. Sampling results from OT30-04 suggest that the DRO plume at MW-57 is having an impact on the river bank at that location. A more extensive study has been conducted in that area under a separate contract.

5.5.2 A-Aquifer Monitoring Wells

Analytical data showed GRO and DRO above cleanup levels in the samples from MW-51. MW- 62 exceeded the cleanup level for GRO, and 502 exceeded the cleanup level for DRO. MW-57 had detectable product this year and was not sampled.

There were no RAO exceedances for benzene, and toluene. Ethylbenzene and naphthalene exceeded the ADEC groundwater cleanup levels in all three of the A-Aquifer monitoring wells sampled. MW51 and 502 also had exceedances of total xylenes. TCE was not detected in any of the wells sampled.

5.5.3 B-Aquifer Monitoring Wells and Residential Wells

DRO was detected in B-Aquifer monitoring wells at levels well below the cleanup levels. The five residential wells also had similar detections of DRO (0.028 - 0.052 mg/L). GRO was detected in one residential well at 0.015 mg/L.

5.5.4 Surface Water and Sediment

As in previous years, petroleum hydrocarbons decreased from the outlet of the product recovery system at OT30-01 downstream to the outfall of the culvert at OT30-03, indicating that the wetlands are degrading petroleum hydrocarbons at this site. GRO was ND in both the surface water and sediment samples from OT30-01. DRO was detected in OT30-01 surface water sample in a lower concentration than the previous year’s result and in the sediment sample at an increased concentration over the previous years’ results. At OT30-03, GRO decreased while DRO result was a slight increase over the previous year in both surface water and sediment. Concentrations of ethylbenzene, naphthalene and total xylenes were above sediment criteria in the sample collected at OT30-1.

OT30-04 surface water GRO and DRO results were 0.72 and 2.7 mg/L (sheen), respectively. Sediment GRO and DRO results were 35 and 4,000 mg/Kg, respectively. The PAHs benzo(a)anthracene, benzo(a)pyrene, benzo(k)fluoranthene, and naphthalene exceeded criteria.

5.6 ZONE 4 RECOMMENDATIONS

- Monitoring should continue because of the drinking water wells.
- Chloride, sulfate, and alkalinity results are not providing any useful information, and should be eliminated from the sampling program.

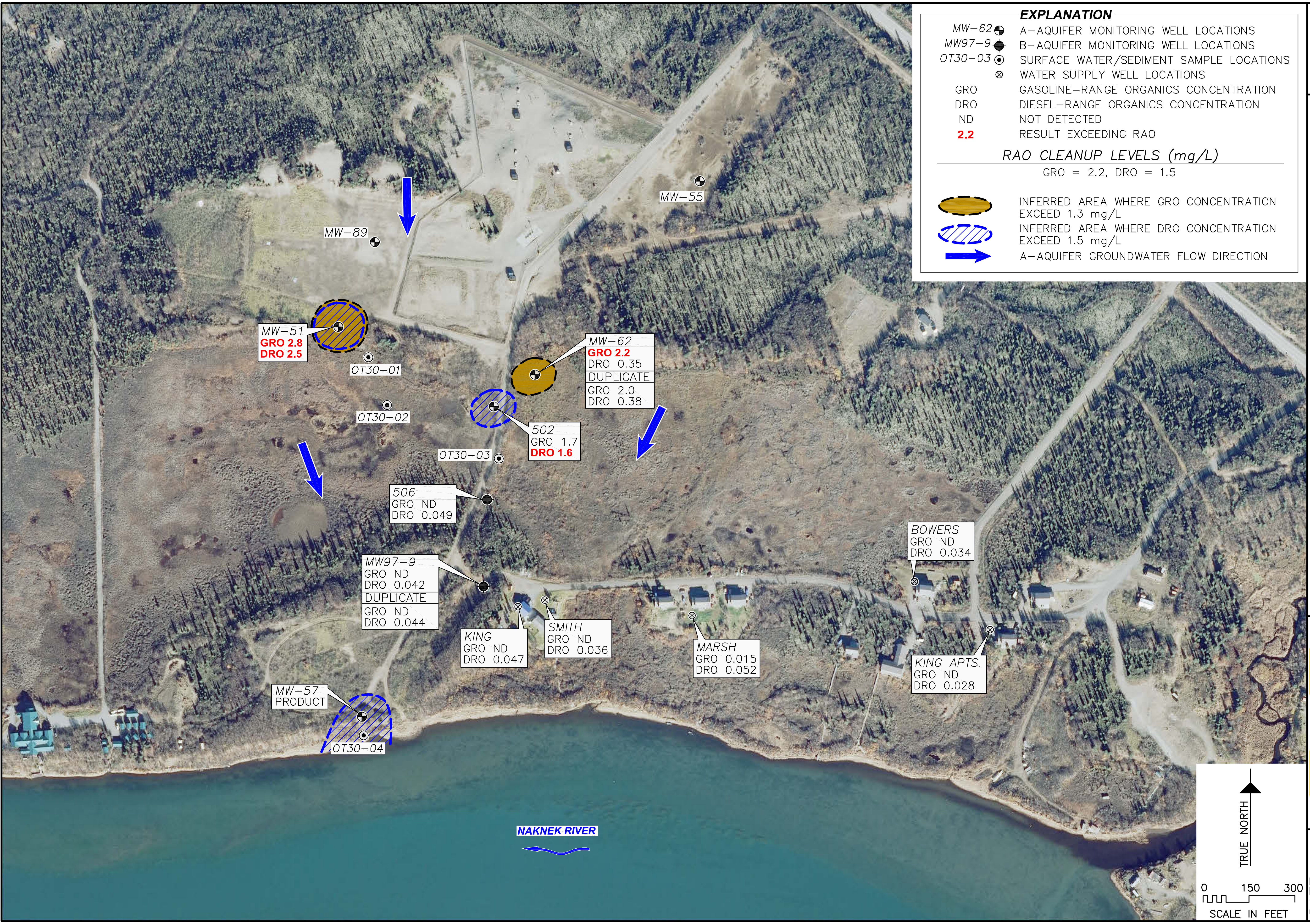

FIGURE 5-1

GROUNDWATER DRO AND GRO PLUME EXTENT AND ANALYTICAL RESULTS GROUNDWATER ZONE 4

NAKNEK RIVER STORAGE (GWZ4, OT–030)
2016 LONG TERM MANAGEMENT
King Salmon Divert, Alaska

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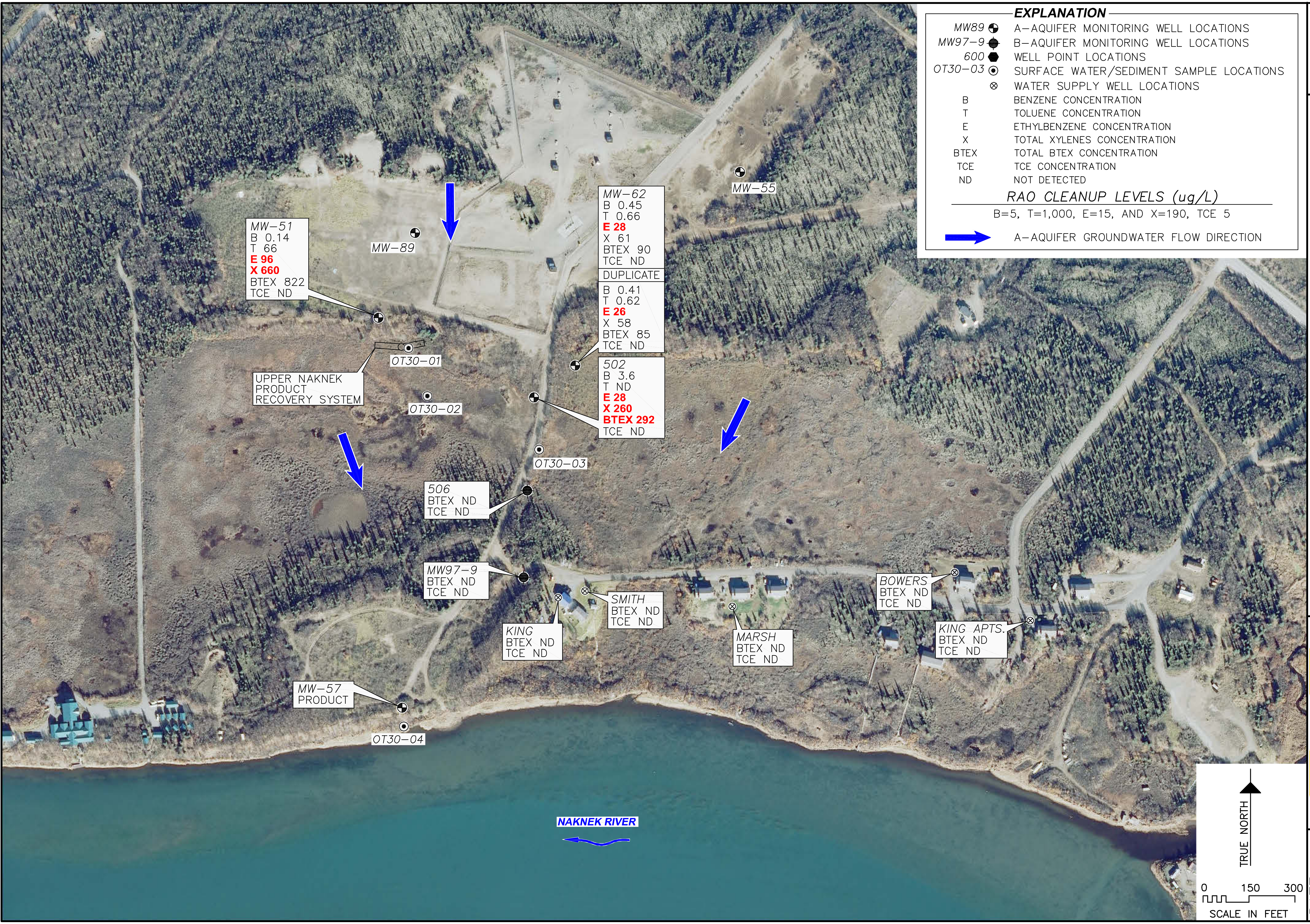

EXPLANATION

MW89 ⊕	A-AQUIFER MONITORING WELL LOCATIONS
MW97-9 ⊕	B-AQUIFER MONITORING WELL LOCATIONS
600 ●	WELL POINT LOCATIONS
OT30-03 ⊙	SURFACE WATER/SEDIMENT SAMPLE LOCATIONS
⊗	WATER SUPPLY WELL LOCATIONS
B	BENZENE CONCENTRATION
T	TOLUENE CONCENTRATION
E	ETHYLBENZENE CONCENTRATION
X	TOTAL XYLENES CONCENTRATION
BTEX	TOTAL BTEX CONCENTRATION
TCE	TCE CONCENTRATION
ND	NOT DETECTED

RAO CLEANUP LEVELS (ug/L)

B=5, T=1,000, E=15, AND X=190, TCE 5

➡ A-AQUIFER GROUNDWATER FLOW DIRECTION

FIGURE
5-2

BTEX AND TCE ANALYTICAL RESULTS GROUNDWATER ZONE 4

NAKNEK RIVER STORAGE (GWZ4, OT-030)
2016 LONG TERM MANAGEMENT
King Salmon Divert, Alaska

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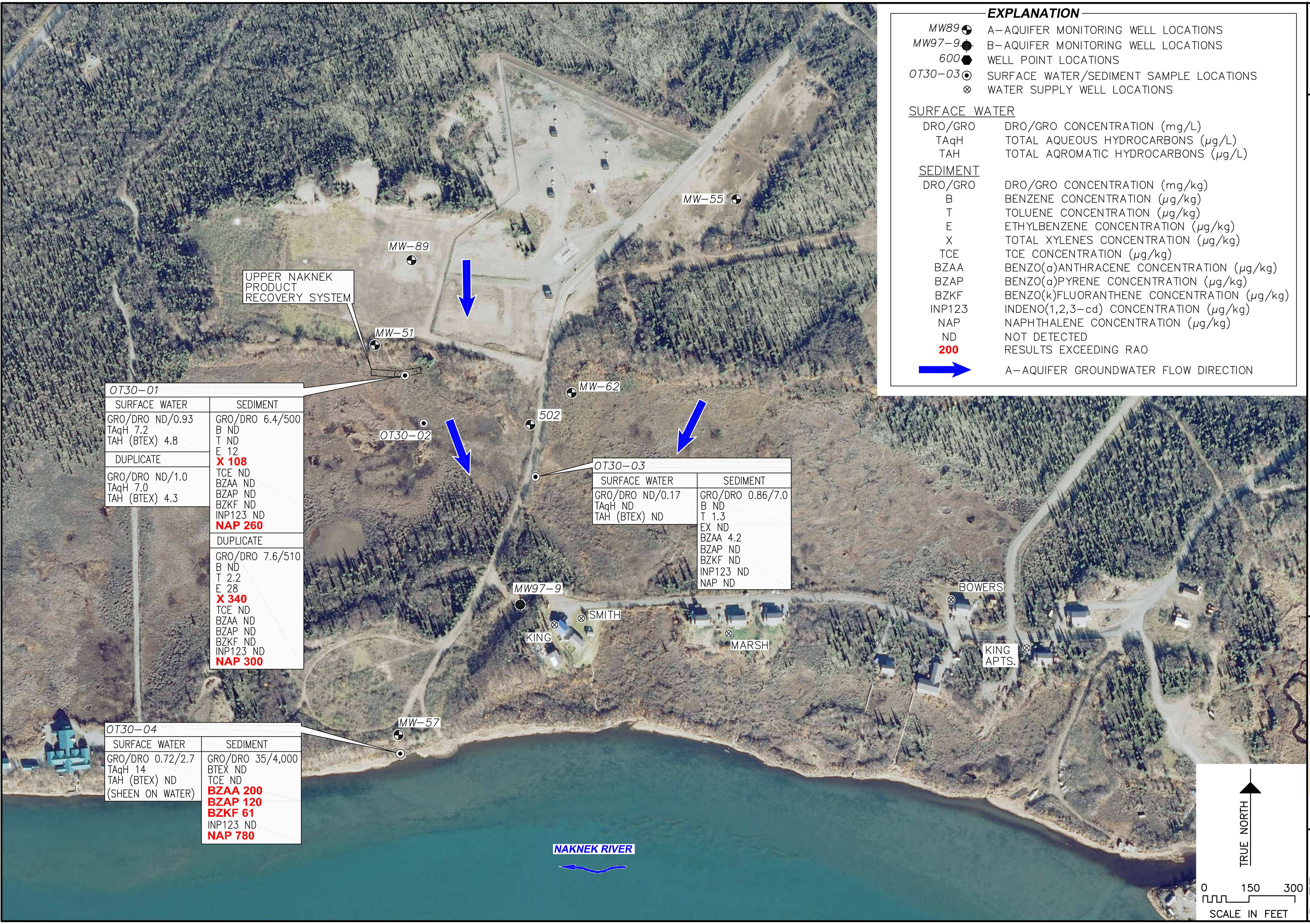
SURFACE WATER AND SEDIMENT ANALYTICAL DATA GROUNDWATER ZONE 4

NAKNEK RIVER STORAGE (GWZ4, OT-030)
2016 LONG TERM MANAGEMENT
King Salmon Divert, Alaska



EXPLANATION

MW89 ⊕	A-AQUIFER MONITORING WELL LOCATIONS
MW97-9 ●	B-AQUIFER MONITORING WELL LOCATIONS
600 ●	WELL POINT LOCATIONS
OT30-03 ⊙	SURFACE WATER/SEDIMENT SAMPLE LOCATIONS
⊗	WATER SUPPLY WELL LOCATIONS

SURFACE WATER

DRO/GRO	DRO/GRO CONCENTRATION (mg/L)
TAqH	TOTAL AQUEOUS HYDROCARBONS (μg/L)
TAH	TOTAL AQROMATIC HYDROCARBONS (μg/L)

SEDIMENT

DRO/GRO	DRO/GRO CONCENTRATION (mg/kg)
B	BENZENE CONCENTRATION (μg/kg)
T	TOLUENE CONCENTRATION (μg/kg)
E	ETHYLBENZENE CONCENTRATION (μg/kg)
X	TOTAL XYLENES CONCENTRATION (μg/kg)
TCE	TCE CONCENTRATION (μg/kg)
BZAA	BENZO(a)ANTHRACENE CONCENTRATION (μg/kg)
BZAP	BENZO(a)PYRENE CONCENTRATION (μg/kg)
BZKF	BENZO(k)FLUORANTHENE CONCENTRATION (μg/kg)
INP123	INDENO(1,2,3-cd) CONCENTRATION (μg/kg)
NAP	NAPHTHALENE CONCENTRATION (μg/kg)
ND	NOT DETECTED
200	RESULTS EXCEEDING RAO
→	A-AQUIFER GROUNDWATER FLOW DIRECTION

OT30-01

SURFACE WATER	SEDIMENT
GRO/DRO ND/0.93 TAqH 7.2 TAH (BTEX) 4.8	GRO/DRO 6.4/500 B ND T ND E 12 **X 108** TCE ND BZAA ND BZAP ND BZKF ND INP123 ND **NAP 260**
DUPLICATE	DUPLICATE
GRO/DRO ND/1.0 TAqH 7.0 TAH (BTEX) 4.3	GRO/DRO 7.6/510 B ND T 2.2 E 28 **X 340** TCE ND BZAA ND BZAP ND BZKF ND INP123 ND **NAP 300**

OT30-03

SURFACE WATER	SEDIMENT
GRO/DRO ND/0.17 TAqH ND TAH (BTEX) ND	GRO/DRO 0.86/7.0 B ND T 1.3 EX ND BZAA 4.2 BZAP ND BZKF ND INP123 ND NAP ND

OT30-04

SURFACE WATER	SEDIMENT
GRO/DRO 0.72/2.7 TAqH 14 TAH (BTEX) ND (SHEEN ON WATER)	GRO/DRO 35/4,000 BTEX ND TCE ND **BZAA 200** **BZAP 120** **BZKF 61** INP123 ND **NAP 780**

FIGURE
5-3

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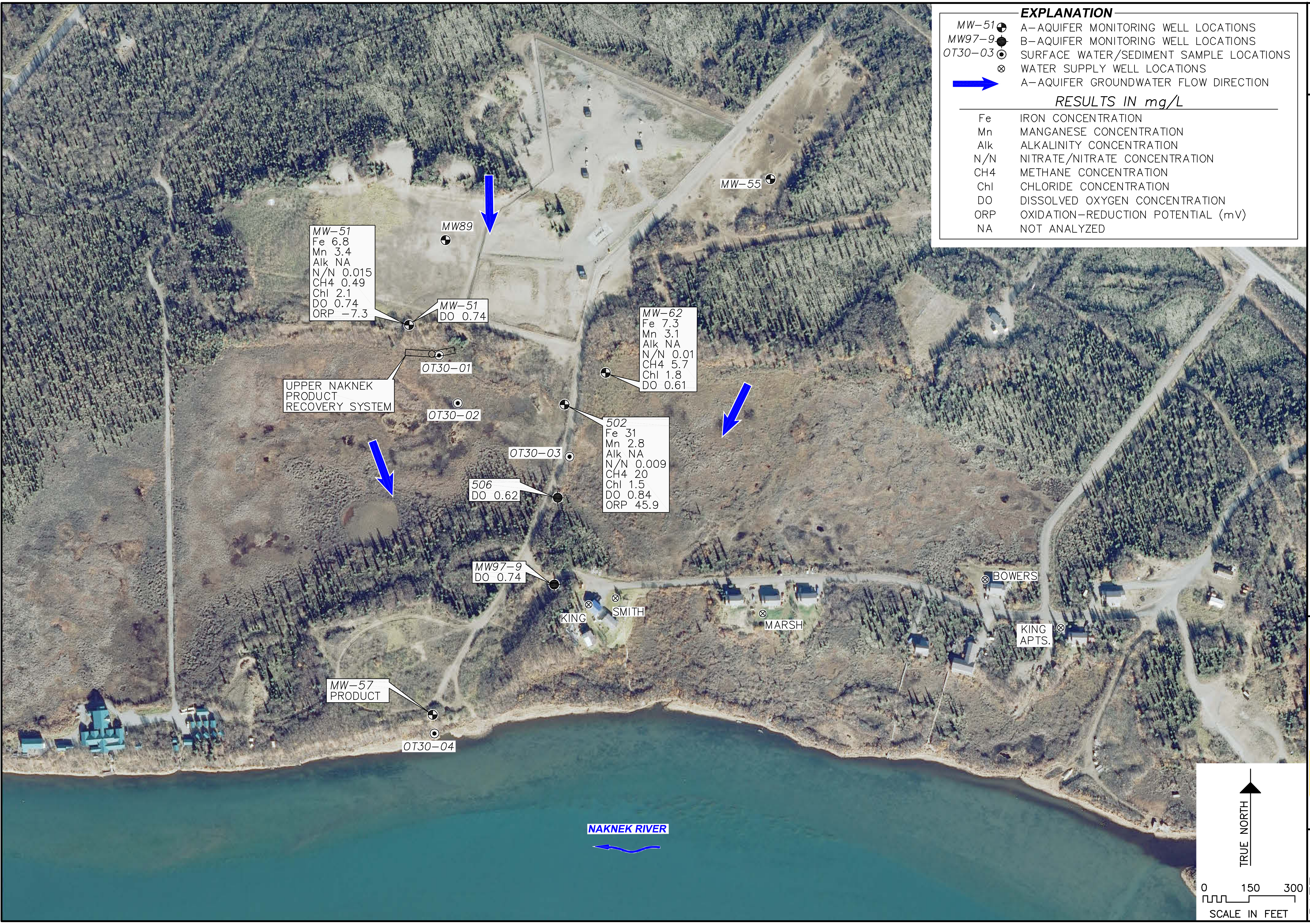

FIGURE 5-4

MONITORED NATURAL ATTENUATION RESULTS GROUNDWATER ZONE 4

NAKNEK RIVER STORAGE (GWZ4, OT-030)
2016 LONG TERM MANAGEMENT
King Salmon Divert, Alaska

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6 ZONE 5 - RAPCON AND RED FOX CREEK

Historical spills and operational practices at RAPCON have resulted in contamination of the water table with petroleum-based products and chlorinated solvents, specifically petroleum product floating on the groundwater, DRO, GRO, and VOCs, including TCE dissolved in the groundwater. Red Fox Creek and its tributary drainages have contained contaminants resulting from RAPCON and other contaminated sites.

The Air Force has contracted through the Corps of Engineers to complete a Zone 5 Record of Decision.

6.1 DESCRIPTION OF CURRENT STUDY

When two consecutive sampling events showed no groundwater contamination above the cleanup levels for specific analytes at specific monitoring locations, monitoring for those analytes at those locations was discontinued. When two consecutive sampling events showed no TAH and no TAqH surface water contamination above cleanup levels, surface water and sediment sampling was discontinued at that location. The following changes to the 2013-2016 monitoring programs were made based on recommendations from the 2012 comprehensive groundwater monitoring report (Paug-Vik, 2013c):

- Monitoring wells FT01-SVE1 and FT01-FD9 were analyzed for DRO only.
- FT01-SVE2 and FT01-MW01 were analyzed for DRO and GRO only. FT01-MW01 was also analyzed for PFOA/PFOS.
- FT01-MW02 was analyzed for VOCs, DRO, and GRO.
- MW-83 is located 1,000 feet southeast of RAPCON and was analyzed for PFOA/PFOS.
- Monitoring was discontinued at RFC-1 and RFC-7 because all TAH and TAqH results have been below water quality criteria since 2005.
- VOC and PAH analyses were continued at RFC-4 and RFC-5 for surface water and sediment.
- A visual inspection of the area will be conducted to ensure that no drinking water wells have been installed and no excavations have been made.

Surface water sampling at RFC-5 was eliminated when results for TAH and TAqH in 2013 and 2014 were below cleanup levels.

The purpose of the current study was to collect groundwater samples from six monitoring wells at the RAPCON site, and to collect a surface water and sediment sample pair from RFC-4 and a sediment sample only from RFC-5. The data collected during this project includes concentrations of petroleum hydrocarbons, VOC, and MNA parameters in groundwater, and VOC and PAH parameters in surface water and sediment. Two wells were also analyzed for PFOA/PFOS which are COCs found in fire training areas.

6.2 REMEDIAL ACTION OBJECTIVES FOR RAPCON/RED FOX CREEK

The cleanup levels presented in Table 6-1 are based on the ADEC 18 AAC 75 Method 2 cleanup levels and ecological benchmark screening levels. Surface water screening criteria found in 18 AAC 70 and relevant EPA and ORNL screening criteria were used to establish RAOs for surface water at Red Fox Creek. Because sediment cleanup levels are not provided in the AWQS (18 AAC 70), ORNL ecological benchmarks, EPA (OSWER) Sediment Screening Benchmarks, and NOAA SQuiRT Sediment Screening Values were used to provide screening levels for analytical results. The ORNL ecological benchmarks were taken from the *Tier II Secondary Chronic Surface Water Benchmarks*.

Table 6-1 Cleanup Levels for RAPCON

Chemical of Concern	Maximum Concentration	Maximum Concentration Location (Date)	Maximum Concentration (Location) in 2006	Clean Up Level	Basis
Groundwater (µg/L)					
TCE	**636**	GP-9 (1996)	**84.8** (SVE-2)	2.8	18AAC75(a)
DRO	**43.2** (mg/L)	GP-9 (1996)	**8.95** (SVE-2)	1.5 (mg/L)	18AAC75(a)
GRO	**21** (mg/L)	GP-9 (1996)	**6.26** (SVE-2)	2.2 (mg/L)	18AAC75(a)
Benzene	**1,430**Y	GP-9 (1996)	**16.3** (SVE-2)	4.6	18AAC75(a)
Toluene	**8,190Y**	GP-9 (1996)	**1,230** (SVE-2)	1,100	18AAC75(a)
Ethylbenzene	**706**	GP-9 (1995)	239 (SVE-2)	15	18AAC75(a)
EDB	**94.9**Y	GP-9 (1996)	ND (<10 or <1)	0.075	18AAC75(b)
Surface Water (µg/L)					
Benzene	**113**	(SW-1 -1996)	2.18 (RFC-04)	4.6	18AAC70
Benzo(k) fluoranthene	**18.2**	(RFC-04 – 2003)	ND (52.6)	0.012	EPAWQC
Naphthalene	**12.2**	(RFC-04 – 2003)	6.8 (RFC-04)	1.7	Per ADEC
TAH	**2,026**	(SW-1 - 1996)	**51.7** (RFC-04)	10	18AAC70
TAqH	**2,026(c)**	(SW-1 -1996)	**52** (RFC-04)	15	18AAC70

Definitions:

18 AAC 75 = ADEC Oil and Hazardous Substances Pollution Control Regulations, as amended through July 1, 2017
18 AAC 70 = ADEC Alaska Water Quality Standards, as amended through February 5, 2017
ORNL = Oak Ridge National Laboratory (ORNL) Tier II Secondary Chronic Surface Water Benchmark; from https://rais.ornl.gov/tools/eco_search.php
EPAWQC = EPA National Recommended Water Quality Criteria – Human Health Criteria Table: 2015; from https://epa.gov/wqc

RAO = remedial action objectives
GRO = gasoline-range organics
TAH = total aromatic hydrocarbons
mg/L = milligrams per liter
bgs = below ground surface
TCE = trichloroethene
EDB = 1,2-dibromoethane (ethylene dibromide)
TAqH = total aqueous hydrocarbons
mg/Kg = milligrams per kilogram
Y = samples received at pH>2
DRO = diesel-range organics

Results shown in **bold font** exceed the RAO.

Notes:
(a) 18 AAC 75.345 (b) (1) Table C Groundwater Cleanup Level
(b) Calculated cleanup level in accordance with 18 AAC 75.340(g); provided in ADEC Tech Memo 01-007.
(c) PAHs were not analyzed in this sample; therefore, the TAqH concentration is the same as the TAH concentration.

(d) Although petroleum hydrocarbon contamination remains in RAPCON smear zone soil and possibly under the RAPCON building foundation, soil cleanup has already been performed to the maximum extent practicable (i.e., excavation to the groundwater table followed by SVE/AS and bioventing). Therefore, no further active soil cleanup is practicable, although natural processes will continue to clean up the soil contamination over time.

6.3 PROJECT TASKS

6.3.1 RAPCON Groundwater Monitoring

Monitoring was conducted at RAPCON to document changes in contaminant concentrations in the groundwater. Groundwater monitoring was performed September 26-27, 2016. A list of the groundwater laboratory samples collected during this project is presented in Table 6-2. Groundwater sampling results are displayed on Figure 6-1 and in Table 6-4 and Table 6-5. PFOA/PFOS results are depicted on Figure 6-3.

6.3.2 Red Fox Creek Sampling

To evaluate potential impacts to Red Fox Creek resulting from contamination at RAPCON, one surface water and two sediment samples were collected October 3, 2016, from two locations in a drainage ditch that flows by the RAPCON site into Red Fox Creek. A list of the surface water and sediment samples collected is presented in Table 6-3. The surface water and sediment sampling results are shown on Figure 6-2, Table 6-8, and Table 6-9.

6.3.3 Work Plan Deviations

There were no deviations from the work plan.

Table 6-2: RAPCON Groundwater Sample Analyses Summary

Location ID Sample Point	Comments	Matrix	Location Type	Analytical Methods					
				Alaska Method AK 102 DRO	Alaska Method AK 101 GRO	EPA Method 8260B VOCs	PFOA PFOS	EPA Method 6020 Fe & Mn (dissolved)	Sample Number
FT01-FD9		Groundwater	Monitoring Well	1				1	16KS5ZFD9-101WG
MW-01		Groundwater	Monitoring Well	1	1		1	1	16KS5ZMW1-102WG
MW-02		Groundwater	Monitoring Well	1	1	1		1	16KS5ZMW2-103WG
SVE-1	Upgradient	Groundwater	Monitoring Well	1				1	16KS5ZSV1-104WG
SVE-2	Upgradient	Groundwater	Monitoring Well	1	1			1	16KS5ZSV2-105WG
BV-17		Groundwater	Monitoring Well	1	1	1		1	16KS5ZBV17-106WG
FT003120	Downgradient	Groundwater	Monitoring Well				1		16KS5ZMW83-108WG
Duplicate Sample		Groundwater	Monitoring Well	1	1	1		1	16KS5ZMW3-107WG
Duplicate Sample	MS/MSD	Groundwater	Monitoring Well	2	2	2		2	16KS5ZMW2-103WG
Trip Blanks		Water	QA/QC		1	1			16KS5ZTB-MMDD
Sample Analyses Totals				**9**	**8**	**6**	**2**	**9**	

Table 6-3: Red Fox Creek Surface Water/Sediment Sample Analyses Summary

Location ID Sample Point	Comments	Matrix	Location Type	EPA Method 8260B VOCs	EPA Method 8260B-LL/ 5035A VOCs	EPA Method 8270 SIM PAHs	EPA Method SW3550 Percent Moisture	Sample Number
RFC-04		Surface Water	Stream	1		1		16KS5ZRFC4-502WS
RFC-04		Sediment	Stream Bed	1	1	1	1	16KS5ZRFC4-602SE
RFC-05		Sediment	Stream Bed	1	1	1	1	16KS5ZRFC5-603SE
Duplicate Sample		Surface Water	Stream	1		1		16KS5ZRFC9-505WS
Duplicate Sample	MS/MSD	Surface Water	Stream	2		2		16KS5ZRFC4-502WS
Duplicate Sample		Sediment	Stream Bed	1	1	1	1	16KS5ZRFC9-605SE
Duplicate Sample	MS/MSD	Sediment	Stream Bed	2	2	2		16KS5ZRFC4-602SE
Surface Water Trip Blank		Water	QA/QC	1				16KS5ZTB-MMDD
Low-Level Trip Blank	Low Level Blank	Sediment	QA/QC		1			16KS5ZTB-MMDD
Sediment Trip Blank	Methanol and Silica	Sediment	QA/QC	1				16KS5ZTB-MMDD
Sample Analyses Totals				**11**	**6**	**9**	**3**	

Method 8260B-LL for sediment samples will be analyzed using a low level technique requiring samples be frozen for preservation.

6.4 RAPCON/RED FOX CREEK FINDINGS

6.4.1 RAPCON Groundwater Analytical Results

Analytical results are provided in Appendix C, Zone 5 Tables. Table 6-4 presents current and historical sample analytical results for the contaminants of potential concern at this site (benzene, total BTEX, DRO, GRO, and TCE). Table 6-5 presents a summary of 2016 analytical data.

6.4.1.1 Petroleum Hydrocarbons

Three of the four wells sampled for GRO exceeded the RAO of 2.2 mg/L. GRO concentrations ranged from 1.9 mg/L to 4.1 mg/L. Four of the six wells sampled for DRO exceeded the RAO of 1.5 mg/L. DRO concentrations ranged between 1.2 mg/L to 2.2 mg/L. Overall, concentrations of GRO and DRO increased from the previous year.

6.4.1.2 BTEX

VOCs samples were collected from FT01-MW02 and FT01-BV17. Benzene was not detected in either of the wells. Toluene was detected in both of the wells at concentrations below cleanup levels. Ethylbenzene and xylenes were detected in both of the wells at concentrations above their respective cleanup levels.

6.4.1.3 TCE

The concentration of TCE in FT01-MW02 was ND, while the TCE concentration in FT01-BV17 was 0.0032 mg/L, which is above the cleanup level of 0.0028 mg/L.

6.4.1.4 Cis-1,2-Dichloroethene (Cis- DCE)

Cis-DCE was detected in FT01-MW02. Cis-DCE is an indicator of anaerobic degradation of TCE.

6.4.1.5 Iron

Iron concentrations detected in RAPCON groundwater ranged from 2.0 mg/L (FT01-BV17) to 11 mg/L (FT01-MW02). Higher iron concentrations correspond to the wells with the greatest petroleum hydrocarbon contamination, suggesting that natural biodegradation of the petroleum hydrocarbons is occurring.

6.4.1.6 Other VOC Results

Both of the wells sampled for VOCs exceeded the cleanup levels for 1,2,4-trimethylbenzene and naphthalene. Appendix C presents a listing of all the detected analytes from the 2016 groundwater-monitoring event.

6.4.1.7 PFOA and PFOS

FT01-MW01 and MW-83 were analyzed for PFOA and PFOS. The results from FT01-MW01 for PFOA/PFOS were 3.3/11 μg/L, which are above the ADEC cleanup level of 0.40 μg/L. MW-83 had PFOA/PFOS results well below the cleanup level.

Table 6-4: Historical RAPCON Groundwater Analytical Data

Well	Analyte (RAO in mg/L)	8/16/01 (Paug-Vik)	10/21/01 (Paug-Vik)	9/26/02 (Paug-Vik)	5/13/2003 (Paug-Vik)	9/16/2003 (Paug-Vik)	9/22/04 (Paug-Vik)	9/21/2005 (Paug-Vik)	9/18/2006 (Paug-Vik)	8/2007 (Paug-Vik)	8/2008 (Paug-Vik)	9/2009 (Paug-Vik)	9/2010 (Paug-Vik)	8/2011 (Paug-Vik)	9/2012 (Paug-Vik)	9/2013 (Paug-Vik)	9/2014 (Paug-Vik)	9/2015 (Paug-Vik)	10/2016 (Paug-Vik)
SVE-1	Benzene (0.0046)	**0.0083 VJM**	**0.0093**	**0.0137**	**0.0068**	**0.0089**	**0.0126**	**0.005**	0.0033	0.00279	0.00070	ND	0.00067	ND	0.00018	NS	NS	NS	NS
	Total BTEX	0.319 VJM	0.285 VJM	0.7207 VJ	0.3145 VJ	0.4293	1.3446	0.587	0.553	0.578	0.392	0.399	0.816	0.302	0.81100	NS	NS	NS	NS
	GRO (2.2)	1.09	0.945	**3.01 VJ**	1.65	1.23	**3.4**	1.58	1.67 VJ	1.35	1.3	1.6	**3.8**	1.2	0.78	NS	NS	NS	NS
	DRO (1.5)	**2.61 VJM**	**8.74 VJM**	**3.96 VM**	**2.7**	**3.71**	**6.88**	**4.94 VM**	**4.35 VJ**	**3.16**	**1.5**	**1.6**	**2.0**	**1.5**	1.4	**1.5**	**1.6**	0.79	1.2
	TCE (0.0028)	0.0025 VJ	**0.0036**	**0.0069**	**0.0029**	**0.0042**	**0.0092**	ND	**0.0039**	ND	0.0019	0.0015	0.0019	0.00090	0.00082	NS	NS	NS	NS
	EDB (0.000075)					**ND (0.001)**	**ND (0.001)**	**ND (0.001)**	**ND (0.001)**	**ND (0.001)**	**ND (0.002)**	**ND (0.01)**	ND (0.000019)	ND (0.000019)	ND	NS	NS	NS	NS
	Iron	5.99	2.83	12.6	6.19	7.27	7.89	3.78	5.82	5.52	5.8	5.0	4.35	3.79	3.7	5.8	7.1	4.5	2.1
	DO	2.81	11.37	0.12	0.3	0.18	0.35	0.26	2.06	1.12	0.56	1.00	0.63	1.04	1.61	0.50	0.70	1.10	1.47
SVE-2	Benzene (0.0046)	**0.0905 VJM**	**0.0485 VJ**	**0.0865**	**0.0236**	**0.025**	**0.0172**	**0.00768**	**0.0163**	**0.00869**	**0.0063**	**0.0074**	0.0037	0.0013	0.0015	NS	NS	NS	NS
	Total BTEX	1.9765 VJM	2.1025 VJM	4.3625 VJ	1.7496 VJ	1.3694	1.7422	0.511	2.909	2.69	2.86	2.05	1.10	0.156	0.461	NS	NS	NS	NS
	GRO (2.2)	**12.8**	**5.69 VJ**	**12.8**	**6.11**	**3.1**	**4.6**	**4.84**	**6.26**	**4.22**	**5.8**	**6.0**	**4.0**	0.57	2.000	**3.70**	**7.70**	2.0	**4.1**
	DRO (1.5)	**14.5 VJM**	**11.4 VJM**	**11.7 VM**	**20**	**15.8**	**2.87**	**7.81 VM**	**8.95**	**10.9**	**6.0**	**5.1**	**3.2**	1.40	**2.00**	**4.00**	**3.60**	**2.4**	**1.5**
	TCE (0.0028)	**0.162 VJ**	**0.0648 VJ**	**0.108**	**0.0581**	**0.060**	**0.0573**	**0.0248**	**0.0848**	**0.0478**	**0.060**	**0.017**	**0.011**	0.0027	**0.0042**	NS	NS	NS	NS
	EDB (0.000075)					**0.0011**	**ND (0.001)**	**ND (0.001)**	**ND (0.001)**	**ND (0.001)**	**ND (0.002)**	**ND (0.04)**	0.0000088	0.000018	ND	NS	NS	NS	NS
	Iron	22.7	17	20.6	16.5	11.2	7.44	6.77	11.1	9.05	10.5	7.2	4.7	2.26	7.5	14.00	13.00	12.00	12.00
	DO	0.91	9.82	NM	0.25	0.22	0.54	0.23	1.77	0.94	0.57	0.67	2.19	0.61	1.32	0.65	0.63	0.71	0.63
FT01-FD9	Benzene (0.0046)	0.0016	ND (0.0003)	ND (0.0005)	**0.0139**	**0.0219**	**0.0157**	**0.021**	**0.0105**	**0.0155**	**0.0075**	0.0012	0.0031	0.0022	0.00047	NS	NS	NS	NS
	Total BTEX	0.0483	0.1503	0.079	0.0846 VJ	0.0661	0.1294	0.115	0.054	0.1537	0.207	0.087	0.129	0.134	0.27	NS	NS	NS	NS
	GRO (2.2)	0.533	0.571	0.479	0.531	0.435	0.93	0.807 VJ	0.41	0.965	0.43	1.1	1.1	1.0	1.1	NS	NS	NS	NS
	DRO (1.5)	**41.1 VJM**	**15.1 VJM**	**5.62 VM**	**8.74**	**11.3**	**9.09**	**6.73 VM**	**6.85 VJ**	**5.26**	**2.6**	0.12	1.4	**2.0**	**1.7**	**1.8**	**1.9**	1.2	**1.7**
	TCE (0.0028)	**0.0145**	**0.0072**	**0.0036**	**0.0174**	**0.0374**	**0.0296**	**0.0401**	**0.0159**	**0.015**	**0.012**	**0.0042**	0.0023	0.0012	0.0022	NS	NS	NS	NS
	EDB (0.000075)					**0.0007**	**ND (0.001)**	**ND (0.001)**	**ND (0.001)**	**ND (0.001)**	**ND (0.002)**	**ND (0.004)**	0.000014	ND(0.000019)	0.0000067	NS	NS	NS	NS
	Iron	3.09	ND (0.062)	2.23	8.3	8.56	8.01	5.88	3.1	5.02	4.1	2.9	3.59	3.74	4.5	4.3	5.2	3.3	3.6
	DO	0.55	11.3	1.42	0.51	0.15	1.4	0.47	0.36	4.55	0.32	0.30	2.21	0.72	0.92	0.63	0.49	0.99	1.62
MW-01	Benzene (0.0046)	0.0039	ND (0.0003)	0.0006	**0.0264**	**0.0367**	**0.0162**	**0.00836**	**0.0115**	**0.00812**	**0.0073(0.0080)**	0.0023 (0.0029)	0.0024 (0.0023)	0.0025 (0.0022)	0.00049/0.00047	NS	NS	NS	NS
	Total BTEX	0.3918	0.0631	0.3802	0.7986 VJ	0.3297	0.3966	0.181	0.174	0.1055	0.117(0.094)	0.263 (0.252)	0.126 (0.121)	0.214 (0.188)	0.035/0.023	NS	NS	NS	NS
	GRO (2.2)	**2.95 VJ**	0.354	1.45	**2.75**	1.12	1.65	1.01 VJ	0.63	0.536	0.99(0.99)	1.5 (1.5)	1.6 (1.7)	1.6 (1.5)	0.44 (0.32)	0.57	**2.50**	1.20	**2.80**
	DRO (1.5)	**28.7 VJM**	**13.4 VJM**	**14.6**	**10.3**	**10.1**	**8.58**	**4.63 VM**	**5.76 VJ**	**5.95**	**3.9 (3.5)**	**2.2 (2.2)**	**1.6 (1.7)**	**2.8 (2.3)**	0.37 (1.1)	1.4	0.8	1.4	1.2
	TCE (0.0028)	**0.0195 VJ**	**0.0051**	**0.0052**	**0.0298**	**0.0467**	**0.0295**	**0.0489**	**0.0201**	**0.0113**	**0.0082 (0.0080)**	**0.0053(0.0085)**	**0.0030(0.0028)**	0.0017 (0.0013)	0.0013/0.0014	NS	NS	NS	NS
	EDB (0.000075)					**0.0006**	**ND (0.001)**	**ND (0.001)**	**ND (0.001)**	**ND (0.001)**	**ND (0.002)**	**ND (0.004)**	0.000022(0.000015)	0.000014 (0.000019)	0.000016 (0.000019)	NS	NS	NS	NS
	PFOA (0.00040)																		**0.0033**
	PFOS (0.00040)																		**0.0110**
	Iron	7.51	ND (0.062)	6.1	10	12.8	9.94	8.47	6.33	6.86	7.2 (7.2)	5.6 (5.7)	5.6 (5.7)	3.59 (7.67)	3.3 (3.1)	3.60	15.00	10.00	2.90
	DO	0.28	10.85	0.48	0.21	0.15	0.38	0.22	0.33	4.56	0.59	0.4	0.4	0.5	0.25	0.32	0.55	0.44	0.72
MW-02	Benzene (0.0046)	ND (0.0003)	ND (0.0003)	ND (0.0005)	**0.0259**	**0.0484**	**0.0232**	**0.0124**	**0.0138**	**0.0197**	0.0042	**0.0050**	NS	**0.0071**	0.0038	0.0043(0.0042)	0.00041 (0.00031)	0.0011	ND
	Total BTEX	0.1901 VJM	0.2217 VJM	0.1957 VJ	0.2566 VJ	0.1794	0.1105	0.198	0.187	0.188	0.257	0.218	NS	0.336	0.6030	0.524(0.6)	0.397(0.183)	0.349	0.449
	GRO (2.2)	1.62 VJ	1.88 VJ	1.5	2.13	0.981	1.39	1.37 VJ	1.09 VJ	1.57	1.2	1.6	NS	**3.7**	**3.1**	**2.2**	1.9 (1.7)	1.4	1.9
	DRO (1.5)	**12.6 VM**	**24.1 VJM**	**22.7**	**15.5**	**15**	**14.1**	**9.44 VM**	**5.88**	**8.65**	**5.8**	**1.8**	NS	**5.1**	**3.8**	**3.3 (3.2)**	**2 (2.9)**	**2.7**	**2.2**
	TCE (0.0028)	0.0045 VJ	ND (0.005)	**0.0029**	**0.0235**	**0.0802**	**0.0842**	**0.0793**	**0.0334**	**0.0221**	**0.0097**	**0.0070**	NS	**0.011**	**0.0088**	0.0012(0.0011)	0.00039(0.00032)	0.00093	ND
	EDB (0.000075)					**ND (0.001)**	**ND (0.001)**	**ND (0.001)**	**ND (0.001)**	**ND (0.001)**	**ND (0.002)**	**ND (0.01)**	NS	ND(0.000020)	ND	NS	NS	NS	NS
	Iron	6.97	13.7	6.9	11.2	14.4	6.72	10.5	7.79	4.94	9.0	6.8	NS	8.6	11.0	11	11	10	11
	DO	0.19	0.75	NM	0.13	0.11	0.4	0.27	0.27	4.63	0.34	0.54	NS	0.10	0.35	0.34	0.72	0.54	0.80
BV-17	Benzene (0.0046)							0.00285	ND	ND	0.0031	0.00047	0.00039	0.00020	0.0037	0.002	0.0014	0.0004(0.00035)	ND
	Total BTEX							0.00468	ND	ND	0.0043	0.00047	0.0029	0.0026	0.265	0.21	0.9114	0.081	0.658/0.649
	GRO (2.2)							0.043 F	0.04 F VB	0.012	1.5	0.22	0.24	0.16	0.99	1.1	**3.9**	0.46 (0.45)	**2.6/2.7**
	DRO (1.5)							**2.26 VM**	0.88	**3.72**	**4.4**	**2.0**	1.0	0.80	1.3	**2**	**2.5**	0.95 (0.85)	**1.9/2.1**
	TCE (0.0028)							**0.00737**	ND	0.00072	**0.0076**	0.0021	0.00098	0.00061	**0.0042**	**0.0033**	**0.0052**	0.0017	**0.0032/0.0031**
	EDB (0.000075)							**ND (0.001)**	**ND (0.001)**	**ND (0.001)**	**ND (0.002)**	**ND (0.002)**	ND (0.000019)	0.0000097	0.00001	NS	NS	NS	NS
	Iron							ND	ND	ND	ND	0.0980	0.0283	0.359	1.2	1.1	1.4	0.73 (0.76)	2.1
	DO							1.8	10.3	12.05	0.4	0.65	0.28	0.45	0.51	0.60	1.05	0.59	0.95

Table 6-5: Summary of Zone 5 A-Aquifer Analytical Data

Well Number	GRO (mg/L)	DRO (mg/L)	TCE (ug/L)	PFOA (ug/L)	PFOS (ug/L)	Ferrous Iron (mg/L)	DO (mg/L)	ORP (mV)	pH	Con. (µS/cm)
RAO	**2.2**	**1.5**	**2.8**	**0.40**	**0.40**	**NA**	**NA**	**NA**	**NA**	**NA**
FD-9	NA*	**1.7**	NA*	NA*	NA*	3.6	1.62	46	6.26	149
MW-01	**2.8**	1.2	NA*	**3.3**	**11**	2.9	0.72	19.6	6.25	154
MW-02	**1.9**	**2.2**	ND	NA*	NA*	11	0.8	37.1	5.83	118
SVE-1	NA*	1.2	NA*	NA*	NA*	2.1	1.47	89.3	5.74	176
SVE-2	**4.1**	**1.5**	NA*	NA*	NA*	12	0.63	49.9	5.54	144
BV-17	**2.6/2.7**	**1.9/2.1**	**3.2/3.1**	NA*	NA*	2.1	0.95	5.7	6.43	322
MW83**	NA*	NA*	NA*	0.0044	0.0050	NA*	7.52	123.5	5.93	64

NA* - Not Analyzed

NA - Not Applicable

ND - Not detected above method reporting level (MRL)

RAO - Remedial action objectives

Analytical results exceeding RAOs shown in **BOLD.**

**Downgradient well sampled for PFOA/PFOS only.

6.4.2 RAPCON Statistical Trend Analysis

The ProUCL software, Version 5.1 was used to assess benzene, DRO, GRO, and TCE concentration trends for six RAPCON monitoring wells. Output from this program can be found in Appendix E. Table 6-6 and Table 6-7 summarize the concentration trends observed in six key monitoring wells (FT01-BV1, FT01-FD9, FT01-MW01, FT01-SVE1, and FT01-SVE2) with historical concentrations of contaminants near or above RAOs. The tables list the numbers of wells exhibiting a specific concentration trend for benzene, DRO, GRO, and TCE. Well location data sets which did not have the minimum number of four observations, where the results were all below the reporting limit for a specific analyte, or were not sampled for a particular analyte are not included in the trend summary table. Note that 57% of the concentration trends were decreasing and 7% were increasing. Another 36% of the concentration trends showed no trend. Overall, since the majority of concentration trends are decreasing, the trend analysis supports the conclusion that intrinsic remediation is keeping contaminant concentrations stable or decreasing at this site.

Table 6-6 RAPCON Mann-Kendall Analysis Summary

Trend	Benzene	DRO	GRO	TCE	% of Total
Decreasing	1	5	1	1	57%
Increasing	0	0	1	0	7%
No Trend	1	1	2	1	36%
Totals	2	6	4	2	14

Table 6-7 RAPCON Mann-Kendall Trend Summary

Well	Benzene	DRO	GRO	TCE
FT01-BV17	NT	NT	**I**	NT
FT01-FD9	NA	**D**	NA	NA
FT01-MW01	NA	**D**	NT	NA
FT01-MW02	**D**	**D**	NT	**D**
FT01-SVE1	NA	**D**	NA	NA
FT01-SVE2	NA	**D**	**D**	NA

D - Decreasing I – Increasing
NT – No Trend NA – Not Analyzed

6.4.3 Red Fox Creek Surface Water Analytical Results

Surface water contaminant levels detected in the RFC-04 sample were compared to regulatory criteria and benchmark screening levels. The AWQS in 18 AAC 70 provides regulatory criteria for surface water. Analytical results are shown in Appendix C, Zone 5 Tables. Table 6-8 presents current and historical surface water sample analytical results for selected COCs at Red Fox Creek.

6.4.3.1 Petroleum Hydrocarbons

RFC-04 surface water was not analyzed for DRO and GRO. Low levels of several PAHs were detected the RFC-04 surface water sample.

6.4.3.2 VOCs

The m,p-Xylene concentration (0.18 mg/L) and o-Xylene concentration (0.035 mg/L) in the sample from RFC-04 exceeded the applicable water quality criteria of 0.0018 mg/L and 0.011 mg/L respectively. The TAH (BTEX) concentration of 0.292 mg/L and TAqH (BTEX + PAH) concentration of 0.293 mg/L detected in RFC-04 were above the water quality criteria of 0.010 mg/L and 0.015 mg/L respectively.

6.4.4 Sediment Analytical Results

There are no regulatory criteria for sediment samples; sediment analytical results are evaluated using the NOAA SQuiRT (NOAA, 2008) and benchmark screening levels found on ORNL’s Risk Assessment Information System (ORNL, 2017). Table 6-8 presents current and historical sediment sample analytical results for selected contaminants of potential concern at Red Fox Creek.

6.4.4.1 Petroleum Hydrocarbons

RFC-04 and RFC-05 were not analyzed for DRO and GRO. RFC-04 exceeded the screening criteria for 2-methylnaphthalene, acenaphthylene, fluorine, and naphthalene. No PAHs were detected in the sample from RFC-05.

6.4.4.2 VOCs

Sediment samples were collected for low level (frozen) and medium level (methanol preservation) analysis. There are no low level sample results for RFC-04 because target and non-target analytes were too highly concentrated to be analyzed by low level analysis. Naphthalene was detected in RFC-04 and RFC-05 above screening criteria.

6.4.5 Institutional Control Inspection

There were no indications that drinking water wells have been installed or that excavating has occurred.

6.4.6 Condition of Wells

The six wells scheduled for Zone 5 were sampled and in good condition.

Table 6-8: Historical Red Fox Creek Surface Water Analytical Data

Location	Location	Analyte	Water Quality Criteria	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
RFC-01	Located in drainage ditch upgradient of RAPCON site.	TAH	0.01	ND	0.0004	0.0048	ND	ND	ND	0.00012 (ND)	ND	ND	ND	ND	NS	NS	NS	NS
		TAqH (mg/L)	0.015	ND	**0.017**	0.0048	ND	ND	ND	0.00012 (ND)	ND	0.000009(0.0000047)	ND	0.0000185 (0.0000097)	NS	NS	NS	NS
		GRO (mg/L)	NA	NS	ND	0.058 F VB	ND	ND	0.0108	0.014 (0.041)	ND	ND	ND	ND	NS	NS	NS	NS
		DRO (mg/L)	NA	ND	0.303 VBJM	2.19 VM	0.14 F VM	0.269 VBJM	0.434	0.17 (0.28)	0.11 (0.15)	0.12	0.16 (0.15)	0.083 (0.077)	NS	NS	NS	NS
		TCE (mg/L)	0.005	ND	ND	ND	ND	ND	ND	ND	ND	0.00018	0.00020(0.00021)	ND	NS	NS	NS	NS
		cis-1,2-DCE (mg/L)	0.07	ND	ND	0.00094 F	ND	ND	ND	0.0001 (ND)	ND	ND	ND	ND	NS	NS	NS	NS
		Benzene (mg/L)	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NS	NS	NS	NS
		m,p-Xylene (mg/L)	0.0018	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NS	NS	NS	NS
		o-Xylene (mg/L)	0.013	ND	ND	ND	ND	ND	ND	0.00012 (ND)	ND	ND	ND	ND	NS	NS	NS	NS
		Naphthalene (mg/L)	0.012	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NS	NS	NS	NS
RFC-04	Located in drainage ditch adjacent to the RAPCON site.	TAH (mg/L)	0.01		**0.071**	0.011		**0.0517**	**0.0166**	**0.0311**	**0.0521**	**0.036**	**0.159**	0.0065	**0.06 (0.065)**	**0.089 (0.0394)**	**0.099 (0.0663)**	**0.257 (0.292)**
		TAqH (mg/L)	0.015		**0.072**	0.011		**0.052**	**0.0170**	**0.0330**	**0.0526**	**0.037**	**0.162**	0.0117	**0.064 (0.069)**	**0.09217 (0.0513)**	**0.109 (0.0727)**	**0.259 (0.293)**
		GRO (mg/L)	NA		0.463 VM	0.13		0.352 VM	0.114	0.26	0.30	0.26	0.94	0.63	NA	NA	NA	NA
		DRO (mg/L)	NA		2.49 VM	3.5 VM		1.75 VJM	4.30	2.30	0.12	1.3	2.8	0.83	NA	NA	NA	NA
		TCE (mg/L)	0.005		0.0014	ND		0.00106 VJ	0.00104	0.0010	0.00055	0.0012	0.00095	0.00047	0.00054(0.00061)	0.0002 (ND)	0.00045(0.00026)	ND
		cis-1,2-DCE (mg/L)	0.07		0.0149	0.0078		0.0136 VJ	0.0032	0.0085	0.0052	0.0055	0.0058	0.00480	0.0078(0.0077)	0.0044 (0.0028)	0.0044(0.0034)	0.009 (0.0073)
		Benzene (mg/L)	0.005		**0.0068**	0.00106		0.00218 VJ	0.00041	0.0023	0.0011	0.00066	0.00054	0.00051	0.00077(0.00085)	ND	ND	ND
		m,p-Xylene (mg/L)	0.0018		**0.0231**	**0.00313**		**0.0172 VJ**	**0.00553**	**0.014**	**0.024**	**0.012**	**0.065**	**0.069**	**0.023 (0.025)**	**0.046** (0.017)	**0.052 (0.032)**	**0.16 (0.18)**
		o-Xylene (mg/L)	0.013		**0.0323**	0.00503		**0.0273 VJ**	0.0090	0.0094	**0.016**	**0.016**	**0.083**	**0.062**	**0.021 (0.022)**	**0.023 (0.013)**	**0.023 (0.017)**	**0.033 (0.035)**
		Naphthalene (mg/L)	0.012		**0.0122**	0.0016		0.0068 VJ	0.00004	0.00064	0.0042	0.0039	0.0064	**0.014**	**0.015 (0.015)**	**0.01** (0.004)	0.0059 (0.0036)	**0.051 (0.058)**
RFC-05	Located in drainage ditch downgradient from RAPCON site and just before confluence with Red Fox Creek.	TAH (mg/L)	0.01	ND	**0.011**	0.0027	**0.0128**	0.0015	ND	0.0012	0.00043	ND	**0.022**	**0.022**	0.0022	0.00047	NS	NS
		TAqH (mg/L)	0.015	ND	0.012	0.0028	0.0132	0.0015	ND	0.0012	0.00043	ND	**0.022**	**0.023**	0.00227	0.00048	NS	NS
		GRO (mg/L)	NA	NS	0.083 F VM	0.0193 F VB	0.105	0.032 F VM	ND	0.015	ND	ND	0.16	0.15	NA	NA	NS	NS
		DRO (mg/L)	NA	ND	2.09 VM	0.865 VM	1.26 VM	1.47 VJM	1.6	1.0	0.79	0.36	0.99	0.36	NA	NA	NS	NS
		TCE (mg/L)	0.005	ND	0.0006	0.00045 F	0.00089	0.00047 F VJ	ND	0.00053	0.00056	0.00055	0.00082	0.00031	0.00029	ND	NS	NS
		cis-1,2-DCE (mg/L)	0.07	ND	0.0036	ND	0.00405	0.00224 VJ	ND	0.00080	0.00030	0.00038	0.0015	0.001	0.00044	ND	NS	NS
		Benzene (mg/L)	0.005	ND	0.0026	ND	0.00071	0.00024 VJ	ND	ND	ND	ND	0.00021	ND	ND	ND	NS	NS
		m,p-Xylene (mg/L)	0.0018	ND	**0.0024**	ND	**0.00302**	ND	ND	ND	ND	ND	**0.0067**	**0.0081**	0.00062	0.0002	NS	NS
		o-Xylene (mg/L)	0.013	ND	0.004	ND	0.0078	0.00122 VJ	ND	ND	ND	ND	**0.013**	0.01	0.00083	0.00027	NS	NS
		Naphthalene (mg/L)	0.012	ND	0.0019	0.000017	0.0025	0.00065 F VJ	ND	0.0000043	0.00015	ND	0.00092	0.002	0.001	ND	NS	NS
RFC-07	Located in Red Fox Creek drainage downgradient from where RAPCON drainage ditch enters.	TAH (mg/L)	0.01				0.001	0.00056	ND	0.0012	0.00039	0.00048	ND	0.0007	NS	NS	NS	NS
		TAqH (mg/L)	0.015				0.001	0.00078	ND	0.0012	0.00039	0.00048	0.0000082	0.00071	NS	NS	NS	NS
		GRO (mg/L)	NA				ND	ND	ND	0.050	ND	ND	ND	0.008	NS	NS	NS	NS
		DRO (mg/L)	NA				0.435 VM	0.494 VJM	1.56	0.80	0.22	0.11	0.18	0.10	NS	NS	NS	NS
		TCE (mg/L)	0.005				ND	ND	ND	ND	ND	ND	0.00015	ND	NS	NS	NS	NS
		cis-1,2-DCE (mg/L)	0.07				0.0004	ND	ND	0.00011	ND	ND	0.00012	ND	NS	NS	NS	NS
		Benzene (mg/L)	0.005				ND	ND	ND	ND	ND	ND	ND	ND	NS	NS	NS	NS
		m,p-Xylene (mg/L)	0.0018				ND	ND	ND	ND	ND	ND	ND	ND	NS	NS	NS	NS
		o-Xylene (mg/L)	0.013				0.00035	ND	ND	ND	ND	ND	ND	0.00029	NS	NS	NS	NS
		Naphthalene (mg/L)	0.012				ND	0.000094 F VJ	ND	0.0000084	ND	ND	ND	0.0076	NS	NS	NS	NS

Notes:

Results shown in **BOLD** exceed ADEC 18 AAC 70 Water Quality Criteria.

TCE - Trichloroethene, cis-1,2-DCE - cis-1,2-Dichloroethene

TAH - Total Aromatic Hydrocarbons (BTEX)

TAqH - Total Aqueous Hydrocarbons (TAH + PAH)

Results in parentheses are duplicate samples.

NA - Not Analyzed

NS - Not Sampled

ND - Not Detected

Table 6-9: Historical Red Fox Creek Sediment Analytical Data

Location	Analyte	Criteria	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
RFC1	GRO (mg/Kg)	NA	NS	0.499 F VJ	1.22 F VB	0.471 F VBJ	0.638 F VJ	0.461	NS	ND	ND (2.9)	3.2 (3.5)	ND	NS	NS	NS	NS
	DRO (mg/Kg)	NA	216 VJM	227 VJ	87.9	115 F	216 F VJ	54	20 (73)	330 (240)	52 (50)	100 (100)	58 (72)	NS	NS	NS	NS
	Anthracene (mg/Kg)	0.01	**0.0107 VM**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NS	NS	NS	NS
	Chrysene (mg/Kg)	0.02683	**0.0305 VJM**	ND	ND	ND	ND	0.0123	0.016 (0.012)	ND	0.016 (0.025)	0.010 (ND)	ND	NS	NS	NS	NS
	Fluorene (mg/Kg)	0.01	**0.0844 VJM**	ND	ND	**0.0381 F**	ND	**0.0151**	ND	ND	ND	ND	ND	NS	NS	NS	NS
	Naphthalene (mg/Kg)	0.01465	ND	**0.0318 F VM**	ND	ND	ND	0.00453	ND	ND (0.0039)	ND (0.0042)	0.0025 (0.0030)	0.001/ND	NS	NS	NS	NS
	Xylenes (mg/Kg)	0.025	ND	ND	ND	ND	ND	ND	ND (0.01)	ND	ND	ND	ND	NS	NS	NS	NS
	Acetone (mg/Kg)	0.0099	ND	ND	**0.0161 VJM**	**0.046 F VBJ**	**0.38**	ND	**0.023 (0.074)**	**0.051 (0.19)**	**0.12 (0.039)**	ND	0.0036 (0.0093)	NS	NS	NS	NS
	TCE (mg/Kg)	0.04	ND	ND	0.00088 F VJM	ND	ND	ND	0.0012 (0.0015)	0.0054 (ND)	0.0010 (0.0011)	ND	ND	NS	NS	NS	NS
	cis-1,2-DCE (mg/Kg)	0.4	ND	ND	0.00113 F VJM	ND	ND	ND	ND	ND	ND	ND	ND	NS	NS	NS	NS
RFC4	GRO (mg/Kg)	NA		3.11	1.07 F VBJ		131 VJ	8.63	NS	38	36	110	33	NA	NA	NA	NA
	DRO (mg/Kg)	NA		826 VJ	492		3,100 VJ	683	140	64	120	370	240	NA	NA	NA	NA
	Anthracene (mg/Kg)	0.01		ND	ND		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Chrysene (mg/Kg)	0.02683		**0.0527 F VM**	ND		ND	ND	0.0053	ND	ND	ND	ND	0.019 (0.0013)	0.0029 (0.0068)	ND	ND
	Fluorene (mg/Kg)	0.01		**0.049 F VM**	ND		**0.111 F VJ**	**0.0403**	**0.030**	0.004	0.016	ND	ND	**0.044 (0.017)**	**0.037 (0.059)**	**0.046 (0.050)**	**0.049 (0.058)**
	Naphthalene (mg/Kg)	0.01465		**0.391 VM**	**0.639 VM**		**0.905 VJ**	**0.212**	**0.260**	**0.470**	**0.22**	**0.84**	**0.18**	**0.16 (0.24)**	**2.4 (1.8)**	**1.2 (0.92)**	**2 (5.3)**
	Xylenes (mg/Kg)	0.025		**0.0313 VM**	**0.0965 VJM**		**0.12**	**0.0425**	**0.79**	**1.0**	**0.29**	**1.1**	**0.064**	**0.13 (0.24)**	**7.3 (4.51)**	**3.165 (2.557)**	**9.15 (17.9)**
	Acetone (mg/Kg)	0.0099		ND	**0.0257 VJM**		ND	ND	**0.18**	**0.033**	**0.032**	**0.19**	**0.15**	**0.11**	**ND (0.17)**	ND	ND
	TCE (mg/Kg)	0.04		0.0008 F VM	ND		ND	ND	0.0018	ND	ND	0.0024	0.00073	ND	ND	ND	ND
	cis-1,2-DCE (mg/Kg)	0.4		0.0299 VM	0.0185 VJM		ND	ND	0.013	0.0042	0.0021	0.0020	0.0012	ND	0.0150	ND	ND
RFC5	GRO (mg/Kg)	NA	NS	ND	0.391 F VBJ	ND VJ	1.67 F VJ	ND	NS	ND	ND	3.2	ND	NA	NA	NA	NA
	DRO (mg/Kg)	NA	57.4 VJM	26.2 F VJ	89.4 F	37 F	53.1 F VJ	21.2	9.6	7.7	22	24	11	NA	NA	NA	NA
	Anthracene (mg/Kg)	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Chrysene (mg/Kg)	0.02683	0.0102 VJM	ND	ND	ND	ND	ND	0.00047	ND	ND	ND	0.00085	ND	0.0018	ND	ND
	Fluorene (mg/Kg)	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Naphthalene (mg/Kg)	0.01465	ND	0.0038 F VBM	ND	0.0007 F VBJ	ND	ND	0.0043	ND	0.0091	0.0098	0.00046	ND	**0.017**	**0.02**	**0.025**
	Xylenes (mg/Kg)	0.025	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**0.057**
	Acetone (mg/Kg)	0.0099	ND	ND	**0.0128 VJM**	**0.046 F VBJ**	**0.43**	ND	**0.14**	**0.13**	**0.32**	**0.19**	**0.36**	**0.12**	**0.14**	**0.025**	**0.02**
	TCE (mg/Kg)	0.04	ND	ND	ND	0.0024 F VJ	ND	ND	0.0030	0.0150	0.0018	0.0015	ND	0.0084	ND	ND	0.00076
	cis-1,2-DCE (mg/Kg)	0.4	ND	ND	ND	0.0026 F VJ	ND	ND	0.0027	ND	ND	ND	ND	ND	ND	ND	ND
RFC7	GRO (mg/Kg)	NA				1.43 F VBJ	ND VJ	ND	NS	ND	ND	5.7	ND	NS	NS	NS	NS
	DRO (mg/Kg)	NA				48.7 F	626 F VJ	114	28	14	7.8	32	9.2	NS	NS	NS	NS
	Anthracene (mg/Kg)	0.01						ND	ND	ND	ND	ND	ND	NS	NS	NS	NS
	Chrysene (mg/Kg)	0.02683						ND	ND	ND	ND	ND	0.0015	NS	NS	NS	NS
	Fluorene (mg/Kg)	0.01				ND	ND	**0.0166**	ND	ND	ND	ND	ND	NS	NS	NS	NS
	Naphthalene (mg/Kg)	0.01465				ND	ND	ND	0.0023	ND	ND	0.011	0.00066	NS	NS	NS	NS
	Xylenes (mg/Kg)	0.025						ND	0.012	ND	ND	0.010	ND	NS	NS	NS	NS
	Acetone (mg/Kg)	0.0099				**0.108 VBJ**	**0.63**	ND	**0.30**	**0.52**	**0.12**	**0.47**	**0.48**	NS	NS	NS	NS
	TCE (mg/Kg)	0.04				ND	ND	ND	ND	ND	ND	ND	ND	NS	NS	NS	NS
	cis-1,2-DCE (mg/Kg)	0.4				ND	ND	ND	ND	ND	ND	ND	ND	NS	NS	NS	NS

Results shown in **BOLD** exceed Sediment Benchmark Screening Criteria.

TCE - Trichloroethene, cis-1,2-DCE - cis-1,2-Dichloroethene

Results in parentheses indicated duplicate sample.

NA - Not Analyzed

NS - Not Sampled

6.5 RAPCON/RED FOX CREEK CONCLUSIONS

6.5.1 RAPCON Groundwater

Information gained from the 2016 field activities was reviewed along with previous investigation results to draw conclusions on the progress of monitored natural attenuation at the RAPCON site. The ProUCL statistics analysis of groundwater contaminants revealed that 57% of concentration trends are decreasing. Since the majority of concentration trends are decreasing, this indicates that intrinsic remediation is attenuating contaminants, or at the very least keeping contaminant concentrations in check.

Detected groundwater contaminant concentrations in 2016 were generally higher for GRO and lower for DRO than those from previous sampling events. High iron concentrations in groundwater continue to correlate with higher petroleum hydrocarbon concentrations in the monitoring wells, thus providing evidence for natural biodegradation of petroleum compounds. Depleted dissolved oxygen levels in all of the wells sampled is another indication that aerobic biodegration has occurred.

Concentrations of 1,2,4-trimethylbenzene, ethylbenzene, total xylenes, and naphthalene exceeded ADEC cleanup levels in monitoring wells MW-2 and BV-17. The sample from BV-17 also had a TCE concentration of 3.2 µg/L, which exceeded the ADEC cleanup level of 2.8 µg/L.

FT01-MW01 has concentrations of PFOA/PFOS well above ADEC cleanup levels while MW-83, located 1,000 feet southeast of RAPCON is well below the cleanup levels. The low level PFOA/PFOS detection in MW-83 indicates that PFOA/PFOS has migrated downgradient through groundwater.

6.5.2 Red Fox Creek Sampling

Contaminants detected in the surface water at RFC-04 in 2016 are generally similar to those detected the two previous monitoring events with TAH, TAqH, and xylenes above water quality criteria.

Naphthalene, fluorene, and xylenes remain above sediment screening criteria at RFC-04. Naphthalene, xylenes, and acetone were also above the screening criteria at RFC-05. TCE was detected in the low level sediment sample from RFC-05 below screening criteria.

6.6 RAPCON/RED FOX CREEK RECOMMENDATIONS

- Sampling in Zone 5 RAPCON/Red Fox Creek should continue without changes with the following exception: VOCs need to be added to the list of analytical samples collected from SVE-2 since two consecutive rounds of sampling have not achieved cleanup levels for TCE at 0.0028 mg/L.

EXPLANATION

FT01–MW1 ⊕	A–AQUIFER MONITORING WELL LOCATIONS
FT01–AS1 ⊞	BIOVENTING WELL LOCATIONS
GRO	GASOLINE–RANGE ORGANICS CONCENTRATION
DRO	DIESEL–RANGE ORGANICS CONCENTRATION
TCE	TRICHLOROTHHENE CONCENTRATION
Cis–DCE	Cis–1,2–DICHLORORTHENE CONCENTRATION
PFOA	PERFLUOROOTANOIC ACID CONCENTRATION
PFOS	PERFLUOROOCTANE SULPHONIC ACID CONCENTRATION
1.5	RESULT EXCEEDING RAO
ND	NOT DETECTED

RAO CLEANUP LEVELS (mg/L)

GRO = 2.2, DRO = 1.5, TCE = 0.0028, Cis–DCE = 0.036
PFOA/PFOS = 0.0004

➡ GROUNDWATER FLOW DIRECTION

NOTE:
1. ONLY ANALYTES EXCEEDING A CLEANUP LEVEL IN AT LEAST ONE SAMPLING EVENT ARE SHOWN ON THIS FIGURE.

PATH: D:\16 Dwgs\16 PV\16039 KS LTM RPT FILE: 16-KS-LTM-RPT-F6-1.DWG PLOT: 5/17/18

FIGURE
6-1

RAPCON GROUNDWATER ANALYTICAL RESULTS

RAPCON AND RED FOX CREEK
2016 LONG TERM MANAGEMENT
King Salmon Divert, Alaska

PACIFIC AIR FORCES REGIONAL SUPPORT CENTER
& AIR FORCE CIVIL ENGINEERING CENTER
JBER, ALASKA

DATE
MAY 2018
CHKD
H.L.H.
DRAWN
C.E.H.
PROJ. NO
16039

EXPLANATION

RFC-04 ⊙	SURFACE WATER/SEDIMENT SAMPLE LOCATIONS
TCE	TRICHLOROETHENE CONCENTRATION
ACE	ACETONE CONCENTRATION
FLE	FLUORENE CONCENTRATION
NAP	NAPHTHALENE CONCENTRATION
X	XYLENES CONCENTRATION
TAH	TOTAL AROMATIC HYDROCARBONS CONCENTRATION
TAqH	TOTAL AQUEOUS HYDROCARBONS CONCENTRATION
(SED)	SEDIMENT (mg/Kg)
(SW)	SURFACE WATER (mg/L)
ND	NOT DETECTED
0.049	RESULT EXCEEDING RAO AND/OR WATER QUALITY CRITERIA

RAO CLEANUP LEVELS

SEE TABLE 6–8 FOR SURFACE WATER RAOs.
SEE TABLE 6–9 FOR SEDIMENT RAOs.

➡	GROUNDWATER FLOW DIRECTION

RFC–04

TCE	(SED/SW)	ND/ND
ACE	(SED/SW)	ND/ND
FLE	(SED)	**0.049**
NAP	(SED/SW)	**2/0.051**
X	(SED/SW)	**9.15/0.193**
TAH	(SW)	**0.257**
TAqH	(SW)	**0.259**

DUPLICATE

TCE	(SED/SW)	ND/ND
ACE	(SED/SW)	ND/ND
FLE	(SED)	**0.058**
NAP	(SED/SW)	**5.3/0.058**
X	(SED/SW)	**17.9/0.215**
TAH	(SW)	**0.292**
TAqH	(SW)	**0.293**

RFC–05

TCE	(SED)	0.00076
ACE	(SED)	**0.020**
FLE	(SED)	ND
NAP	(SED)	**0.025**
X	(SED)	**0.057**

FIGURE
6-2

RED FOX CREEK SURFACE WATER AND SEDIMENT ANALYTICAL RESULTS

RAPCON AND RED FOX CREEK
2016 LONG TERM MANAGEMENT
King Salmon Divert, Alaska

PACIFIC AIR FORCES REGIONAL SUPPORT CENTER
& AIR FORCE CIVIL ENGINEERING CENTER
JBER, ALASKA

DATE
FEB. 2017
CHKD
H.L.H.
DRAWN
C.E.H.
PROJ. NO
16039

PATH: D:\16 Dwgs\16 PV\16039 KS LTM RPT FILE: 16-KS-LTM-RPT-F6-2.DWG PLOT: 2/17/17.

7 FT004 GROUNDWATER MONITORING

Fire Training Area No. 4 (FT004) is located approximately 1,600 feet northeast of the centerline of Runway 29. The fire training area was a circular sandy clearing approximately 50 feet in diameter. It was reportedly used until 1980 for training in fighting aircraft fires. A complete description of excavation and well installation activities can be found in *Remedial Action-Construction Final Report* and *Remedial Action Construction LF006 & FT004 Well Installation and Sampling (King Salmon, Divert, Paug-Vik, June, 2016).*

7.1 DESCRIPTION OF CURRENT STUDY

The purpose of the current study was to collect water samples from eight FT004 monitoring wells. Samples were analyzed for VOCs, EDB, GRO, DRO, PFOA/PFOS, and MNA parameters. In addition, one downgradient well was also sampled for PFOA/PFOS only.

7.2 REMEDIAL ACTION OBJECTIVES FOR FT004

RAOs for FT004 are ADEC cleanup levels Table C Groundwater Cleanup Levels (ADEC, 2016). Table 7-1 lists the contaminants of concern at this site and their ADEC cleanup levels.

Table 7-1 Remedial Action Objectives for Fire Training Area No. 4 (FT004)

Chemical of Concern	Maximum Concentration	Maximum Concentration Location (Depth) (Date)	Maximum Concentration in 2006 (Location)	Cleanup Level	Basis
Groundwater (mg/L)					
TCE	**0.16**	FT04-MW5 (2006)	**0.16** (FT04-MW5)	0.0028	18AAC75(a)
GRO	**16**	FT04-MW7 (2015)		2.2	18AAC75(a)
DRO	**3.65**	FT04-MW2 (1997)	Not analyzed	1.5	18AAC75 (a)
Benzene	**0.292**	FT04-MW2 (1997)	**0.059** (FT04-MW5)	0.0046	18AAC75 (a)
Toluene	**2.7**	FT04-MW7 (2015)	**1.5** (FT04-MW5)	1.1	18AAC75 (a)
EDB	**0.00237**	FT04-MW2 (1996)	ND (<0.001) (FT04-MW4)	0.000075	18AAC75 (a)
PFOA	**17**	FT04-MW7 (2016)	NA	0.00040	18AAC75 (a)
PFOS	**30**	FT04-MW7 (2016)	NA	0.00040	18AAC75 (a)
Soil (mg/kg)					
DRO	**20,860**	SS02(0 ft bgs)(1996)	Not analyzed	230	18AAC75(c)
Benzene	**0.8**	FT04B (10 ft bgs)(1993)	Not analyzed	0.025	18AAC75(b)
TCE	**0.64**	FT04A-MW5 (10 ft bgs) (1993)	Not analyzed	0.020	18AAC75(b)

Definitions:

18AAC75 = Oil and Hazardous Substances Pollution Control Regulations, as amended through July, 2017.

RAO = remedial action objective
GRO = gasoline-range organics
bgs = below ground surface
TCE – trichloroethene
EDB = 1,2-dibromoethane (ethylene dibromide)
mg/L = milligrams per liter
DRO = diesel-range organics
mg/kg = milligrams per kilogram

Notes:
(a) 18 AAC 75.345(b)(1)Table C Groundwater Cleanup Levels
(b) 18AAC75.340(c)(1) Table B1 Method Two – Soil Cleanup Levels Table, Migration to Groundwater
(c) 18AAC75.340(d)(1) Table B2 Method Two – Petroleum Hydrocarbon Soil Cleanup Levels, Migration to Groundwater

7.3 PROJECT TASKS

7.3.1 FT004 Groundwater Sampling

Groundwater monitoring was conducted at FT004 to document contaminant concentrations and MNA parameters in the groundwater. Samples were collected September 28-29, 2017. A list of the groundwater laboratory samples collected during this project is presented in Table 7-2. Groundwater sampling results are displayed on Figure 7-1 and listed in Table 7-3.

7.3.2 Work Plan Deviations

Down gradient monitoring wells FT04-MW3 and FT04-MW4 (both installed in 1996) were damaged and obstructed with sand at 10.1 and 9.2 feet respectively. They were not sampled, and there were no alternative wells in the area to sample instead.

Table 7-2: FT004 Groundwater Sample Analyses Summary

Location ID Sample Point	Matrix	Location Type	Analytical Methods										Sample Number
			EPA Method 8260B VOCs	Alaska Method AK 101 GRO	Alaska Method AK 102 DRO	537 PFOA PFOS	Alkalinity SM 2320B	Chloride & Sulfate 9056	Nitrate & Nitrite 353.2	EPA Method 6020 Fe & Mn	EPA Method 504.1 EDB	Methane RSK-175	
FT04-MW1	Groundwater	Monitoring Well	1	1	1	1	1	1	1	1	1	1	16FT04-MW1WG
FT04-MW2	Groundwater	Monitoring Well	DAMAGED - NOT SAMPLED										16FT04-MW2WG
FT04-MW3	Groundwater	Monitoring Well	DAMAGED - NOT SAMPLED										16FT04-MW3WG
FT04-MW4	Groundwater	Monitoring Well	1	1	1	1	1	1	1	1	1	1	16FT04-MW4WG
FT04-MW5R	Groundwater	Monitoring Well	1	1	1	1	1	1	1	1	1	1	16FT04-MW5WG
FT04-MW6	Groundwater	Monitoring Well	1	1	1	1	1	1	1	1	1	1	16FT04-MW6WG
FT04-MW7	Groundwater	Monitoring Well	1	1	1	1	1	1	1	1	1	1	16FT04-MW7WG
FT04-MW8	Groundwater	Monitoring Well	1	1	1	1	1	1	1	1	1	1	16FT04-MW8WG
FT003-120*	Groundwater	Monitoring Well				1							16KS5ZMW120-108WG
Duplicate Sample	Groundwater	Monitoring Well	1	1	1	1	1	1	1	1	1	1	16FT04-MW9WG
MS/MSD	Groundwater	Monitoring Well	2	2	2	2	2	2	2	2	2	2	16FT04-MW8WG
Project Trip Blanks	Water	QA/QC	1	1									16KS5ZTB-MMDD
Water Analyses Totals			**10**	**10**	**9**	**10**	**9**	**9**	**9**	**9**	**9**	**9**	

*Downgradient from FT004 - sampled for PFOA/PFOS only.

7.4 FT004 FINDINGS

7.4.1 Analytical Results

Analytical results are shown in Appendix C, Zone 5 Tables. Table 7-3 presents current and 2015 groundwater sample analytical results for selected FT004 COCs. Figure 7-1 shows FT004 analytical results and Figure 7-2 shows PFOA/PFOS results for FT004 and downgradient monitoring well FT003-120.

7.4.1.1 GRO

GRO was detected in three of the six samples above the RAO of 2.2 mg/L. Results ranged between 2.3 (2.2) mg/L in FT04-MW-2 to 12 mg/L in FT04-MW7. The other three wells sampled for GRO were ND. Results are listed on Table 7-3.

7.4.1.2 DRO

DRO was detected in all of the wells below the RAO of 1.5 mg/L. This highest concentration was 1.3 mg/L in FT04-MW7 which also had the highest concentration of GRO. The other DRO result ranged between 0.035 mg/L to 1.1 mg/L.

7.4.1.3 EDB

FT04-MW2 and FT04-MW5R were the only wells with detectable levels of EDB. The results were 0.026 (0.022) µg/L and 0.0087 µg/L respectively, which are below the RAO of 0.075 µg/L.

7.4.1.4 TCE

TCE concentrations in monitoring wells FT04-MW2 (0.019/0.021 mg/L), FT04-MW5R (0.0067 mg/L) and FT04-MW7 (0.099 mg/L) were above the RAO of 0.0028 mg/L. The other three wells sampled were ND for TCE.

7.4.1.5 BTEX

Concentrations of ethylbenzene and total xylenes in FT04-MW2, FT04-MW5R, and FT04-MW7 exceeded RAOs. FT04-MW7 was the only well with benzene and toluene above RAOs.

7.4.1.6 1,2,4-Trimethylbenzene

1,2,4-Trimethylbenzene concentrations in monitoring wells FT04-MW2, FT04-MW5R, and FT04-MW7 were above the RAO of 15 µg/L. Concentrations were 83, 240, and 350 µg/L, respectively. The other three wells sampled were non-detect for 1,2,4-trimethylbenzene.

7.4.1.7 Naphthalene

Concentrations of naphthalene in monitoring wells FT04-MW2, FT04-MW5R, and FT04-MW7 were above the RAO of 1.7 µg/L. Concentrations were 23, 22, and 71 µg/L, respectively. Concentrations of naphthalene in the other three wells sampled were ND, 0.16 and 0.32 µg/L.

7.4.1.8 PFOA and PFOS

Four of the wells sampled were above the cleanup level of 0.4 µg/L for PFOA and PFOS. Concentrations for PFOA ranged from 0.007 µg/L (FT04-MW1) to 25 µg/L in FT04-MW5R. PFOS ranged from 0.023 µg/L in FT04-MW1 to 30 µg/L in FT04-MW7. Monitoring well FT003-120, located 1,650 feet south and downgradient from FT004, was sampled for PFOA/PFOS only. The concentration of PFOA was 0.0017 µg/L and ND for PFOS.

7.4.1.9 Inorganics

Various geochemical indicators important for assessing aerobic biodegradation of fuel hydrocarbons were measured to evaluate if intrinsic remediation is taking place. A summary of FT004 analytical results can be found in Table 7-3.

- Nitrate-nitrite as nitrogen was detected at low levels all of the wells sampled at concentrations ranging from 0.026 to 0.19 mg/L. All of the wells also exhibited detectable dissolved hydrocarbons. There does not appear to be a correlation between contamination levels and nitrate-nitrite concentrations. Current nitrate-nitrite results would suggest nitrate reduction is not a significant biodegradation mechanism for petroleum hydrocarbon contamination at FT004.
- Sulfate concentrations ranged between 0.73 to 2.5 mg/L, but there does not appear to be a good correlation between low sulfate concentrations and high DRO concentrations. As with nitrate-nitrite, sulfate reduction does not seem to be a significant biodegradation mechanism.
- Ferrous iron concentrations ranged from ND in FT04-MW6 and FT04-MW8, to 12 mg/L in FT04-MW7. There appears to be a good correlation between high ferrous iron concentrations and high GRO/DRO concentrations. Iron reduction seems to be a significant biodegradation mechanism at FT004.
- Manganese concentrations ranged from 0.003 mg/L in FT04-MW6 to 2.6 mg/L in FT04-MW7. While higher GRO did correlate with higher manganese at FT04-MW2 and FT04-MW7, higher GRO did not correlate with higher manganese at FT04-MW5R. It is unclear if manganese reduction is an important biodegradation mechanism at this site.
- Methane concentrations ranged from ND in FT04-MW1, FT04-MW6, and FT04-MW8, to 0.071 mg/L in FT04-MW7. Higher GRO concentrations did correlate with detectable methane at MW2, MW5R, and MW7. Methanogenesis may be an important biodegradation mechanism at this site.

- Alkalinity measurements ranged from 9.1 to 88 mg/L (FT04-MW7), and generally, elevated petroleum hydrocarbon levels correlated with increased alkalinity concentrations.

7.4.1.10 Field Measured Parameters

While collecting groundwater samples from monitoring wells, several water-quality parameters were recorded to determine groundwater characteristics relevant to assessing intrinsic remediation. Field measurements can be found on the sample data sheets for FT004 in Appendix A and a summary of results can be found in Table 7-3.

- Free Product: Free product was not observed in any of the wells.
- Temperature: Groundwater temperatures measured in September were between 4.47˚C and 8.64˚C. These temperatures are suitable for biodegradation processes.
- pH: Measurements were between 4.19 and 6.27 pH units. These levels are suitable for biodegradation processes.
- Conductivity: The conductivity measurements ranged from 53 to 112 micro Siemens per centimeter (µS/cm). Elevated levels of conductivity may be associated with groundwater contamination.
- Dissolved Oxygen: DO levels ranged between 1.17 mg/L and 12.09 mg/L. Areas with elevated petroleum hydrocarbons generally have depressed DO levels (<2.0 mg/L). At FT004, the wells with the highest concentrations of GRO had the lowest DO levels, and the wells with the lower GRO concentrations had higher DO levels.
- Redox Potential: Redox potentials were between 20.1 and 327.4 millivolts (mV). Lower redox potentials correlated with areas of petroleum contamination.

Table 7-3: Summary of FT004 A-Aquifer Analytical Results (2016)

Well	GRO (mg/L)	DRO (mg/L)	EDB (µg/L)	PFOA (µg/L)	PFOS (µg/L)	Benzene (mg/L)	Toluene (mg/L)	TCE (mg/L)	Chloride (mg/L)	Nitrate-Nitrite (mg/L)	Sulfate (mg/L)	Alkalinity (mg/L)	Ferrous Iron (mg/L)	Manganese (mg/L)	Methane (mg/L)	DO (mg/L)	ORP (mV)	Temp	pH	Conductivity
RAO	**2.2**	**1.5**	**0.075**	**0.40**	**0.40**	**0.0046**	**1.1**	**0.0028**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
MW1	ND	0.038	ND	0.007	0.023	ND	ND	ND	3.6	0.095	1.7	28	0.2	0.016	ND	12.09	256.2	4.47	5.85	47
MW2	**2.3(2.2)**	0.45	0.026(0.022)	**9.3(3.4)**	**7.9(11)**	0.0036(0.0037)	0.21	**0.019(0.021)**	3.3(3.2)	0.026(0.027)	0.94(0.73)	61	6.5(6.8)	2.1(2.2)	0.015(0.016)	1.17	20.1	6.12	6.27	127
MW5R	**3.6**	1.1	0.0087	**25**	**20**	ND	0.094	**0.0067**	2.4	0.06	1.9	36	4.3	0.74	0.0023	3.44	110.4	8	5.47	68
MW6	ND	0.036	ND	0.30*	0.10*	ND	ND	ND	1.9	0.1	2.5	17	ND	0.003	ND	10.47	327.4	8.64	4.19	38
MW7	**12**	1.3	ND	**17**	**30**	**0.01**	**2**	**0.099**	2.3	0.19	1.1	88	11	2.6	0.071	2.29	60.8	7.69	6	152
MW8	ND	0.035	ND	**6.1**	**22**	ND	ND	ND	1.5	0.19	1.3	9.1	ND	0.017	ND	10.92	283.9	7.95	5.14	23
MW120*	NA	NA	NA	0.0017	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	12.57	247.2	4.97	5.28	51

NA - Not Applicable
NS - Not sampled
ND - Not detected above method reporting level (MRL)
RAO - Remedial action objectives
*Exceeds EPA Health Advisory level (0.070 ug/L) for PFOA/PFOS in drinking water (USEPA, 2016a).

Analytical results exceeding RAOs shown in **BOLD**
Results in parentheses are Duplicate samples.
*Downgradient well sampled for PFOA/PFOS only

FT004 Analytical Results (2015)

Well	GRO (mg/L)	DRO (mg/L)	EDB (ug/L)	PFOA (ug/L)	PFOS (ug/L)	Benzene (mg/L)	Toluene (mg/L)	TCE (mg/L)
RAO	**1.3**	**1.5**	**0.075**	**0.4**	**0.4**	**0.0046**	**1.1**	**0.0028**
MW5R	**13**	**1.7**	NA	**14**	**11**	ND	0.26	**0.016**
MW7	**16 (15)**	**1.5** (1.1)	NA	**11(13)**	**8.4(8.3)**	**0.026(0.029)**	**2.2 (2.7)**	**0.13**
MW8	1.2	0.59	NA	**19**	**68**	0.00015	0.002	ND

7.4.2 Condition of Wells

Six of the eight wells at FT004 were sampled and in good condition. FT04-MW3 and FT04-MW4 were damaged at 9-10 feet below top of casing and obstructed with sand.

7.5 FT004 CONCLUSIONS

FT04-MW1, located upgradient of the fire training area had PFOS/PFOA concentrations below cleanup levels.

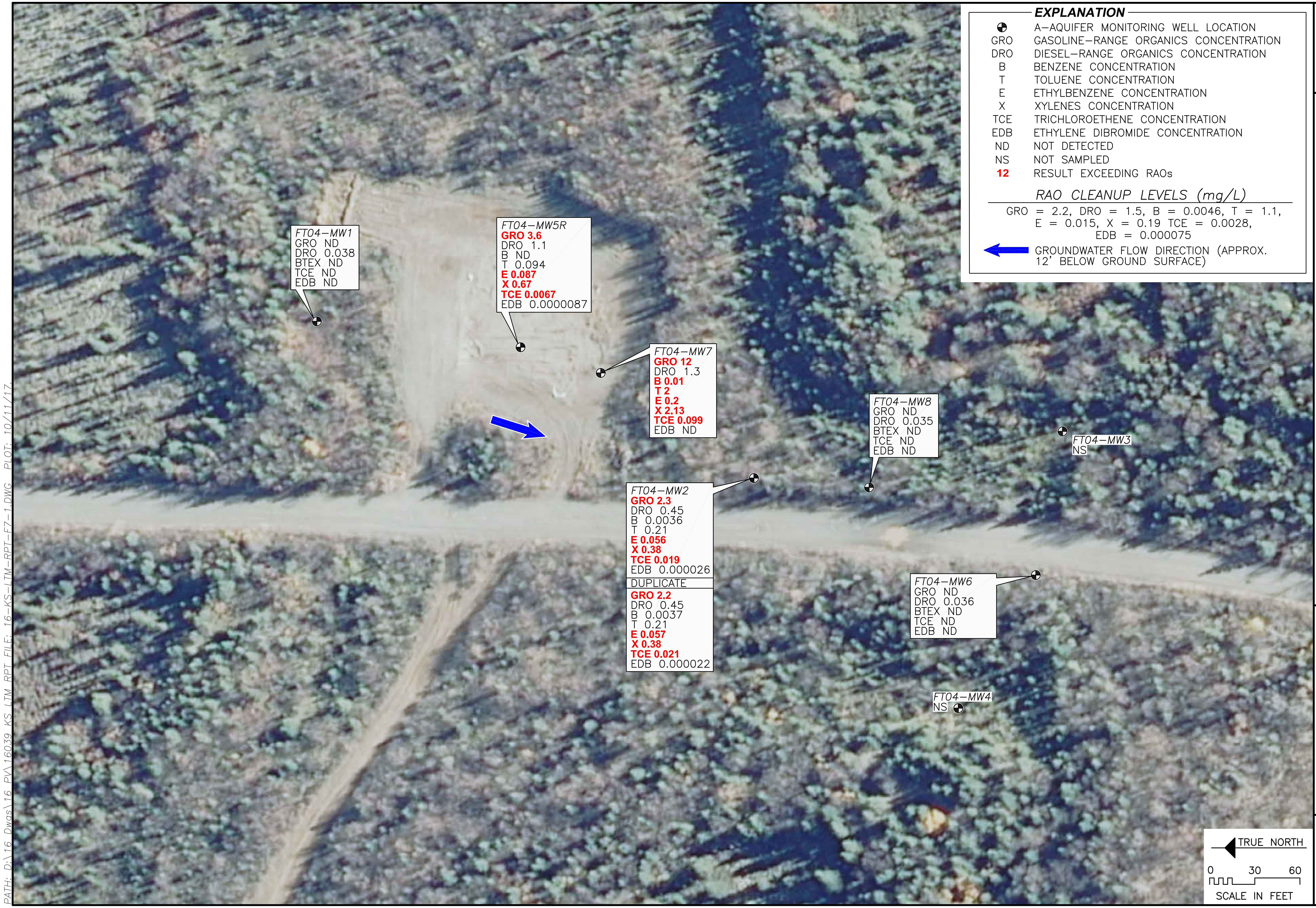
FT04-MW5R and FT04-MW7, both located in the previously excavated fire training area, exceeded cleanup levels for GRO, TCE, ethylbenzene, naphthalene, total xylenes, PFOA, and PFOS. FT04-MW7 also exceeded cleanup levels for benzene and toluene.

FT04-MW2 and FT04-MW8 are located 120 feet and 180 feet, respectively, downgradient from the edge of the excavated area. FT04-MW2 exceeded cleanup levels for GRO, TCE, ethylbenzene, naphthalene, total xylenes, PFOA, and PFOS, while FT04-MW8 exceeded cleanup levels for PFOA and PFOS only.

FT04-MW6 is located 300 feet southwest and downgradient from the edge of the fire training area. There were no exceedances in the sample from this well. Monitoring well FT003-120, located 1,650 feet south of the fire training area had a low level of PFOA and was ND for PFOS.

7.6 FT004 RECOMMENDATIONS

- Sampling of the viable FT004 wells should continue with the exception of up gradient FT04-MW1.
- Sampling for nitrate/nitrite and sulfate, should be discontinued since nitrate and sulfate reduction don’t appear to be significant biodegradation mechanisms for petroleum hydrocarbon contamination at FT004.
- There are three berms approximately 200, 450, and 700 feet south of FT004 (Figure 7-2). The area between the berms could have potentially been used for additional fire training areas. Between the last two berms, there is an area that appears to have sparse vegetation. These areas between the berms should be investigated for PFOA and PFOS.



EXPLANATION

●	A–AQUIFER MONITORING WELL LOCATION
GRO	GASOLINE–RANGE ORGANICS CONCENTRATION
DRO	DIESEL–RANGE ORGANICS CONCENTRATION
B	BENZENE CONCENTRATION
T	TOLUENE CONCENTRATION
E	ETHYLBENZENE CONCENTRATION
X	XYLENES CONCENTRATION
TCE	TRICHLOROETHENE CONCENTRATION
EDB	ETHYLENE DIBROMIDE CONCENTRATION
ND	NOT DETECTED
NS	NOT SAMPLED
12	RESULT EXCEEDING RAOs

RAO CLEANUP LEVELS (mg/L)

GRO = 2.2, DRO = 1.5, B = 0.0046, T = 1.1,
E = 0.015, X = 0.19 TCE = 0.0028,
EDB = 0.000075

← GROUNDWATER FLOW DIRECTION (APPROX. 12' BELOW GROUND SURFACE)

FIGURE
7-1

GROUNDWATER GRO, DRO, BENZENE, TOLUENE, TCE, AND EDB ANALYTICAL RESULTS FT004

FT004
2016 LONG TERM MANAGEMENT
King Salmon Divert, Alaska

PACIFIC AIR FORCES REGIONAL SUPPORT CENTER
& AIR FORCE CIVIL ENGINEERING CENTER
JBER, ALASKA

DATE
OCT. 2017
CHKD
H.L.H.
DRAWN
C.E.H.
PROJ. NO
16039

PATH: D:\16 Dwgs\16 PV\16039 KS LTM RPT FILE: 16–KS–LTM–RPT–F7–1.DWG PLOT: 10/11/17.

EXPLANATION

⊕	A-AQUIFER MONITORING WELL LOCATIONS
PFOA	PERFLUOROOTANOIC ACID CONCENTRATION
PFOS	PERFLUOROOCTANE SULPHONIC ACID CONCENTRATION
9.3	RESULT EXCEEDING RAOs
ND	NOT DETECTED
NS	NOT SAMPLED

RAO CLEANUP LEVELS (ug/L)

PFOA/PFOS = 0.4

← GROUNDWATER FLOW DIRECTION (APPROX. 12' BELOW GROUND SURFACE)

FIGURE

7-2

GROUNDWATER PFOA AND PFOS ANALYTICAL RESULTS
FT004

FT004
2016 LONG TERM MANAGEMENT
King Salmon Divert, Alaska

PACIFIC AIR FORCES REGIONAL SUPPORT CENTER
& AIR FORCE CIVIL ENGINEERING CENTER
JBER, ALASKA

DATE	OCT. 2017
CHKD	H.L.H.
DRAWN	C.E.H.
PROJ. NO	16039

PATH: D:\16 Dwgs\16 PV\16039 KS LTM RPT FILE: 16-KS-LTM-RPT-F7-2.DWG PLOT: 10/11/17.

8 ZONE 6 – RAPIDS CAMP

Groundwater Zone 6 (Rapids Camp) is located on the northern bank of the Naknek River, roughly 4 miles southeast of KSD. The camp occupies about 12.5 acres of land and was established in 1952 as part of a USAF program to build facilities for “morale, recreation, and welfare.” Included were boat docks, fish camps, lodging, and a fuel storage area. The camp was closed in 1977, and all structures and tanks have been removed. All groundwater contaminant concentrations in the Rapids Camp area were below the appropriate regulatory requirements, and in 2008, eight monitoring wells were decommissioned. The only remaining data needs are satisfied by long-term monitoring of the landfill site.

An inspection was conducted in the Rapids Camp Landfill (LF003) following the requirements of the ROD (USAF, 2000). The primary objective is monitoring the landfill cap to make sure it is acting as a competent cover for landfilled materials. The document entitled *Final Operation, Monitoring, and Maintenance Manual, North and South Barrel Bluffs, King Salmon, Alaska* (Hart Crowser, 2000) was used as a guide for the inspection activities performed at the landfill.

8.1 RAPIDS CAMP LANDFILL INSPECTION

Slopes, vegetation, and erosion-control features at Rapids Camp Landfill (Site LF003) were inspected on September 23, 2016. The inspection was documented on the Landfill Inspection Form, which has been included in Appendix A. Photographs can be found in Appendix F. During this inspection, there was no evidence of erosion of the landfill cap. No sinkholes were observed. Vegetation cover was estimated at 100%, and the vegetation, consisting of birch, alder, and grass, was in good conditions.

Institutional controls listed in the Zone 6 ROD prohibit drinking water wells within 100 feet of the boundaries of the former generator pad and landfill, excavation of soils deeper than five feet bgs in the area of the former generator pad, and excavation or construction in the area of the landfill. Bristol Bay Telephone dug a trench to bury a cable. The trench was near the powerline and went through the generator pad portion of the area. They stated they encountered some debris below the surface, but they were able to leave it in place. Some metal runway material was left above ground at the bottom of the hill where they constructed a small pad. There were no other observations of noncompliance of institutional controls at the former landfill or generator pad.

8.2 ZONE 6 RECOMMENDATIONS

- ADEC should be petitioned for Site Status change to Cleanup Complete with Institutional Controls.

FIGURE
8-1

LANDFILL INVESTIGATION
GROUNDWATER ZONE 6

NAKNEK RECREATIONAL CAMP (RAPIDS CAMP GWZ6)
2016 LONG TERM MANAGEMENT
King Salmon Divert, Alaska

PACIFIC AIR FORCES REGIONAL SUPPORT CENTER
& AIR FORCE CIVIL ENGINEERING CENTER
JBER, ALASKA

DATE
FEB. 2017
CHKD
H.L.H.
DRAWN
C.E.H.
PROJ. NO
16039

PATH: D:\16 Dwgs\16 PV\16039 KS LTM RPT FILE: 16-KS-LTM-RPT-F8-1.DWG PLOT: 2/17/17.

9 ZONE 7 – LAKE CAMP

Historical spills and operational practices at Lake Camp have resulted in contamination of the water table with petroleum-based products. In 2009, approximately 255 cubic yards of POL contaminated soil were excavated from SS004, a former vehicle maintenance site. Another 900 cubic yards were excavated from SS005. A fuel storage tank to supply fuel for a generator was previously located at SS005. Both excavations were to groundwater at approximately 4-5 feet below ground surface. Sheen was observed on the groundwater. No groundwater samples were collected in 2009. A complete description of excavation activities can be found in *Remedial Action Projects, King Salmon, Airport (Paug-Vik, November, 2012).*

The Air Force has contracted through the Corps of Engineers to complete a Zone 7 Record of Decision.

9.1 DESCRIPTION OF CURRENT STUDY

The purpose of the current study was to collect groundwater samples from two monitoring wells located at SS005, and one monitoring well located at LF001. Five additional wells were eliminated from the sampling program in 2015 after two consecutive years of sampling indicated no groundwater contamination at those locations. The data collected during this project includes concentrations of DRO and MNA parameters in groundwater.

A land use control inspection was also conducted to ensure no drinking water wells have been installed or unauthorized excavating has occurred.

9.2 REMEDIAL ACTION OBJECTIVES FOR ZONE 7

RAOs for Lake Camp are ADEC cleanup levels. The RAOs are listed in Table 9.1.

Table 9-1 Cleanup Levels for Lake Camp

	Site Data			**Regulatory Criteria**	
Media	Chemical of Concern	Maximum Conc. (Location, Date)	Maximum Conc. 2000 (Location)	Regulatory Criteria for Unrestricted Use	Basis
Ground-water (mg/L)	DRO	**12** (MW-08, 2000)	**12** (MW-08)	1.5	18AAC75 Table C
Soil (mg/Kg)	DRO	**54,000** (0-2' SB-05 2000)	**54,000** (0-2' SB-05)	230	18AAC75. Method Two
	PAHs^2	*		various	18AAC75. Method Two

Notes:

** Because polynuclear aromatic hydrocarbons (PAHs) are commonly associated with DRO contamination, they are considered to be potential COCs for these sites. There has been no PAH analysis of soil samples at SS004 and SS005 to confirm the presence or absence of PAHs in site soil. Regulated PAHs include the following compounds: acenaphthene, anthracene, benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, and pyrene.*

*Results exceeding cleanup levels are shown in **bold** font.*

Definitions:

18AAC75 = Oil and Hazardous Substances Pollution Control Regulations

Method Two refers to the 18 AAC 75.341 Method Two Table B1 or Table B2 (Under 40-inch zone) soil cleanup levels, which are protective of residential land use and migration to groundwater (unlimited use/unrestricted exposure).

Table C refers to the 18 AAC 75.345 Table C groundwater cleanup levels, which are protective of drinking water.

RAOs = remedial action objectives
DRO = diesel-range organics
bgs = below ground surface
PAH = polynuclear aromatic hydrocarbons
mg/L = milligrams per liter
mg/Kg = milligrams per kilogram

9.3 PROJECT TASKS

9.3.1 Zone 7 Groundwater Sampling

Groundwater monitoring was conducted at Lake Camp to document contaminant concentrations and MNA parameters in the groundwater. Samples were collected September 29, 2016. A list of the groundwater laboratory samples collected during this project is presented in Table 9-2. Groundwater sampling results are displayed on Figure 9-1 and listed in Table 9-3.

9.3.2 Institutional Control Inspection

Institutional controls are part of the selected remedy necessary to meet the RAOs. The goals of the institutional controls are to prevent the drinking of groundwater contaminated above 18 AAC 75.345 Table C groundwater cleanup levels and to help ensure the proper management of soil contaminated above Method Two cleanup levels in order to comply with State regulations (18 AAC 75.375). Institutional controls within the site boundaries consist of:

- Prohibiting the installation of water supply wells as long as the aquifer fails ADEC Table C cleanup levels.
- A restriction on excavation without a proper soil management plan.

A visual inspection was performed to verify that no water wells have been installed and no soil excavating has taken place.

9.3.3 Work Plan Deviations

There were no deviations from the work plan.

Table 9-2: Zone 7, A-Aquifer Sample Analyses Summary

				Analytical Methods						
Location ID Sample Point	Comments	Matrix	Location Type	Alaska Method AK 102 DRO	EPA Method 2320B Alkalinity	EPA Method 9056 Chloride & Sulfate	EPA Method 353.2 Nitrate + Nitrite	EPA Method 6020 Fe and Mn (dissolved)	RSK 175 Methane	Sample Number
LF02		Groundwater	Monitoring Well	1	1	1	1	1	1	16KS7ZLF02-107WG
GP01		Groundwater	Monitoring Well	1	1	1	1	1	1	16KS7ZGP01-109WG
MW22		Groundwater	Monitoring Well	1	1	1	1	1	1	16KS7ZMW22-111WG
Duplicate		Groundwater	Well Point	1	1	1	1	1	1	16KS7Z801-130WG
GP01	MS/MSD	Groundwater	Well Point	2	2	2	2	2	2	16KS7ZGP01-109WG
SAMPLE ANALYSES TOTALS				**6**	**6**	**6**	**6**	**6**	**6**	

9.4 ZONE 7 FINDINGS

9.4.1 Field Measured Parameters

While collecting groundwater samples from monitoring wells, several water-quality parameters were recorded to determine groundwater characteristics relevant to assessing intrinsic remediation. Field measurements can be found on the sample data sheets for Zone 7 in Appendix A and a summary of results can be found in Table 9-3.

Free Product: Free product was not observed in any of the wells.

Temperature: Groundwater temperatures measured in the A-Aquifer wells during September were between 9.16˚C and 9.63˚C. These temperatures are suitable for biodegradation processes.

pH: Measurements taken during September were between 4.97 and 5.93 pH units. These levels are suitable for biodegradation processes.

Conductivity: The conductivity measurements ranged from 53 to 112 micro Siemens per centimeter (µS/cm). Elevated levels of conductivity may be associated with groundwater contamination.

Dissolved Oxygen: DO levels ranged between 2.01 mg/L and 3.11 mg/L. Areas with elevated petroleum hydrocarbons generally have depressed DO levels (<2.0 mg/L). In Zone 7, the well with the lowest DRO (LF02) had the highest DO while the well with the highest DRO had a lower DO.

Redox Potential: Redox potentials were between 95.9 and 169.8 millivolts (mV). Lower redox potentials generally correlate with areas of petroleum contamination.

Table 9-3: Summary of Zone 7 A-Aquifer Analytical Data

Well	DRO (mg/L)	Choride (mg/L)	Nitrate-Nitrite (mg/L)	Sulfate (mg/L)	Ferrous Iron (mg/L)	Manga-nese (mg/L)	Methane (mg/L)	Alkalinity (mg/L)	Tempera-ture	DO (mg/L)	ORP (mV)	pH	Con. (µS/cm)
RAO	**1.5**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
LF02	0.47(0.43)	3.7	0.047(0.042)	1.4	0.095(0.11)	0.049	0.03	35	9.63	3.11	152.6	5.93	79
MW22	**2.2**	2.2	0.016	1.7	0.65	0.16	0.011	24	9.16	2.79	169.8	4.97	53
GP01	**4.1**	2.3	0.014	1.4	3.4	1.4	10	81	9.38	2.01	95.9	5.6	112

NA - Not Applicable
ND - Not detected above method reporting level (MRL)
RAO - Remedial action objectives
Analytical results exceeding RAOs shown in **BOLD.**

9.4.2 Analytical Results

Analytical results are shown in Appendix C, Zone 7 Tables. Table 9-4 presents current and historical groundwater sample analytical results for selected Zone 7 COCs.

9.4.2.1 DRO

The petroleum hydrocarbon levels (DRO) detected in Zone 7 groundwater are shown on Figure 9-1. Monitoring wells GP01 and MW22 exceeded the RAO of 1.5 mg/L for DRO with concentrations of 4.1 mg/L and 2.2 mg/L respectively. Overall, DRO concentrations ranged from 0.43 to 4.1 mg/L. Current and historical DRO results for selected Zone 7 monitoring wells/well points can be found in Tables 9-3 and 9-4.

9.4.2.2 Inorganics

Various geochemical indicators important for assessing aerobic biodegradation of fuel hydrocarbons were measured to evaluate if intrinsic remediation is taking place. A summary of Zone 7 analytical results can be found in Table 9-3.

- Nitrate-nitrite as nitrogen was detected at low levels all of the wells sampled during 2016 at concentrations ranging from 0.014 to 0.047 mg/L. All of the wells also exhibited detectable dissolved hydrocarbons. However, the well with the highest hydrocarbon concentration had the lowest concentration of nitrate-nitrite. There does not appear to be a correlation between contamination levels and nitrate-nitrite concentrations. Current nitrate-nitrite results would suggest nitrate reduction is not a significant biodegradation mechanism for petroleum hydrocarbon contamination in Zone 7.
- Sulfate concentrations ranged between 1.4 to 1.7 mg/L, but there does not appear to be a good correlation between low sulfate concentrations and high DRO concentrations. As with nitrate-nitrite, sulfate reduction does not seem to be a significant biodegradation mechanism in Zone 7.
- Ferrous iron concentrations ranged from 0.095 in LF02 to 3.4 mg/L in GP01, but there does not appear to be a good correlation between high ferrous iron concentrations and high DRO concentrations except in GP-01. As with nitrate-nitrite, iron reduction does not seem to be a significant biodegradation mechanism in Zone 7.
- Manganese concentrations ranged from 0.049 mg/L in LF02 to 1.4 mg/L in GP01. While higher DRO did correlate with higher manganese at GP01, higher DRO did not correlate with higher manganese at MW22. It is unclear if manganese reduction is an important biodegradation mechanism at this site.
- Methane concentrations ranged from 0.011mg/L in MW22 to 10.0 mg/L in GP01. While higher DRO did correlate with higher methane at GP01, higher DRO did not correlate with higher methane at MW22. It is unclear if methanogenesis is an important biodegradation mechanism at this site.

- Alkalinity measurements ranged from 24 to 81 mg/L (GP01), and generally, elevated petroleum hydrocarbon levels correlated with increased alkalinity concentrations at GP-01, but not MW22.

9.4.1 DRO and TCE Concentration Trends

The statistical software ProUCL, Version 5.1 was used to assess DRO concentration trends for three Zone 7 monitoring wells. Output from the ProUCL evaluation can be found in Appendix E.

Table 9.4 and Table 9.5 summarize the concentration trends observed in the three monitoring wells with historical concentrations of contaminants near or above RAOs. The tables list the numbers of wells exhibiting a specific concentration trend for each analyte. Well location data sets, which did not have the minimum number of four observations, or where the results were all below the reporting limit for a specific analyte, are not included in the trend summary table. Note that 100% of the wells had no trend. Overall, since the majority of concentration trends are stable, the trend analysis supports the conclusion that intrinsic remediation is keeping contaminant concentrations stable at this site.

Table 9-4 Zone 7 MANN-Kendall Analysis Summary

Trend	DRO	% of Total
Decreasing	0	0%
Increasing	0	0%
No Trend	3	100%
Totals	3	3

Table 9-5 Zone 7 MANN-Kendall Trend Summary

Well	DRO
GP-01	NT
LF02	NT
MW22	NT

NT – No trend

9.4.2 Institutional Control Inspection

There were no indications of water well installations or excavating occurring within the property boundaries of Zone 7.

9.4.3 Condition of Wells

The three wells scheduled for Zone 7 were sampled and in good condition.

9.5 ZONE 7 CONCLUSIONS

Two of three wells sampled in 2016 exceeded RAO for DRO.

DRO concentrations at MW22 and GP01 have increased since last year's sampling event, while there is a slight DRO decrease at LF02.

In summary, the data at this site are sparse, and only limited conclusions concerning trends and MNA processes can be made. The data we do have suggested that overall DRO concentrations may be steady or declining, and that some biodegration processes may be occurring.

9.6 ZONE 7 RECOMMENDATIONS

- Sampling should continue at monitoring wells LF02, GP-01, and MW22. If the DRO concentration in 2017 at LF02 remains below the cleanup level of 1.5 mg/L, sampling of the well should be discontinued.

- Sampling for nitrate/nitrite, sulfate, and ferrous iron should be discontinued.

- 2015 soil samples collected from three LF01 locations indicated DRO contaminated soil above cleanup levels. This soil should be excavated and treated.

Table 9-6: Historical Zone 7 A-Aquifer DRO Results

Well	1994 Analytical Results (mg/L)	1998 Analytical Results (mg/L)	2000 Analytical Results (mg/L)	2013 Analytical Results (mg/L)	2014 Analytical Results (mg/L)	2015 Analytical Results (mg/L)	2016 Analytical Results (mg/L)
RAO	1.5	1.5	1.5	1.5	1.5	1.5	1.5
LF02	0.82	**5.2**	NS	0.95 (0.83)	**2.1**	0.64(0.55)	0.47(0.43)
MW07	NI	NI	0.03	ND	0.061/0.055	NS	NS
MW08	NI	NI	**12**	NF	NF	NS	NS
GP01	0.024	ND	?	**2.6**	**4.5**	**2.9**	**4.1**
GP02	**5.7**	**2.4**	?	0.1	0.2	NS	NS
MW21	NI	NI	**3.23**	0.25	0.25	NS	NS
MW22	NI	NI	**2.6**	**2.7**	0.84	1	**2.2**
WP19	NI	NI	0.2	0.087	0.12	NS	NS
WP20	NI	NI	0.17	0.34	0.29	NS	NS

ND - Not Detected
NS - Not Sampled
NI - Not Installed
NF- Not Found
? - Well Removed according to ROD
(Duplicate Sample Result)

PATH: D:\16 Dwgs\16 PV\16039 KS LTM RPT FILE: 16-KS-LTM-RPT-F9-1.DWG PLOT: 2/17/17.

DATE
FEB. 2017
CHKD
H.L.H.
DRAWN
C.E.H.
PROJ. NO
16039

PACIFIC AIR FORCES REGIONAL SUPPORT CENTER
& AIR FORCE CIVIL ENGINEERING CENTER
JBER, ALASKA

GROUNDWATER DRO RESULTS GROUNDWATER ZONE 7

NAKNEK RECREATIONAL CAMP (GWZ7)
2016 LONG TERM MANAGEMENT
King Salmon Divert, Alaska

FIGURE
9-1

10 LANDFARM OPERATION & MAINTENANCE

In 2014, excavation of POL-contaminated soil occurred at sites DA031, FT004, SA036-DR13, SA039-DR3, SA039-DR14, SA039-DR16, and SA039-DR18. A total of 1,550 yd^3 of POL-contaminated soil was taken to the newly-constructed landfarm for ex-situ bioremediation. An additional 32 yd^3 and 3 to 5 yd^3 of POL-contaminated soil from two other contractors were added to the northwest section of the landfarm. The total quantity of POL-contaminated soil in the landfarm is approximately 1,587 yd^3.

Multi Increment soil samples were collected in July 2015 from the landfarm and were analyzed for previously identified contaminants to establish contamination levels prior to treatment. All soils besides those coming from FT004 were sampled as Decision Unit 1. The soil from FT004 was sampled as Decision Unit 2 because it had potential PFOA and PFOS contamination. The POL contaminants sampled in both decision units include GRO, DRO, RRO, PAHs, and VOCs. The analytical results were compared to 18 AAC 75 Method Two soil cleanup levels (Tables B1 and B2) for migration to groundwater (ADEC, 2016)

Cleanup level exceedances were DRO in the three samples from Decision Unit 1 and PFOS and PFOA in Decision Unit 2. All other analytes were below cleanup levels (Final *Landfarm Operations & Maintenance Report*, Paug-Vik Services, November 2016). Table 10-1 shows the 2015 MI sampling results.

Table 10-1 2015 Landfarm Multi Increment Soil Sample Results

Sample Description	**Analyte**				
	GRO (mg/kg)	DRO (mg/kg)	RRO (mg/kg)	PFOA (µg/kg)	PFOS (µg/kg)
DU 1 Primary	29	**1,500**	1,700	NA	NA
DU 1 Duplicate	30	**1,400**	1,400	NA	NA
DU 1 Triplicate	38	**1,400**	1,400	NA	NA
DU 1 RSD (%)	15.3	4.03	11.5	NA	NA
DU 1 95% UCL	40.6	**1,530**	1790	NA	NA
DU 2 Primary	72	140	280	**98**	**210**
DU 2 Duplicate	33	120	300	**77**	**180**
DU 2 Triplicate	52	110	230	**100**	**240**
DU 2 RSD (%)	37.3	12.4	13.4	**13.9**	**14.3**
DU 2 95% UCL	85.2	149	330	**113**	**260**
Cleanup Level	**300**	**250**	**11,000**	**1.7**	**3.0**

Definitions:

mg/kg = milligrams per kilogram
GRO = gasoline-range organics
RRO = residual-range organics
PFOS = Perfluorooctane Sulfonate
RSD = Relative Standard Deviation
NA = Not Applicable
µg/kg = micrograms per kilogram
DRO = diesel-range organics
PFOA = Perfluorooctanoic acid
DU = Decision Unit
UCL = Upper Confidence Limit

Notes:

-Sample IDs are abbreviated. The full sample IDs are 12KSBC-SP01SO.
-Cleanup levels are most stringent levels from ADEC 18 AAC 75 Table B1, Method 2-Soil Cleanup Levels, Ingestion or Migration to Groundwater (ADEC, 2017).
-Concentrations in **BOLD** exceed cleanup levels.

Also in 2015, excess leachate in the landfarm from rain was pumped through a granular activated carbon (GAC) filter and stored in temporary holding ponds until analytical results showed the water met ADEC Water Quality Standards and could be discharged through a silt fence on site. Approximately 150,000 gallons were treated and discharged on-site. In October 2015, while proposed regulations for PFOS/PFOA in water were being evaluated by ADEC, both analytes were added to discharge criteria. The water in the holding ponds at that time was above the proposed cleanup levels for PFOS/PFOA, so water discharges from the site were discontinued. Approximately 120,000 gallons remained in the four holding ponds and, as described below, was retreated in 2016 to meet PFOS/PFOA criteria before being discharged off site.

10.1 PROJECT OBJECTIVES

The primary objectives of this project associated with the landfarm included:

- Determining the ideal flow rate for the minimum residence time in the GAC that ensures discharge criteria are reached.
- Refiltering 120,000 gallons of 2015 water in the four existing holding ponds.
- Constructing three new holding ponds with dimensions 50x50x8 feet.
- Pumping and filtering excess landfarm water into holding ponds and then sampling the water.
- Performing Multi Increment (MI) sampling to characterize soil in the landfarm.
- Tilling and managing leachate weekly.
- Evaluating the C:N:P ratio and adding soil amendments as needed.
- Installing winter cover.
- Providing reports that document and summarize the work.

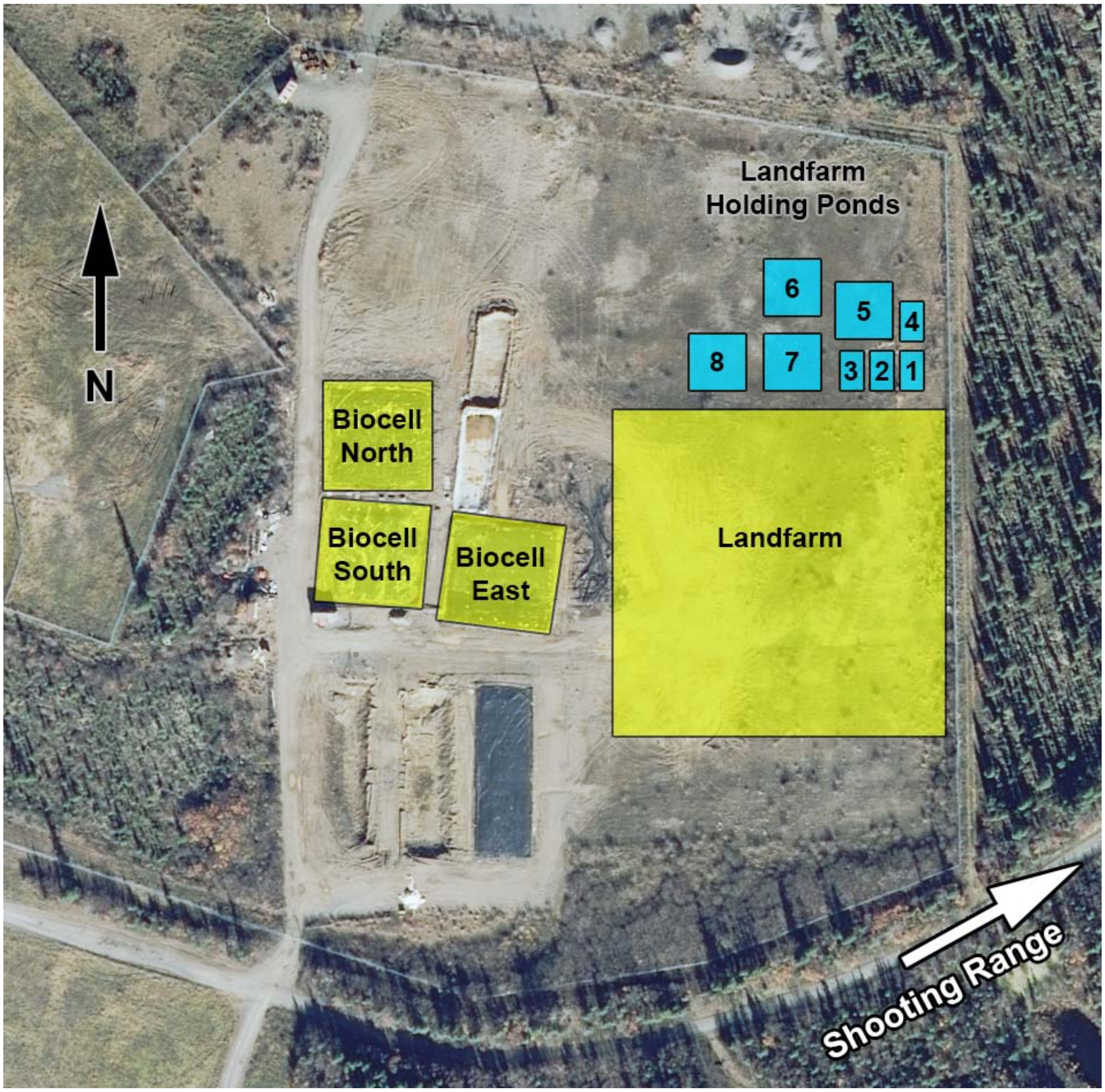


Figure 10-1. King Salmon Landfarm Location in Fenced Biocell Area

10.2 LEACHATE MANAGEMENT

At the start of the 2016 field season, the minimum residence time in the GAC that ensured discharge criteria were reached was determined to be a flow rate of about 30 gallons/minute. Once this ideal flow rate was determined, three new holding ponds were constructed with dimensions 50ft x 50ft x 7ft. The ponds were lined with Seaman 8130 XR-5 material, which is 30-mil polyester, chemically-resistant geotextile. Water from the landfarm was treated and pumped into the new holding ponds. When a sufficient volume was treated, pumping into that holding pond was stopped. A sample of the treated water was then collected and sent to the project laboratory for VOC, PAH, and PFOA/PFOS analyses.

Over the winter of 2015-2016, part of the landfarm cover in the northeast corner slid down off of the surrounding berm and probably allowed water on top of the cover to come into contact with water beneath it. As a result, all of the water on top of the liner was treated as if it was in contact with the soil being treated in the landfarm.

Approximately 452,000 gallons of landfarm water were filtered into the holding ponds. This included the 120,000 gallons pumped from the holding ponds that didn't meet discharge criteria in 2015. Thirteen post-treatment water samples were collected from the holding ponds between August 1 and October 9, 2016, and submitted to the project laboratory for PFOA/PFOS, TAH, and TAqH analyses. Analytical results were compared to the 18 AAC 70 Water Quality Standards (ADEC, 2017a). A summary of the analytical results is presented in Table 10-2. Complete analytical reports can be found in Appendix C. Filtered water with results below criteria was discharged off site through silt fencing to prevent the off-site migration of any silt.

Sample 16LFW13 from Pond 6 met criteria for TAH and TAHq, but failed the cleanup levels for PFOA. The water associated with this sample remains in the holding pond and will be retreated and retested next year until it meets discharge criteria.

One pretreated landfarm water sample was collected from beneath the landfarm cover to assess contaminant concentrations prior to filtering through the GAC. Results were 7.7 µg/L for PFOA and 2.9 µg/L for PFOS, which are above the water quality standard of 0.40 µg/L for both.

Table 10-2 2016 Landfarm Filtered Pond Water

Sample Description	Sample ID	Analyte			
		TAH (µg/L)	TAqH (µg/L)	PFOA (µg/L)	PFOS (µg/kg)
Pond 7	16LFW01-0108	ND	0.0071	ND	ND
Pond 5	16LFW02-0108	ND	ND	ND	ND
Pond 6	16LFW03-0816	ND	ND	0.0017	0.0013
Pond 7	16LFW04-0816	ND	ND	ND	0.00064
Pond 8	16LFW05-0816	ND	ND	0.030	0.0081
Pond 5	16LFW06-0905	ND	ND	ND	0.00048
Pond 7	16LFW07-0905	ND	ND	ND	0.00034
Pond 1	16LFW08-0916	ND	0.0065	0.029	0.0085
Pond 2	16LFW09-0916	ND	0.0073	0.078	0.022
Pond 3	16LFW10-0916	ND	0.0097	0.022	0.016
Pond 6	16LFW11-1006	ND	ND	0.0020	0.0019
Pond 6	16LFW13-1009	ND	ND	**0.51**	0.17
Pond 5	16LFW14-1009	ND	ND	0.12	0.031
Unfiltered*	16LFW12-1006	ND	ND	**7.7**	**2.9**
Water Quality Standard		10	15	0.40	0.40

*Sample collected from unfiltered water beneath the landfarm cover.

Definitions:

ND = non-detect
µg/L = micrograms per liter
TAH = Total Aromatic Hydrocarbons (sum of benzene, toluene, ethylbenzene, and xylene)
TAqH = Total Aqueous Hydrocarbons (sum of TAH and all PAHs)
PAH = Polyaromatic hydrocarbons
PFOA = Perfluorooctanoic acid
PFOS = Perfluorooctane Sulfonate
NA = Not Applicable

Notes:

- Sample IDs are abbreviated. The full sample IDs are 16LFW01-0801.
- The last 4 digits of the Sample ID are the month and day the sample was collected.
- Criteria are based on ADEC 18 AAC 70 Water Quality Standards (ADEC, 2017a).
- Concentrations in **BOLD** exceed water quality criteria.

10.3 TILLING OPERATIONS

Tilling activities were performed to mix and aerate the soil, while minimizing compaction, in order to stimulate aerobic microbial activity in the soil and enhance biodegradation of POL contaminants. The project goal was to till the landfarm weekly during the summer months, as soil conditions allowed.

The landfarm cover was removed from the contaminated-soil section of the landfarm and tilling activities were started in early August. Excess water in the landfarm was removed and treated to achieve soil moisture conditions that were amenable to tilling. To avoid damaging the landfarm liner with the tilling equipment, care was taken to not till when excessive water existed in the landfarm soil. Due to heavy rains in August and September, tilling operations were performed a total of two times. Tilling was halted and landfarm was re-covered for the season on October 9th.

10.4 PROGRESS SAMPLING

Sampling activities were performed in accordance with the project work plans (2016 Long Term Monitoring Work Plans (PVS, 2016a), the Field Sampling Plan (PVS, 2016b), and the Quality Assurance Project Plan (PVS, 2016c)).

A Multi Increment (MI) sampling was performed to characterize the level of hydrocarbon contamination in the landfarm and determine if any subset(s) of the soil in the landfarm exceed(s) ADEC cleanup levels for PFOS/PFOA. This sampling occurred from September 2nd to September 7th, 2016.

The landfarm was divided into six decision units (DUs). A decision unit is the defined area or volume to be characterized. As shown in Figure 10-2, the soil from FT004 containing PFCs was divided into two decision units of approximately 135 yd^3 each. The remaining soil was divided into 4 decision units of approximately 325 yd^3 each. Note that the 32 yd^3 of soil from another project, located in the northwest corner of the landfarm, was included with Decision Unit 3.

MI sampling was conducted by sampling multiple random locations throughout each decision unit. Each decision unit was divided into four equally sized quadrants. Each of the four quadrants were subdivided into approximately 50 subsections. Decision Units 1 and 2 each had 49 subsections, Decision Units 3, 4, and 6 each had 50 subsections, and Decision Unit 5 had 2 quadrants with 48 subsections and 2 with 46. The subsections were numbered 1 to 50 (depending on the decision unit) for the first section and 51 to 100 for the second, etc. A total of 188 to 200 subdivisions were created for each decision unit. Using a random number generator, 8 subdivisions from each quadrant were chosen for a total of 32 samples per decision unit. Because the depth of the soil in the landfarm is 12 inches, samples were collected from a single depth of 6 inches below the surface.

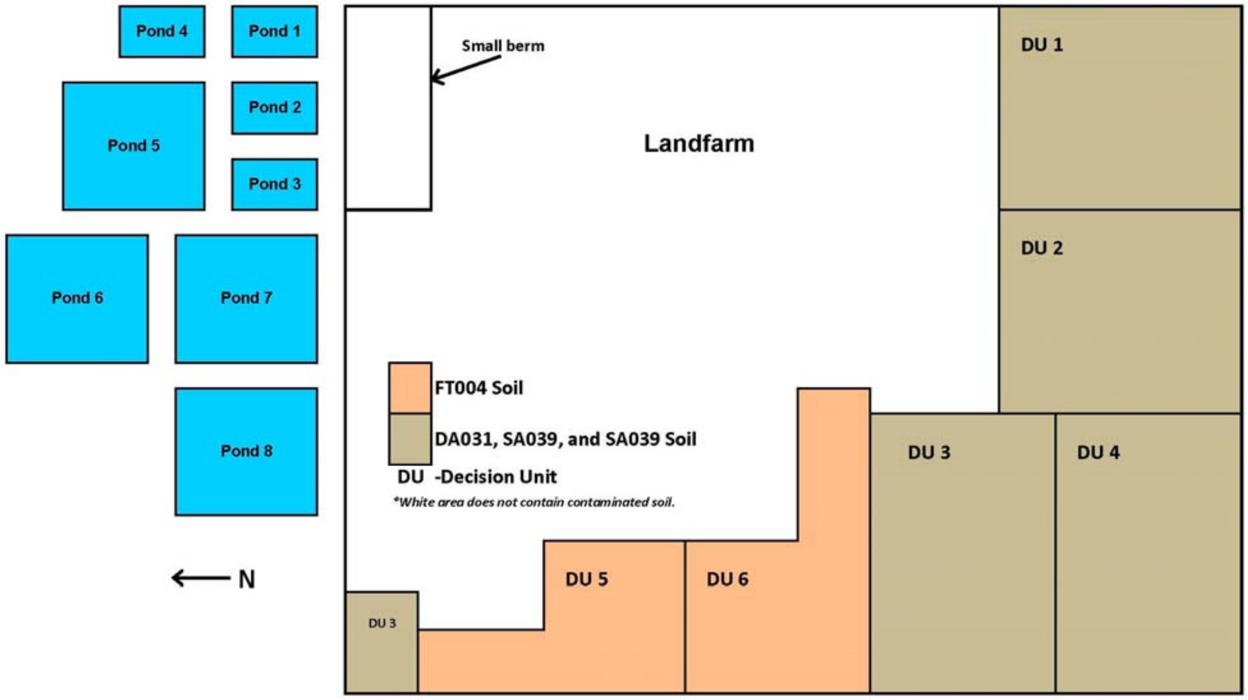


Figure 10-2. Landfarm MI Sampling Decision Units

Triplicate sampling was collected in order to verify that an MI sample truly represented the decision unit. A total of one set of duplicate/triplicate samples were collected from the two decision units comprised of FT004 soil and a total of one set of duplicate/triplicate samples were collected from the four decision units comprised of non-FT004 soil. The primary sampling process was repeated for both the duplicate and triplicate samples.

Multi Increment sampling was performed according to the procedures in Section 4.1 of the Field Sampling Plan.

Samples for the landfarm were sent to the project laboratory for the following analyses:

- EPA Method 8260B (VOCs)
- Methods AK 101/102/103 (GRO/DRO/RRO)
- EPA Method 8270 SIM (PAHs)
- Modified EPA 537 (PFOS/PFOA)

Analytical results for the landfarm soil samples were compared to 18 AAC 75 Method Two soil cleanup levels (Tables B1 and B2) for migration to groundwater (ADEC, 2016). Sample results are discussed in Section 10.7 of this report.

10.4.1 MI Sampling Procedures

The following procedures were performed in accordance with the *ADEC Draft Guidance on Multi Increment Soil Sampling* (ADEC, 2009).

10.4.1.1 Volatile Analyses – GRO, VOCs

Narrow-mouth 500 mL pre-tared containers and methanol were provided by an ADEC Contaminated Sites (CS) Program approved laboratory. The pre-tared bottle weight; bottle with methanol weight; bottle with soil and methanol weight; and volume of methanol were recorded and given to the project laboratory for calculating analyte concentrations.

MI samples for volatile analyses were collected according to the following procedure:

- Approximately 5g of soil was collected from each predetermined increment location using an ESS Lock N' Load disposable core sampler. This was done by setting the sampler to collect the proper volume of soil, pushing the sampler into the soil to obtain the sample, and then using the syringe to extrude the soil out of the core sampler and into a 500 mL narrow mouth amber bottle already containing methanol. The amber bottle was pre-tared and had aTeflon lined lid to prevent escape of volatiles. The 500 mL bottle was pre-filled with 150 ml of methanol to completely submerge the soil in the methanol. To minimize the loss of methanol, the bottle was kept sealed except for brief moments to place additional soil increments in the jar. The same core sampling device was used for all increment locations making up a single sample. A new core sampling device was used for each sample.
- A second soil sample (about 5g) was collected from the same predetermined increment locations and placed in an unpreserved 8ounce amber soil sample jar for percent moisture (% moisture) determination.
- After the sampler collected a volatile sample increment and a % moisture sample increment from a predetermined increment location, the sampler proceeded to the next increment location, and repeated the process, placing the soil samples into the same methanol preserved container and unpreserved container. The soil to methanol ratio remained a minimum of 1:1, and the soil was completely submerged in the methanol.
- Once all the volatile sample increments were collected for a single sample, the bottle was mixed by swirling. The soil/methanol extract was allowed to settle overnight while the semivolatile portions of the sample were being prepared. The soil/methanol extract was stored in a cooler with frozen gel ice until being ready to process. Three 25 mL aliquots of methanol were transferred with a disposable 5 mL HDPE pipette from the 500 mL bottle to three individual 40 mL VOA vials for shipment to the laboratory.

10.4.1.2 Non-Volatile Analyses – DRO, RRO, PAHs, PFOS/PFOA

After volatile samples were collected:

- The sampler collected soil (30-60g) from each predetermined increment.
- The soil was scooped with a disposable metal spoon into a small disposable plastic cup to get the same volume of soil at each location. The soil was then transferred from the plastic cup into a new gallon-size Ziploc bag.
- After all the predetermined sample increments were collected into the Ziploc bag, the entire bulk MI sample was spread out onto a disposable aluminum pan for drying.
- When the sample was sufficiently dry (1 to 3 days) to allow sieving, the entire sample was sieved using a #10 (2 mm) sieve into a large stainless steel bowl. Any clumps of soil found in the sample were broken up so that all of the <2mm fraction was used. The sieve and the bowl were decontaminated after each use.
- After sieving, the <2 mm fraction was spread evenly on the aluminum pan used for drying to approximately ½ inch in depth.
- The soil on the tray was divided into 30 sections. Using a small plastic measuring spoon, equally sized portions of soil were collected from each of the sections to achieve the necessary amount of soil for each analysis. The measuring spoon was decontaminated after each sample.
- For PAH, DRO, RRO, and % moisture analyses, soil collected from each sample was placed into 4 ounce amber glass soil sampling jars. For PFC analyses, the soil was placed into a 250 mL HDPE bottle with no Teflon lid. For DRO, RRO, and % moisture analyses, 30g of soil was submitted in each jar. For PAH analyses, 10g of soil was submitted in each jar. For PFC analyses, 5g of soil was submitted in each bottle. Extra jars/bottles with soil were submitted to the lab for MS/MSD analyses and as backups.

10.5 LANDFARM NUTRIENT SAMPLING

On September 17, 2016, three soil nutrient samples were collected from the landfarm to assess C:N:P (carbon:nitrogen:phosphorus) ratios. Two evenly distributed subsamples from each decision unit were collected and composited with one other decision unit for each sample. DU1 and DU2 were composited, DU3 and DU4 were composited, and DU 5 and DU6 were composited. The samples were submitted to the project laboratory for ammonia, phosphorous, and nitrate/nitrite analyses. Sample results are discussed in Section 10.6.2 of this report.

One bulk density sample was also collected from each decision unit for calculating nutrient levels. The samples were collected in 8 oz. soil jars and weighed before and after drying. The following bulk densities (kg/yd^3) were calculated:

- Decision Unit 1: 1,270

- Decision Unit 2: 1,210
- Decision Unit 3: 1,300
- Decision Unit 4: 1,470
- Decision Unit 5: 1,130
- Decision Unit 6: 1,500

When collecting the soil nutrient samples, an aliquot of each soil sample was taken to measure soil pH. The soil pH was between 6.8 and 7.5.

10.5.1 C:N:P Ratio

For the soil being treated in the landfarm, a C:N:P (carbon:nitrogen:phosphorous) ratio between 100:10:1 and 100:1:0.5 is desired to sustain the biodegradation process.

Three nutrient samples were collected from the landfarm and were sent to the project laboratory for the following analyses:

- EPA Method SW9056A (Nitrate/Nitrite).
- EPA Method 350.2 (Ammonia).
- EPA Method 365.3M (Phosphorous).

To calculate the quantities of C, N, and P in the landfarm soil, the product of the bulk density and total volume of soil in each landfarm decision unit will be the total mass of soil in that decision unit. It will be assumed that the total mass of hydrocarbon in the soil represents the mass of carbon available for biodegradation. The concentrations of GRO, DRO, and RRO from the multi incremental samples will be added together and used as the total petroleum hydrocarbon (TPH) concentration for that decision unit. The product of the TPH concentration and total mass of soil in the decision unit will give the total mass of carbon for that decision unit. The mass of nitrogen and phosphorous will also be the products of their concentrations and the total mass of soil in the decision unit.

10.6 ANALYTICAL RESULTS

10.6.1 Multi Increment Samples

Ten landfarm Multi Increment soil samples were submitted to the project laboratory for the following analyses:

- EPA Method 8260B (VOCs)
- Methods AK101/102/103 (GRO/DRO/RRO)

- EPA Method 8270 SIM (PAHs)
- Modified EPA Method 537 (PFOA/PFOS)

Analytical results were compared to the 18 AAC 75 Method Two soil cleanup levels (Tables B1 and B2) for migration to groundwater (ADEC, 2016).

Decision Units 1, 2, 3, and 4 exceeded the cleanup levels for DRO. Decision Units 3, 5, and 6 exceeded the cleanup levels for PFOA and PFOS. All other analytes were below cleanup levels. A summary of the analytical results is presented in Table 10-3. Complete analytical reports can be found in Appendix C.

Table 10-3 2016 Landfarm MI Sampling Analytical Results

Sample Description	**Analyte**				
	GRO (mg/kg)	**DRO (mg/kg)**	**RRO (mg/kg)**	**PFOA (µg/kg)**	**PFOS (µg/kg)**
LF DU1	6.6	**980**	830	0.091	0.21
LF DU1 (dup)	11	**1,200**	1,000	ND	0.016
LF DU1 (trip)	7.5	**1,100**	940	0.068	0.19
RSD (%)	28	10	9.3	18	14
95% UCL	12	1,300	1,100	0.098	0.23
LF DU2	2.7	**770**	1,000	0.096	0.32
LF DU3	2.6	**840**	970	**4.0**	**2.7**
LF DU4	2.8	**920**	1,900	0.21	1.2
LF DU5	4	61	170	**8.2**	**110**
LF DU5 (dup)	4.3	58	160	**8.0**	**110**
LF DU5 (trip)	3.9	64	180	**9.2**	**130**
RSD (%)	5.1	4.9	5.9	7.6	9.9
95% UCL	4.4	66	190	9.5	140
LF DU6	2.9	73	290	**29**	**170**
Cleanup Level	**300**	**250**	**11,000**	**1.7**	**3.0**

Definitions:

mg/kg = milligrams per kilogram
GRO = gasoline-range organics
RRO = residual-range organics
PFOS = Perfluorooctane Sulfonate
RSD = Relative Standard Deviation
LF = Landfarm
dup = Duplicate
µg/kg = micrograms per kilogram
DRO = diesel-range organics
PFOA = Perfluorooctanoic acid
DU = Decision Unit
UCL = Upper Confidence Limit
NA = Not Applicable
trip = Triplicate

Notes:

-Cleanup levels are most stringent levels from ADEC 18 AAC 75 Table B1, Method 2-Soil Cleanup Levels, Ingestion or Migration to Groundwater (ADEC, 2016).

-Concentrations in **BOLD** exceed cleanup levels.

10.6.2 Nutrient Samples

Three landfarm nutrient soil samples were collected and submitted to the project laboratory for the following analyses:

- EPA Method 350.1 (Ammonia)
- EPA Method 9056 (Nitrate/Nitrite as N)
- EPA Method 365.1 (Phosphorus)

For soil being treated in a landfarm, a C:N:P ratio between 100:10:1 and 100:1:0.5 is recommended to sustain the biodegradation process (Lens, 2005; USEPA, 2004a). It is assumed the total mass of hydrocarbon in the soil represents the mass of carbon available for biodegradation. The sum of GRO, DRO, and RRO concentrations from each Multi Increment sample were labeled TPH (total petroleum hydrocarbons), and used to represent the available carbon in each Decision Unit. After the TPH value was calculated for each decision unit, the average of both decision units used for each composite nutrient sample was used. The two sets of duplicate and triplicate samples were also used to calculate an average TPH for each sample area. The C:N:P ratios for each Decision Unit are given in Table 10-4.

The carbon to nitrogen ratios in Decision Units 1, 2, 3, and 4 are slightly below the lower recommended limit. Using the highest TPH of the MI samples collected from those decision units, the product of the TPH concentration and the bulk density in Decision Unit 4 provides a total mass of 4,150g C/yd^3 soil. To achieve the desired range of C:N ratios 100:1 to 100:10, a total of 41.5g to 415g N/yd^3 would be needed. The amount of N currently in the soil is calculated using the product of the ammonia concentration and the soil bulk density. In Decision Unit 4, there is 29.4g N/yd^3 soil present. By subtracting the N currently in the soil from what would be needed, it is shown that between 12.1g and 385g N/yd^3 soil is recommended. For the approximate 1,280 yd^3 of soil in Decision Unit 1, the addition of approximately 15.5kg (34 lbs.) to 493kg (1,090 lbs.) N is recommended.

In all of the decision units, the carbon to phosphorus ratios exceeded recommendations, so no amendments are required. In Decision Units 5 and 6, the carbon to nitrogen ratios are within the recommended range of 100:1 to 100:10, so no amendments are needed.

A summary of the analytical results is presented in Table 10-4. Complete analytical reports can be found in Appendix C.

Table 10-4 Landfarm Nutrient Sample Results

Sample Description	**Analyte**				
	Ammonia (mg/kg)	Phosphorus (mg/kg)	Nitrate/Nitrite as N (mg/kg)	TPH (mg/kg)	C : N : P
DU 1 & 2	18	170	ND	1,900	100 : 1 : 9
DU 3 & 4	20	200	ND	2,300	100 : 1 : 9
DU 5 & 6	25	170	0.49	290	100 : 9 : 60

Definitions:

mg/kg = milligrams per kilogram
GRO = gasoline-range organics
RRO = residual-range organics
C:N:P = carbon:nitrogen:phosphorus
TPH = Total Petroleum Hydrocarbons (sum of GRO, DRO, and RRO)
DRO = diesel-range organics
DU = Decision Unit

10.7 LANDFARM COVER

The landfarm was covered for the winter in the beginning of October with a 15-mil HDPE, UV-insensitive cover that extended 2 feet beyond the outside edges of the berms. The cover was held down on the edges by two to three feet of clean sand at the outside base of the berms. Sand bags and tires were also placed on the cover at a minimum of 50 feet on center to keep the cover down in the wind.

In the northeast corner of the landfarm, which is the lowest point in elevation where the sump is located, the cover was not long enough to drape over the berm and be secured by overlying sand. To effectively separate the water on top of the cover from the water that is in contact with the soil being treated beneath the cover, a small berm was constructed inside the landfarm on top of the liner. As shown in Figure 10-2, the berm was constructed approximately 80 feet in from the east edge of the landfarm and 20 feet in from the north edge. The berm was approximately 2.5 feet tall. The landfarm cover was draped over this berm and secured by clean sand. Another small piece of liner was placed over the new berm and extended over the original landfarm berms to the north and east to capture any rain or snow that fell in the exposed corner of the landfarm. The small cover was secured with clean sand on the outside of the landfarm berm and with large tires inside the berm. The berm can be seen on landfarm photos in Appendix F.

10.8 QUALITY ASSURANCE REVIEW

A quality assurance review (QAR) was performed to determine any data problems and evaluate the impact of these problems on the intended uses of the data. The QAR, provided in Appendix C, discusses the data quality assurance/quality control (QA/QC) procedures and presents the results of the QA/QC analysis. Additionally, Alaska Department of Environmental Conservation (ADEC) Laboratory Data Review Checklists have been completed for each laboratory work order associated with this project and are provided in Appendix D. The laboratory analytical data reports for this project are contained electronically on the CD-ROM that accompanies this report.

This analytical program included the collection of project samples, QC samples (duplicates), and trip blanks. The duplicate samples were collected at a minimum frequency of ten percent of the project samples per site. The QA/QC procedures for the project were performed in accordance with the QAPP (Paug-Vik, 2016c).

Overall, QA/QC data associated with the landfarm indicate that measurement data are acceptable and defensible for project use. Based on the data assessment, some of the analytical results were flagged with qualifiers to indicate potential problems with the qualified results. Data qualifiers are displayed with the analytical results that are provided in Appendix B tables.

10.9 CONCLUSION

Approximately 452,000 gallons of water were pumped from the landfarm and filtered into holding ponds. This included the 120,000 gallons of water in four 2015 holding ponds that required additional treatment. Once the sample from a pond confirmed that contaminants of concern were below ADEC criteria, the water from that pond was discharged. The last holding pond sampled at the beginning of October contained PFOA above ADEC criteria. This water will be refiltered in 2017.

The landfarm was divided into six decision units and sampled at the beginning of September. Decision units 1, 2, 3, and 4 were above the ADEC cleanup level of 250 mg/kg for DRO (770 – 1,200 mg/kg). Decision units 3, 5, and 6 were above the ADEC cleanup level for PFOS and PFOA. Decision units 5 and 6 consisted of soil from FT004, while decision unit 3 was POL contaminated soil placed into the landfarm adjacent to FT004 soil.

While DRO, PFOA, and PFOS concentrations remain above cleanup levels, overall, the concentrations of each of these contaminants of concern have decreased since the landfarm was MI sampled in 2015.

11 BIOCELLS

Characterizing soils in the north and south biocells was necessary to determine the effectiveness of treatment over time and to investigate the presence of perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) from soil that came from site FT004. The north and south biocells were sampled from August 29th to September 2nd, 2016.

11.1 BIOCELL WATER SAMPLING

One water sample was collected from the sump riser of each biocell on October 4th, 2016 and analyzed for PFOA and PFOS.

11.2 MULTI INCREMENT SAMPLING

Multi Increment sampling was performed on each biocell according to the 2016 LTM Work Plan (PVS, 2016) and the ADEC Draft Guidance on Multi Increment Soil Sampling (ADEC, 2009). To be valid, MI sampling was performed for appropriate decision units. A decision unit is the defined area or volume to be characterized. As shown in Figure 11-1, the North and South Biocells were each divided into two decision units since the amount of soil in those biocells exceeds 1,200 yd^3 each.

To avoid puncturing the liner when collecting samples at depth, the area within 8 ft. of the edge on all sides were excluded from the sampling area. The surface of the biocell was divided into two equal-sized sections. Each section was a separate decision unit. Each decision unit was divided into four quadrants. Each quadrant was subdivided into 50 subsections. The subsections were numbered 1 to 50 for the first quadrant and 51 to 100 for the second, etc. A total of 200 subdivisions were created for each decision unit. Using a random number generator, 8 subdivisions from each quadrant were chosen for a total of 32 samples per decision unit.

For the North Biocell, each MI sample location was assigned a random number between 0 and 5. Zero represented the surface and 1 through five corresponded to the depth below the surface that samples were collected. The maximum sampling depth of 5 ft. was chosen to avoid puncturing the biocell liner or damaging the air pipes. For the South Biocell, each MI sample location was assigned a random number between 0 and 6 since this biocell is 1 ft. deeper than the North Biocell.

For duplicate and triplicate sampling, the sampling process mentioned in the previous paragraphs was repeated for both the duplicate and triplicate samples. An MS/MSD sample pair was collected for each analysis. Since the North Biocell and South Biocell contain soil from the same sites, only 1 duplicate/triplicate sample set was collected. They were collected from the North Biocell Decision Unit 1.

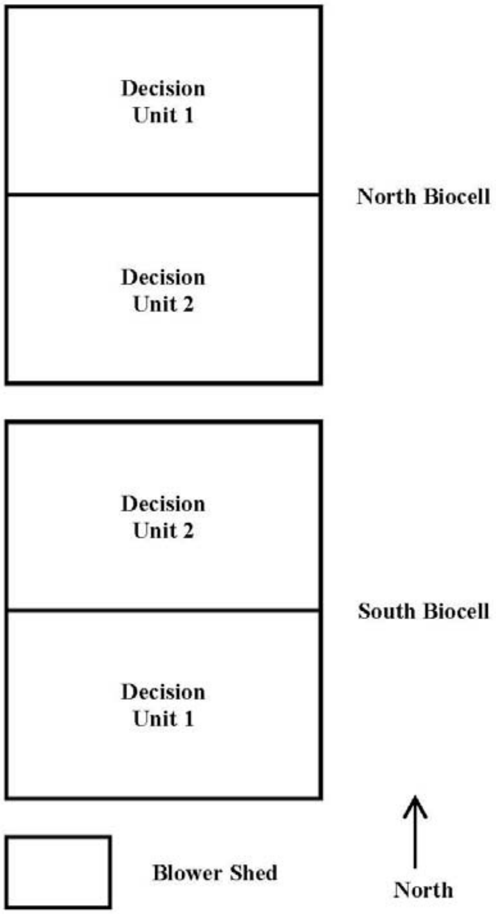


Figure 11-1. Biocell Multi Increment Decision Units

Multi Increment sampling was performed according to the procedures in Section 4.1 of the Field Sampling Plan.

All biocell samples were submitted to the project laboratory for the following analyses:

- Alaska Method AK 101 - GRO
- EPA Method 8260B - VOCs
- Alaska Method AK 102/103 - DRO/RRO
- EPA Method 8270 SIM - PAHs
- Modified EPA Method 537 – PFOS/PFOA
- Percent Solids

11.3 ANALYTICAL RESULTS

11.3.1 Multi Increment Samples

Six biocell Multi Increment soil samples were submitted to the project laboratory for the following analyses:

- EPA Method 8260B (VOCs)
- Methods AK101/102/103 (GRO/DRO/RRO)
- EPA Method 8270 SIM (PAHs)
- Modified EPA Method 537 (PFOA/PFOS)

Analytical results were compared to the 18 AAC 75 Method Two soil cleanup levels (Tables B1 and B2) for migration to groundwater (ADEC, 2016).

DRO results for the north biocell ranged from 2,100 mg/kg to 2,700 mg/kg. The ADEC cleanup level for DRO is 250 mg/kg. PFOS and PFOA concentrations ranged from 14 to 240 µg/kg and 52 to 210 µg/kg, respectively. The ADEC cleanup levels are 1.7 µg/kg for PFOS and 3.0 µg/kg for PFOA.

DRO results for both decision units in the south biocell were 1,200 mg/kg. The results for PFOS were 880 µg/kg and 1,400 µg/kg. The results for PFOA were 740 µg/kg and 1,300 µg/kg.

All other analytes were below cleanup levels. A summary of the analytical results is presented in Table 11-1. Complete analytical reports can be found in Appendix C.

11.3.2 Biocell Water Samples

Two biocell water samples were submitted to the project laboratory for analysis by a modified EPA Method 537 for PFOS and PFOA. Analytical results were compared to the cleanup levels in 18 AAC 75 (amended as of July 1, 2017).

Both sample results were well above the ADEC criteria of 0.40 µg/L. The PFOS and PFOA results from the north biocell were 22 µg/L and 120 µg/L, respectively. The PFOS and PFOA results from the south biocell were 100 µg/L and 36 µg/L, respectively.

Table 11-1 2016 Biocell MI Soil Sample Results

Sample Description	Analyte				
	GRO (mg/kg)	DRO (mg/kg)	RRO (mg/kg)	PFOA (µg/kg)	PFOS (µg/kg)
BCN DU1	130	**2,600**	5,200	**82**	**160**
BCN DU1 (dup)	160	**2,700**	3,100	**52**	**140**
BCN DU1 (trip)	160	**2,200**	3,500	**75**	**160**
RSD (%)	12	11	28	23	7.5
95% UCL	180	2,900	5,800	96	170
BCN DU2	140	**2,100**	4,500	**210**	**240**
BCS DU1	250	**1,200**	5,400	**1,300**	**1,400**
BCS DU2	200	**1,200**	5,200	**740**	**880**
Cleanup Level	**300**	**250**	**10,000**	**1.7**	**3.0**

Definitions:

mg/kg = milligrams per kilogram
GRO = gasoline-range organics
RRO = residual-range organics
PFOS = Perfluorooctane Sulfonate
RSD = Relative Standard Deviation
LF = Landfarm
dup = Duplicate

µg/kg = micrograms per kilogram
DRO = diesel-range organics
PFOA = Perfluorooctanoic acid
DU = Decision Unit
UCL = Upper Confidence Limit
NA = Not Applicable
trip = Triplicate

Notes:

-Cleanup levels are most stringent levels from ADEC 18 AAC 75 Table B1, Method 2-Soil Cleanup Levels, Ingestion or Migration to Groundwater (ADEC, 2016).

-Concentrations in **BOLD** exceed cleanup levels.

11.4 BIOCELL COVERS

On August 31, 2016, immediately prior to sampling the biocells, the existing 20-mil HDPE covers were removed and disposed of at the local landfill. After the sampling was performed, new covers made from Layfield Enviro Liner 6030 geotextile were installed. As shown below in Figure 11-2, the cover was placed over the contaminated soil and the surrounding berms to prevent precipitation from entering the biocell. The sump riser extends through the top cover, and it was sealed so that precipitation cannot enter the cell around this protrusion through the top cover. The cover is held down on the edges by two to three feet of clean soil or sand at the outside base of the berms.

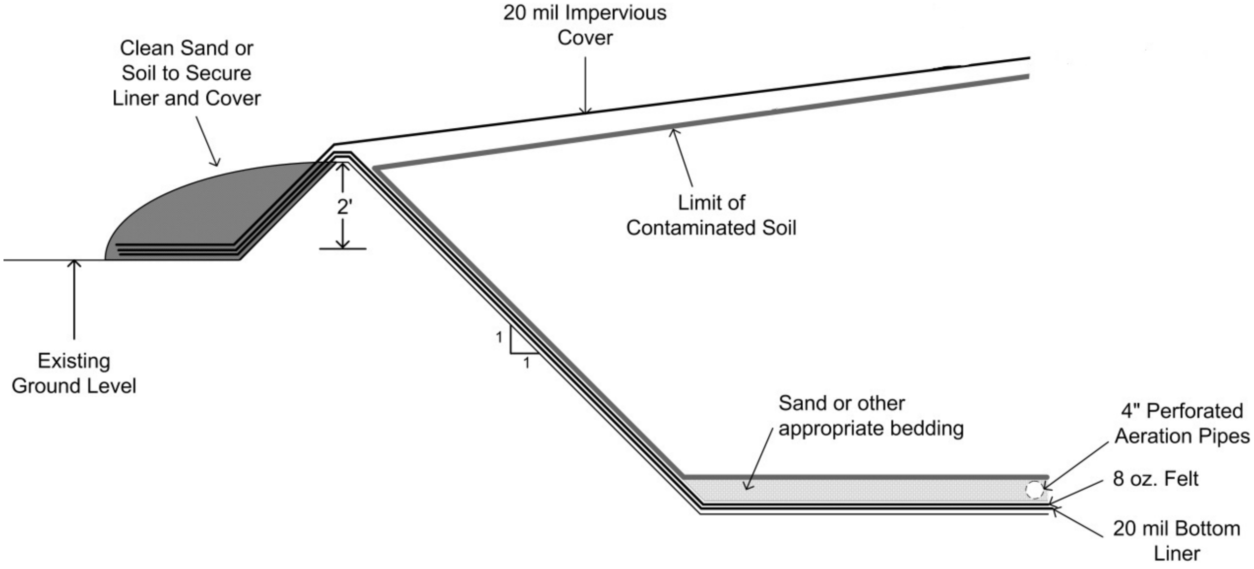


Figure 11-2. Cross-sectional view of King Salmon Biocells.

11.5 QUALITY ASSURANCE REVIEW

A quality assurance review (QAR) was performed to determine any data problems and evaluate the impact of these problems on the intended uses of the data. The QAR, provided in Appendix C, discusses the data quality assurance/quality control (QA/QC) procedures and presents the results of the QA/QC analysis. Additionally, Alaska Department of Environmental Conservation (ADEC) Laboratory Data Review Checklists have been completed for each laboratory work order associated with this project and are provided in Appendix D. The laboratory analytical data reports for this project are contained electronically on the CD-ROM that accompanies this report.

This analytical program included the collection of project samples, QC samples and trip blanks. The duplicate samples were collected at a minimum frequency of ten percent of the project samples per site. The QA/QC procedures for the project were performed in accordance with the QAPP (Paug-Vik, 2016c).

Overall, QA/QC data associated with the biocells indicate that measurement data are acceptable and defensible for project use. The overall completeness calculated for this project was 100 percent. Based on the data assessment, some of the analytical results were flagged with qualifiers to indicate potential problems with the qualified results. Data qualifiers are displayed with the analytical results that are provided in Appendix B tables.

11.6 CONCLUSION

The North and South Biocells were divided into two decision units each and sampled at the end of August. All four decision units were above the ADEC cleanup level of 250 mg/kg for DRO and the ADEC cleanup levels for PFOS and PFOA.

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